FINAL

PRE-REMEDIATION FIELD SAMPLING PLAN
PAINESVILLE FUSRAP SITE
PAINESVILLE, OHIO

Prepared for:

U.S. ARMY ENGINEER DISTRICT, BUFFALO
Buffalo, New York
Formerly Utilized Sites Remedial Action Program

US Army Corps of Engineers®

Contract No. DACW49-03-D-00003/0002

Prepared by:

CABRERA SERVICES, INC.
East Hartford, CT

and

Argonne National Laboratory
Environmental Assessment Division
Argonne, IL

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FIELD SAMPLING PLAN (FSP)

Contract No. DACW49-03-D-0003/0002

FIELD SAMPLING PLAN APPROVALS

By their specific signature, the undersigned certify that they reviewed and provided comments on this FSP for use during activities at the Painesville FUSRAP Site, Painesville, Ohio.

APPROVED BY:

[redacted]

9/30/05
Date

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ACRONYMS, ABBREVIATIONS, AND SYMBOLS

AA	Alternate Action
AEC	US Atomic Energy Commission
AOC	Area of Concern
AL	Action Level
ANL	Argonne National Laboratory
BDE	butadiene
CABRERA	Cabrera Services, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Chain of Custody
CHP	Certified Health Physicist
CSM	Conceptual Site Model
cm	centimeter(s)
DCGL	Derived Concentration Guideline Level
$DCGL_{emc}$	Derived Concentration Guideline Level, Elevated Measurement Comparison
$DCGL_{w}$	Derived Concentration Guideline Level, Wilcoxon Rank Sum
DMC	Diamond Magnesium Company
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DQA	Data Quality Assessment
DQCR	Daily Quality Control Report
DQO	Data Quality Objectives
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
FUSRAP	Formerly Utilized Sites Remedial Action Program
ft	foot (feet)
FS(A)	Feasibility Study (Addendum)
FSM	Field Site Manager
FSP	Field Sampling Plan
FSS	Final Status Survey
g	gram(s)
GEL	General Engineering Laboratories
GPS	Global Positioning System
GWS	Gamma Walkover Survey
HDPE	High-Density Polyethylene
IDW	Investigation Derived Waste
keV	kilo-electron volts
LBGR	Lower Bound of Gray Region
LOSA	Lake Ontario Storage Area
m, m^2	meter(s), square meter(s)
MARSSIM	Multi Agency Radiation Survey and Site Investigation Manual

NAD83	North American Datum, 1983
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
OEPA	Ohio Environmental Protection Agency
ODOH	Ohio Department of Health
pCi, pCi/g	picoCurie(s), picoCurie(s) per gram
PM	Project Manager
POC	Point of Contact
ppm	Parts per million
QA/QC	Quality Assurance / Quality Control
QAC	Quality Assurance Coordinator
QAPP	Quality Assurance Project Plan
QCM	Quality Control Manager
QCP	Quality Control Plan
Ra	Radium
RESRAD®	Argonne National Laboratory's RESidual RADioactivity computer code
RI	Remedial Investigation
RCOC	Radiological Contaminant of Concern
RSP	CABRERA Radiation Safety Program
SOP	Standard Operating Procedure
SOR	Sum of Ratios
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
SU	Survey Unit
TBD	to be determined
Th	Thorium
TPP	Technical Planning Process
U	Uranium
UCC	Uniroyal Chemical Company
USACE	U.S. Army Corps of Engineers
USACE–Buffalo	U.S. Army Corps of Engineers, Buffalo District
USGS	U.S. Geological Survey
Z_{rep}	Replicate Z-score

1.0 INTRODUCTION

1.1 PURPOSE AND APPROACH

Cabrera Services Inc. (CABRERA) has been contracted by the U.S. Army Corps of Engineers – Buffalo District (USACE-Buffalo) under Contract No. DACW49-03-D-0003 (hereafter referred to as the "Contract") (USACE, 2004), to provide Hazardous, Toxic, and Radioactive Waste environmental services for the Painesville FUSRAP Site (hereafter referred to as the "Site") in Painesville, Ohio. This site has been identified as containing various levels of residual radioactive material in soils and sediments from previous operations, including thorium-232 (Th-232), thorium-230 (Th-230), radium-226 (Ra-226), and uranium-238 (U-238). This Field Sampling Plan (FSP) has been prepared to describe the project requirements for pre-remediation radiological surveys, sample collection, and radiological analysis of Site soils.

The purpose of this field effort is to refine the existing Conceptual Site Model (CSM) for the Site by distinguishing areas that need to be remediated in order for the Site to meet established closure requirements.

This Field Sampling Plan (FSP) provides the rationale and protocol for collecting samples and other data in preparation for remediation and closure of the Site. The logic of this FSP is driven by looking toward the endpoint (i.e., remediation and site closure) and being consistent with the widely accepted Multi-Agency Site Survey and Investigation Manual (MARSSIM) protocols. [U.S. Environmental Protection Agency (EPA) 2000b]

Data will be collected to 1) refine the horizontal and vertical boundaries of soil that is to be removed and to 2) conclusively test the assumptions and parameter values in the CSM. One assumption of the CSM is that subsurface contamination exists only where surface soil is also contaminated, with the exception of the former butadiene (BDE) tank area, where construction of the tank and berm took place over contaminated material. A second assumption is that subsurface lenses of contamination do not extend outside of the bounds of the areas to be excavated.

Further, data will be collected in those areas not requiring remediation to confirm closure of those areas. The results from the field effort will be compared to cleanup guidelines established as part of the Feasibility Study Addendum for the Site (USACE 2005). The guidance contained in the MARSSIM (EPA 2000b), USACE's technical project planning (TPP) process (EM 200-1-2), and the DQO process (EPA 2000 and 2000a) will be used to demonstrate compliance.

1.2 REPORT ORGANIZATION

This FSP consists of the following sections:

1. Introduction – presents purpose of the report and report organization.
2. Site Description – contains a physical description of the site and site contaminants
3. Organization and Responsibilities – lists the parties involved in survey activities and the general responsibilities of each party
4. Data Quality Objectives – outlines a systematic procedure for defining the site criteria by which the data collection design is satisfied
5. Field Activities – specifies the characterization strategy and methods used to conduct field activities
6. Field Operations Documentation – specifies field documentation for quality assurance
7. Laboratory Analysis – specifies the methods for analyzing soil/sediment samples collected
8. Reporting – provides an overview of the basic information to be provided in final reports detailing characterization results
9. References – lists citations

This plan is based on information available at the time of its preparation. It is recognized that additional historic information on site operations, conditions encountered at the time of the survey implementation, and findings as the survey progresses may trigger modifications to this plan. If modifications are determined necessary they will be justified, documented, and approved by the USACE prior to implementation.

2.0 SITE DESCRIPTION

2.1 BACKGROUND

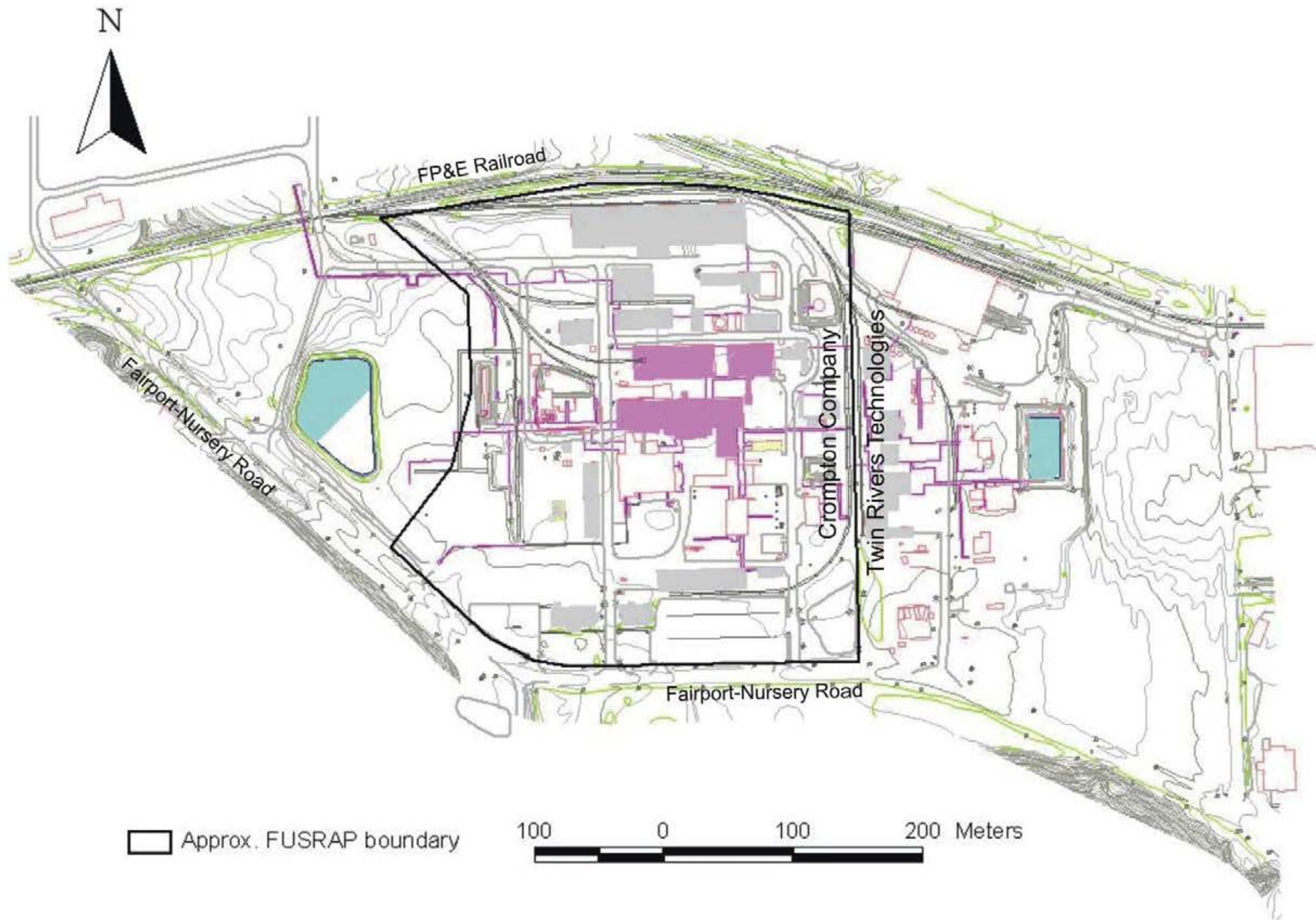
The Site is located at 720 Fairport-Nursery Road in Painesville, Ohio, approximately 35.4 kilometers (km) [22 miles (mi)] northeast of Cleveland. Figure 2-1 shows the site's proximity to the surrounding area. The site is located at approximately 41 degrees, 45 minutes north latitude, 81 degrees, 15 minutes east longitude, and is shown on the Perry Quadrangle, Ohio-Lake County, 7.5 minute series, United States Geological Survey (USGS) map.

The Site is bounded on the north by the FP&E Railroad, on the south and west by Fairport Nursery Road, and on the east by Hardy Road. Painesville Township Park lies north of the site, while industrial properties are located on the other sides of the site. The Diamond Alkali Waste Lake, a confirmed hazardous waste site under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), is located to the south of the site, and residential properties are to the northeast. An abandoned industrial site is located to the northwest. The Grand River is located approximately 0.2 kilometers (km) [0.1 miles (mi)] southwest of Fairport Nursery Road, and flows in a northwesterly direction towards Lake Erie.

The site contained as many as 35 buildings and structures. Except for one, the buildings on the Uniroyal portion of the site have been demolished. Available information on the construction and function of most of these buildings is limited. Information on the original site boundary and information on the former locations of buildings is illustrated in Figure 2-1.

2.2 SUMMARY OF SITE HISTORY

In the early 1940s, the Defense Plant Corporation constructed a magnesium production facility in Painesville, Ohio, on property owned by the Diamond Magnesium Company (DMC). The DMC operated this facility from the early 1940s to the early 1960s for the General Services Administration (GSA) in support of the war effort and later government operations. In 1963 the GSA sold the plant in two parcels. Uniroyal Chemical Company (UCC) purchased approximately 15.5 hectares (ha) [38 acres] located at 720 Fairport-Nursery Road. Lonza Chemical Company (LCC) purchased the remaining property (approximately 5.6 ha [14 acres]) located at 679 Hardy Road, which is adjacent to the eastern UCC property line. Combined, the two properties compose the property on which the Defense Plant Corporation operated (ORNL 1990, 1991).



(Figure courtesy of Argonne National Laboratory)

Figure 2-1. Painesville Site Study Area. Site configuration portrayed circa 1998

There is no known history of processing or production of radioactive materials at the Site. The radioactivity present at the site resulted from the use of contaminated scrap ferrous metal to scrub chlorine gas released during the magnesium production process. The GSA obtained the scrap metal from the Atomic Energy Commission's (AEC) inventories at the Lake Ontario Storage Area (LOSA) in Niagara Falls, New York. By the early 1950s, LOSA had accumulated significant quantities of scrap metal, in part because metal drums were used to ship and store pitchblende ores and residues of uranium extraction from ores. When the pitchblende residues were consolidated into a storage facility at LOSA, the emptied drums were cleaned for reuse or scrapped. These drums, which contained observable residues of pitchblende ores, were part of the scrap shipped to the Site (ORNL 1991). Because of the documented site history, only those radionuclides associated with the pitchblende residues [primarily radium-226 (Ra-226), thorium-230 (Th-230), uranium-238 (U-238) and their decay products] are considered Manhattan Engineering District (MED)/AEC related.

Approximately 1,650 tons of scrap metal were shipped to the Site in three shipments that occurred in December 1951, July 1952, and April 1953 (Hershman 1952 and Hershman 1953). The scrap metal was delivered by railroad to the western side of the property and stored uncovered on the ground surface. Former employees have indicated that an additional delivery route was also used on the eastern side of the buildings, where scrap was moved from the west railroad siding to the east siding by sliding uncovered rail-sided wooden skids or sheds pulled by a tractor (Eddington 1996). In a recent interview a former plant manager indicated that scrap was off loaded from both east and west spurs and was moved via rail car from one siding to another (Trumbel 2001). From the eastern side, the scrap metal was either immediately added to the hydrochloric acid digester tanks or stored on the ground (ORNL 1990).

Because the contaminants of concern (COCs) in the scrap metal were related to MED/AEC activities, a preliminary and limited radiological survey was conducted by ORNL in 1988 to determine whether the site met the current radiological guidelines for release or if additional investigation and cleanup was required. The results from this survey indicated that the site contained radioactivity greater than the existing guidelines for unrestricted use (ORNL 1990, 1991). The primary RCOCs were determined to be Ra-226, Th-230, U-238 and their decay products (thorium-232 [Th-232] is also present at much lower concentrations as a constituent in uranium ore material). Based on these initial surveys, the site was designated by DOE as a FUSRAP site for further evaluation and remedial implementation, as appropriate (Williams 1992). The authorization for remedial action at the Site only includes radionuclides that are related to MED/AEC activities.

2.3 SITE CHARACTERIZATION

2.3.1 Historical Data Collection Programs

Several investigations have been conducted at the Site to provide information on the locations and concentrations of radionuclides associated with former MED/AEC activities. The first survey was conducted by ORNL in October, 1988. This preliminary site evaluation consisted of a gamma walkover survey and selected soil samples from the UCC property (now owned by Crompton Company). ORNL returned to the site in September 1990 and collected additional data from surface and subsurface soil (including locations within the LCC property [now owned by Twin Rivers Technologies]). The results from the ORNL surveys indicated that MED/AEC related radionuclides were present in surface and subsurface soil in excess of DOE guidelines for unrestricted use. The primary COCs for this investigation were U-238, Th-230, and Ra-226, with activity levels as high as 76 pCi/g, 310 pCi/g, and 1,500 pCi/g, respectively.

The Department of Energy (DOE) conducted a detailed investigation of the Site in 1996 as part of the FUSRAP process. This investigation included ambient air sampling, external gamma exposure rate measurements, building radiological surveys, gamma walkover surveys, groundwater sampling, surface geophysical surveys, surface water and sediment sampling, ecological sampling, and soil sampling. The results from this investigation are documented in the *Characterization Report for the Painesville Site* (USACE 1998a) and are included in the Investigation Area summaries discussed below.

Following the DOE characterization investigation, an Engineering Evaluation/Cost Analysis Report was developed in support of a CERCLA Removal Action (USACE 1998b). As part of this effort, a site cleanup goal of 27 pCi/g Ra-226 was specified and used as the basis for removal actions conducted in late 1998. Removal Action activities were suspended for winter after excavation of slightly more than 1,300 yd^3 of soil. Some additional samples were taken during the Removal Action in areas that were not excavated. These sample results are also included in the discussion of site characterization results (Section 2.3.2 below).

While performing the Removal Action, the contractor found more contamination present than had been expected based on the results from the previous investigations. Subsequent to the Removal Action, Uniroyal Chemical Company decided to close its facility located on part of the Site. The results from the 1998 Removal Action samples and the cessation of site operations resulted in a re-evaluation of site conditions and a decision to conduct a focused Remedial Investigation/Feasibility Study (RI/FS).

The focused RI/FS was conducted by USACE in September 2000 and primarily addressed residual radionuclides in soil (USACE 2003). The RI/FS consisted of additional field sampling and baseline human health and ecological risk assessments. Field activities included collection of surface and subsurface soil samples, groundwater samples, and collection of gamma exposure rate data through a gamma walkover survey. The results from these activities were used to identify potential source areas, determine if vertical zones within the shallow soil have been impacted by past operations, and delineate the extent of impacted areas. The following section provides more detailed information concerning the results from each of the characterization efforts, including the focused RI/FS.

2.3.2 Site Characterization Results

Several areas of residual radionuclide contamination have been identified for further investigation based on results from the field sampling efforts described in the previous section. Figure 2-2 shows the locations of the historical investigation areas (IAs), and the following sections provide brief descriptions of the IAs, with summaries of sample results showing residual contamination conditions. Characterization results are summarized for Ra-226, Th-230, and U-238. These radionuclides represent the primary radionuclides of concern for the site and are the radionuclides that impact cleanup decisions. Because uranium is present in natural abundances, U-238 results provide characterization of total uranium contamination. In addition, while Th-232 is present at low concentrations, a review of the RI database for the site showed that even in the limited areas where Th-232 is present above background levels, it is typically collocated with Ra-226 and U-238 at much higher concentrations, and it is not present within any investigation area at sufficient concentrations to impact cleanup decisions (i.e., the Th-232 concentrations do not have a significant impact on SOR calculations).

The discussion of the existing characterization data supports the CSM, which indicates where remediation is likely to be necessary. Subsequent to the excavation, a separate sampling and analysis plan will be developed utilizing the strategy in the FSSP to demonstrate that the remediation is successful and closure of the excavated survey units (SUs) can be achieved.

Figure 2-2 illustrates the site layout with the proposed excavation footprints under the construction worker exposure scenario. These footprints represent proposed excavations based on currently available data and are a working best estimate for the size and distribution of excavation footprints.

Investigation Area A

Investigation area A corresponds to the location where radiologically contaminated steel was apparently stored on the site prior to its use. This area includes the soil around the former BDE tank and the excavation area from the removal action conducted in 1998. A large number of soil samples (more than 150) were taken in area A during the course of investigative activities in 1996, 1998 (removal action), and 2000 (RI sampling). The results from these samples show Ra-226 concentrations to 862 pCi/g, Th-230 concentrations to 422 pCi/g, and U-238 concentrations to 282.7 pCi/g.

The highest levels of contamination in area A are found along the former rail bed and south of the former BDE tank. Contamination above cleanup guidelines (SOR >1) is primarily found in the upper two feet of soil. However there is localized contamination in deeper soil just south of the former BDE tank, and in soil within the asphalt berm around the spill containment basin. Proposed additional excavation at area A is approximately 13,500 square feet in size and extends to a depth of approximately 10 feet.

(Figure courtesy of Argonne National Laboratory)

Figure 2-2. Historical Investigation Areas and Proposed Excavation for Working Best Estimate of Soil Based on the Construction Worker Scenario. Site configuration portrayed circa 1998.

Investigation Area B

Investigation area B includes the soil along the eastern rail spur in the east central portion of the site. Several samples were taken of soil within area B during the investigations in 1996 and 2000. While this area contains contaminated soil, it was not addressed during the removal action in 1998. The results from samples in area B showed maximum Ra-226, Th-230, and U-238 concentrations of 10.6 pCi/g, 10.5 pCi/g, and 8.4 pCi/g, respectively. Contamination above cleanup guidelines is primarily found in near surface soil (to a depth of approximately two feet below ground surface). Area B is approximately 1,100 square feet in size.

Investigation Area C

Investigation area C includes the soil in the area between the MDI/TDI transfer station on the Crompton Company property and the eastern rail spur in the southeast portion of the site (adjacent to the property line with Twin Rivers Technology). Area C corresponds to the former location of the acid digester tanks, into which the radiologically contaminated scrap steel was immersed as part of the chlorine scrubbing process. Several samples were taken of soil within area C during the investigations in 1996 and 2000. While this area contains contaminated soil, it was not addressed during the removal action in 1998. The results from samples in area C showed maximum Ra-226, Th-230, and U-238 concentrations of 285 pCi/g, 312 pCi/g, and 320 pCi/g, respectively.

Within area C the highest levels of contamination in surface soil are found just east of the fence on the Twin Rivers Technologies property, and just west of the railroad tracks on the Crompton Company property. Contamination above cleanup guidelines is primarily found in the upper two feet of soil, though one sample indicates contamination to a depth of approximately 4 feet. Area C is approximately 15,400 square feet in size.

Investigation Area D

Investigation area D includes the soil along the southeast portion of the Crompton Company property behind Building 402 (magnesium cell warehouse). Several samples were taken of soil within area D during the investigations in 1996 and 2000. The results from samples in area D showed maximum Ra-226, Th-230, and U-238 concentrations of 14.8 pCi/g, 20.7 pCi/g, and 5.3 pCi/g, respectively.

Within area D the highest levels of contamination in surface soil are found southeast of Building 402 and along the railroad tracks. Contamination above cleanup guidelines is primarily found in the near surface soil (to a depth of approximately 1 ft.). Area D is approximately 3,600 square feet in size.

Areas E and F

Areas E and F were established as investigative areas early in the site characterization process. As a result of the past characterizations it has been determined that these areas no longer need to be carried forward as areas where special attention is required and they will be addressed along with the remainder of the site under the site closure protocol.

Investigation Area G

Investigation area G includes the soil between two old rail spurs south of the former Building 428. Several samples were taken of soil within this area during the investigations in 1996 and 2000. The results from samples in area G showed maximum Ra-226, Th-230, and U-238 concentrations of 22.4 pCi/g, 13.5 pCi/g, and 12.1 pCi/g, respectively. Within area G contamination above cleanup guidelines is primarily found in the near surface soil (to a depth of approximately 0.5 ft.below ground surface). Area G is approximately 5,100 square feet in size.

Investigation Area I

Area I lies outside of the area addressed under FUSRAP authority and is not addressed by this FSP.

Rubble Pile Area

The Rubble Pile investigative area is an area south and east of the eastern rail spur, and consists of soil and construction debris from the excavation of foundations in the vicinity of the former acid digesters. Several samples were taken of soil within the northern portion of the Rubble Pile and an area immediately north of the Rubble Pile during the investigations in 1996 and 2000. The results from samples in these areas showed maximum Ra-226, Th-230, and U-238 concentrations of 75.8 pCi/g, 79.0 pCi/g, and 22.0 pCi/g, respectively. Contamination above cleanup guidelines within an estimated 5,100 square foot area encompassing these sample locations has an uncertain depth expected to be primarily to a depth of approximately 3 ft. or less below ground surface.

Post 1950 Structures

The Post 1950s Structures Investigative area was established to evaluate possible contaminated fill around buildings. While no scrap metal containing radionuclides was shipped to the site after 1953, construction of new buildings provided the possibility that contaminated soil could have been used as fill around structures. The buildings covered in this investigative area included the pump house south of the former BDE tank, the MDI/TDI transfer facility, and buildings 413, 414, and 415. Results from soil samples collected around these facilities show very few results greater than background levels. The maximum concentrations of Ra-226, Th-230, and U-238 in these samples were 7.42 pCi/g, 3.73 pCi/g, and 2.99 pCi/g, respectively. The maximum results for all three primary contaminants of concern were found in the 4 to 5 foot sample from soil boring SB00016, located east of the MDI/TDI facility on the fringes of area C. These results are likely associated with the acid digestion facility associated with area C rather than fill around the MDI/TDI facility. No excavation is currently planned for areas associated with these structures.

2.3.3 Overall Summary of Site Characterization Results

Table 2-1 provides an overall summary of sampling results for the site, including the range of concentrations, average concentration, and variability (standard deviation) for each of the primary contaminants of concern for each investigation area. From this summary it appears that Th-230 and U-238 are generally present at concentrations approximately equal to or less than Ra-226. The site database was queried and sorted to evaluate whether the presence of Ra-226 could be used to infer the presence of other RCOCs, and thus gamma emissions from Ra-226 could be used as a field indicator of conditions requiring further investigation or remediation (SOR = 1.0). The results from this evaluation showed that the SOR values for historical samples were less than one when the Ra-226 concentration was less than 5.61 pCi/g. When the Ra-226 concentration was above 8.95 pCi/g, all samples had an SOR greater than one. The range from 5.61 to 8.95 pCi/g had 18 samples; three of these samples had an SOR greater than one (17%). Thus a screening level of 6 to 9 pCi/g could be selected as a surrogate for the DCGLw SOR of 1.0, depending on the desired level of confidence. Since Ra-226 can easily be detected with field gamma instrumentation at well below 12 pCi/g, gamma scan measurements will be a primary tool in determining the need for additional investigation or remediation.

Table 2-1. Summary of Radiological Sample Results by Investigation Area

Investigation Area	RCOC	No. Samples	Summary of Detected Concentration Values			
			Minimum (pCi/g)	Maximum (pCi/g)	Average (pCi/g)	Standard Deviation (1σ, pCi/g)
IA-A	Ra-226	177	0.67	862.0	15.46	73.04
	Th-230	145	0.36	422.0	10.64	43.0
	U-238	89	0.52	282.7	12.57	33.33
IA-B	Ra-226	22	0.82	10.64	2.98	2.91
	Th-230	19	1.16	10.47	3.27	2.31
	U-238	3	1.92	8.35	4.66	3.32
IA-C	Ra-226	66	0.61	285.05	13.7	37.24
	Th-230	49	1.03	311.8	12.89	44.42
	U-238	32	1.34	320.2	20.98	56.09
IA-D	Ra-226	20	0.38	14.76	3.51	4.03
	Th-230	15	1.58	20.7	6.60	6.61
	U-238	7	2.13	5.32	3.37	1.10
IA-E	Ra-226	2	0.62	0.81	0.72	0.13
	Th-230	1	0.78	1.21	1.21	--
	U-238	1	0.78	0.78	0.78	--
IA-F	Ra-226	5	0.52	2.60	1.42	1.00
	Th-230	2	4.82	5.47	5.15	0.46
	U-238	2	1.55	1.75	1.65	5.15
IA-G	Ra-226	18	0.49	22.4	2.97	5.10
	Th-230	17	0.97	13.5	2.95	2.97
	U-238	18	1.10	12.12	5.00	3.99
IA-H (includes area contiguous with IA-A, and data of IA-I)	Ra-226	98	0.28	125.11	4.41	15.70
	Th-230	93	0.36	304.20	5.92	31.53
	U-238	95	0.38	25.38	2.94	3.65
Post 1950 Bldgs.	Ra-226	20	0.69	7.42	1.46	1.62
	Th-230	20	1.03	3.73	1.54	0.62
	U-238	13	0.95	2.99	1.55	0.52
Rubble Pile	Ra-226	16	0.64	75.78	7.58	17.75
	Th-230	16	1.22	79.04	7.32	17.28
	U-238	16	1.31	21.96	4.53	5.81

2.4 CONCEPTUAL SITE MODEL

The primary source of RCOCs at the Site was contaminated scrap steel transported to the site from the LOSA. This steel was used in magnesium production operations to scrub chlorine gas generated during the magnesium production process. Contamination was likely initially transported from the contaminated scrap metal barrels by rain and mechanical processes (physical movement of barrels) to soil underlying the storage areas. Potential secondary sources of RCOCs include the soil along transportation routes and storage areas, building surfaces, and pipes used to transport acid wastes to discharge points. Contamination was likely moved from the source areas primarily via surface water runoff, with some windblown contamination movement also possible via operations activities that generated dust. Because of the source and nature of the contamination, most of the residual radioactivity is expected to be in surface soil in and around former scrap metal storage areas, transportation corridors and drainage pathways. Subsurface contamination is present in some areas where surface soil has been disturbed during construction activities; however, results from historical investigations indicate that subsurface contamination is not expected to be present in areas without surface contamination.

Much of the site had already been developed and paved prior to the receipt of the contaminated barrels. Therefore, large areas of the site are unlikely to have been exposed to the potential for contamination. Evaluation of aerial photographs was supplemented with historical research to target locations for sampling soil associated with post-1950s structures and surrounding areas that would be most likely to be radiologically contaminated. The results of this investigation showed a very low likelihood that the soil associated with these structures would be contaminated above the range of criteria being considered for the site.

This investigation will focus on aspects of the Conceptual Site Model (CSM), as defined in the Remedial Investigation (RI) Report for the Site (USACE 2003), that require further definition to support the remedial design phase of the project. The portions of the CSM that have been identified include size of the source term as well as nature and extent of the source term. The other inputs into the CSM are understood well enough at the Site to not require further evaluation during this investigation.

Final status survey (FSS) activities will focus on verifying that surface soil concentrations are less than calculated DCGLs. In designated Class 2 survey units (SUs), these samples will be collected from the first six inches (0-6”) of undisturbed surface soils. In areas where excavation is expected, these samples will be taken from the first six inches of soil on the exposed excavation surface prior to backfilling. The CSM may be refined by activities described in this FSP, including update of the horizontal and vertical extent of contamination requiring excavation. These updates will aid in precisely delineating excavation boundaries, depths, and volumes for disposal.

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3.0 ORGANIZATION AND RESPONSIBILITIES

Under the direction of USACE, CABRERA is responsible for implementation of work assignments related to radiological survey activities at the Site. The following contains descriptions of project responsibilities for the functional roles for the Site sampling and analysis. The project-specific organization chart is provided as Figure 3-1.

3.1 USACE RESPONSIBILITIES

USACE personnel within the organizational structure hold overall management responsibility for the entire project. The USACE-Buffalo Project Manager will be the prime interface with the site property owners, the U.S. Environmental Protection Agency (USEPA), the Ohio Environmental Protection Agency (OEPA), and the Ohio Department of Health (ODOH). For purposes of QA, USACE personnel will be responsible for project direction and decisions concerning technical issues and strategies, and will set the basic policies in accordance with work assignments.

3.2 VICE PRESIDENT

The Vice President, [redacted], PhD, CHP, is the corporate officer responsible for the quality of CABRERA's work products. For the Painesville FUSRAP project, he will be responsible for assuring the project team implements the policies and procedures required under the USACE Contract and assuring that all corrective action is taken if performance is not acceptable to USACE. He will work closely with the CABRERA Quality Assurance Coordinator and Project Manager to ensure established protocols and procedures are implemented.

3.3 PROJECT MANAGER

The Project Manager (PM) for this effort will be [redacted], CHP. He is responsible for evaluating the appropriateness and adequacy of the technical services provided for the project, and for developing the technical approaches and level of effort required to address each task. He is also responsible for the day-to-day conduct of work, including integration of input from supporting disciplines, USACE, and subcontractors. He will work closely with the Field Site Manager during implementation of the field program. Specific responsibilities of this role include:

- Initiating project planning and directing project activities;
- Ensuring that qualified technical personnel are assigned to various tasks, including subcontractors;
- Identifying and fulfilling equipment and other resource requirements;
- Monitoring project activities to ensure compliance with established scopes, schedules, and budgets;
- Ensuring overall technical quality and consistency of all project activities and deliverables; and
- Serving as the primary CABRERA Point of Contact (POC) with the USACE.

The CABRERA Managing Principal and Project Manager have overall responsibility for ensuring that all activities are performed in accordance with USACE, EPA, OEPA, ODOH requirements, and according to this FSP.

3.4 QUALITY ASSURANCE COORDINATOR

The QAC, [redacted], P.G., is responsible for planning, implementing, and tracking quality assurance (QA) activities and maintaining communication with quality control (QC) and analytical task staff members. The QAC will work with the Vice President, Project Manager, and Data Management Coordinator to ensure that established QC procedures are implemented. She, or a designee, may conduct periodic site and project audits as part of this process. She may conduct periodic audits of on-site procedures, including safety procedures. The QAC's duties include QC task staffing; and ensuring that quality control data evaluation, data verification, and reporting procedures are followed. The ultimate goal of these activities is to produce data that satisfy the project objectives as defined in the project Quality Assurance Project Plan (QAPP, CABRERA 2005b).

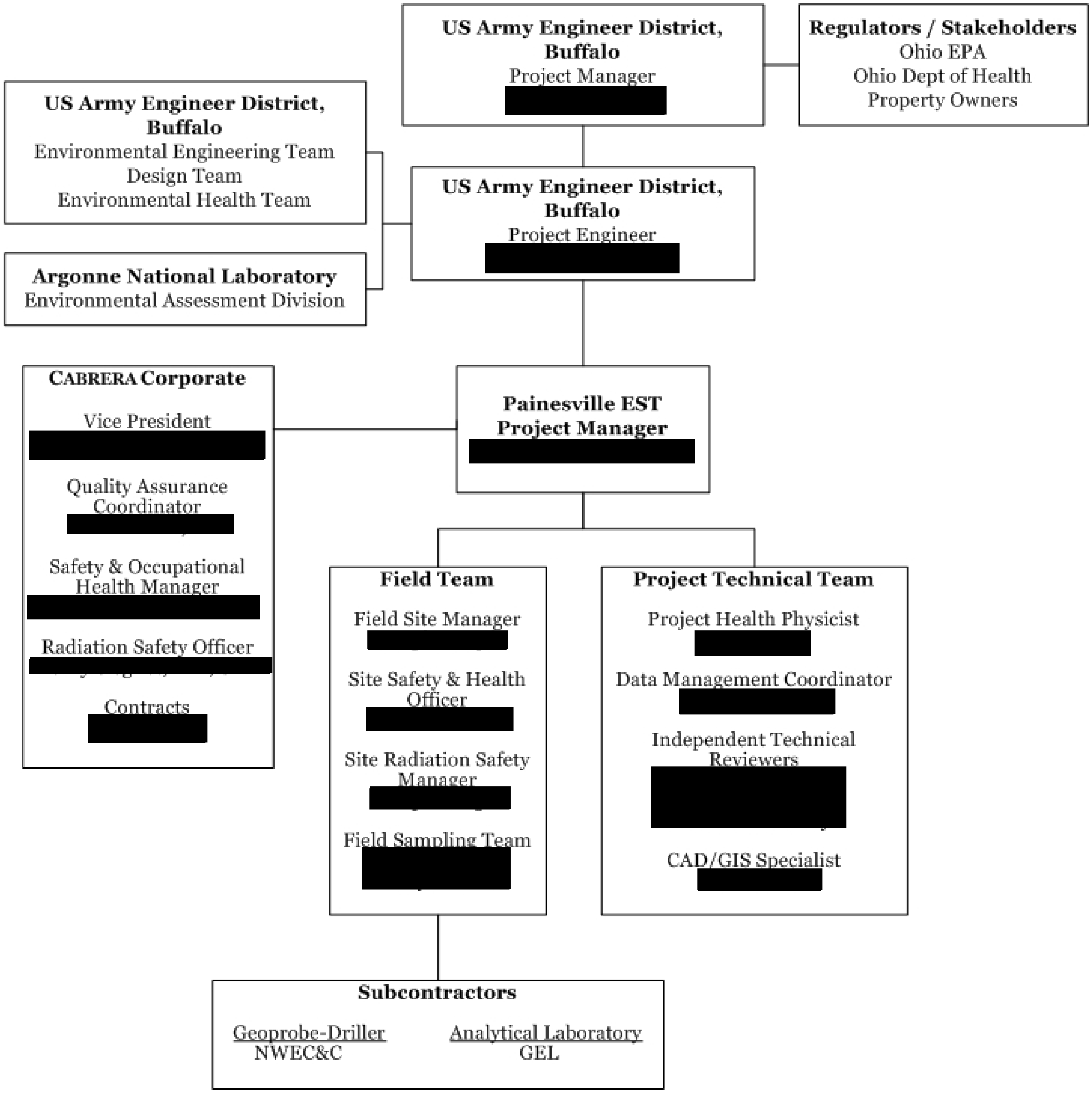

Figure 3-1. Project Organizational Chart

3.5 DATA MANAGEMENT COORDINATOR

The Data Management Coordinator, [redacted], is responsible for management of project tasks associated with field data collection and laboratory analytical data. She will also be responsible for managing the project database and coordinating near-real time data transfers between USACE, ANL, and CABRERA project personnel. She reports to the PM and will work closely with the Field Site Manager for resolution of concerns during data collection.

3.6 PROJECT HEALTH PHYSICIST

The Project Health Physicist, [redacted] is responsible for oversight and review of all radiological field activities and data. He will also be responsible for reviewing data deliverables from the laboratories, interfacing with the analytical laboratory client services coordinators, and coordinating the resolution of laboratory problems. The Project Health Physicist has the authority to direct such activities, to stop work (and restart based on consultation with the PM), and to take appropriate actions, as required, to address radiological emergency situations. He will work directly with the Field Site Manager, the Site Safety and Health Officer, and in concert with the Corporate Radiation Safety Officer (RSO) to ensure that the CABRERA RSP and QAPP are properly implemented and followed.

3.7 SITE SAFETY AND HEALTH OFFICER

The Site Safety and Health Officer, [redacted], reports directly to the PM and is responsible for ensuring that the Site Safety and Health Plan (SSHP, CABRERA 2005c) is followed and that site personnel are appropriately trained in its provisions. They both have authority to issue stop work orders on site tasks that they believe may be unsafe. When so stopped, work shall not recommence until the Corporate Safety and Occupational Health Manager, Corporate Radiation Safety Officer, and Project Manager approve the restart.

3.8 FIELD SITE MANAGER

The Field Site Manager, [redacted], reports directly to the Project Manager and is responsible for management of project tasks associated with sampling and analysis. The responsibilities of the Field Site Manager include ensuring that the field team has all the materials needed for field sampling and calibration, and reviewing analytical results. The Field Site Manager serves as the task leader for the field investigative activities for the sampling and analysis program. He will be responsible for specific field operations, such as surface soil and sediment sampling, subsurface soil sampling by Geoprobe®, instrumentation calibration, field measurements, field QA/QC, and recordkeeping. He is also responsible for ensuring that field health and safety practices are in compliance with the SSHP. He is responsible for the overall direction of field investigations for the sampling and analysis program. This includes oversight of field staff and subcontractors and ensuring that procedures for field activities are executed in the proper manner, activities are properly documented, the prescribed scope of work is completed, and communication protocols are performed.

3.9 FIELD TEAM

The CABRERA field team members are responsible for performing field activities as stipulated in this plan and will report directly to the FSM. In addition to the FSM and SSHO/SRSM, the field team members and responsibilities will be:

- Field Health Physics Technician(s) ([redacted]) – perform periodic instrument checks, perform gamma walkover surveys (GWS), collect soil/ samples, establish and maintain radiological zones and controls, perform surveys of personnel and equipment, complete instrument and data records.

- Laboratory Technician ([redacted]) – prepare soils and perform Onsite Laboratory gamma spectroscopy counts of samples, log data, maintain documentation, and perform laboratory instrument QA/QC functions.

- Geoprobe®/soil coring crew (NWEC&C, Inc.) - under the direction of the CABRERA field team, access and setup at subsurface sampling locations, perform removal of soil cores, assist in the removal and stabilization of the cores for transfer to the onsite laboratory, and assist in the decontamination of their equipment. Maintain appropriate subsurface soil coring documentation and logs.

3.10 ANALYTICAL LABORATORY

General Engineering Laboratories (GEL) of Charleston, South Carolina, will provide offsite radioanalytical and waste characterization services during the pre-remediation site work.

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4.0 DATA QUALITY OBJECTIVES

The DQOs for the pre-remediation sampling activities to be conducted at the Site are provided below to establish a systematic procedure for defining the criteria that must be met for the data collection design to be satisfied. The DQO process includes a description of when to collect samples, where to collect samples, the tolerable level of decision errors for the study, and how many samples to collect. The DQO process consists of the following seven steps (EPA 2000 and 2000a):

1. State the problem,
2. Identify the decision,
3. Identify inputs to the decision,
4. Define the study boundaries,
5. Develop the decision rule,
6. Specify tolerable limits on decision errors, and
7. Optimize the design.

The DQO process is described in the following sections as it applies to the pre-remediation sampling activities to be conducted at the Site.

4.1 STATE THE PROBLEM

This FSP will be used to determine whether residual radionuclide concentrations comply with cleanup criteria as defined in the Feasibility Study Addendum for the Site (USACE 2005). Where they do not comply, remediation will be required. In places where the horizontal and vertical boundaries of soil to be excavated will be refined, additional characterization will occur to ensure that subsurface lenses of contamination do not extend outside the planned excavation boundaries.

The first step in the DQO process is to provide a clear and concise problem statement so that the focus of the project is unambiguous. The problem statements for the Site pre-remediation sampling effort are as follows:

- **Boreholes in Class 1 SUs are needed to determine the depth profile of contamination in known areas of impact.**
- **Downhole gamma logging correlation factors are required to help focus remediation planning and removal volume estimates.**

- **Downhole gamma logging is needed at boreholes bounding Class 1 units to verify the appropriateness of the CSM and either adjust or improve the certainty of the boundaries of known contaminated areas specified in the existing CSM.**

- **Data on the residual concentrations and distributions of RCOCs in surface soils of Class 2 SUs are needed to demonstrate that residual radioactivity in soil meets all cleanup criteria.**

- **Waste profile samples are needed to characterize the radionuclide content for future disposal.**

4.2 IDENTIFY THE DECISION

The second step in the DQO process is to identify the decision that must be made using data on the concentrations and distributions of RCOCs. The objective of this step is to develop decision statements that require environmental data to address the problem statement. The fundamental decision that must be made using this data is whether the soil meets the cleanup requirements defined in the Feasibility Study for the Site. Exposures are limited to 25 mrem/yr consistent with the criterion established by the NRC decommissioning rule (10 CFR 20 Subpart E). The exposure scenario used to establish the soil concentration guidelines specified in this FSP is the construction worker scenario.

4.2.1 Principal Study Questions and Alternative Actions

To determine if the site meets the cleanup requirements, specific decision statements are developed to address each MARSSIM-consistent requirement shown above. These specific decision statements consist of two key elements – three principal study questions (PSQ), and alternative actions (AA) for each PSQ. If a PSQ is not met, the AA defines what additional steps must be taken. For areas not expected to require excavation (Class 2 SUs), answering “yes” to both PSQs indicates that all requirements have been met and no further action is required. The PSQs and AAs for the Site FSS are shown in Table 4-1.

Table 4-1. Principal Study Questions and Alternative Actions for Painesville Soils

	Principal Study Question		AA No.	Alternative Action (AA)
	No.	**Question**		
Areas Where CSM Indicates Excavation is Likely to be Required (Class 1 SUs)	**1**	Does subsurface soil exceeding the $DCGL_w$ criterion (SOR > 1) extend into areas where existing data indicate that excavation is not required?	1	Yes - Reconfigure boundary such that the area(s) that fail to meet the criteria are classified as soil likely to require remediation and investigate likely reason for encountering buried contamination. Refine the CSM and evaluate the implications for the assumption that buried contamination (in the absence of surface contamination) is unlikely to occur at this site. This is a dynamic aspect of the investigation. New subsurface sample locations should be located away from the contaminated zone at a distance equal to the site's geostatistical correlation range with a goal of bounding the subsurface contamination. If any new borehole is observed to be contaminated, the process is repeated.
			2	No – Boundary between areas requiring excavation and not requiring excavation is defined.
	2	Based on existing data and data gathered at boundaries between areas requiring excavation and not requiring excavation, can depth of soil exceeding the $DCGL_w$ criterion (SOR > 1) be discerned within ± 1 ft vertically?	1	Yes – No additional data needed.
			2	No – Acquire data vertically from areas to be excavated using a biased sampling scheme until required resolution is met.

Table 4-1 (cont). Principal Study Questions and Alternative Actions for Painesville Soils

Areas Where CSM Indicates Excavation is Unlikely to be Required (Class 2 SUs)	**3**	Does soil within Class 2 SUs contain RCOCs at average concentrations less than or equal to the $DCGL_w$ criterion ($SOR \leq 1$)?	1	Yes - If $DCGL_w$ criterion is met, then no further action (NFA) is required.
			2	No – Reconfigure boundary such that the area(s) that fail to meet the criteria are classified as soil likely to require remediation. New surface sample locations should be dynamically planned and located using an indicator geostatistical tool to determine optimal placement of the additional samples to most cost effectively reduce the uncertainty to acceptable levels.

Using the PSQs and AAs shown in Table 4-1, the following key DQO decision statements were developed for the Site pre-remediation field sampling project:

1. For each survey unit likely to require excavation, determine whether subsurface soil exceeding the $DCGL_w$ criterion ($SOR > 1$) extends into areas expected to be clean. If subsurface soil contamination is observed to extend into those areas, reconfigure the area boundaries to include locations that fail to meet the subsurface soil criterion. Refine the CSM and evaluate the implications for the assumption that buried contamination (in the absence of surface contamination) is unlikely to occur at this site. Otherwise, no further characterization is necessary.

2. For each survey unit likely to require excavation, determine whether the depth of soil exceeding the $DCGL_w$ criterion ($SOR > 1$) can be discerned within ± 1 foot (ft) vertically. If not, conduct an investigation targeting areas within the SUs where uncertainty remains. Otherwise, no further characterization is necessary.

3. For each survey unit where the CSM indicates that remediation is not necessary, determine whether surface soil contains RCOCs at concentrations less than or equal to the $DCGL_w$ criteria ($SOR \leq 1$). This will require a gross gamma count rate equivalent as a surrogate for an SOR score based on laboratory results. If the soil scan survey of the survey unit results in count rates greater than the surrogate greater than or equal to the $DCGL_W$ criteria, a biased soil sample shall be collected for analysis. Otherwise, no further sampling is required.

4. For each survey unit where the CSM indicates that remediation is not expected to be necessary, determine whether the average SOR value (based on concentrations of RCOCs in surface soil across the survey unit) is less than or equal to the $DCGL_w$ criterion ($SOR_w \leq 1$), and thus no further action is required. Otherwise reconfigure boundary such that the

area(s) that fail to meet the criteria are classified as soil likely to require remediation (SOR_w >1).

To demonstrate that a survey unit meets all of the cleanup criteria requirements, decision statement Nos. 3 and 4 must indicate that no further action is required.

For the waste profile sampling, the field decision will center on determining whether surface and subsurface samples obtained through borehole sampling are in fact representative of contaminated soil. These samples will be screened in the onsite lab, then sent to the offsite lab for radiological and chemical quantification.

Decisions regarding downhole scanning at Class 1 boreholes for the purpose of determining the depth of contamination will rely on downhole core scanning results. Correlation between downhole gamma counts and laboratory analysis, as described later in this document, will be performed using data from the initial depth-bounding boreholes. Field decisions will focus on determining at what depth the subsurface materials transition from contaminated material to non-contaminated native soil or fill.

In cases where the areal-bounding boreholes indicate the presence of subsurface contamination, additional boreholes will be drilled to the outside of the contaminated zone. These boreholes will have downhole gamma logging performed to test for the presence of contamination at the new boundary location. These locations will be spaced at a distance within the Site's geostatistical correlation range. If any of these new bounding boreholes are observed to be contaminated, the process will be repeated until the known contamination is sufficiently bounded. The Class 1/Class 2 boundary will then be reconfigured, along with the sampling locations of the triangular grid within the Class 2 SUs.

4.2.2 Proposed Cleanup Guidelines

Proposed derived concentration guideline levels (DCGLs) for residual radioactivity in soil (i.e., cleanup guidelines) were developed for the Site using the Residual Radioactivity (RESRAD) computer code, version 6.22. (ANL 2003) These cleanup guidelines were based on limiting future doses to the 25 mrem/yr criterion established by the NRC decommissioning rule (10 CFR 20 Subpart E), for the critical group as defined in the Feasibility Study Addendum (USACE 2005). The exposure scenario that was used was for a construction worker.

The initial list of radionuclides of concern included the primary radionuclides in the thorium decay series and uranium decay series (Th-232, Ra-228, Th-228, U-234, U-235, U-238, Th-230, Ra-226, and Pb-210). The thorium decay series was included because low levels of Th-232 and its decay products have been detected at the site, are not unexpected in uranium ore residuals. The primary radionuclides present in uranium ore material are U-234, U-235, U-238, Th-230, and Ra-226 (and their decay products).

Because many of these radionuclides are present as decay products associated with a long-lived (long half-life) "parent" radionuclide, the list of RCOCs was simplified by combining the decay products with their respective parent radionuclides where appropriate. Grouping decay series radionuclides in this manner simplifies the site survey and verification processes, without eliminating consideration of the health effects associated with exposures to the decay products.

Grouping simply means that the health effects impacts (radiological dose or risk) associated with decay products have been added to the overall parent radionuclide impact.

For example, the cleanup guideline for Th-232+D (thorium 232 plus decay products) includes consideration of the Th-232 progeny Ra-228 and Th-228 (as well as their short-lived decay products). Inherent in this approach is the conservative assumption that all decay products associated with a long-lived parent are in secular equilibrium (or present at the same activity concentration as the parent). The individual guidelines for the uranium isotopes were also simplified into a combined "U-total" value. The U-total guideline assumes the uranium isotopes are present in their natural activity ratios of 1:1:0.046 for U-238, U-234, and U-235, respectively. A complete description of the derivation of the DCGLs for the Site, including a detailed listing of assumptions used in the modeling process is provided in the Feasibility Study Addendum [FSA, (USACE 2005)].

DCGLs were developed for two specific areas: 100 m^2 and 10,000 m^2. The primary DCGL values for each RCOC at the Site are based on an area of 10,000 m^2 and depth of 2 m. These guidelines (DCGLw) apply to the average concentration over an entire survey unit. The other DCGL value will be used as potential guidelines for localized areas of elevated activity (elevated measurement criteria or DCGLemc value). The DCGLemc ensures that while localized areas of elevated activity may significantly exceed the DCGLw at specific locations, the overall impact of these smaller areas will not cause the average concentration for the survey unit to exceed the DCGLw.

Table 4-2 shows the proposed DCGL values for the Site. The proposed DCGLs are incremental to background. Soil containing radioactivity at the DCGL level (for a single radionuclide) would result in an annual dose to a construction worker of 25 mrem/yr. Since it is possible for more than one radionuclide to be present in soil, the DCGLs will be applied using a sum-of-ratios (SOR) approach. The residual concentration in soil for each radionuclide (after background subtraction) will be divided by its respective DCGL, and these ratios will be added together. As long as this sum-of-ratios is less than or equal to 1.0, the dose criterion of 25 mrem/yr will be met.

Table 4-2. Derived Concentration Guideline Levels for the Painesville Site[1]

Radionuclide	Average Background Levels (pCi/g)	Construction Worker Scenario $DCGL_w$ (pCi/g)	Construction Worker Scenario 100 m^2 $DCGL_{emc}$ (pCi/g)
U-total	2.64	482	810
Ra-226+D	0.95	9	12
Th-230	1.45	25	34
Th-232+D	1.07	6	8

[1] DCGLs represent soil concentrations that would result in a dose rate of 25 mrem/yr to an individual representative of the modeled exposure conditions. Note that DCGLs are incremental to background.

The general SOR formula for use with the DCGLs in Table 4-2 is shown below. The concentration terms used in the numerators of the SOR equation are the net concentrations after subtraction of the average background concentrations for each radionuclide.

$$SOR_{DCGLw} = \frac{Ra-226}{Ra-226\_DCGL} + \frac{Th-230}{Th-230\_DCGL} + \frac{Th-232}{Th-232\_DCGL} + \frac{U-total}{U-total\_DCGL}$$

4.3 IDENTIFY INPUTS TO THE DECISION

Information on RCOCs must be collected from four key components in the field: (1) Subsurface soil samples in and around the existing Class1 SUs; (2) Downhole gamma measurements within each borehole location to direct biased subsurface soil sampling; (3) surface soil samples in existing Class 2 SUs; and (4) Surface gamma walkover survey scans. A more detailed discussion of specific field activities is included in Section 5.0.

Three techniques will be used in the field to generate information pertinent to the principal study questions. These include surface gamma walkover surveys, downhole gamma logging, and surface/subsurface soil sampling combined with an appropriate laboratory analytical techniques (e.g., gamma and alpha spectrometry).

For subsurface soil, downhole gamma logging will primarily be used to determine whether RCOCs exceed DCGLs at depth. Soil sampling within known Class 1 SUs will be used to develop relationships between the gross measurements collected using the downhole gamma instruments and soil activity concentrations. The goal of this investigation is to develop reliable field screening indicators that will correlate increased count rates to the presence of RCOCs that approach SOR > 1. These indicators will be developed using the onsite gamma spectroscopy lab in concert with the downhole gamma counts performed at the same intervals. Details of this approach are provided in Section 4.3.4.

4.3.1 Surface Gamma Scans

Surficial scans, where possible, are particularly effective at identifying spatial trends in surficial contamination and potential DCGL concerns. Surficial gamma scans will be collected through systematic walkovers and through stationary readings at selected locations by using either a two-inch by two-inch (2x2) or a three-inch by three-inch (3x3) sodium iodide (NaI) scintillation detector. Locations for both mobile and stationary scans will be logged by using a global positioning system (GPS) unit.

Site-specific detection sensitivities have been calculated for a 3x3 NaI scintillation detector by following the approach detailed in NUREG-1507 (NRC 1998), which is presented in Appendix C of this FSP. Ra-226, Th-232 (and progeny), and U-238 (and progeny) are readily detectable by these NaI GWSs. Th-230 alone is not, but the co-located presence of the other three RCOCs will aid in the ability to identify Th-230. A review of the existing site data (Section 2.3) indicates that Th-230 is usually found at concentrations equal to or less than Ra-226. In addition, the DCGLs for Th-230 are much higher than for Ra-226, so the use of gamma detection technologies should be adequate for identifying areas where Th-230 is present in significant amounts (and co-located with Ra-226). Trigger levels for surficial soils will be developed by determining background count rates for a set of locations across the area of concern, determining an average background response and its variability, developing a detection limit estimate based on MARSSIM's recommended process, and using this gross activity detection limit as the trigger level for further investigation/biased sampling.

The use of direct scanning technologies for screening potential surface contamination above DCGL requirements is most likely to be successful and implementable when both surface moisture and surface vegetation are at a minimum over soil surfaces. This fact should be taken into consideration when scanning activities are being scheduled.

For areas covered with either asphalt (i.e., roadways) or concrete pads (i.e. slabs of former buildings), surface GWS may prove to be ineffective due to reduced sensitivity. Scan MDC calculations will be performed for overburden layers of each to determine the minimum concentrations of RCOCs that could be expected to be detected. If shown to be ineffective, high density GWS will be supplanted with strategically placed biased and random soil samples in these areas. The goal of these additional samples is to investigate the potential for contamination located under various overburden layers. To assess this potential contamination, cores will be bored through the asphalt or concrete to allow access to the underlying soil. The number of samples required and actual placement will be determined while in the field, based on the results of the GWS and field crew observations.

4.3.2 Downhole Gamma Logging

Gross gamma count rates will be collected at each internal and bounding Class 1 SU borehole in 6-inch increments starting from the bottom and working upwards. A 1 in. by 1 in. (1 x 1) NaI detector suspended from a nylon cord will be used to obtain these measurements. Results will be compared to Action Levels (ALs) developed using activity correlation factors developed from analysis of sectioned soil cores taken in the Class 1 SU's. Analysis will performed both in the onsite lab and at the offsite lab (See Section 4.3.4).

Application of these correlation factors will be used during downhole gamma counting in all borehole locations bounding the Class 1 SUs. Subsurface soil from intervals exceeding established ALs will be selected for biased soil sampling and analysis in the onsite and offsite labs.

4.3.3 Soil Samples

Physical samples will be collected from surface and subsurface soils to support the MARSSIM survey process. Surface soil samples will be representative of the top 15 cm (6 in.) of soil. Subsurface soil samples will be extracted from segmented borings into representative subsurface intervals of 30-cm (12-in.) each that may pose SOR concerns. Physical soil samples will be screened in the onsite gamma spectroscopy lab and sent to the off-site analysis for Ra-226 by Lucas Cell, and isotopic Th, and isotopic U by alpha spectroscopy.

4.3.4 Development of Activity Correlation Factors

In order to improve characterization performance and reduce costs, this FSP proposes to use near real-time measurement technologies where appropriate. Near real-time measurement technologies can potentially serve two roles by: (1) providing information about the contamination status of surficial soils, and (2) providing information about the contamination status of subsurface soil cores and/or samples.

After instrument detection levels have been established, a set of approximately 30 to 40 surface soil samples and gamma count rate measurements, and 30 to 40 subsurface soil samples and downhole gamma count rate measurements will be collected at specific locations representing a range of contamination levels across the site. If possible, the majority of the correlation samples will be collected from locations where the gamma count range spans across and on either side of the range from the $DCGL_w$ (i.e., lowest) to the $DCGL_{emc}$ (highest). Soil samples will be screened with the onsite gamma spectroscopy lab for Ra-226, Th-230, Th-232, and U-238 before being sent to the offsite lab for confirmatory analysis. Table 7-1 provides a summary of expected analytical methods and capabilities associated with soil sampling. While quick-count gamma spectroscopy may be used for samples comprising part of the initial correlation data analysis, the analytical data used to support the correlation for surface scans used to demonstrate compliance with the $DCGL_{emc}$ will be from an approved qualified offsite laboratory.

These sets of paired, co-located, soil concentration and count rate data points will be used to construct statistically based relationships between gamma count rate and surface soil or subsurface soil concentrations of the RCOCs. These two relationships (i.e., one for surface soil and one for subsurface soil) will involve the use of a non-parametric statistical approach that will categorize the data into three separate groups or “bins.” One bin will represent a range of count rates for which there is a very small probability of surface soil results equaling or exceeding an SOR of 1 (i.e., ‘uncontaminated’). Another bin will represent a range of count rates for which there is a high probability of surface soil sample results exceeding an SOR of 1 (i.e., ‘contaminated’). A third (mid-range) bin will represent a range of count rates where there is a moderate probability that soil samples will either equal or exceed an SOR of 1 (“too close to tell”). This mid range group represents a range of count rates where sampling is highly recommended to achieve definitive results. The low range group will be used to establish a count rate trigger value that will provide high confidence that a survey unit will pass (i.e., be released) if all gamma scan measurements are at or below this trigger value. Similarly, the high range group provides a count rate threshold indicative of a high probability of the cleanup criteria being exceeded.

For Th-230, which is not easily detected by gamma scanning, the relationship between site concentrations of Th-230 and Ra-226 will be used to support the correlations of activity and gamma count rate described above. As discussed previously, historical site data indicates that Th-230 is usually found at concentrations equal to or less than Ra-226. In addition, the DCGLs for Th-230 are higher than for Ra-226. Sample results from the characterization efforts conducted prior to the FSS will be evaluated to verify that Th-230 is not expected to be present at any location where gamma emitters such as Ra-226 are not also present. As long as there is a reasonably consistent relationship between Th-230 and other gamma emitters, the correlation approach described above will be sufficient to ensure that areas with concentrations approaching an SOR of 1 are not missed by gamma scan surveys.

4.4 DEFINE THE STUDY BOUNDARY

The fourth step in the DQO process is to define the spatial and temporal boundaries that the data must represent to support the decision statements. The study area boundary consists of surface and subsurface soil within the FUSRAP boundary of the Site. Figure 2-1 provides the boundary for the Site as defined under FUSRAP.

The study area will be divided into Class 1 and Class 2 SUs consistent with MARSSIM guidance. (Note: Class 3 SUs are not anticipated at this site). Class 1 units have been defined as areas where remediation has taken place or where data indicate the presence of contamination above DCGL requirements. However, the CSM may need to be refined as the Class1/Class2 boundary samples are collected to determine if subsurface contamination indeed extends across the boundaries. It is expected that Class 1 units will include areas where contaminated scrap steel was stored or moved about the Site, or was used as part of the chlorine scrubbing process. The initial layout of the FSS SUs for the Site is provided in Figure 4-1. Figure 4-2 provides an overview of the initial sampling effort as described in Section 4.3, *Inputs to the Decision.* The sampling locations shown in Figure 4-2 were chosen to best test the current assumptions of the CSM.

Figure 4-1. Layout of Preliminary Final Status Survey Units. Site configuration portrayed circa 1998.

Figure 4-2. Locations of initial depth and areal bounding borehole locations. Site configuration portrayed circa 1998.

Class 2 SUs will be defined as areas where there may be evidence of the potential presence of elevated levels of residual radionuclides, but where concentrations of the RCOCs are not expected to exceed DCGL requirements. Class 2 SUs may be as large as 10,000 m^2, and will likely surround the Class 1 units.

While not anticipated, Class 3 SUs may be designated if needed. Class 3 SUs will be defined as areas that have a low probability of containing RCOCs associated with site activities. There is no size limit for Class 3 units.

The general survey unit boundaries described above are for planning purposes only. The actual layout of units and individual unit boundaries may be redefined at the discretion of the project technical team with the approval of USACE, as dictated by field conditions and sample data. The discovery of unexpected contamination during FSS work in Class 2 or Class 3 areas may require remediation and reclassification of areas as Class 1 SUs.

4.5 DEVELOP THE DECISION RULE

The decision rules for this FSP flow from the principal study questions and the decision logic is structured to promote an efficient and cost-effective investigation. The order and basic structure of the decision logic can be expressed in the following four steps.

1. Refine the Class 1/Class 2 boundaries through surface and downhole scanning,
2. Determine the depth of contamination in Class 1 areas,
3. Conduct FSS in Class 2 SUs, and
4. Investigate and resolve any anomalies.

Sampling and analysis for waste classification will be performed in conjunction with determining the depth of contamination in Class 1 areas.

4.5.1 Decision Rules for Class 1 Units

Figure 4-3 illustrates the decision rules for Class 1 units. The decision logic follows two parallel branches:

The left branch provides the logic applied to surface scanning. Note that the initial activity on the left branch calls for performing gamma walkover scans over all accessible soil (Class 1 and Class 2) at the site. Soil samples will need to be acquired to establish the relationship between the concentration of the COCs in soil and the gamma scan readings. Based on the walkover surveys and the existing CSM, sampling locations are selected for those samples. Prior to collecting each sample, a direct gross gamma reading is obtained at each sample location. After the scan/soil concentration relationship is established, the scans made in the Class 1 areas are evaluated to determine whether there are any exceedances of the DCGLs near the common boundaries with Class 2 areas as initially estimated. If so, the boundary between the two classes is adjusted. If not, the boundaries are deemed to be acceptable, and it is appropriate to proceed to the Class 2 decision logic.

The right branch provides the logic applied to downhole scans. Like the left branch, the right branch establishes the relationship between scan readings and the concentrations of COCs in soil.

Since soil will be extracted in a core from each borehole, samples will be carefully acquired from each core to ensure that they correspond with the targeted depths of the downhole scan readings.

The scans will then be used to determine the depth of contamination in each borehole. The location of the each depth-bounding borehole will be determined by evaluating the existing CSM and the use of indicator geostatistics.

After the downhole scan/soil concentration relationship is established, the area-bounding downhole work can proceed simultaneously with the depth-bounding downhole work. However, results from downhole scans completed along the estimated Class 1/Class 2 boundaries will be compared to the $DCGL_w$ to determine whether the boundary is appropriately located. If the scan results are greater than the $DCGL_w$, the boundary between the two classes is adjusted. If not, the boundaries are deemed to be acceptable, and it is appropriate to proceed to the Class 2 decision logic.

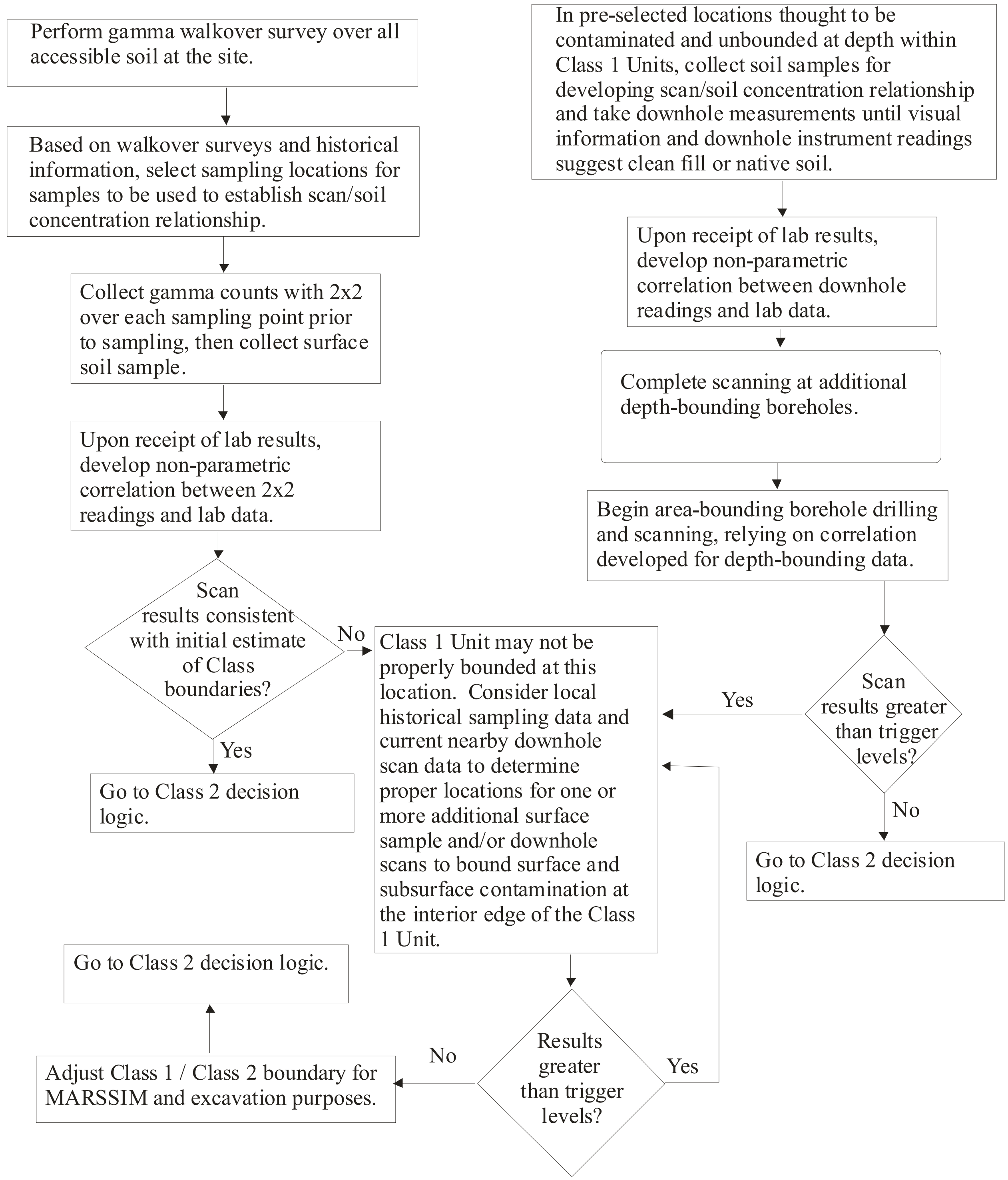

Figure 4-3. Decision Flow Diagram for Class 1 SUs

4.5.2 Decision Rules for Class 2 Units

Figure 4-4 illustrates the decision logic for FSS data collection and decision making applied to Class 2 units. The following text describes the decision logic presented in the flowchart.

1. Technically defensible gross count rate trigger levels will have been developed for gamma walkover survey instrumentation. These trigger levels will include gross count rate thresholds that reliably identify soil concentrations representative of an SOR value of 1.0 based on the $DCGL_w$ values. This will require development of a relationship for gamma count rate to surface soil activity concentrations using data collected during the planned characterization effort prior to site remediation. The relationships developed using historical site data can be a starting point for this, but these relationships should be refined with surface gamma scan and sample data collected specifically for that purpose, at exactly the same locations.

2. Class 2 FSS unit numbers and layout will be determined on the basis of sampling results to date, excavation footprints, and prior civil surveys. Class 2 units should encompass all areas in the study area not included as Class 1 units. Figure 4-2 includes an initial layout of Class 2 SUs based on historical data. This figure can be used as a starting point for establishing the final survey unit classification scheme based on the most recent characterization data.

3. Surface scans will have been performed over 100% of accessible areas using standard walkover gamma scan survey techniques and NaI detectors. Gamma scan data from walkover surveys over Class 2 SUs will be obtained by walking the areas in parallel paths using a traverse spacing of 1 meter (orthogonal walkovers will not be required). The goal is to have a data density of approximately one measurement per square meter. Surface gamma scan results will be compared to the trigger levels discussed above, and locations with results greater than the applicable trigger level will be flagged as anomalies requiring further investigation. If scanning is not possible, biased sampling will be conducted at these locations to confirm DCGL compliance. Additional remediation and reclassification of the affected area of the survey unit to Class 1 may be required.

4. The number of systematic surface sampling locations will be determined for each unit. The minimum number of locations will be determined by MARSSIM Sign test design requirements (details provided in Appendix D). Based on historical data and Type I (alpha) and Type II (beta) error tolerances of 0.025 and 0.05, respectively, the minimum number of samples per survey unit is 17. Sampling locations will be laid out on triangular grids, where possible.

5. A surface gamma scan measurement will be taken, and one surface sample representative of the top 15 cm (6-in.) of soil will be collected at each surface sample location within a survey unit. These samples will be analyzed by Lucas Cell for Ra-226 and by alpha spectrometry for total uranium, Th-230, and Th-232. The results from these analyses will be used to compute the average SOR score for each survey unit. If the average SOR score exceeds the $DCGL_w$ requirement (survey unit average SOR > 1), remediation and reclassification of the affected area of the survey unit to Class 1 may be required. If the

average meets the $DCGL_w$ requirement, the Sign test will also be applied to surface sample results. If the unit fails the Sign test, additional investigation may be undertaken to determine the cause, and additional remediation may be required. Ultimately each survey unit must pass the Sign test (at specified error tolerances) in order to be in compliance with the cleanup criteria.85

6. If a survey unit satisfies all DCGL requirements, the unit will be considered to be in compliance with cleanup criteria and ready for release. If a survey unit fails one or more of the DCGL requirements and requires additional remediation, the affected areas of the FSS unit may be reclassified as a Class 1 unit dependent upon the cleanup criteria that are used in the Record of Decision.

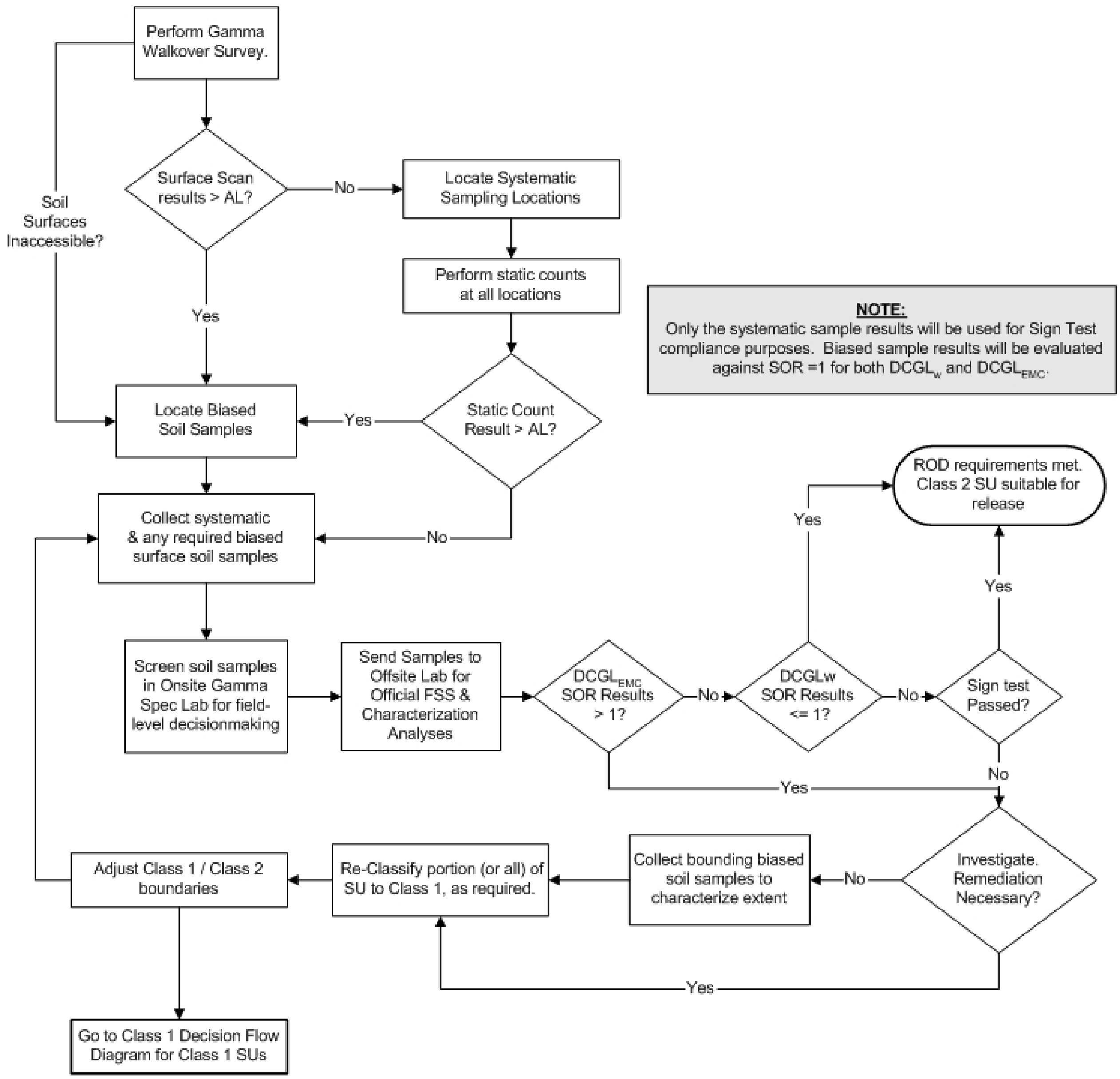

Figure 4-4. Decision Flow Diagram for Class 2 SUs

4.6 SPECIFY TOLERABLE LIMITS ON DECISION ERROR

As part of the DQO process, the null hypothesis for demonstrating compliance of data with cleanup goals must be stated. The null hypothesis (H_0) tested is that residual contamination exceeds the acceptance criterion (cleanup goal). If the null hypothesis is rejected, the alternative hypothesis must be accepted, and the finding of the evaluation is that the site satisfies the guideline. The Sign test will be used, as described in MARSSIM, to test the null hypothesis for $DCGL_W$ compliance. For the $DCGL_{emc}$ requirements, scan results will be compared against scanning/screening triggers derived for that purpose, and sample results will be compared directly to $DCGL_{emc}$ requirements.

To enable testing of data relative to cleanup goals, the USACE has established acceptable decision errors for the project. There are two types of fundamental errors. The Type I (alpha) decision error is that the survey unit will be found to have met the release criteria when, in fact, it does not. The probability of a Type I error is set at 0.025. This provides a confidence level of 97.5% that the statistical tests will not determine that a surveyed area satisfies criteria when, in fact, it does not. The Type II (beta) decision error is that the survey unit will be found not to have met the release criteria when, in fact, it does. The probability of a Type II error used to determine sample quantity per survey unit is set at 0.25. This provides a confidence level of 75% that the statistical tests will not determine that a surveyed area does not satisfy criteria when, in fact, it does. Type II errors affect disposal costs and do not adversely affect public safety and health.

The following laboratory data quality indicators for precision, accuracy, representativeness, completeness, and comparability have been established for this survey effort. Details and formulae are provided in the project Quality Assurance Project Plan (QAPP, Cabrera 2005a).

- Precision will be determined by comparison of replicate values from field measurements and sample analysis; the objective will be either a relative percent difference (RPD) of 30% or less at 50% of the criterion value for non-radiological analyses, and a Z_{Rep} of 2 for radiological analyses, corresponding to agreement at the 95% confidence level.

- Accuracy is the degree of agreement with the true or known; the objective for this parameter will be ± 30% at 50% of the criterion value.

- Representativeness and comparability are assured through the selection and proper implementation of systematic sampling and measurement techniques.

- Completeness refers to the portion of the data that meets acceptance criteria and is therefore usable for statistical testing. The objective is 90% for this project.

Note that characterization survey data often include radionuclide concentrations in the range of background, making data quality indicators difficult to evaluate. For example, there may be few data at concentrations near 50% of the criterion value. Data analysts should consider these limitations during the data quality assessment.

4.7 OPTIMIZE THE DESIGN

Field survey and screening techniques, soil sampling methods, instrument selection and detection capabilities, survey/sampling frequency, and the DQO process will be used, as appropriate, throughout data collection to focus efforts and minimize cost. As data is collected and analyzed, the assumptions in this plan should be reviewed for accuracy. That is, the sampling and analysis process detailed in the next section should be revisited if initial data indicate that conditions are significantly different than the initial assumptions.

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5.0 FIELD ACTIVITIES

A number of field activities will be conducted as part of the pre-remediation characterization work. The principal activities include:

- *Gamma Walkover Surveys*
- *Downhole Gamma Logging*
- *Sample Collection*
- *Onsite Sample Screening*

The remainder of this section describes each of these activities in more detail. A current Project Schedule is included as Appendix A to this FSP.

5.1 GAMMA WALKOVER SURVEYS

A 100% GWS will be performed over accessible areas in each Class 2 survey unit, as designed in the Draft FSSP. The purpose of the GWS is to identify areas of elevated radioactivity. Surficial scans, where possible, are particularly effective at identifying spatial trends in surficial contamination and potential $DCGL_{emc}$ concerns. These types of surveys have been used with considerable success at other USACE FUSRAP sites with similar radiological contaminants of concern.

Equipment required for performing the GWS survey includes the following:

- Trimble Pathfinder Pro - XRS (or equivalent)
- 2x2 or 3x3 NaI detector and associated rate-meter/scaler, equipped with RS-232 download port
- Hardware: IBM-compatible Pentium (minimum) personal computer, color printer, large capacity data storage device (e.g., zip drive), modem, large format plotter, (note that some hardware may not be site-based).
- Software: Trimble Pathfinder Office, AutoCAD (or equivalent CAD software) with coordinate geometry capability.

The survey will be performed following MARSSIM protocol by walking straight parallel lines over an area while moving the detector in a serpentine motion, 0.05 to 0.10 m (2 to 4 in) above the ground surface. Survey passes will be approximately one meter apart. Data from the ratemeter/scaler will be automatically logged into the GPS unit once per second. After completion of the survey, the raw data will be downloaded from the GPS and sent to a data processing specialist for export into a geospatial software program. After completion of data processing, an electronic file with the contoured results of the survey will be returned to the FSM for evaluation.

The GWS data will then be forwarded to ANL for evaluation after processing by CABRERA. Gamma walkover survey data will be delivered to ANL/USACE in electronic format (easting and northing in US State Plane feet, Ohio North, NAD83). This evaluation will determine if any

GWS anomalies exist that warrant further investigation by collecting biased surface soil samples for laboratory radioanalysis. Anomalies identified by ANL will be reported to the CABRERA PM, or designee, for evaluation and concurrence. Anomaly locations will be forwarded to the field team, and will be physically marked, have a stationary one minute reading collected, and a surface soil sample collected. If more than one location per 100 m^2 area is identified, only the surface sample exhibiting the highest gross activity reading will be collected from that 100 m^2 area.

Before a detection system is utilized for surveys, it is necessary to perform an *a priori* calculation of the Scan Minimum Detectable Concentration (Scan MDC) for the system. The Scan MDC for a Ludlum Model 44-20 3x3 NaI detector for Ra-226 has been calculated to be 3.64 pCi/g. Appendix C of this FSP presents the process and calculations for determining this *a priori* Scan MDC.

5.2 DOWNHOLE GAMMA LOGGING

Downhole logging will be performed at each borehole to provide data regarding the variation in gamma fluence with depth. A one minute integrated measurement will be performed using a Bicron G1 environmentally encapsulated 1 inch by 1 inch (1x1) NaI detector. Measurements will be collected at six-inch intervals, starting at the bottom of the borehole and working toward ground surface. Each borehole will be sleeved prior to insertion of the G1 probe to prevent cave-in of sidewall soils and capture of the detector at depth. Data from each borehole location will be logged on the Field Boring Log sheet.

5.3 SOIL SAMPLING

5.3.1 General

Surface and subsurface samples will be collected per the conditions listed below. Sampling will consist of:

- Subsurface core bore samples collected with a Geoprobe® direct-push rig to a depth of 10 feet (ft) within and around the boundaries of defined Class 1 SUs,
- Surface samples obtained from the top six inches (or 15 cm) on systematic sampling grids in the Class 2 SUs,
- Biased samples obtained from Class 2 surface soil locations identified by GWS or placed at locations where the GWS could not be performed due to obstructions or heavy overburden,
- Biased samples from 30 cm (12 in.) subsurface core intervals from systematic sampling locations identified as of potential concern by downhole gamma logging and/or counting in the Onsite Lab.

All samples will be packaged in high-density polyethylene (HDPE) containers. These containers will be supplied by the laboratory. Soils that are not designated for offsite analysis will be packaged in HDPE containers, properly labeled, and transferred to the USACE-Buffalo for archiving or disposal.

Upon receipt at the offsite laboratory, the samples will be weighed, dried, and reweighed. The sample will be prepared according to the offsite laboratory's internal procedures.

5.3.2 Borehole and Surface Sample Quantities

A potential layout for Class 1 (red) and Class 2 (green) SUs is shown in Figure 4-1. The number and layout of the actual FSS units will likely deviate from this arrangement, depending on the final remediation footprint of the Site. Class 2 sample locations were designed on a triangular grid pattern and generated using random starting locations using MARSSIM methodology provided in Appendix D. Sampling point locations may be refined and field crews may relocate or shift locations due to obstructions, as required.

Table 5-1 and Table 5-2 provide estimates of the expected number of borehole locations and surface samples to be collected as part of this field sampling plan. This estimate assumes one surface samples per sampling location for a total of 204 systematic surface samples in Class 2 areas laid out on a triangular, random start grid. As a contingency measure to address possible $DCGL_{emc}$ concerns, an additional 40 biased samples (20%) have been allocated across all SUs. Table 5-4 lists the quantities of preliminary downhole scan locations.

Table 5-1. Preliminary Number of Borehole Locations

Type	Number of Borehole Locations
Establish Background Count Rate	5
Class 1 (Depth Bounding)	150
Class1/Class 2 Boundary (Areal Bounding)	100
Downhole Gamma Correlation Boreholes (co-located with Class 1 Depth Bounding Locations)	40*
Total Number of Boreholes	**255**

Table 5-2. Preliminary Number of Surface Soil Sample Locations

Type	Number of Samples
MARSSIM Class 1	None during pre-remediation
MARSSIM Class 2	204
GWS $DCGL_{emc}$ Correlation Samples	40
Contingency Samples:	
Class 2 (and Class 1, if necessary)	40
correlation	10
Total	**294**

5.3.3 Determination of Borehole Locations

A dynamic scheme for completing these boreholes is proposed. Only a limited number of actual sampling locations have been determined using the information gleaned from the existing CSM. Therefore, only 77 of the anticipated 150 depth-bounding locations are shown because these are the areas where the current CSM indicates uncertainty in the vertical extent of contamination. These initial locations are shown as black circles on Figure 4-2. The coordinates of these locations are provided in Appendix A. Up to 73 additional locations will be dynamically selected based on field data. Additional locations will only be selected if the geostatistical model indicates that additional reduction in decision uncertainty will result. Sixty-seven of the anticipated 100 areal bounding boreholes are shown as blue crosses on Figure 4-2, with their corresponding coordinates provided in Appendix A. The spacing of these initial areal-bounding locations is 20 meters.

As stated above, the locations for the remainder of the areal bounding boreholes will be dynamically selected using the indicator geostatistical model, Bayesian Approaches for Adaptive Spatial Sampling (BAASS), developed at Argonne National Laboratory (ANL). BAASS is a set of computational routines for the design and deployment of adaptive sampling and analysis programs (ASAPs) (Johnson et al. 2005). In particular, BAASS is intended to support delineation of contamination above a threshold at sites with spatially correlated sampling data. The method relies on a combination of "soft" conceptual information, "hard" sampling data, and real-time updating of a site's spatial distribution of contamination probabilities using appropriate field analytical methods.

BAASS incorporates a combination of Bayesian techniques and ordinary indicator geostatistics into its routines. As new nearby sample results become available, Bayesian analysis provides a mechanism for updating a prior conceptual model of contamination probabilities. Geostatistics is a set of tools for the analysis of spatially correlated data and allows estimation of the probability of contamination at a location where no samples have been collected, on the basis of the neighboring sample data. An outcome of BAASS analysis is a sampling program that achieves much better delineation results with far fewer samples than a traditional grid program can accomplish.

Initial boreholes will be used for establishing the correlation data set discussed in Section 4.3.4. Subsequent to establishing the correlation between the downhole gamma logging and analytical results for the soil samples, the downhole scanning within Class 1 units will be conducted using the guidance provided by BAASS to dynamically select the locations based on maximizing the reduction in the uncertainty related to the spatial (primarily vertical) extent of contamination. The SOR for the DCGLw will be used as the threshold cleanup criterion for the initial indicator geostatistical analyses.

After the vertical extent of contamination has been defined within the interiors of the Class 1 units, downhole scanning will begin along the boundaries between the Class1 and Class 2 units (areal defining boreholes).

Appendix A contains the proposed locations for the initial systematic and bounding samples. These sample locations were determined by survey unit classification, grid geometry, and grid spacing developed using the methodology provided in Appendix D. Final locations may be modified to ensure that samples in fact fall within the area of concern, to avoid locations that are not accessible by the Geoprobe® or provide refusal to the required one-meter sample depth, to avoid locations with excess standing water, and/or to address areas not previously identified as falling in the area of concern. The CABRERA Field Site Manager may modify the Appendix A locations by relocating within a two-meter radius of the original location. In such a case, the coordinates of the new location will be determined by GPS and recorded in the project logbook and the project manager will be notified in accordance with Section 6.0 of this FSP.

5.3.4 Borehole Sample Collection

Systematic surfaces/subsurface soil samples will be collected by direct push method using a Geoprobe® or equivalent unit as terrain and access permits. This method has the advantage of retrieving intact, undisturbed cores for analysis with minimum potential for cross contamination. Subsurface soil samples will be collected by advancing a stainless steel macro-sampler core barrel (minimum 2-inch diameter) to the required sample depth or refusal. The undisturbed soil sample will be contained inside a clear acetate liner inserted into the core barrel prior to sampling. The liner will be removed from the core barrel and secured with end caps at the coring location. The exterior of the liner will be decontaminated, identified, and clearly labeled in accordance with the Sample ID Numbering Scheme in Section 6.4.1 of this FSP and the core will be transported to the core storage location. The core location will be flagged by inserting a wire flag or wooden stake into the borehole to facilitate relocation at a later date, if necessary.

5.3.5 Class 2 Surface Sample Collection

The Class 2 SUs will only have surface soil samples collected from the first 15 cm (0-6" interval). Surface soil samples will have a mass of approximately 1 kg and will be collected by using a hand-auger or stainless steel trowel and will be homogenized in a stainless steel bowl or container prior to containerization. Visually identifiable non-soil components such as stones, twigs, and foreign objects will be manually separated in the field and excluded from the laboratory samples to avoid biasing results low. Samples will not be preserved in the field, as there are no preservation requirements for the radiological analyses. Augers, mixing utensils, and homogenizing bowls will be decontaminated between samples to avoid cross-contamination. Decontamination will be performed by rinsing with water and returning the rinsate to the ground surface in the location where the sample was collected.

The number of samples per survey unit may be adjusted on the basis of available information. If adjustments are made on the basis of new data, sample spacing (grid node locations) will also be adjusted, as appropriate, using the formulas provided in Appendix D. Because some of the SUs at the Site have irregular shapes, use of the preferred triangular grid may not be feasible in all locations. For areas of the site where this is the case, locations may be systematically distributed linearly down the survey unit. This is the situation for the narrow Class 2 unit along the east side of Figure 4-1. In either case, the start point for the systematic grid will be randomly selected. At each individual location, a 0 to 15-cm (0 to 6-in.) surface sample will be collected. The field team leader may also collect biased samples, with the approval of USACE, of surfaces with elevated gamma activity if they are identified.

5.3.6 QA Samples

Field QA and USACE QA duplicate samples will be collected simultaneously, or in immediate succession, with the original sample. The duplicates will be recovered in the same manner as the original, homogenized and split between the appropriate containers, and treated in the same manner during storage, transportation, and analysis. Field duplicate will be collected on a 5% schedule up to a maximum of 20. USACE QA samples will be collected at a frequency of approximately 5% with a limit of twenty samples. USACE QA samples will be collected by the CABRERA field team, labeled, and submitted to the USACE QA laboratory in accordance with Appendix E of the project QAPP, USACE *Radiological Quality Assurance for the Painesville FUSRAP Site*.

Field duplicate samples will be collected at the frequency specified in Table 7-1. All field duplicates will be counted in the onsite laboratory as well as by the offsite laboratory. Comparison of the initial results to the duplicate sample results will be performed via Replicate Z-score analysis. Details of the Z-score evaluation are provided in Section 7.5.3 the project QAPP.

Duplicate samples will be numbered, logged, and transferred, under the CABRERA chain of custody procedures, to the offsite laboratory for analyses. The offsite laboratory will prepare and provide containers that meet their analytical requirements. The containers will have sufficient capacity to hold the contents of a one-liter marinelli sample container.

5.4 ONSITE GAMMA SPECTROSCOPY LABORATORY

5.4.1 General

The CABRERA field team will collect soil samples for subsequent on-site analysis utilizing the Onsite Laboratory at the Site. The Onsite Laboratory analyses will be performed using a gamma spectroscopy system utilizing a high purity germanium (HPGe) coaxial detector, or equivalent. The HPGe gamma spectroscopy system will be used to provide field screening of volumetric samples. The system will include a HPGe detector with a >30% relative efficiency and lead shielding. System efficiency calibration will be either based on detector response to a NIST traceable standard or based on a mathematical calibration derived from instrument response to a NIST traceable standard. If a mathematical calibration is utilized, it will be verified in the field using a NIST traceable standard. System energy calibrations will be performed using a designated standard with known gamma energies.

Soil samples will be collected at selected locations in the NFA SUs. Personnel collecting samples will ensure each sample is placed into a clean, unused container. Each sample will be labeled and annotated with the appropriate sample number, the sampler's name, the sampling date and time, the sample location and any applicable comments. For each single sample or related batch of samples, a sample chain-of-custody form will be filled out. The samples will be either individually listed or batch listed (by chain of custody form number) in the Project Logbook. Samples awaiting shipment to the contract off-site laboratory will be stored in a designated, secure location. Original chain-of-custody forms will remain with the samples to which they apply throughout their life cycle and will be annotated with the shipper's tracking number during times when they are in transit.

Following collection, these samples will be prepared for analysis in accordance with approved procedures by being heated in an oven for moisture removal, ground, and sieved, and subsequently transferred into one-liter marinelli containers prior to gamma spectroscopy analysis. The gamma spectroscopy system will be operated by a trained operator in accordance with standard operating procedures. The operator will perform spectral analysis during each measurement, which will encompass the evaluation of spectra for problems such as peak shift, high dead-time and other potential inconsistencies in spectral structure. A qualified Radiological Engineer will review the integrity of the sample analysis results for each sample. This review will encompass the analysis of sample results for spectral energy shift, agreement between progeny activities assumed to be in secular equilibrium, the presence of potentially unidentified radionuclides, potential source model inconsistencies, as well as other potential inconsistencies.

Count times will be long enough to accomplish sufficient MDCs for each radionuclide to meet applicable Site action levels.

5.4.2 Spectroscopic Energy Lines

Site RCOCs may be quantified for activity concentrations directly via gamma decays, or inferred via gamma-emitting progeny, assuming a secular equilibrium state. Table 5-3 provides a list of gamma and x-ray emissions from the Site RCOCs that may be used for determining soil activity concentrations. The list is broken down into direct emissions from the RCOC itself or from its decay progeny which can be used to infer the parent's activity.

Table 5-3. Spectroscopic Gamma Energy Lines for Site RCOCs

RCOC	Direct / Inferred	Inferred Nuclide	Photon Emission (keV), *primary	Yield (%)	Sample HPGe MDA (pCi/g)[1]
Th-232	Inferred	Pb-212	238.6	43.3	0.04
		Ac-228	*911.2	25.8	0.1
Th-230	Direct	N/A	*12.3 (x-ray)	8.6	3.85
			67.6 (x-ray)	0.38	
Ra-226	Direct	N/A	*186.2	3.59	0.4
	Inferred	Bi-214	609.3	46.3,	0.05
		Pb-214	1764.5	15.8	0.04
			295.2, 351.9	19.2, 37.2	
U-238	Inferred	Th-234	*63.3	4.8	0.35
		Pa-234m	1001.0	0.84	2.70

1. The nuclide MDA values stated in the table are from a 1500g sugar background sample in a marinelli beaker counted for 20 minutes on CABRERA's 60% ReGE detector inside a lead cave. Actual Site MDAs will vary depending upon detector characteristics, count time, geometry, and activity content of samples.

Ra-226 may be measured directly by detection of its 186.2 kilo-electron volt (keV) energy line. However, it should be noted that the presence of U-235 can cause interference with direct Ra-226 detection since it has a gamma line of similar energy (185.7 keV). Should Ra-226 be encountered, the short-lived equilibrium daughters of radium may be used to determine radium-226 concentrations in the soil. Unfortunately, once the soil is disturbed, these short-lived daughters must be allowed to grow back in. The parent of these daughters, Rn-222, has a moderate half life of 3.8 days, therefore requiring at least two to three weeks of progeny ingrowth to reestablish equilibrium. Since the purpose of establishing the Onsite Laboratory is to obtain real time sample results to control excavation activities and enhance remediation decision making, this delay is not practical. The presence of U-235 will be determined via offsite analyses by alpha spectrometry during the Technology Verification phase of the project. Uranium is not expected to be detected in significant quantities on this project. Thus, the only result from this issue may be minor over reporting of Ra-226 during field screening.

Gamma spectroscopy will also identify other gamma emitting radionuclides that may be present in soils. CABRERA's Onsite Laboratory will use a gamma library compiled with data from the National Nuclear Data Center, which lists gamma energy yields for a full range of gamma emitting radionuclides. The data used to compile the library is updated through March 2002.

5.4.3 Onsite Laboratory Quality Assurance

Initial and daily calibrations of the Onsite Laboratory gamma spectroscopy system will be performed using a mixed-gamma NIST traceable source. System quality assurance will be ensured by tracking peak energy, peak resolution, and net peak area for a high and low energy peak, based on daily source counts. These quality assurance checks will be performed in accordance with applicable CABRERA quality control procedures. The procedures in question are included in CABRERA's Nuclear Materials License and, as such, have been reviewed and found adequate by the NRC. Copies are available for inspection upon request. Instrument control charts will be generated and evaluated and will be included as part of the FSS report.

Gamma spectroscopy system quality assurance will be ensured by tracking peak energy, peak resolution, and net peak area for a high and low energy peak, based on daily counts of a designated source. This source will consist of Co-60 (for the high-energy peak at 1,332.5 keV) and a low energy gamma emitter (e.g., Am-241 at 59.54 keV, Cd-109 at 88.01 keV, etc.). These quality assurance checks will be performed in accordance with the instrument's standard operating procedure. Instrument control charts will be generated and evaluated in accordance with this procedure. QC data and each spectral data report will be reviewed by a qualified radiological engineer.

Details of the Onsite Laboratory QA/QC protocols are provided in the Site QAPP (CABRERA 2005b)

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6.0 FIELD QUALITY CONTROL

Project Quality Control will be maintained through the implementation of the Site Quality Control Plan [QCP, (CABRERA, 2005a)], the Site Quality Assurance Project Plan (CABRERA, 2003b), and CABRERA's corporate Quality Assurance procedures. The CABRERA Radiation Safety Program (CABRERA, 2001) contains radiological procedures that have been approved by the U.S. Nuclear Regulatory Commission (NRC) in support of CABRERA's NRC Radioactive Materials License. Procedures from the Radiation Safety Program that are applicable to the activities conducted for this project will be implemented for the duration of this project. Controlled copies of pertinent plans and procedures shall be available on-site for the duration of the project. The CABRERA PM and Quality Control Manager shall be responsible for the execution of the Quality Control Program.

CABRERA will maintain direct, concise, and daily contact/coordination with the USACE concerning field operations and scheduling field activities. The primary POCs for all communications regarding the Site project will be [redacted] (USACE Project Engineer) and [redacted] CABRERA PM). The CABRERA PM, or designee, will participate in a weekly project meeting throughout the period of performance of the Contract. Participation may be by phone when field activities are not scheduled.

In the event of an emergency, CABRERA will promptly notify the USACE Health and Safety Officer and the USACE Field Representative.

6.1 DAILY QUALITY CONTROL REPORTS

CABRERA will submit to the designated USACE representative a Daily Quality Control Report (DQCR) for each day that field activities are conducted. The DQCR form is provided in the project QCP. (CABRERA, 2005a) The field DQCR will identify the current activities, any unanticipated delays or occurrences, departures from the FSP, communications with other USACE contractors or regulators, and any needed corrective actions. The DQCR will be signed and dated by the CABRERA FSM and will be submitted to the designated USACE representative on a weekly basis. Any deviation that may affect the project DQOs will be immediately communicated to the designated USACE representative.

6.2 CORRECTIVE ACTIONS

Any non-conformance with established procedures presented in the project plans will be identified and corrected. The CABRERA PM will issue a non-conformance report for each non-conforming condition. In addition, corrective actions will be implemented and documented in the appropriate field logbook. Non-conforming conditions include, but are not limited to:

- Improper instrument calibrations or operational checks,
- Improper survey or sampling procedures,
- Physical or documentation discrepancies with samples upon receipt at the laboratory.

The CABRERA PM shall be notified in the event discrepancies are discovered by field personnel, during a desk or field audit, by the independent QA laboratory, or during data assessment. The CABRERA PM will immediately suspend applicable survey operations until the extent of the discrepancy and its impact on the accuracy and the validity of the survey data can be assessed. The cause of the discrepancy will be identified and corrective actions, such as procedure revisions or personnel retraining, will be instituted to prevent a reoccurrence. If necessary, re-surveys or re-sampling will be performed to correct the discrepancy. The CABRERA PM will notify the designated USACE representative of the identified problem, corrective action(s), and the impact on the overall project.

6.3 FIELD DOCUMENTATION

6.3.1 Field Logbooks

Information pertinent to field activities including field instrument calibration data will be recorded in field logbooks. The logbooks will be bound and the pages will be consecutively numbered. Sufficient information will be recorded in the logbooks to permit reconstruction of site characterization activities conducted. Information recorded on other project documents will not be repeated in the logbooks except in summary form where determined necessary. Field logbooks will be kept in the possession of the appropriate field personnel, or in a secure place when not being utilized during field work. Upon completion of the field activities, logbooks will become part of the final project evidence file. Entries recorded in logbooks will be made in black, waterproof ink and include, but not be limited to, the following information:

- Author, date, and times of arrival at and departure from the work site;
- Description of the field activity and summary of daily tasks;
- Names and responsibilities of field crew members;
- Sample collection method;
- Number and volume of sample(s) collected;
- Information regarding sampling changes and scheduling modifications;
- Details of the sampling location, including a sketch map illustrating the sampling location;
- Field observations;
- Types of field instruments used and purpose of use, including calibration methods and results;
- Field measurements made (e.g., radiological activity and landfill gas);
- Sample identification number(s); and
- Sample documentation information.

6.3.2 Photographs

Photographs taken during the project will be noted in the field logbook. If photographs are taken to document sampling points, to facilitate relocating the point at a later date, they will attempt to include two or more permanent reference points within the photograph. In addition to the information recorded in the field logbook, one or more site photograph reference maps will be prepared as required.

6.3.3 Electronic Data

Electronic data collected during the day will be backed-up at the end of the same day in the field (e.g. to tape or zip drive) and before processing or editing. This is an archive of the raw data and, once created, shall not be altered. More than one day's data may go on a single tape or zip disk. Field computer(s) used to store GPS data will be backed up weekly. Raw archived data will be stored in a different location from weekly backups. Electronic GPS data will be provided daily to off-site data processing specialists. The date and time that data files are transmitted will be recorded in the data logbook. File names will be verified by comparison with field notes and corrected if necessary, following approval by the CABRERA PM.

6.3.4 Post-Processing

Post-processing specialists will convert daily GWS/GPS data to state plane coordinates, as necessary, and review the data for errors to fluctuations/interferences in the GPS signal. Post-processing specialists will be able to determine qualitatively, by density of recorded GPS positions, rapid or increased velocity of the surveyor performing the GWS, which could have an adverse effect on the predicted scan MDC. Post-processing specialists will inform the project manager of any identified deficiencies and will make corrections as directed. Conversions, errors, corrections, and/or adjustments to project data shall be documented in the data logbook.

6.4 SAMPLE DOCUMENTATION

6.4.1 Sample Numbering System

A unique sample numbering scheme will be used to identify each sample designated for laboratory analysis. The purpose of this numbering scheme is to provide a tracking system for the retrieval of analytical and field data on each sample. Sample identification numbers will be used on sample labels or tags, field data sheets and/or logbooks, chain of custody (COC) records, and all other applicable documentation used during the project.

The sample numbering scheme used for field samples will be used for duplicate samples so that these types of samples will not be discernible by the laboratory. Other field QC samples; however, will be numbered so that they can be readily identified. A summary of the sample-numbering scheme to be used for the project is presented in Table 6-1.

Table 6-1. Sample ID Numbering Scheme

Sample Type	Sample ID
Surface Sample	PV-SSXXX-Y-Z.Z-Z.Z
Subsurface Sample	PV-SBXXX-Y-Z.Z-Z.Z

SAMPLE ID NOTES:

PV	Painesville Site identifier.
SS	Surface Sample
SB	Subsurface Soil Sample
XXX	Location ID. Unique for each boring/sample location.
Y	Sample Type ID: 0 = Routine (systematic) sample 1 = Field Duplicate Samples, 2 = USACE QA split samples, 3 = Biased Samples, and 4 = Onsite Lab Duplicate.
Z.Z-Z.Z	Depth interval of sample in feet below ground surface (e.g., 0.0-0.5)

6.4.2 Sample Labels

Labels will be affixed to all sample containers during sampling activities. Information will be recorded on each sample container label at the time of sample collection. The information to be recorded on the labels will be as follows:

- Sample identification number;
- Sample type (discrete or composite);
- Site name and location number;
- Analysis to be performed;
- Type of chemical preservative present in container;
- Date and time of sample collection; and
- Sampler's name and initials.

6.4.3 Cooler Receipt Checklist

The condition of shipping coolers and enclosed sample containers will be documented upon receipt at the analytical laboratory. This documentation will be accomplished using the cooler receipt checklist presented in the QAPP.

One of these checklists will be placed either into each shipping cooler along with the completed COC form or provided to the laboratory at the start of the project. A copy of the checklist will be faxed to the contractor's field manager immediately after it has been completed at the laboratory. The original completed checklist will be transmitted with the final analytical results from the laboratory.

6.4.4 Chain of Custody Records

COC procedures implemented for the project will provide documentation of the handling of each sample from the time of collection until completion of laboratory analysis. The COC form serves as a legal record of possession of the sample. A sample is considered to be under custody if one or more of the following criteria are met:

- The sample is in the sampler's possession;
- The sample is in the sampler's view after being in possession;
- The sample was in the sampler's possession and then was placed into a locked area to prevent tampering; and
- The sample is in a designated secure area.

Custody will be documented throughout the project field sampling activities by a COC form initiated each day during which samples are collected. The COC will accompany the samples from the site to the laboratory and will be returned to the laboratory coordinator with the final analytical report. Personnel with sample custody responsibilities will be required to sign, date, and note the time on a COC form when relinquishing samples from their immediate custody (except in the case where samples are placed into designated secure areas for temporary storage prior to shipment). Bills of lading or air bills will be used as custody documentation during times when the samples are being shipped from the site to the laboratory, and they will be retained as part of the permanent sample custody documentation.

COC forms will be used to document the integrity of all samples collected. To maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory, COC forms will be filled out for sample sets as determined appropriate during the course of fieldwork.

The individual responsible for shipping of the samples from the field to the laboratory will be responsible for completing the COC form and noting the date and time of shipment. This individual will also inspect the form for completeness and accuracy. After the form has been inspected and determined to be satisfactorily completed, the responsible individual will sign, date, and note the time of transfer on the form. The COC form will be placed in a sealable plastic bag and placed inside the cooler used for sample transport after the field copy of the form has been detached. The field copy of the form will be appropriately filed and kept at the site for the duration of the site activities.

In addition to the COC form, COC seals will also be placed on each cooler used for sample transport. These seals will consist of a tamper-proof adhesive material placed across the lid and body of the coolers. The COC seals will be used to ensure that no sample tampering occurs between the time the samples are placed into the coolers and the time the coolers are opened for analysis at the laboratory. Cooler custody seals will be signed and dated by the individual responsible for completing the COC form contained within the cooler.

6.4.5 Receipt of Sample Forms

The contracted laboratory will document the receipt of environmental samples by accepting custody of the samples from the approved shipping company. In addition, the contracted laboratory will document the condition of the environmental samples upon receipt.

6.5 DOCUMENTATION PROCEDURES

The tracking procedure to be utilized for documentation of all samples collected during the project will involve the following series of steps:

- Collect and place samples into laboratory sample containers;
- Complete sample container label information, as defined in Section 6.4;
- Complete sample documentation information in the field logbook, as defined in Section 6.3;
- Complete project and sampling information sections of the COC form(s), as defined in Section 6.4, and in the QAPP;
- Complete the airbill for the cooler to be shipped;
- Perform a completeness and accuracy check of the COC form(s);
- Complete the sample relinquishment section of the COC form(s) and place the form(s) into cooler;
- Place COC seals on the exterior of the cooler;
- Package and ship the cooler to the laboratory;
- Receive cooler at the laboratory, inspect contents, and transmit via fax of contained COC form(s), and cooler receipt form(s); and
- Transmit original COC form(s) with final analytical results from laboratory.

6.6 CORRECTIONS TO DOCUMENTATION

Original information and data in field logbooks, on sample labels, on COC forms, and on any other project-related documentation will be recorded in black waterproof ink and in a completely legible manner. Errors made on any accountable document will be corrected by crossing out the error and entering the correct information or data. An error discovered on a document will be corrected by the individual responsible for the entry, as possible. Erroneous information or data will be corrected in a manner that will not obliterate the original entry, and corrections will be initialed and dated by the individual responsible for the entry.

6.7 SAMPLE PACKAGING AND SHIPPING

Sample containers will be packaged in thermally insulated rigid-body coolers. Samples will be packaged, classified, labeled, shipped, and tracked in accordance with current U.S. Department of Transportation regulations (DOT) and CABRERA SOPs. During the time period between collection and shipment, all samples will be stored in a secure area. Samples will be shipped for radiological analysis when a batch/cooler has been collected. It is not anticipated that samples will be collected/analyzed for environmental (non-radiological) constituents.

6.8 DOCUMENTATION PROCEDURES / DATA MANAGEMENT AND RETENTION

Original copies of field data, field records, analytical data, training records, and other project-specific documentation will be retained in the CABRERA New York Office in accordance with CABRERA SOP AP-001, *Record Retention*.

6.9 INVESTIGATION-DERIVED WASTE

Investigation-Derived Waste (IDW) will be generated as a result of the field activities for this project. When accumulated, the media must be managed appropriately to minimize the exposure to human health and the environment while adhering to applicable regulatory requirements. The objective of this section is to establish specific management practices for the handling and subsequent disposition of this media.

IDW includes all materials generated during project performance that cannot be effectively reused, recycled, or decontaminated in the field. Two types of IDW will be generated during the implementation of field activities: indigenous and non-indigenous. The types of indigenous IDW expected to be generated during the site characterization activities at the Site include subsurface and surface soils. The types of non-indigenous IDW expected to be generated include decontamination fluid/water and miscellaneous trash including PPE.

IDW generated during project activities will be collected, containerized, and stored in a location approved by the USACE. Waste packaging, labeling, and tracking will be performed in accordance with CABRERA SOPs. Waste characterization and shipping for off-site disposal are not within the CABRERA scope of activities for this project.

6.10 FIELD DECONTAMINATION

Field sampling equipment used during surface and subsurface soil sampling will be decontaminated. Equipment to be decontaminated may include stainless steel scoops, bowls, spoons, core barrels, and hand auger barrels. Other equipment used during sampling activities that does not directly contact sample materials (such as down-hole rods, shovels, etc.) will be cleaned to remove visible soil contamination using a suitable process (e.g., a pressurized steam-cleaner). A field decontamination location will be selected and established. This location will require the approval of the USACE-Buffalo District. Decontamination activities will be conducted so that all solid and liquid wastes generated can be properly contained and collected.

Equipment and materials will be surveyed for radioactive contamination in accordance with the methods and criteria in CABRERA SOPs and the SSHP (CABRERA, 2005c).

7.0 LABORATORY ANALYSIS

General Engineering Laboratories (GEL), of Charleston, South Carolina, an independent offsite laboratory, will provide radioanalysis of soils. GEL is a qualified radiochemistry laboratory with prior FUSRAP and USACE experience capable of providing the analytical services required to meet the project DQOs.

Soil samples will be transferred to GEL for analyses in accordance with documented laboratory-specific standard methods. Specific analyses for each sample will include Isotopic Thorium and Uranium analysis by alpha spectroscopy and for Ra-226 via the Lucas Cell method (EPA 903.1M). In accordance with MARSSIM, analytical techniques will provide a minimum detection level of 25% of the individual radionuclide cleanup goals for primary contaminants, with a preferred target minimum detection level of 10% of these individual radionuclide cleanup goals.

Table 7-1 summarizes sampling and analytical requirements. Matrix spike/matrix spike duplicate (MS/MSD), field duplicate, and USACE-Buffalo District QA split samples will be collected from the same locations to enhance comparability of results. USACE split samples will be sent to a third-party laboratory for analysis.

Table 7-1. Preliminary Sampling and Analytical Requirements for the Painesville Pre-Remediation Sampling Effort

Surface and Subsurface Soil Samples	Analytical Parameter	Test Method	Field Samples[a]	Field Duplicate Samples[b]	LCS/MS/ MSD Samples	Trip Blanks	Total Samples[c]	USACE QA Split Samples[b]
All Samples	Onsite Lab Gamma Spectroscopy	EPA 901.1	375	18	—	—	393	—
All Samples	Ra-226 via Lucas Cell	EPA 903.1M	375	18	18	—	411	18
All Samples	Isotopic Thorium (Th-228, Th–230, and Th-232)	DOE EML HASL 300 Th-01-RC mod	375	18	18	—	411	18
All Samples	Isotopic Uranium (U-234, U-235, and U-238)	DOE EML HASL 300 U-02-RC mod	375	18	18	—	411	18

(a) – Sample numbers are approximate. Actual numbers will reflect screening results and biased sampling needs. Initial estimate is based on 17 compliance samples per survey unit
(b) – Field Duplicates and USACE Splits represent a 5% criterion, based on the anticipated total number of samples.
(c) – Estimates may be adjusted as additional data become available.

It is preferred that soil samples of approximately one kilogram be obtained for laboratory radioanalysis. However, due to factors such as the sampling protocol, the diameter of the core and length of interval sampled, and site-specific soil densities, the entire sampling interval may be less than one kilogram. If so, the soil sample weight must be the minimum required by the analytical laboratory for the performance of the required analyses. Samples will be packaged and uniquely identified in accordance with chain–of–custody and site-specific procedures. Sample containers will be supplied by GEL and will be HDPE. Lucas Cell chambers will be used for quantification of Ra-226, after sufficient time has elapsed to allow in-growth of daughter radon-222 (Rn-222). The decayed sample is then run through a purge-and-trap apparatus to collect the emanated radon gas and associated daughter progeny. The gas is then counted on a zinc-sulfide (ZnS) coated alpha detector. Wet chemistry separation and alpha spectroscopy will be used to measure concentrations of isotopic uranium and thorium. Concentrations in soil will be reported in units of pCi/g. Other quality control activities are incorporated into specific field survey procedures.

Specific sample and laboratory requirements are provided in the project QAPP.

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8.0 REPORTING

The data collected from the field activities will be organized into tabular form and be presented in a final report. The final report will contain:

- An overview of the field and sampling activities,
- Concentrations of contaminants at each sampling location, and
- Figures depicting sample sites.

This report will be prepared and submitted in the format specified in Section 4.0, *Description/Specifications/Work Statement* of the Contract (USACE, 2004).

If requested by the USACE - Buffalo, CABRERA will provide all original files, including, but not limited to, documents, databases, RESRAD® runs, and model output. Original files to be submitted shall include working copies of any documents/data in the appropriate MS format (i.e. Word, Excel, Access, etc.).

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APPENDIX A

PROPOSED SYSTEMATIC SAMPLING LOCATIONS

Table A-1: Initial Sample Locations for Depth-Bounding Boreholes in Class 1 SUs

Sample ID	Easting (m)	Northing (m)
PV-SB001	704990.8	232912.9
PV-SB002	704994.9	232913.3
PV-SB003	705034.8	232889.4
PV-SB004	705003.7	232892.5
PV-SB005	705010.6	232864.2
PV-SB006	704983.9	232880.3
PV-SB007	704993.6	232880.9
PV-SB008	704993.0	232873.4
PV-SB009	704996.2	232888.4
PV-SB010	704950.0	232820.3
PV-SB011	704945.6	232812.7
PV-SB012	704934.6	232801.1
PV-SB013	704958.5	232813.0
PV-SB014	704970.7	232791.4
PV-SB015	704982.0	232807.7
PV-SB016	704985.5	232825.3
PV-SB017	704985.5	232831.6
PV-SB018	704975.4	232829.4
PV-SB019	704990.2	232820.3
PV-SB020	704994.9	232818.4
PV-SB021	705002.8	232821.8
PV-SB022	705007.8	232823.1
PV-SB023	705005.0	232872.4
PV-SB024	704995.5	232841.9
PV-SB025	704983.3	232844.1
PV-SB026	704994.6	232855.4
PV-SB027	705005.6	232842.3
PV-SB028	704920.1	232828.4
PV-SB029	704929.9	232833.5
PV-SB030	704933.6	232811.8
PV-SB031	704947.5	232801.7
PV-SB032	704994.9	232799.2
PV-SB033	704981.7	232792.0
PV-SB034	704973.9	232816.2
PV-SB035	705000.9	232907.6
PV-SB036	705044.2	232881.8
PV-SB037	705056.2	232880.0
PV-SB038	705010.9	232906.0
PV-SB039	705249.8	232903.7
PV-SB040	705243.6	232903.8
PV-SB041	705255.6	232904.0
PV-SB042	705252.9	232896.4
PV-SB043	705249.3	232884.0

Sample ID	Easting (m)	Northing (m)
PV-SB044	705258.2	232891.7
PV-SB045	705255.8	232801
PV-SB046	705270.1	232749.1
PV-SB047	705270.1	232736.5
PV-SB048	705267.8	232744.2
PV-SB049	705276.5	232789.4
PV-SB050	705278.6	232795.8
PV-SB051	705272.7	232735.8
PV-SB052	705272.4	232756.8
PV-SB053	705271.7	232781.7
PV-SB054	705262.7	232796.1
PV-SB055	705260.6	232787.9
PV-SB056	705247.0	232751.9
PV-SB057	705251.9	232756.6
PV-SB058	705243.9	232763.2
PV-SB059	705254.0	232778.1
PV-SB060	705261.7	232776.3
PV-SB061	705263.7	232766.8
PV-SB062	705259.9	232748.9
PV-SB063	705188.5	232713.5
PV-SB064	705196.2	232706.5
PV-SB065	705198.5	232701.4
PV-SB066	705220.3	232698.6
PV-SB067	705232.1	232700.4
PV-SB068	705231.9	232696.3
PV-SB069	705248.3	232706.8
PV-SB070	705257.0	232695.7
PV-SB071	705262.9	232698.3
PV-SB072	705261.4	232708.1
PV-SB073	705252.4	232721.7
PV-SB074	705248.3	232682.1
PV-SB075	705264.5	232685.2
PV-SB076	705253.4	232688.8
PV-SB077	705215	232706.8

Table A-2. Initial Sample Locations for Areal-Bounding Boreholes

Sample ID	Easting (m)	Northing (m)
PV-SB100	704929.2	232843.4
PV-SB101	704909.5	232842.9
PV-SB102	704941.9	232835.8
PV-SB103	704948.8	232826.6
PV-SB104	704966.1	232835.1
PV-SB105	704973.0	232852.5
PV-SB106	704973.0	232873.0
PV-SB107	704972.7	232893.8
PV-SB108	704983.9	232901.4
PV-SB109	704983.5	232921.7
PV-SB110	704983.5	232940.7
PV-SB111	704997.2	232926.8
PV-SB112	705011.7	232912
PV-SB113	705027.1	232899.0
PV-SB114	705044.6	232888.5
PV-SB115	705063.7	232882.1
PV-SB116	705074.0	232869.1
PV-SB117	705066.7	232862.7
PV-SB118	705049.2	232872.4
PV-SB119	705033.3	232883.2
PV-SB120	705017.2	232895.4
PV-SB121	705013.5	232881.5
PV-SB122	705013.8	232861.8
PV-SB123	705013.5	232841.6
PV-SB124	705013.5	232821.9
PV-SB125	705013.5	232802.0
PV-SB126	705010.8	232785.3
PV-SB127	704990.8	232785.9
PV-SB128	704970.3	232785.9
PV-SB129	704949.8	232786.3
PV-SB130	704934.0	232779.3
PV-SB131	704918.9	232784.8
PV-SB132	704918.0	232805.6
PV-SB133	704908.9	232822.8
PV-SB134	705226.8	232906.7
PV-SB135	705243.7	232907.0
PV-SB136	705261.3	232906.9
PV-SB137	705267.3	232892.6
PV-SB138	705267.7	232872.8
PV-SB139	705252.1	232868.9
PV-SB140	705232.4	232869.0
PV-SB141	705221.5	232877.9
PV-SB142	705221.3	232895.4
PV-SB143	705248.2	232816.3

Sample ID	Easting (m)	Northing (m)
PV-SB144	705267.5	232817.1
PV-SB145	705272.7	232801.7
PV-SB146	705283.5	232792.3
PV-SB147	705276.0	232779.7
PV-SB148	705276.0	232759.9
PV-SB149	705276.0	232740.1
PV-SB150	705276.3	232720.2
PV-SB151	705273.0	232702.6
PV-SB152	705272.7	232682.8
PV-SB153	705257.9	232678.4
PV-SB154	705238.3	232678.4
PV-SB155	705218.5	232678.2
PV-SB156	705198.7	232678.4
PV-SB157	705185.5	232685.3
PV-SB158	705186.1	232705.1
PV-SB159	705190.7	232718.9
PV-SB160	705210.3	232718.9
PV-SB161	705230.1	232718.9
PV-SB162	705235.8	232735.4
PV-SB163	705235.8	232754.9
PV-SB164	705235.8	232775.0
PV-SB165	705243.3	232787.1
PV-SB166	705252.6	232798.1

Table A-3. Systematic Sample Locations for Class 2 SUs

Sample ID	Easting (m)	Northing (m)	Class 2 SU#	SU Sample #
PV-SS301	704985.14	232668.25	17	1
PV-SS302	705009.39	232668.25	17	2
PV-SS303	705033.65	232668.25	17	3
PV-SS304	705057.9	232668.25	17	4
PV-SS305	704973.01	232692.51	17	5
PV-SS306	704997.27	232692.51	17	6
PV-SS307	705021.52	232692.51	17	7
PV-SS308	705045.77	232692.51	17	8
PV-SS309	705070.03	232692.51	17	9
PV-SS310	704936.63	232716.76	17	10
PV-SS311	704960.89	232716.76	17	11
PV-SS312	704985.14	232716.76	17	12
PV-SS313	705009.39	232716.76	17	13
PV-SS314	705033.65	232716.76	17	14
PV-SS315	705057.9	232716.76	17	15
PV-SS316	705082.16	232668.25	20	1
PV-SS317	705106.41	232668.25	20	2
PV-SS318	705130.66	232668.25	20	3
PV-SS319	705154.92	232668.25	20	4
PV-SS320	705179.17	232668.25	20	5
PV-SS321	705203.42	232668.25	20	6
PV-SS322	705227.68	232668.25	20	7
PV-SS323	705251.93	232668.25	20	8
PV-SS324	705118.54	232692.51	20	9
PV-SS325	705142.79	232692.51	20	10
PV-SS326	705167.04	232692.51	20	11
PV-SS327	705130.66	232716.76	20	12
PV-SS328	705154.92	232716.76	20	13
PV-SS329	705179.17	232716.76	20	14
PV-SS330	704924.51	232741.01	13	1
PV-SS331	704948.76	232741.01	13	2
PV-SS332	704973.01	232741.01	13	3
PV-SS333	704997.27	232741.01	13	4
PV-SS334	705021.52	232741.01	13	5
PV-SS335	705045.77	232741.01	13	6
PV-SS336	705070.03	232741.01	13	7
PV-SS337	704936.63	232765.27	13	8
PV-SS338	704960.89	232765.27	13	9
PV-SS339	704985.14	232765.27	13	10
PV-SS340	705009.39	232765.27	13	11
PV-SS341	705033.65	232765.27	13	12
PV-SS342	705057.9	232765.27	13	13
PV-SS343	705021.52	232789.52	13	14

Sample ID	Easting (m)	Northing (m)	Class 2 SU#	SU Sample #
PV-SS344	705045.77	232789.52	13	15
PV-SS345	705070.03	232789.52	13	16
PV-SS346	705033.65	232813.77	13	17
PV-SS347	705094.28	232692.51	18	1
PV-SS348	705082.16	232716.76	18	2
PV-SS349	705106.41	232716.76	18	3
PV-SS350	705094.28	232741.01	18	4
PV-SS351	705118.54	232741.01	18	5
PV-SS352	705082.16	232765.27	18	6
PV-SS353	705106.41	232765.27	18	7
PV-SS354	705130.66	232765.27	18	8
PV-SS355	705094.28	232789.52	18	9
PV-SS356	705118.54	232789.52	18	10
PV-SS357	705082.16	232813.77	18	11
PV-SS358	705106.41	232813.77	18	12
PV-SS359	705130.66	232813.77	18	13
PV-SS360	705094.28	232838.03	18	14
PV-SS361	705118.54	232838.03	18	15
PV-SS362	705203.42	232716.76	19	1
PV-SS363	705142.79	232741.01	19	2
PV-SS364	705167.04	232741.01	19	3
PV-SS365	705191.3	232741.01	19	4
PV-SS366	705215.55	232741.01	19	5
PV-SS367	705154.92	232765.27	19	6
PV-SS368	705179.17	232765.27	19	7
PV-SS369	705203.42	232765.27	19	8
PV-SS370	705227.68	232765.27	19	9
PV-SS371	705142.79	232789.52	19	10
PV-SS372	705167.04	232789.52	19	11
PV-SS373	705191.3	232789.52	19	12
PV-SS374	705215.55	232789.52	19	13
PV-SS375	705239.8	232789.52	19	14
PV-SS376	705154.92	232813.77	19	15
PV-SS377	705179.17	232813.77	19	16
PV-SS378	705142.79	232838.03	19	17
PV-SS379	704912.38	232765.27	23	1
PV-SS380	704912.38	232813.77	23	2
PV-SS381	704948.76	232838.03	23	3
PV-SS382	704912.38	232862.28	23	4
PV-SS383	704936.63	232862.28	23	5
PV-SS384	704960.89	232862.28	23	6
PV-SS385	704924.51	232886.54	23	7
PV-SS386	704948.76	232886.54	23	8
PV-SS387	704973.01	232886.54	23	9
PV-SS388	704912.38	232910.79	23	10

Sample ID	Easting (m)	Northing (m)	Class 2 SU#	SU Sample #
PV-SS389	704936.63	232910.79	23	11
PV-SS390	704960.89	232910.79	23	12
PV-SS391	704924.51	232935.04	23	13
PV-SS392	704948.76	232935.04	23	14
PV-SS393	704912.38	232959.3	23	15
PV-SS394	704936.63	232959.3	23	16
PV-SS395	705021.52	232838.03	16	1
PV-SS396	705045.77	232838.03	16	2
PV-SS397	705033.65	232862.28	16	3
PV-SS398	705057.9	232862.28	16	4
PV-SS399	705082.16	232862.28	16	5
PV-SS400	705106.41	232862.28	16	6
PV-SS401	705021.52	232886.54	16	7
PV-SS402	705070.03	232886.54	16	8
PV-SS403	705094.28	232886.54	16	9
PV-SS404	705057.9	232910.79	16	10
PV-SS405	705082.16	232910.79	16	11
PV-SS406	705106.41	232910.79	16	12
PV-SS407	705070.03	232935.04	16	13
PV-SS408	705094.28	232935.04	16	14
PV-SS409	705057.9	232959.3	16	15
PV-SS410	705082.16	232959.3	16	16
PV-SS411	705106.41	232959.3	16	17
PV-SS412	705203.42	232813.77	15	1
PV-SS413	705227.68	232813.77	15	2
PV-SS414	705191.3	232838.03	15	3
PV-SS415	705215.55	232838.03	15	4
PV-SS416	705239.8	232838.03	15	5
PV-SS417	705264.06	232838.03	15	6
PV-SS418	705130.66	232862.28	15	7
PV-SS419	705154.92	232862.28	15	8
PV-SS420	705179.17	232862.28	15	9
PV-SS421	705203.42	232862.28	15	10
PV-SS422	705227.68	232862.28	15	11
PV-SS423	705251.93	232862.28	15	12
PV-SS424	705118.54	232886.54	15	13
PV-SS425	705142.79	232886.54	15	14
PV-SS426	705167.04	232886.54	15	15
PV-SS427	705191.3	232886.54	15	16
PV-SS428	705215.55	232886.54	15	17
PV-SS429	705033.65	232910.79	22	1
PV-SS430	704973.01	232935.04	22	2
PV-SS431	704997.27	232935.04	22	3
PV-SS432	705021.52	232935.04	22	4
PV-SS433	705045.77	232935.04	22	5

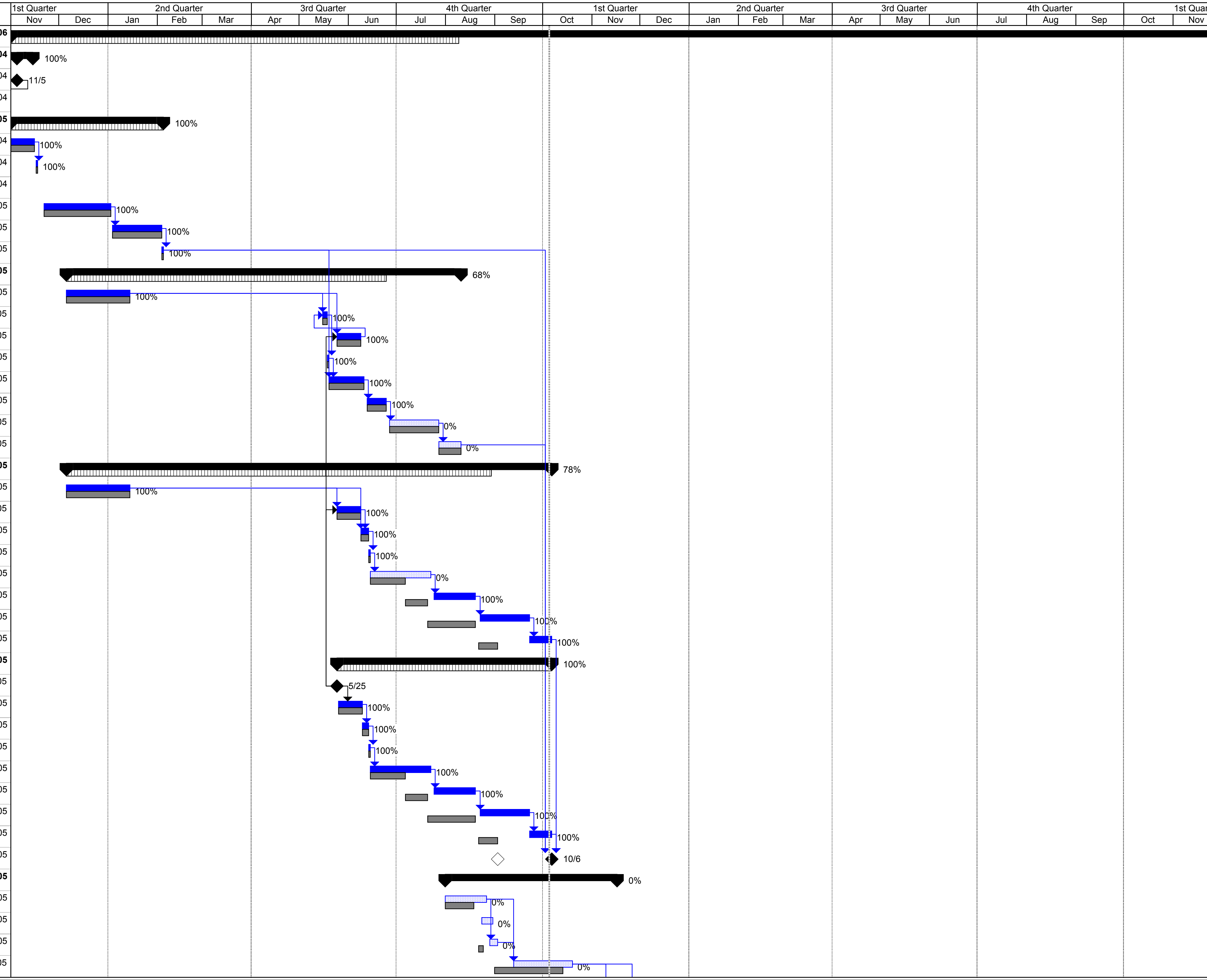
Sample ID	Easting (m)	Northing (m)	Class 2 SU#	SU Sample #
PV-SS434	704960.89	232959.3	22	6
PV-SS435	704985.14	232959.3	22	7
PV-SS436	705009.39	232959.3	22	8
PV-SS437	705033.65	232959.3	22	9
PV-SS438	704924.51	232983.55	22	10
PV-SS439	704948.76	232983.55	22	11
PV-SS440	704973.01	232983.55	22	12
PV-SS441	704997.27	232983.55	22	13
PV-SS442	705021.52	232983.55	22	14
PV-SS443	705045.77	232983.55	22	15
PV-SS444	705096.39	232982.20	21	1
PV-SS445	705071.41	232971.14	21	2
PV-SS446	705095.66	232971.14	21	3
PV-SS447	705119.92	232971.14	21	4
PV-SS448	705144.17	232971.14	21	5
PV-SS449	705168.42	232971.14	21	6
PV-SS450	705192.68	232971.14	21	7
PV-SS451	705216.93	232971.14	21	8
PV-SS452	705201.71	232978.68	21	9
PV-SS453	705148.29	232979.85	21	10
PV-SS454	705059.28	232995.39	21	11
PV-SS455	705083.62	232995.29	21	12
PV-SS456	705107.87	232995.29	21	13
PV-SS457	705132.12	232995.29	21	14
PV-SS458	705156.38	232995.29	21	15
PV-SS459	705180.46	232995.49	21	16
PV-SS460	705204.38	232995.59	21	17
PV-SS461	705154.92	232910.79	14	1
PV-SS462	705179.17	232910.79	14	2
PV-SS463	705203.42	232910.79	14	3
PV-SS464	705227.68	232910.79	14	4
PV-SS465	705251.93	232910.79	14	5
PV-SS466	705118.54	232935.04	14	6
PV-SS467	705142.79	232935.04	14	7
PV-SS468	705167.04	232935.04	14	8
PV-SS469	705191.3	232935.04	14	9
PV-SS470	705215.55	232935.04	14	10
PV-SS471	705239.8	232935.04	14	11
PV-SS472	705264.06	232935.04	14	12
PV-SS473	705130.66	232959.3	14	13
PV-SS474	705154.92	232959.3	14	14
PV-SS475	705179.17	232959.3	14	15
PV-SS476	705203.42	232959.3	14	16
PV-SS477	705227.68	232959.3	14	17
PV-SS478	705279.74	232672.44	24	1

Sample ID	Easting (m)	Northing (m)	Class 2 SU#	SU Sample #
PV-SS479	705279.74	232703.87	24	2
PV-SS480	705271.89	232719.59	24	3
PV-SS481	705279.74	232735.31	24	4
PV-SS482	705279.74	232766.74	24	5
PV-SS483	705271.89	232813.9	24	6
PV-SS484	705287.6	232813.9	24	7
PV-SS485	705279.74	232829.62	24	8
PV-SS486	705271.89	232845.34	24	9
PV-SS487	705287.6	232845.34	24	10
PV-SS488	705279.74	232861.05	24	11
PV-SS489	705271.89	232876.77	24	12
PV-SS490	705271.89	232908.21	24	13

APPENDIX B

PROJECT SCHEDULE

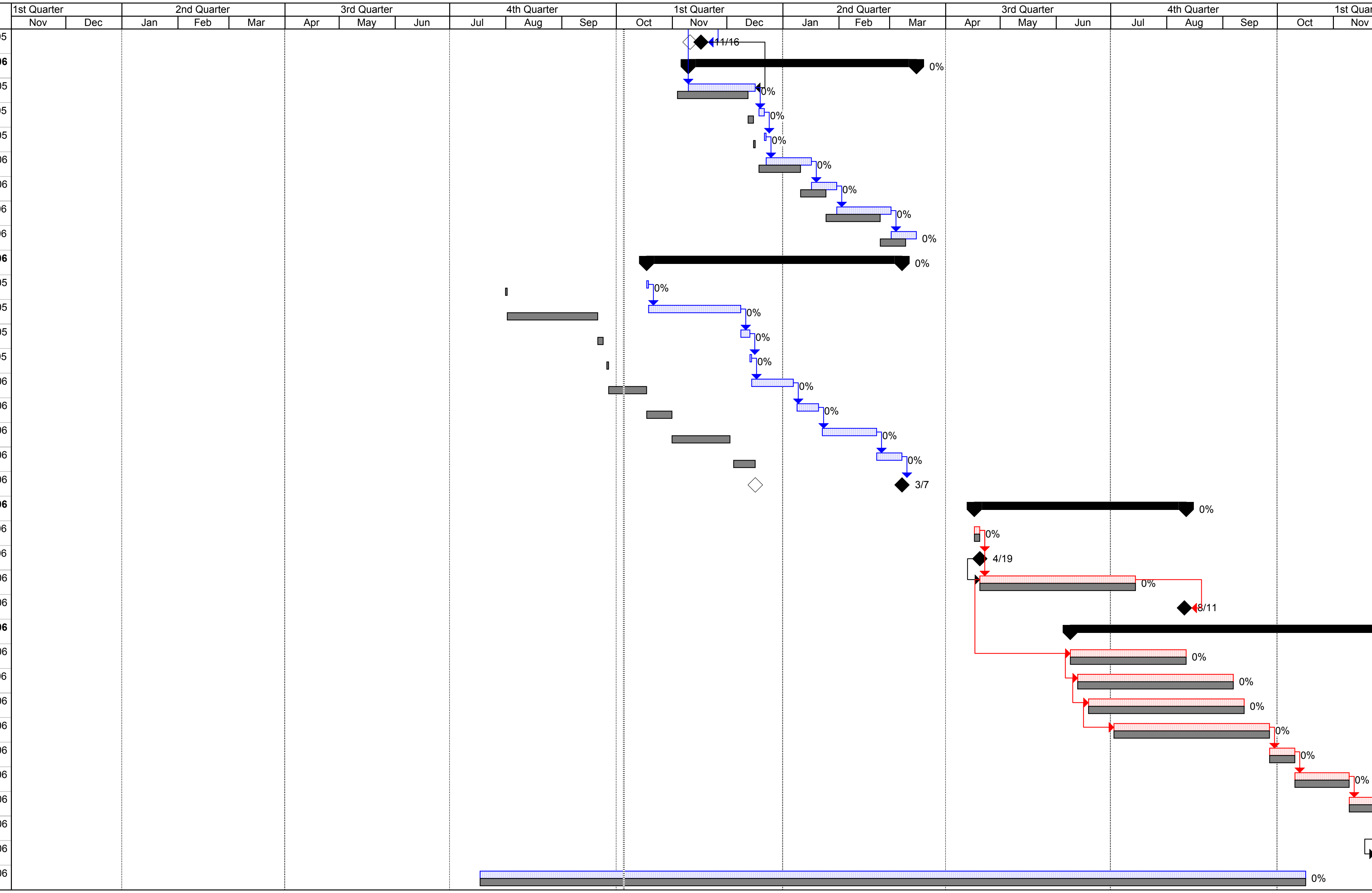
ID		Task Name	Duration	Start	Finish
1		**Painesville FUSRAP EST Project**	**529 days**	**Mon 11/1/04**	**Mon 11/27/06**
2	✓	**Task 01 - Visual Site Inspection**	**6 days**	**Fri 11/5/04**	**Mon 11/15/04**
3	✓	Notice to Proceed	0 days	Fri 11/5/04	Fri 11/5/04
4	✓	Visual Site Inspection	0 days	Mon 11/15/04	Mon 11/15/04
5	✓	**Task 02 - QC & ITR Plans**	**70 days**	**Mon 11/1/04**	**Fri 2/4/05**
6	✓	Prepare Draft QCP/ITR	11 days	Mon 11/1/04	Tue 11/16/04
7	✓	Internal Review of Draft QCP/ITR	1 day	Wed 11/17/04	Thu 11/18/04
8	✓	Prepare QCP/ITR for USACE Review	0 days	Fri 11/19/04	Fri 11/19/04
9	✓	USACE Review of Draft QCP/ITR	30 days	Mon 11/22/04	Mon 1/3/05
10	✓	Incorporate USACE Comments/Prepare Final QCP	23 days	Tue 1/4/05	Thu 2/3/05
11	✓	Submit Final QCP to USACE	1 day	Fri 2/4/05	Fri 2/4/05
12		**Task 03 - SSHP**	**176 days**	**Mon 12/6/04**	**Wed 8/10/05**
13	✓	Prepare Draft SSHP	30 days	Mon 12/6/04	Fri 1/14/05
14	✓	Internal Review of Draft SSHP	3 days	Mon 5/16/05	Wed 5/18/05
15	✓	Review/Modify Draft SSHP based on Draft FSP Rec'	10 days	Wed 5/25/05	Wed 6/8/05
16	✓	Prepare SSHP for USACE Review	1 day	Thu 5/19/05	Thu 5/19/05
17	✓	USACE Review of Draft SSHP	15 days	Fri 5/20/05	Fri 6/10/05
18	✓	Incorporate USACE Comments	10 days	Mon 6/13/05	Fri 6/24/05
19		Regulator Review of Draft Final SSHP	22 days	Mon 6/27/05	Wed 7/27/05
20		Incorporate Reg. Comments/Prepare Final	10 days	Thu 7/28/05	Wed 8/10/05
21		**Task 04 - QAPP**	**216 days**	**Mon 12/6/04**	**Thu 10/6/05**
22	✓	Prepare Draft QAPP	30 days	Mon 12/6/04	Fri 1/14/05
23	✓	Review/Modify Draft QAPP based on Draft FSP Rec	10 days	Wed 5/25/05	Wed 6/8/05
24	✓	Internal Review of Draft QAPP	3 days	Thu 6/9/05	Mon 6/13/05
25	✓	Prepare QAPP for USACE Review	1 day	Tue 6/14/05	Tue 6/14/05
26		USACE/ANL Review of Draft QAPP	27 days	Wed 6/15/05	Fri 7/22/05
27	✓	Incorporate USACE/ANL/CX Comments	20 days	Mon 7/25/05	Fri 8/19/05
28	✓	Regulator Review of Draft Final QAPP	22 days	Tue 8/23/05	Thu 9/22/05
29	✓	Incorporate Reg. Comments/Prepare Final	10 days	Fri 9/23/05	Thu 10/6/05
30	✓	**Task 05 - Pre Remediation FSP**	**94 days**	**Wed 5/25/05**	**Thu 10/6/05**
31	✓	USACE provides Draft FSP to Cabrera	1 day	Wed 5/25/05	Wed 5/25/05
32	✓	Cabrera Prepares Draft FSP	10 days	Thu 5/26/05	Thu 6/9/05
33	✓	Internal Review of Draft FSP	2 days	Fri 6/10/05	Mon 6/13/05
34	✓	Prepare FSP for USACE/ANL Review	1 day	Tue 6/14/05	Tue 6/14/05
35	✓	USACE/ANL Review of Draft FSP	27 days	Wed 6/15/05	Fri 7/22/05
36	✓	Incorporate USACE/ANL/CX Comments	20 days	Mon 7/25/05	Fri 8/19/05
37	✓	Regulator Review of Draft Final FSP	22 days	Tue 8/23/05	Thu 9/22/05
38	✓	Incorporate Reg. Comments/Prepare Final FSP	10 days	Fri 9/23/05	Thu 10/6/05
39	✓	All Final Plans Submitted to USACE	0 days	Thu 10/6/05	Thu 10/6/05
40		**Task 06 - Pre Remediation Field Sampling**	**77 days**	**Mon 8/1/05**	**Wed 11/16/05**
41		Field Preps & Coordination of Field Team	20 days	Mon 8/1/05	Fri 8/26/05
42		Deliver & Calibrate Mobile Gamma Spec Lab	5 days	Wed 8/24/05	Tue 8/30/05
43		Mobilization to Site	5 days	Mon 8/29/05	Fri 9/2/05
44		Conduct Pre-Remediation Sampling	27 days	Tue 9/13/05	Wed 10/19/05



Project: Painesville FUSRAP EST
Date: Wed 10/5/05

Critical	Split	Baseline Milestone	Rolled Up Critical
Critical Split	Task Progress	Milestone	Rolled Up Critical Split
Critical Progress	Baseline	Summary Progress	Rolled Up Critical Progress
Task	Baseline Split	Summary	Rolled Up Task
Rolled Up Split	Rolled Up Milestone		
Rolled Up Task Progress	External Tasks		
Rolled Up Baseline	Project Summary		
Rolled Up Baseline Milestone			

ID		Task Name	Duration	Start	Finish
45		Receive All Lab Result Packages	0 days	Wed 11/16/05	Wed 11/16/05
46		**Task 07 - Pre Remediation Sampling Report**	**86 days**	**Thu 11/10/05**	**Wed 3/15/06**
47		Prepare Draft Sampling Report	25 days	Thu 11/10/05	Fri 12/16/05
48		Internal Review of Draft Sampling Report	3 days	Mon 12/19/05	Wed 12/21/05
49		Prepare Sampling Report for USACE Review	1 day	Thu 12/22/05	Thu 12/22/05
50		USACE Review of Draft Sampling Report	15 days	Fri 12/23/05	Mon 1/16/06
51		Incorporate USACE Comments/Prepare Draft Final S	10 days	Tue 1/17/06	Mon 1/30/06
52		Regulator Review of Draft Final Sampling Report	22 days	Tue 1/31/06	Wed 3/1/06
53		Incorporate Reg. Comments/Prepare Final	10 days	Thu 3/2/06	Wed 3/15/06
54		**Task 08 - FSS Sampling Plan**	**97 days**	**Tue 10/18/05**	**Tue 3/7/06**
55		USACE Provide Draft of FSS Plan	1 day	Tue 10/18/05	Tue 10/18/05
56		Prepare Draft FSS Sampling Plan	35 days	Wed 10/19/05	Thu 12/8/05
57		Internal Review of Draft FSS Sampling Plan	3 days	Fri 12/9/05	Tue 12/13/05
58		Prepare Draft FSS Plan for USACE Review	1 day	Wed 12/14/05	Wed 12/14/05
59		USACE Review of Draft FSS Sampling Plan	15 days	Thu 12/15/05	Fri 1/6/06
60		Incorporate USACE Comments/Prep Draft Final	10 days	Mon 1/9/06	Fri 1/20/06
61		Regulator Review of Draft Final FSS Plan	22 days	Mon 1/23/06	Tue 2/21/06
62		Incorporate Reg. Comments/Prep Final	10 days	Wed 2/22/06	Tue 3/7/06
63		Submit Final FSS Plan to USACE	0 days	Tue 3/7/06	Tue 3/7/06
64		**Task 09 - FSS**	**83 days**	**Mon 4/17/06**	**Fri 8/11/06**
65		Mobilization to Site	3 days	Mon 4/17/06	Wed 4/19/06
66		Remedial Action Contractor Starts Excavation	0 days	Wed 4/19/06	Wed 4/19/06
67		FSS Field Activities	60 days	Wed 4/19/06	Fri 7/14/06
68		All Lab Data Recv'd for FSS Samples	1 day	Fri 8/11/06	Fri 8/11/06
69		**Task 10 - FSS Report**	**118 days**	**Fri 6/9/06**	**Mon 11/27/06**
70		Prepare Draft Tech Data Packages (Rolling)	45 days	Fri 6/9/06	Fri 8/11/06
71		Internal Review of Draft TDPs (Rolling)	60 days	Tue 6/13/06	Wed 9/6/06
72		Prepare Draft TDPs for USACE Review (Rolling)	60 days	Mon 6/19/06	Tue 9/12/06
73		USACE Review of Draft TDPs (Rolling)	60 days	Mon 7/3/06	Tue 9/26/06
74		Incorporate USACE Comments/Prepare Draft Final T	10 days	Wed 9/27/06	Tue 10/10/06
75		Regulator Review of Draft Final TDPs	22 days	Wed 10/11/06	Thu 11/9/06
76		Incorporate Reg. Comments/Prepare Final TDPs for	10 days	Fri 11/10/06	Mon 11/27/06
77		Submit Final TDPs to USACE	0 days	Mon 11/27/06	Mon 11/27/06
78		Project Completion	0 days	Mon 11/27/06	Mon 11/27/06
79		Task 11 - Public Affairs (Ongoing)	318 days	Mon 7/18/05	Mon 10/16/06



Project: Painesville FUSRAP EST
Date: Wed 10/5/05

Critical		Split		Baseline Milestone		Rolled Up Critical		Rolled Up Split		Rolled Up Milestone	
Critical Split		Task Progress		Milestone		Rolled Up Critical Split		Rolled Up Task Progress		External Tasks	
Critical Progress		Baseline		Summary Progress		Rolled Up Critical Progress		Rolled Up Baseline		Project Summary	
Task		Baseline Split		Summary		Rolled Up Task		Rolled Up Baseline Milestone			

APPENDIX C

SCAN MINIMUM DETECTABLE CONCENTRATIONS (NAI)

1.0 SUPPORTING SCAN MDC CALCULATIONS

1.1 INTRODUCTION

The purpose of this Appendix is to estimate gamma walkover scan sensitivities for the ROC radium-226 (Ra-226). The specific objective is to estimate the scan sensitivity of a gamma walkover survey performed using a 3-inch by 3-inch Sodium Iodide (3x3 NaI) scintillation detector to measure Ra-226 in the SUs. Ra-226 has been shown to be an indicator of thorium-230 (Th-230) in previous soil sampling at the Painesville FUSRAP site.

1.2 ESTIMATION OF MINIMUM DETECTABLE CONCENTRATIONS (MDC)

This document utilizes the methodology and approach documented in MARSSIM[1] (Section 6.7.2.1, Table 6.7) for a 3x3 NaI scintillation detector. MARSSIM calculations for the 3x3 detectors are based on NUREG-1507[2]. MARSSIM Table 6.7 does not provide scan MDCs for 3x3 NaI detectors; thus scan MDCs are derived using MARSSIM/NUREG-1507 methods. Factors included in this analysis are the surveyor scan efficiency, index of sensitivity, the natural background of the surveyed area, scan rate, detector to source geometry, areal extent of the potential hot spot(s), and energy and yield of gamma emissions.

The computer code Microshield was used to model the presence of normalized 1 pCi/g sources of Ra-226 and K-40 in soil with the assumption that the activity was uniformly distributed to a depth of 15 cm and spread over a disk shaped area with a diameter of 56 cm. This is consistent with the NUREG-1507 methodology and provides for a count rate to exposure ratio (CPM/μR/hr) to be calculated. Activity concentrations must be entered into Microshield in units of $\mu Ci/cm^3$ with consideration to the density of soil at 1.6 g/cm^3.

$$1 \text{ pCi/g} \times 1\text{E-6 } \mu\text{Ci/pCi} \times 1.6 \text{ g/cm}^3 = 1.6\text{E-6 } \mu\text{Ci/cm}^3$$

The Microshield exposure rate output files are included as an attachment to this Appendix.

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[1] Nuclear Regulatory Commission; *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*; NUREG-1575, Rev. 1; August 2000

[2] Nuclear Regulatory Commission; *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*; NUREG-1507; December 1997

The tables are based upon the NUREG-1507 methodology as applied toward a 3x3 NaI scintillation detector. Additional details and discussion describing the NUREG analysis methodology are described in that publication.

1.3 FLUENCE RATE TO EXPOSURE RATE (FRER)

The fluence rate to exposure rate (FRER) may be approximated by:

$$FRER \approx \frac{1 \mu R / hr}{(E_\gamma)(\mu_{en} / \rho)_{air}}$$

Where:

E_γ = energy of the gamma photon of concern, keV

(μ_{en}/ρ) = the mass energy absorption coefficient for air, cm^2/g

This can be represented in tabular form, as in Table C-1.

1.4 PROBABILITY OF INTERACTION (P) THROUGH DETECTOR END FOR A GIVEN ENERGY

The probability, P, of a gamma ray interaction in the NaI scintillation crystal entering through the end of the crystal is given by:

$$\Pr obability(P) = 1 - e^{-(\mu / \rho)_{NaI}(X)(\rho_{NaI})}$$

Where:

$(\mu/\rho)_{NaI}$ = the mass attenuation coefficient for NaI, cm^2/g

X = the thickness through the end of the 3x3 NaI crystal, 7.62 cm

(ρ_{NaI}) = the density of the NaI crystal, 3.67 g/cm^3

This can be represented in tabular form, as in Table C-2.

1.5 RELATIVE DETECTOR RESPONSE (RDR)

The Relative Detector Response (RDR) as a function of energy is determined by multiplying the relative fluence rate to exposure rate (FRER) by the probability (P) of an interaction and is given by:

$$RDR = (FRER)(P)$$

This can be represented in tabular form, as in Table C-3.

1.6 DETERMINATION OF CPM PER μR/HR AS A FUNCTION OF ENERGY

The equivalent FRER, P, and finally RDR may be calculated for the NaI scintillation detector at the Cesium-137 (Cs-137) energy of 662 keV. Manufacturers of this equipment typically provide an instrument response in terms of CPM and μR/hr at the Cs-137 energy. This point allows one to determine the CPM per μR/hr and ultimately activity concentration and minimum detection sensitivity level in terms of pCi/g for a specific instrument.

Based on a manufacturer's 3x3 NaI response specification (Ludlum Model 44-20) of 2,700 CPM/μR/hr, and using the same methodology as shown in the tables above, the FRER, P, and RDR are calculated. The mass energy absorption coefficient for air and the mass attenuation coefficient for NaI are interpolated from tables in the Radiological Health Handbook[3], Revised Edition January 1970, pages 139, and 140.

FRER = 0.0514

$Energy_{\gamma}$, keV = 662

$(\mu_{en}/\rho)_{air}$, cm^2/g = 0.0294

$(\mu/\rho)_{NaI}$, cm^2/g = 0.0780

P = 0.89

therefore:

Cs-137 RDR (662 keV) = 0.0456

The detector response (CPM) to another energy is based upon the ratio of the RDR at a specific energy to the known CS-137 energy RDR:

$$CPM / \mu R / hr, E_i = \frac{(CPM / \mu R / hr_{Cs-137})(RDR_{E_i})}{(RDR_{Cs-137})}$$

This can be represented in tabular form, as in Table C-4.

[3] Radiological Health Handbook, U.S. Department of HEW, 1970 Edition

1.7 MINIMUM DETECTABLE COUNT RATE

The minimum detectable count rate (MDCR) is calculated using the NUREG-1507 methodology where:

- There is a six inch layer of compacted brush/cattail cuttings on the ground surface with an estimated density of 0.4 g/cc,
- The detector scan rate is such that the detector is over the source for a time interval of one second at nine inches above the ground surface (six inches of compacted brush/cattails and a three inch air gap),
- The average number of background counts in a one second interval, b_i = CPM/60, and
- The Ludlum 44-20 generic count rate to exposure rate ratio value of 2,700 CPM per μR/hr and 10μR/hr measured background gives:

$$B_i = (10\mu R/hr)(2{,}700\ CPM/\mu R/hr)/(60) = 450\ counts$$

The background exposure rate of 10 μR/hr is used as a conservative estimate for the property. Background exposure rates vary but are typically less than 10 μR/hr.

The MDCR is therefore calculated as:

$$MDCR = (d')(b_i)^{0.5}(60sec/1min)$$

Where d' is from Table 6.1 of NUREG-1507 and represents the rate of detections at 95% and a false positive rate of 60%, and b_i is the background counts, giving:

$$MDCR = (1.38)(450)^{0.5}(60) = 1{,}756\ CPM$$

The MDCR for the surveyor is given as:

$$MDCR_{surveyor} = MDCR / (P)^{0.5}$$

Where P is the surveyor efficiency equal to 0.5 to 0.75 as given by NUREG-1507. A conservative value of 0.5 will be used for surveyor efficiency. Therefore, $MDCR_{surveyor}$ is calculated as:

$$MDCR_{surveyor} = 1{,}756 / (0.5)^{0.5} = 2{,}483\ CPM$$

The count rate to exposure ratio for Ra-226 gamma emissions and the contribution to the total exposure rate may be computed using the output of the Microshield runs and the count rate to exposure rate ratios from Table C-5.

1.8 ESTIMATE OF RA-226 SCAN MDC

The Microshield runs are summarized in Table C- for Ra-226. The minimum detectable exposure rate from Ra-226 and progeny is obtained from the $MDCR_{surveyor}$ divided by the Table C-weighted count rate to exposure rate value of 2,325 CPM/μR/hr for a 1 pCi/g normalized concentration.

$$2{,}483 \text{ CPM} / 2{,}325 \text{ CPM} / \mu\text{R/hr} = 1.067\ \mu\text{R/hr}$$

The scan MDC is then equal to the ratio of the Minimum Detectable Exposure Rate in the field to the exposure rate determined for the normalized 1 pCi/g concentration of Ra-226.

$$ScanMDC = \frac{(Normalized\_Ra_{conc})(ExposureRate_{surveyor})}{(ExposureRate_{normalized\_Ra\_conc})}$$

$$\text{Scan MDC} = (1 \text{ pCi/g})(1.067\ \mu\text{R/hr})/(0.2928\ \mu\text{R/hr}) = \mathbf{3.64\ pCi/g}$$

1.9 SUMMARY

Using the NUREG-1507 methodology, the calculated scan MDC for the 3x3 NaI scintillation detector employed for this radiological survey for Ra-226 in equilibrium with progeny down to, but excluding, Pb-210 and its progeny is **3.64 pCi/g**.

1.10 TABLES

Table C-1: Fluence Rate to Exposure Rate

Gamma Energy (keV)	Mass Energy Absorption Coefficient - Air (cm^2/g)	FRER
40	0.0640	0.3906
50	0.0384	0.5208
60	0.0292	0.5708
80	0.0236	0.5297
100	0.0231	0.4329
150	0.0251	0.2656
200	0.0268	0.1866
300	0.0288	0.1157
400	0.0296	0.0845
500	0.0297	0.0673
600	0.0296	0.0563
662	*0.0294*	*0.0514*
800	0.0289	0.0433
1000	0.0280	0.0357
1500	0.0255	0.0261
2000	0.0234	0.0214
3000	0.0205	0.0163

Table C-2: Probability (P) of Interaction Through Detector End for 3-in x 3-in NaI Detector

Gamma Energy (keV)	NaI Mass Attenuation Coefficient (cm^2/g)	P
40	19.3000	1.00
50	10.7000	1.00
60	6.6200	1.00
80	3.1200	1.00
100	1.7200	1.00
150	0.6250	1.00
200	0.3340	1.00
300	0.1670	0.99
400	0.1170	0.96
500	0.0955	0.93
600	0.0826	0.90
662	*0.0780*	*0.89*
800	0.0676	0.85
1000	0.0586	0.81
1500	0.0469	0.73
2000	0.0413	0.68
3000	0.0366	0.64

Table C-3: Relative Detector Response (RDR)

Gamma Energy (keV)	FRER	P	RDR
40	0.3906	1.00	0.3906
50	0.5208	1.00	0.5208
60	0.5708	1.00	0.5708
80	0.5297	1.00	0.5297
100	0.4329	1.00	0.4329
150	0.2656	1.00	0.2656
200	0.1866	1.00	0.1866
300	0.1157	0.99	0.1147
400	0.0845	0.96	0.0813
500	0.0673	0.93	0.0627
600	0.0563	0.90	0.0507
662	*0.0514*	*0.89*	*0.0456*
800	0.0433	0.85	0.0367
1000	0.0357	0.81	0.0288
1500	0.0261	0.73	0.0191
2000	0.0214	0.68	0.0146
3000	0.0163	0.64	0.0104

Table C-4: 3-in x 3-in NaI Detector Response vs. Energy

Gamma Energy (keV)	RDR	CPM per microR/hr
40	0.3906	23129
50	0.5208	30839
60	0.5708	33796
80	0.5297	31362
100	0.4329	25632
150	0.2656	15727
200	0.1866	11046
300	0.1147	6789
400	0.0813	4811
500	0.0627	3711
600	0.0507	3003
662	*0.0456*	*2700*
800	0.0367	2174
1000	0.0288	1704
1500	0.0191	1131
2000	0.0146	867
3000	0.0104	617

Table C-5: Weighted CPM per microR/hr vs. Energy for Ra-226

Gamma Energy (keV)	Microshield Exposure Rate for 1pCi/g (microR/hr w/buildup)	CPM per microR/hr (from Table C-4)	CPM per microR/hr (weighted)
50	3.443 -05	30839	3.627 +00
80	1.127 -03	31362	1.207 +02
100	1.143 -05	25632	1.001 +00
200	3.195 -03	11046	1.205 +02
300	1.045 -02	6789	2.423 +02
400	2.698 -02	4811	4.434 +02
500	1.602 -03	3711	2.031 +01
600	5.178 -02	3003	5.311 +02
800	1.335 -02	2174	9.914 +01
1000	5.441 -02	1704	3.167 +02
1500	4.678 -02	1131	1.807 +02
2000	8.306 -02	867	2.458 +02
TOTAL	**2.928 -01**		**2.325 +03**

APPENDIX D

MARSSIM SURVEY DESIGN METHODOLOGY

Introduction

The rationale and protocol for collecting samples and other data at the Painesville FUSRAP Site ("Site") is consistent with the widely accepted MARSSIM process. The logic of this survey design is driven by looking toward the endpoint (i.e., remediation and site closure) and is designed to be applicable for Final Status Survey (FSS) puposes, if the criteria are met.

The number of samples necessary to statistically demonstrate compliance with $DCGL_w$ requirements can be calculated by using MARSSIM guidance. The data used for the preliminary calculations are based on existing characterization data from the Site. Section 5 provides the rationale for calculation of the number of sample locations per survey unit, and outlines the general approach for conducting the final status survey, including detailed discussions of the decision rules for Class 1 and Class 2 survey units (SUs).

Calculation Method for Sample Numbers

This section presents the equations and methods used to estimate the number of samples required for each survey unit to determine whether the unit may be released without radiological restrictions in accordance with MARSSIM guidance for radionuclides. Sample numbers provided here may be modified on the basis of additional information. There are eight basic steps for calculating the number of samples. Each of the steps that follow is described in detail in the following sections.

1. Classify SUs,
2. Specify decision error,
3. Determine $DCGL_w$,
4. Determine relative shift,
5. Obtain the number of samples per survey unit,
6. Estimate the sample grid spacing,
7. Address small areas with elevated radioactivity, and
8. Determine if the number of samples is reasonable.

Classification of Survey Units

MARSSIM defines impacted areas as areas that have some potential for contamination. Impacted areas are subdivided into three classes:

- Class 1 areas have, or had prior to remediation, radionuclide contamination that exceeded the $DCGL_{w.}$
- Class 2 areas have a potential for radioactive contamination or known contamination, but levels are not expected to exceed the $DCGL_w$.
- Class 3 areas are expected to contain no residual radioactivity or levels of residual activity at only a small fraction of the $DCGL_w$.

By definition, any area requiring remediation will be encompassed by Class 1 units. For soil, MARSSIM suggests that a Class 1 unit be limited to a maximum area of 2,000 m^2 and a Class 2 unit be limited to a maximum area of 10,000 m^2. There is no limitation to the size of Class 3 units.

Section 4.4 discusses the definition and layout of FSS units for the Site in more detail. Figure 5-1 shows the proposed layout which includes 12 Class 1, and 12 Class 2 SUs. Several of the units are located outside the boundary of the original FUSRAP site. This preliminary layout should be expected to change in response to information generated during the pre-remediation characterization, remediation, and final status survey process.

Decision Error

The probability of making decision errors can be controlled by adopting an approach called hypothesis testing. The null hypothesis (H_0) is treated like a baseline condition and is defined as follows:

H_0 = residual radioactivity in the survey unit exceeds the release criteria.

This means that SUs are assumed to be contaminated above criteria until proven otherwise. A Type I error occurs when an area is determined to be below the criteria when it is really above the criteria (survey unit is incorrectly released). A Type II error occurs when an area is determined to be above the criteria when it is really below the criteria (survey unit is incorrectly not released).

For a given test that will statistically evaluate whether the null hypothesis is true or false, Type I and Type II error rates may be specified. Sample numbers can then be calculated so that the desired Type I and Type II error rates are achieved. For a fixed Type II error rate, lowering Type I error rates increases the number of samples required. Likewise, for a fixed Type I error rate, lowering the acceptable Type II error rate also increases the number of samples required. Type I error rates are important from the perspective of limiting residual risk. Type II error rates are important from the perspective of remediation costs. The Type I error rate for the Site is set at 0.025 or 2.5%. The Type II error rate is set at 0.05 or 5%, but may be adjusted up or down depending on the requirements of the USACE.

Derived Concentration Guideline Limit

The DCGL is defined in MARSSIM as the radionuclide-specific activity concentration within a survey unit corresponding to the release criterion. DCGLs are of two types, $DCGL_w$ (wide area average criteria, applied to areas the size of SUs) and $DCGL_{emc}$ (elevated area criteria, applied to areas much smaller than a survey unit). Site compliance with the $DCGL_w$ is demonstrated by using discrete samples and a nonparametric statistical test. By using appropriate equations, one can determine the sample numbers required per survey unit to achieve desired Type I and Type II error rates for a particular statistical test.

Site compliance with the $DCGL_{emc}$ is demonstrated through a combination of scanning and sampling. When a suitable scanning technology sensitive enough to detect $DCGL_{emc}$ exceedances exists and this scanning technology can be implemented for 100% of a survey unit's surface, $DCGL_{emc}$ compliance may be demonstrated with scans alone. For situations where either a suitable scanning technology does not exist, or where it is not practicable to obtain complete coverage with a scanning technique, $DCGL_{emc}$ compliance demonstration may also require discrete sampling. In the course of $DCGL_w$ compliance sampling, sufficient systematic samples may be collected to demonstrate $DCGL_{emc}$ compliance as well (or vice versa).

Section 4.2.2 summarizes the derivation of DCGL values for the Site, and the final DCGL values are listed in Table 4-2. A complete description of the modeling process used to derive the DCGLs, including input assumptions, is provided in the *Feasibility Study Addendum for the Painesville Site* (USACE 2005).

Relative Shift

The relative shift is defined in MARSSIM as the Δ/σ, where Δ is the DCGL minus the LBGR (lower bound of the gray region) and σ is the standard deviation of the contaminant distribution in the survey unit. The LBGR is the average level of residual contamination that one would expect to find in a survey unit once remediation in an area is complete. For areas where remediation is not implemented, the LBGR is the residual contamination levels that currently exist. The relative shift is actually a measure of the probability that one would encounter an individual sample below the $DCGL_w$ if one were to sample a survey unit. The larger the relative shift, the easier it is to demonstrate compliance with a $DCGL_w$. Relative shift values that are below 1 result in relatively large sampling requirements to show $DCGL_w$ compliance. Relative shifts that range above 3 generally no longer have an impact on the number of samples required to show $DCGL_w$ compliance.

Within the Site the areas classified as Class 1 SUs (Figure 5-1) are expected to require remediation, and so the existing data from those areas are not representative of the final residual concentrations that will exist during the final status survey process. Class 2 SUs may require selective remediation to address elevated area concerns, but it is not expected that average concentrations in these areas would approach an SOR of 1.0. Given this fact, the existing data for Class 2 SUs are more representative of the levels of residual contamination one is likely to encounter during the final status survey process. To estimate residual concentration conditions, the data from Class 1 SUs with an SOR > 1.0 was removed from the database, and the residual average SOR value for the remainder of the site was calculated, along with the standard deviation of this residual data set. The residual average SOR value provides an estimate of the LBGR, and the standard deviation provides an estimate of σ for use in calculating the relative shift (Δ/σ). The values obtained from this analysis were as follows:

- Average residual SOR (LBGR estimate) = 0.18
- Residual variability (estimate of σ) = 0.21

Based on these parameters, the relative shift is 3.9. Using the approach described in MARSSIM, if the calculated relative shift is greater than 3, then 3.0 is used as the basis for sample number calculations. The Sign p value for a relative shift of 3.0 is 0.998650.

Number of Samples per Survey Unit

The relative shift can be used to obtain the minimum number of samples necessary to satisfy Sign test requirements by using the MARSSIM equation presented below:

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(Sign\ p - 0.5)^2} \qquad \text{Eq. 1}$$

N in Equation 1 is the number of samples required to be collected from a survey unit. $Z_{1-\alpha}$ and $Z_{1-\beta}$ are critical values that can be found in MARSSIM Table 5.2 or statistics textbooks and handbooks, and *Sign p* is a measure of probability available from MARSSIM Table 5.4. A 20% increase in *N* is recommended to allow for lost or unusable samples. Equation 1 is provided for illustration purposes. Sample numbers were not calculated using equation 1, but rather obtained from MARSSIM Table 5.5 as discussed below.

Using a relative shift of 3.0, a Type I error rate of 0.025, and a Type II error rate of 0.05, Table 5.5 from MARSSIM indicates a minimum of 17 samples per survey unit would be required (this includes a 20% increase in *N* to account for lost or unusable samples). If Type II error rates are not a significant concern and can be increased, the required sample size can be reduced to 14 samples for a Type II error rate of 0.1, or to nine samples for a Type II error rate of 0.25, and still demonstrate compliance with the $DCGL_w$ at the prescribed Type I error rate of 0.025.

Sample Grid Spacing

The grid spacing is estimated in one of two ways depending on the shape of the grid. If a triangular grid is used (preferred), the grid spacing is estimated as follows:

$$L = \sqrt{\frac{A}{0.866 \times n}} \qquad \text{Eq. 2}$$

where A = the surface area in the survey unit and n = the number of samples required.

If a square grid is used, the spacing is estimated in Equation 3 below:

$$L = \sqrt{\frac{A}{n}} \qquad \text{Eq. 3}$$

If the study area is long and narrow, the sample grid will extend linearly and not in a square or triangular grid. For portions of the study area, the width of the study area may be less than the distance between grid nodes. Under this condition, the spacing between samples is calculated as follows:

$$\frac{A}{width} = total\ length \qquad \text{Eq. 4}$$

$$\frac{total\ length}{\#\ samples + 1} = L\ (length\ between\ \ samples) \qquad \text{Eq. 5}$$

The "+ 1" term in Equation 5 is added to the denominator so that sample locations do not overlap when long and narrow units lie end to end. Systematic grids will always make use of a randomly selected initial starting point.

Small Areas of Elevated Activity

Small, isolated elevated areas may be encountered either in surface soil, or in subsurface soil. MARSSIM (and this field sampling plan) addresses these areas through the definition of $DCGL_{emc}$ requirements. For the Site, these types of areas would be identified primarily by surface gamma scan results that exceed a calculated screening threshold value for the $DCGL_{emc}$ values.

For the Site, the types and mixture of radionuclides are such that gamma scanning techniques (i.e., surface walkover surveys) should be adequate to detect small areas of elevated activity at concentrations well below the $DCGL_{emc}$ values. Trigger or screening levels of gross gamma count rate will be used to identify small areas of elevated activity that require additional investigation or remediation. These screening levels will be based on correlations of gamma count rate to surface or subsurface activity concentrations (SOR values).

A $DCGL_{emc}$ requirement that applies to areas equal to 100 m^2 will be used at the Site. If an area exhibits an average count rate that indicates the 100-m^2 $DCGL_{emc}$ could be exceeded, then either further compliance evaluation or remediation will be required. The compliance evaluation will involve collection of at least 5 biased samples systematically distributed over an area of 100 m^2. The average SOR value resulting from these samples area will be compared with the 100-m^2 $DCGL_{emc}$. This type of evaluation should only be considered if the gamma scanning results are inconclusive or there are interferences (shielding, high background, etc.) that would make interpretation of the gamma scan measurements questionable.

Based on the historical characterization data and the site conceptual model, small isolated areas of elevated subsurface activity are not expected, since subsurface contamination is not expected unless there is surface contamination at the same location. Any such areas would be addressed in the characterization and remediation effort that precede the final status survey.

Reasonable Number of Samples

The number of samples per unit (17) was calculated based on historical site data and error tolerances described in the preceding sections. Based on 17 samples in each Class 1 and Class 2 survey unit, the initial estimate for the total number of systematic closure samples for this site is 408. For this FSP, samples to be collected for MARSSIM based closure purposes will only be collected from twelve Class 2 areas (i.e., 204 samples).This result should be reviewed to determine if it is reasonable, given the site conditions and levels of error considered acceptable by the responsible parties. The calculated number of samples may be unreasonably high as a result of very low error tolerances, or in cases where final status survey unit sizes are small, as might be the case for Class 1 units that conform to excavation footprints. It is the responsibility of the site managers and health physicists to evaluate whether the number of samples is reasonable. If it is determined that the number of samples is inadequate or excessive, the DQOs should be reevaluated.

Forty contingency samples have also been included for general purposes to be selected at the discretion of USACE. An additional 10 contingency samples have been included for establishing either of the scanning/sample correlations.