FINAL

Work Plan for the Characterization of the Recreation and Center Tank Areas and Radiological Remediation and Final Status Survey of the North Fence Area

Former Monazite Sand Storage Area
Naval Station Great Lakes
Great Lakes, Illinois

Project USN 2000-003, Phase III, Modification I
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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

Acronym or Abbreviation	Definition
AEC	Atomic Energy Commission
AFSC	United States Army Field Support Command
ALARA	As Low As Reasonably Achievable
bgs	below ground surface
DCGL	Derived Concentration Guideline Level
DQA	Data Quality Assessment
DQO	Data Quality Objectives
EMC	Elevated Measurement Comparison
EPA	United States Environmental Protection Agency
FSS	Final Status Survey
GPS	Global Positioning System
GWS	Gamma Walkover Survey
HAZWOPER	Hazardous Waste Operations and Emergency Response
HPGe	High Purity Germanium
JULIE	Joint Utility Locating Information for Excavators
LBGR	Lower Bound of the Gray Region
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
mrem/yr	Millirem per Year
μR/h	Microroentgen per Hour
NaI	Sodium Iodide
Naval Station	Naval Station Great Lakes

Acronym or Abbreviation	Definition
NFA	North Fence Area
NIST	National Institute of Science and Technology
NRC	United States Nuclear Regulatory Commission
Onsite Laboratory	Onsite Gamma Spectroscopy Laboratory
OP	Operations Procedure
OSHA	United States Occupational Safety and Health Administration
pCi/g	Picocurie per Gram
PDOP	Positional Dilution of Precision
QA	Quality Assurance
QC	Quality Control
RA	Reference Area
RASO	Radiological Affairs Support Office
ROPC	Radionuclides of Potential Concern
RSO	Radiation Safety Officer
Site	Former Monazite Sand Storage Area
SOP	Standard Operating Procedure
SOW	Scope of Work
SSHP	Site Safety and Health Plan
TCLP	Toxic Characteristic Leachate Procedure
TEDE	Total Effective Dose Equivalent
TENORM	Technologically-Enhanced Naturally Occurring Radioactive Material
Th-232	Thorium-232
U.S.	United States

Acronym or Abbreviation	Definition
USCG	United States Coast Guard
WAC	Waste Acceptance Criteria
WRS	Wilcoxon Rank Sum Statistical Test

1.0 INTRODUCTION

The United States (U.S.) Army Field Support Command (AFSC) has contracted Cabrera Services, Inc. (CABRERA) to provide a Work Plan describing the methodology for the characterization, remediation and Final Status Survey (FSS) of soils located within the boundaries of the Naval Station Great Lakes (Naval Station), and to perform that characterization, remediation and FSS. This site was formerly used by the Defense Logistics Agency as a storage area for strategic quantities of monazite sand, a thorium-bearing material. Survey and remediation efforts in support of this project will be performed within the former monazite sand storage area, which will be referred to herein as the Site. This project is being conducted under contract number DAAA09-03-D-0029-0017. The Scope of Work (SOW) is defined by *SOW for Radiological Remediation Great Lakes Naval Training Center, USN 2000-003 Phase III, Revision I, and CABRERA proposal 04-077, Revision 2, dated 27 April 2004* to comprise:

- Thorough characterization of the Recreation and Center Tank Areas. These Site areas are shown in the Site Map presented as Figure 1.

- Collection of soil samples from approximately 100 boring locations. Four samples will be collected from each location using a Geoprobe rig at depths of up to four feet deep. Characterization survey sample locations are shown in Figure 2. Additional biased samples will also be collected to further delineate Site contaminants.

- Removal of soil north of Building 8012 (the Warehouse) having activity concentrations of thorium-232 (Th-232) greater than 1 pCi/g above background. Th-232 background has been established, conservatively to be 0.7 pCi/g, by using the lowest reference area Th-232 sample activity result. Therefore, the project action level for Th-232 will be 1.7 pCi/g (i.e., 1 pCi/g DCGL plus 0.7 pCi/g background). This area is referred to as the North Fence Area (NFA) as shown in Figure 1. It is estimated that 462 tons (400 *ex situ* cubic yards) of contaminated soil will require removal and off-site disposal. Soil activity concentrations of Th-232 greater than 1 pCi/g above background will be disposed of as low-level radioactive waste.

- If requested, CABRERA will also perform remedial actions inside the Center Tank and Recreation Areas in the event that the total soil removed from the NFA is significantly less than the projected 462 tons, as directed by the Naval Sea Systems Command Detachment Radiological Affairs Support Office (RASO) and AFSC.

- Design and performance of a post-remediation, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)-based FSS for unrestricted release of the NFA.

CABRERA performed a Site characterization survey in 2000, and a remediation and Final Status Survey in 2003 (CABRERA 2000, CABRERA 2003). These documents form the baseline on which the project is designed; however, the data contained therein will be supplemented with remedial action control surveys during this field effort. This Work Plan and associated Site Safety and Health Plan (SSHP) address the defined Scope of Work.

2.0 PROJECT SCOPE AND PURPOSE

The Scope of Work covers the tasks associated with the following areas of the Site:

2.1 Recreation and Center Tank Areas:

- Collection of soil samples from approximately 100 boring locations. Four samples will be collected at each location using a Geoprobe rig, at depths of up to four feet deep.
- Analysis of all samples at the on-site gamma spectroscopy laboratory (Onsite Laboratory).
- CABRERA may also perform remedial actions inside the Center Tank and Recreation Areas in the event that the total soil removed from the NFA is significantly less than the projected 462 tons, as directed by the RASO/AFSC.

2.2 North Fence Area:

- Removal of soil within the NFA having soil activity concentrations of Th-232 greater than 1 pCi/g above background.
- Design and performance of post-remediation, MARSSIM-based Class 1 and Class 2 final status surveys for unrestricted release of the NFA.

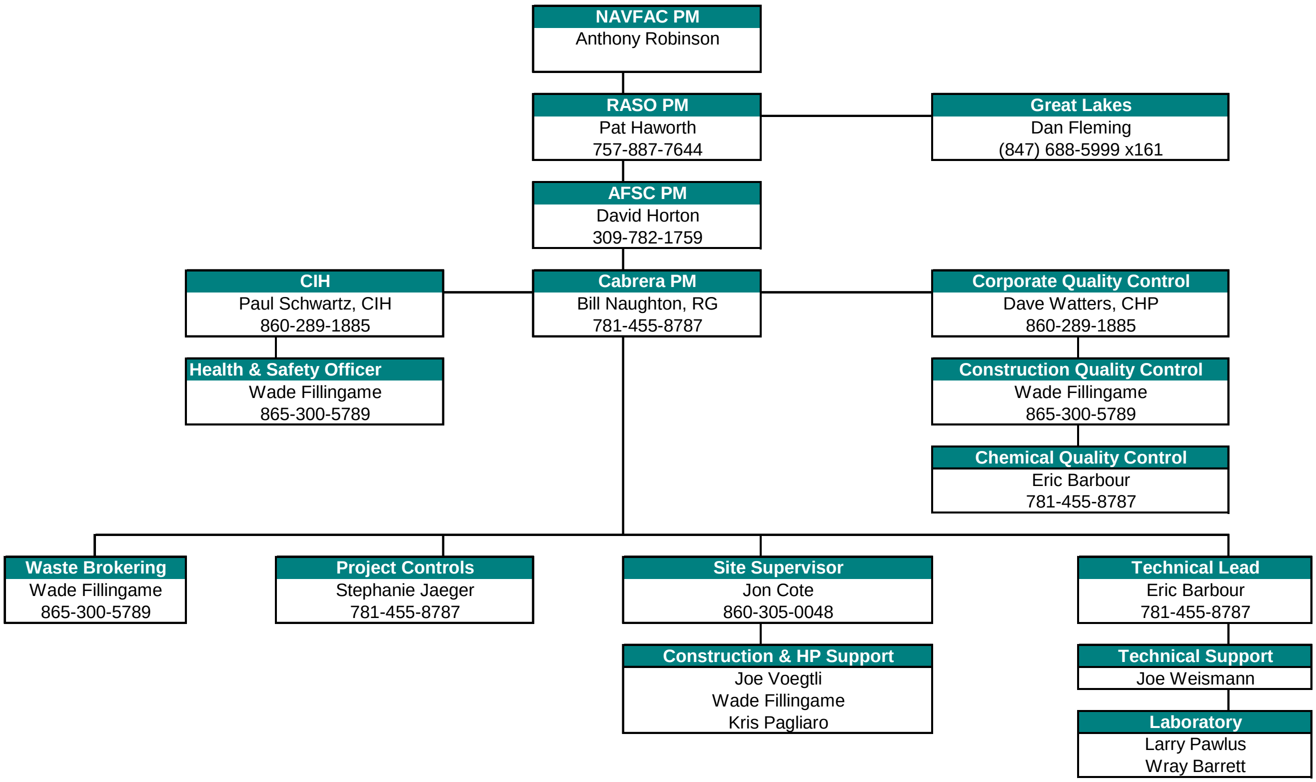
2.3 Schedule

The project schedule is provided as Attachment B to this Work Plan.

2.4 Organization Chart

Cabrera's organization chart is presented below. All critical positions are filled with highly qualified personnel with appropriate reporting relationships to the project manager to ensure the highest level of safety, quality, operational, technical, and project controls performance.

Project Organization Chart



The following are the responsibilities for the various functions in the organization chart:

NAVFAC PM – Overall control of project funding
RASO PM –Technical and contractual lead for project execution
AFSC PM – Technical and contract support
Great Lakes PM – Coordination of project site activities with Base personnel and services
Cabrera PM – Overall responsible for project execution
CIH – Overall responsible for all Health and Safety aspects of project
Health & Safety Officer – Oversight of project site related health and safety
Corporate Quality Control – Directs all aspects of quality assurance and control for projects
Construction Quality Control – Performs inspections to ensure compliance with work plan
Chemical Quality Control – Manages project sampling and analysis activities to ensure compliance with SOW, Work Plans and established procedures
Site Supervisor – Overall control of all onsite activities
Waste Broker – Manages transportation and disposal of HTRW wastes in compliance with regulations and contract requirements.

Project Controls – Manages budget and schedule for project; tracks costs and reconciles invoices
Construction and HP Support – Provides field technical support related to HP surveys, sample collection, walk over surveys, soil excavation, and general construction support.
Technical Lead – Overall responsibility for technical aspects of project including sample collection and analysis, FSS, and final report preparation and submittal
Technical Support – Execution and preparation of technical memo for characterization phase
Laboratory – Operate onsite gamma spectroscopy laboratory including sample preparation and counting.

3.0 BACKGROUND

The general areas of the Naval Station in which this project will take place are shown in Figure 1.

3.1 Historical Site Assessment

The Site is located within the Naval Station in Great Lakes, Illinois. The portions of the Site included in this project are shown in Figure 1. On July 12, 1974, the Atomic Energy Commission (AEC) granted a license (License No. SMC-12078179) to Engelhard Minerals & Chemicals Corporation, authorizing "Repackaging of monazite sands in DOT approved containers." These operations were confined to the following locations: Savannah Army Depot, Savannah, Illinois; Army Ammunitions Plant, Ravenna, Ohio; and U.S. Navy Administrative Command, Supply Depot (currently referred to as Naval Station Great Lakes), Great Lakes, Illinois. The former AEC license indicated that 1,826,153 pounds of monazite containing 9.226% of thorium oxide was held at the Naval Station prior to shipment offsite. Records show that monazite sand was shipped to W.R. Grace & Company, Chattanooga, Tennessee. The sand was shipped from Great Lakes and Savannah, Illinois from early September through mid-October 1974; and from Ravenna from early November through mid November 1974.

No records have been found indicating that a closeout survey of the monazite sand storage area (current Site) was conducted, excluding Site surveys performed by CABRERA.

Monazite is a rare earth phosphate containing a variety of rare earth oxides particularly cerium and thorium oxide. Thorium has wide industrial applications and has been mined as monazite sand since the 1930's. Monazite typically contains five to seven percent of radioactive thorium and 0.1 to 0.3% of uranium. Isotopes from the thorium series dominate.

The U.S. Nuclear Regulatory Commission (NRC) Region III conducted an inspection of the Tank Farm #5 area on January 19, 2000, and found several locations of elevated gamma activity on the north side of the warehouse foundation near the northern boundary. Surface dose rates of 80 μR/h were observed along the North Fence Area northern boundary. Cabrera Services was contracted by the Navy to assess the area and on March 8, 2000, identified locations of elevated gamma activity and by gamma spectroscopy identified the presence of Th-232.

The contamination cleanup and final status surveys are being done in three phases. In phase I, Cabrera Services was contracted to characterize the site formerly known as Tank Farm #5. The entire tank farm was surveyed and surface soil samples were collected and analyzed for Th-232. Gamma radiation levels above the ambient level were identified along the north fence line, in locations surrounding tanks H, L, and K, and in locations between tanks H, L, and K (see Figure 1). During the survey, six soil samples were collected from areas where elevated gamma radiation levels were observed. These samples were analyzed for Th-232 using gamma spectroscopy. Analytical results for the samples indicate that Th-232 concentrations ranged from 0.93 pCi/g to 64.31 pCi/g, with an average activity concentration of approximately 17 pCi/g. During the sampling process, a buried sound powered phone jack containing radium was found below ground level near the south east corner of the soil pile.

During the 2000 effort, CABRERA also performed final status surveys and released the areas surrounding the warehouse Building 8012, as shown in Figure 1 (designated by hatchings). These released survey units were part of the area referred to as the construction zone. Final status release surveys were accepted by the NRC.

In Phase II, Cabrera Services was contracted to remove the Soil Pile and to remediate and conduct a final status survey of the North Fence Area. During the 2003 field effort, the Soil Pile was remediated down to one foot above ground surface, the remaining soil pile soils were characterized, and NFA soils were characterized. Also during the 2003 effort, subsurface samples were collected from, various Site locations and analyzed; results identified elevated concentrations of Th-232 at depths greater than previously suspected. The SP, prior to remedial activities, covered an area approximately 100 feet by 50 feet and was approximately 16 feet high. The pile was leveled prior to remedial activities. The remaining Soil Pile footprint is located to the west of the new warehouse. The remediation occurred incrementally; each removal iteration eliminated approximately a one-foot lift of soil from the pile. Each lift was evaluated as a MARSSIM Class 1 survey unit. Most of the Soil Pile soil was suitable for release for unrestricted use, approximately 1,730 cubic yards. This soil was beneficially reused to provide additional capping material for a nearby, onsite landfill. Approximately 70 cubic yards exceeded the Derived Concentration Guideline Level (DCGL) and were disposed offsite at the U.S. Ecology Grandview, Idaho facility as unimportant quantities of source material. The highest concentration of Th-232 identified in pile soils was 2.7 pCi/g. Characterization surveys were performed on the base of the Soil Pile and the one-foot soil layer beneath it. The characterization surveys identified elevated concentrations of Ra-226 at the base and beneath the Soil Pile with concentrations as high as 110 pCi/g. Characterization surveys were also performed in the NFA. Approximately 170 cubic yards of NFA soils exceeded the DCGL and were disposed of offsite at the U.S. Ecology Grandview Idaho facility as unimportant quantities of source material. The highest concentration of Th-232 identified in these soils was 8.6 pCi/g.

During the 2003 characterization survey, soil samples were collected from the soil pile and NFA to provide information regarding chemical contaminants that could affect disposal options. Laboratory analyses performed were in accordance with U.S. Ecology Waste Acceptance Criteria (WAC) requirements. These analyses included a toxic characteristic leachate procedure (TCLP), metals, mercury, semi-volatiles, volatiles, chlorinated herbicides, and organochlorine pesticides. The sample analytical results were below 40 CFR Part 261 limits, indicating that no hazardous chemical constituents were identified.

3.2 Radionuclides of Potential Concern

Th-232 is the Site radionuclide of potential concern (ROPC). Soil results from the Phase I and Phase II characterization surveys (CABRERA 2000 and 2003) confirmed the presence of Th-232 in secular equilibrium with its progeny. There is no evidence of chemical or physical processes that could disturb this equilibrium. Based on the composition of monazite sands and laboratory analyses, uranium series radionuclides are expected to be present, but in significantly lower concentrations than thorium series radionuclides and are not considered radionuclides of concern.

CABRERA is not aware of any known analytical data supporting the presence of radium in any area except one discrete location at the base of the former soil pile. At this time, radium will not be considered a Site ROPC during this project. If found, discrete radium sources will be packaged, marked for storage, and processed as directed by the AFSC. If radium is identified during this field effort, plans for performing surveys may be revised, as necessary. The scan MDC for Ra-226 in surface soil and in equilibrium with its progeny is approximately 2.8 pCi/g for a 2-inch by 2-inch sodium iodide detector (calculated using the same methodology as presented in Attachment A for Th-232). For Onsite Laboratory gamma spectroscopy analysis of Ra-226 in soil, the analysis MDC is approximately 2 pCi/g via direct measurement of the 186.2 keV line. This MDC for Ra-226 sample analyses may be slightly over-reported due to the presence of a contributing natural U-235 energy line at 185.7 keV.

3.3 Unrestricted Release Criteria

Areas at the Great Lakes Naval Station will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent (TEDE) to an average member of the critical (screening) group that does not exceed 25 millirem per year (mrem/y), and the residual radioactivity has been reduced to levels that are as low as is reasonably achievable (ALARA).

3.4 Derived Concentration Guideline Levels

A radionuclide specific release criteria for Th-232, or derived concentration guideline level (DCGL), was determined using the DandD Screening Code, Version 2.1 (*NUREG/CR-5512, Vols. 1,2&3*) based on the 25 mrem/y TEDE dose limit specified in Section 3.3. For surface soil concentrations, the model for the critical (screening) group was based on a default scenario of "Residential." For the residential scenario, the screening group is adult males who live and work on a farm, producing and consuming a fraction of their diet from the site. They obtain all water required for drinking, domestic and agricultural use from an on-site well. The residential scenario includes external and inhalation exposures and exposure from the following ingestion pathways: drinking water, food grown with contaminated irrigation water, food grown on contaminated soil, fish, and inadvertent ingestion of soil. Land-based foods considered are leafy vegetables, root vegetables, fruit, grain, beef, poultry, milk and eggs. Animal feeds include fresh forage, stored grain, and stored hay. This is the most conservative scenario as it assumes that persons living on the site can use the land for any purpose without land-use restrictions.

This pre-defined model and its generic screening parameters were used to calculate a conservative range of doses that the average individual could receive. Conservatively, the DCGL is based on the upper end of the 95% confidence interval for the 0.9-quantile values for the resultant dose for the radionuclide of concern.

Based on the above, the DCGL for Th-232, in equilibrium with its progeny, is 1 pCi/g. Appendix D provides DandD screening code details (initial activity, chain data, model parameters, exposure pathways, resultant dose, etc.) for the model used.

Considering the conservatism that is factored into the default DandD scenario of "Residential," the DCGL determined by this model is considered ALARA.

4.0 CHARACTERIZATION ACTIVITIES

The Recreation and Center Tank Areas encompass approximately 6,992 square meters. Characterization surveys will be performed in the Recreation Area and Center Tank Area to identify the extent and depth of ROPCs and to quantify concentrations of radioactive contaminants in systematic and biased soil samples collected from survey areas. Systematic and biased surface soil samples will be collected at approximately 100 locations, in one-foot depth intervals to a maximum depth of four feet. Further description of characterization activities and objectives are presented in the sections below. The methodology and approach to surveys and sampling are presented in Section 7.0.

4.1 Gamma Walkover Survey

Gamma walkover surveys will be performed, as necessary, to identify areas of elevated activity in surface and shallow subsurface soils and to fill in data gaps from previous walkover efforts. The walkovers will be performed using the same procedures described in 6.5.1.

4.2 Soil Sampling

Systematic and biased soil samples will be collected at up to 100 boring locations. It is planned to collect up to four samples from each boring location, at one-foot increments to a maximum depth of four feet (up to 400 soil samples). Samples will be collected using GeoProbe direct push technology and continuous soil cores. Soil samples will be analyzed at the Onsite Laboratory with 10% of samples split and analyzed at the offsite laboratory for quality assurance data comparison.

The pre-determined systematic and biased sample locations to be sampled are presented in Figure 2. Systematic subsurface soil sample locations as shown in this figure are generated using a triangular grid-sampling pattern. There are 57 systematic and 24 biased predetermined sample locations and systematic sample location spacing (L) is 11.6 meters. The biased sample locations presented in Figure 2 are based on past survey data, including the contoured results for the GWS performed in 2000, which are presented in Figure 5 (with predetermined sample locations laid over the contoured results). Biased sample locations are also based on historical information, including the Site aerial photographs presented as Figures 4 and 6. The photograph presented in Figure 6 is orthographically corrected by the Geospatial Data Clearinghouse of the State of Illinois. The aerial photos show the locations of storage tanks that may have held monazite sand, as well as the locations of roads, buildings, and potential railroad tracks. Trains were believed to have been utilized for shipping monazite sand into and out of the Site. It is assumed that the highest probability of subsurface Th-232 contamination exists along the tracks running through the Site. The tracks presented in the figures were placed by hand using visual references found at the USGS website, the State of Illinois geological survey website, and Naval Station base maps.

Additional biased soil samples will be collected in the Center Tank and Recreation Areas based on the results of the samples collected from the pre-determined locations presented in Figure 2 and also based on the professional judgment of the CABRERA Technical Lead and Project Manager. Additional recommended biased sample locations will be submitted to RASO for approval prior to the performance of sampling activities at these locations.

4.3 Downhole 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 1 inch by 1 inch NaI detector. Measurements will be collected at one foot intervals.

4.4 Characterization Survey Data Quality Objectives

4.4.1 Step 1: State the Problem

(A) Problem Description

The problem is the presence of radioactive material in the form of monazite sand from former operations in the Center Tank and Recreation Areas. Specific ROPCs present include Th-232 and its radioactive daughter products. Possible additional ROPCs include uranium series radionuclides (see Section 3.2).

The objective of characterization activities is to establish the quantity, distribution, and three-dimensional extent of radioactive contaminants in these two areas in order to support remedial activities and/or final status surveys. Specific ROPCs present include Th-232 and its radioactive daughter products.

The scope of the characterization study area survey tasks is as follows:

- Perform subsurface volumetric sampling in the Recreation and Center Tank Areas to investigate potential for the presence ROPCs.

(B) Primary Decision Maker

Site decisions made based on characterization survey results will rest with RASO, in consultation with the AFSC Project Manager and CABRERA.

(C) Available Resources and Relevant Deadlines

Sufficient resources are available through the combined staff of RASO, AFSC, CABRERA, and the Naval Station to perform and complete work required achieving characterization survey objectives.

4.4.2 Step 2: Identify the Decision

(A) Principle Study Question

The principle study question for the site characterization task is:

What is the horizontal and vertical distribution of ROPCs in the Center Tank and Recreation areas and, where such ROPCs exist, what is their concentration?

(B) Alternative Actions

The alternative actions that may become necessary upon resolution of the principle study question involve decisions regarding final disposition of the study areas. These alternative actions may include:

- Take no action
- Perform Final Status Surveys for radiological release of areas
- Conduct a removal action and perform Final Status Surveys for radiological release of areas

These decisions will be made during a subsequent phase of this project and, as such, detailed discussions of these alternatives is beyond the scope of this characterization program's data quality objectives (DQOs).

(C) Decision Statement

Based on results from characterization fieldwork, combined with historical site data, determine whether site contaminants present an unacceptable risk to human health or the environment and require removal actions or other consideration to reduce that risk, and/or recommend that either radiological release surveys or no further action is necessary. In consideration of the risk discussed above, decisions should be based on the project action level of 1.7 pCi/g Th-232. The action level is based on the previously established 1 pCi/g Th-232 DCGL plus the conservatively established 0.7 pCi/g Th-232 background value, calculated using reference area sample results.

4.4.3 Step 3: Identify inputs to the decision

(A) Information Inputs:

Volumetric sample analysis and downhole gamma logging will provide sufficient information to enable determination of radionuclide concentrations in the study areas. In order to effectively consider the decision specified in the previous section, field data must be collected and analyzed. The input to the decision are:

(1) Results of soil sample analyses and downhole gamma logging

Obtaining this data will facilitate cost effective decision-making about the project's direction and duration.

(B) Information Sources for Above Listed Items:

(1) Concentrations of residual radioactive material in the study areas as determined from the results of Onsite Laboratory analyses:

Volumetric sample analysis will provide sufficient information to enable determination of radionuclide concentrations in the study areas. In order to effectively consider the decision specified in the previous section, field data must be collected and analyzed. Duplicate samples will be analyzed at an offsite laboratory and compared to the onsite sample analysis results for 10% of samples analyzed at the Onsite Laboratory.

4.4.4 Step 4: Define the Study Boundaries

(A) Population of Interest:

The population of interest for the study areas is Th-232 concentration of 1 pCi/g above background in surface and subsurface soils.

(B) Spatial Study Boundaries:

This study is confined to the land areas defined by the Recreation Area and the Center Tank Area at the Naval Station (see Figure 1). Vertical boundaries are limited to soils within approximately 4 feet of the surface.

(C) Temporal Study Boundaries:

Considering that the Recreation Area and Center Tank Area are part of an active Naval Station survey activities should be completed as quickly as is practical to minimize interruption of Site operations.

(D) Scale of Decision Making:

Measurements of residual radioactivity will be reviewed against background activity and Site DCGL criteria to evaluate whether sample concentrations may exceed the dose based release criteria.

(E) Constraints on Data Collection:

Data collection activities can be constrained due to excessive moisture or rain, which can have an adverse effect on field instrumentation and volumetric sample collection. Extremely cold weather can also inhibit data collection, due to its effects on both equipment and project personnel. Macrocore refusal and the presence of other obstructions may constrain sample collection. Other constraints may include those related to Naval Station operations, restrictions, and requirements.

4.4.5 Step 5: Develop a Decision Rule

The results of sample analyses will be compared to background levels and Site DCGLs to establish which portions of the Site are impacted by past radiological operations. Decisions will be made by RASO, in consultation with the AFSC Project Manager and CABRERA regarding future actions.

4.4.6 Step 6: Specify Tolerable Limits on Decision Errors

NRC guidance (NRC 1998a) provides a discussion regarding decision errors. This discussion includes the concept that acceptable error rates, which balance the need to make appropriate decisions with the financial costs of achieving high degrees of certainty, must be specified.

> *Errors can be made when making site remediation decisions. The use of statistical methods allows for controlling the probability of making decision errors. When designing a statistical test, acceptable error rates for incorrectly determining that a site meets or does not meet the applicable decommissioning criteria must be specified. In determining these error rates, consideration should be given to the number of sample data points that are necessary to achieve them. Lower error rates require more measurements, but result in statistical tests of greater power and higher levels of confidence in the decisions. In setting error rates, it is important to balance the consequences of making a decision error against the cost of achieving greater certainty.*

Acceptability decisions are often made based on acceptance criteria. If the mean and median concentrations of a contaminant are less than the associated acceptance criteria, for example, the results can usually be accepted. In cases where data results are not so clear, statistically based decisions are necessary. Statistical acceptability decisions, however, are always subject to error. Two possible error types are associated with such decisions.

It is also essential that the data collection system receive appropriate levels of quality control and quality assurance oversight. As such, in later sections of this plan, as well as in applicable instrument operating procedures, appropriate QA/QC provisions are included. These provisions include daily precision verifications such as instrument source checks and background checks, as well as periodic calibration requirements for survey instruments. Daily precision checks are also included for survey instruments.

5.0 REMEDIATION ACTIVITIES

For the purposes of segregating clean material from contaminated material during this project, the DGGL is 1 pCi/g for Th-232 above background for the NFA. NFA areas to be remediated will be designated using the results of the CABRERA 2003 NFA survey, presented as Attachment C to this Work Plan.

5.1 Area Preparation

Excavation and other possible impacted areas will be clearly marked with white paint, or equivalent, prior to commencing work. Notification of Joint Utility Locating Information for Excavators (JULIE) will be coordinated through the installation Environmental Office at least one week before the start of any earthwork, to mark out and identify any conflicting underground utilities.

Prior to beginning work, areas to be remediated should be posted as "Radioactive Controlled Area", "RWP Required for Entry" and "Authorized Personnel Only." Barrier tape or rope will be utilized to define the active work areas. Each posted area will be restricted to a single ingress/egress point, which will be marked by a step-off pad. A frisking station for personnel contamination monitoring will be setup in the area.

5.2 Removal of Soil in Contaminated Areas

Soil removal will generally be accomplished using an excavator, front-end loader, or equivalent. Removed material will be packaged for transportation predominantly in 25-yard roll-off intermodal containers, but some potential also exists for storage and/or transport of material in end dump trucks, drums, or B-25 containers. Hand tools may be utilized in size-restricted areas and areas near large stationary features that power machinery cannot readily access.

The NFA area is north of the warehouse and is approximately 1,200 m^2 in size (98 m x 12.3 m). The perimeter of the NFA is shown in Figure 3. The majority of the surface of the NFA is bare soil, although some areas are paved or covered with concrete slabs and the southwest portion is grass.

The materials flagged for removal will be temporarily staged on and covered with polyethylene sheeting (poly). It is estimated that 462 tons (400 *ex situ* cubic yards) of contaminated soil will require removal and off-site disposal. Th-232 surface concentrations as high as 9.5 pCi/g have been identified during past CABRERA surveys in this area. On-site analysis of these soils will be completed before the containers are shipped off-site.

The intermodal containers will be surveyed prior to transport and disposal at U.S. Ecology, in Grand View, Idaho (U.S. Ecology), a disposal site licensed for this waste classification. This disposal site has more flexible disposal limits than other disposal facilities and is therefore preferred over other facilities.

By default, soils will be shipped to the U.S. Ecology in Idaho for disposal. However, U.S. Ecology in Idaho cannot accept materials with concentrations in excess of 55 pCi/g Th-232 or 222 pCi/g Ra-226 (or the sum of concentrations of parent and all progeny for Ra-226 and Ra-228 exceeding 2,000 pCi/g).

Radium is not expected to be encountered in this area. However, if discrete radium sources are identified, they will be properly packaged and marked for storage as directed by the AFSC project SOW.

5.3 Packaging of Waste Materials

The waste materials exceeding DCGLs will be excavated from the NFA area, temporarily staged on and covered with poly, and placed into hard-top roll-off intermodal containers. Water absorbing materials (e.g., Water Works America SP-400, or equivalent) will be added, as necessary, to assure that no freestanding water is present within the container. The loading of the intermodal containers will be controlled to ensure that applicable Department of Transportation (DOT) requirements are met.

Soil removed from the NFA that is determined to be below the DCGL will be used as backfill material in the NFA.

5.4 Shipment and Disposal of Waste Materials

Existing NFA soil sample results and, as necessary, additional soil sample analysis performed in the Onsite Laboratory will be used to determine waste disposition. NFA soils were chemically characterized during past CABRERA field efforts for profiling information to meet U.S. Ecology criteria. Waste profiles previously accepted by U.S. Ecology for past Site waste shipments will be re-activated for the shipment of waste during this remedial effort.

The plan is to ship waste materials compliant with U.S. Ecology waste acceptance criteria from the NFA to the disposal facility, shortly after loading. All containers used during this remediation removal effort will be inspected for container integrity and the required labeling. All containers will also be surveyed and weighed prior to shipment. As described above, the intermodal containers will be used to transport the containerized soil for transport and ultimate disposal at the U.S. Ecology disposal facility in Grand View, Idaho.

CABRERA will use an AFSC-approved broker to ship the low-level radioactive waste. CABRERA will provide for exclusive use of vehicles for the shipments. Change out of drivers, trailer, or tractor en route is prohibited. The vehicles will be subject to inspection by the Government who reserves the right to reject any vehicle or driver not meeting the requirements of the Department of Transportation. CABRERA will coordinate shipments directly with the approved processor or disposal facility, prior to the containers leaving Naval Station property.

The CABRERA AFSC-qualified broker will prepare necessary DOT and procedurally required forms (Radioactive Shipment Record, Bill of Lading, etc.). A second quality assurance check on the container labeling shall be performed to ensure compliance. Full, labeled containers should be placed in the designated storage area until shipment. DOT shipping and labeling requirements will be met prior to release of the intermodal and B-25 containers from the site.

5.5 Demobilization Activities

Equipment and materials used on the project within radiological control areas will be surveyed for release and decontaminated as necessary in accordance with CABRERA field operations procedure (OP) OP-004 "Unconditional Release of Materials from Radiological Control Areas". Postings and barriers will be removed and materials and support equipment (office facility, equipment, etc.) will be removed from the site.

5.6 Personnel ALARA Considerations

Dose rates, and the total amount of radioactive materials at the site, indicate that direct external exposure to radiation is of minor consequence during work activities. Measurements of radiation exposure show maximum dose rates in the area are generally well below 40 μR/h at 1 m from the ground surfaces. One hot spot of 90 μR/h was noted by an NRC walk down. Personnel exposures are not anticipated to exceed five millirem total effective dose equivalent (TEDE) for the job duration.

The potential for internal exposure is slight due to the amount of radioactive material present, the type of material that is mixed with the radioactive materials, and the method utilized for removal of the soils. Continuous sampling, using low volume air samplers, along with breathing zone (BZ) air samples obtained from the breathing zone for the worker closest to the sampling or remediation area, will be used for evaluation of the hazard.

No environmental releases or exposures to unmonitored personnel are anticipated. Routine monitoring for environmental exposures will be performed using low volume air samples placed in areas of maximum potential exposure. Gamma scan surveys of the areas around the Survey Unit will be performed daily during the remediation to ensure the spread of contamination is minimized. Equipment used for remediation will be surveyed and decontaminated as necessary to minimize the spread of contamination to areas surrounding the Survey Unit.

5.7 Detailed Work Description

5.7.1 Pre-requisites and Precautions

Project personnel will complete and present evidence of having received Occupational Safety and Health Administration (OSHA) 40 hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training and/or have current 40 hour HAZWOPER refresher training prior to beginning work at the Site. Site personnel shall read and understand the contents of this work plan and the site-specific health and safety plan prior to any physical work on site. Each team member will complete a sign-off sheet indicating his or her understanding of and agreement to the provisions of both plans. These sheets will be filed in the project file.

The work area will be posted as "Access Controlled Area," "RWP [Radiation Work Permit] Required for Entry" and "Authorized Personnel Only," Rope, tape, or an equivalent barrier will be placed around the immediate work area to present a visual barrier and limit access by unauthorized personnel.

RWPs will be prepared documenting the activities to be performed and radiological safety requirements for all project work. Personnel assigned to site work will be required to read and understand the requirements prior to beginning work.

Low-volume air samplers will be utilized and positioned such that data may be obtained to document and verify that no significant release of radioactive materials from work activities has occurred. Personnel BZ air samplers should be run long enough to obtain an air sample of sufficient volume to ensure adequate counting instrument sensitivities.

5.7.2 Removal of Contaminated Soils

Areas identified as exceeding the DCGL of 1 pCi/g for Th-232 above background may require removal. Specific work areas inside the overall controlled area may be prepared in sections of approximately 20 to 40 m^2 at a time for ease of area set-up and control of the soil resulting from the removal actions. Larger areas may be needed to accommodate machinery when used.

CABERA will ensure that prerequisites are completed. Step off pads, along with clearly delineated postings that indicate the locations of personnel entry and egress from the work area, will be set up. Approved waste transport containers will be staged immediately adjacent to the work area or as close as practically achievable, as dictated by site-specific conditions, to ensure the distance soils must travel from the soil staging area to the intermodal container is minimized.

Soil removal will be commenced using a tracked excavator or equivalent. Removal of down to 4 feet from the ground surface may be required to effect remediation in the NFA. This may be done in lifts. Hand tools may be used to assist in the removal of small amounts of material near fencing, storm drains, utilities, etc. where machinery may be inappropriate. Soils will be temporarily staged on and covered with polyethylene sheeting and then loaded into the intermodal container.

Following initial soil removal, a local area gross gamma scan survey will be conducted out with a Ludlum Model 44-10 gamma scintillator (2 in. x 2 in. NaI) and Ludlum Model 2221 ratemeter/scaler or equivalent system, to identify any remaining soil likely to exceed the DCGL. This detection system will be configured to direct its data to a Global Positioning System (GPS) receiver to facilitate precise geo-spatial correlation of the gamma data. If any areas exhibit gamma fluence in excess of the DCGL, an additional 0.05 to 0.10 m (2 to 4 in) of the topmost portion of the soil will be removed. The above steps will be repeated as necessary until no gamma count rates in excess of background are observed.

This methodology will be repeated for subsequent NFA land areas until the entire NFA has been addressed.

Following completion of soil removal actions, equipment used during the effort will undergo release surveys in accordance with approved procedures. Equipment released for unrestricted use shall have documented survey results specifying the particular equipment and verifying that applicable release criteria have been met.

A MARSSIM-based FSS, as described in Section 6.0, will be performed on the entire NFA after remediation has been completed. This FSS will include 100% gross gamma scans and systematic soil sample collection and analysis to support unrestricted radiological release of the NFA. Additional soil samples will be included at biased sample locations, concentrating on areas of greatest contamination potential (rough cracked surfaces, drainage pathways, fence lines, wind breaks, etc.), as well as areas in which the highest gross gamma count rates are observed. The volume of sampled soil will be well mixed and place into one-liter marinelli type sample containers. Any unused soil will be placed back to the location from which it was taken.

The soil samples will be analyzed using the Onsite Laboratory and as a minimum will check 10% of the samples for quality assurance by sending them to an independent third party laboratory for correlating analysis. The offsite laboratory used to analyze soil samples will be certified by the State in which it operates. Section 7.2 provides details of the field operation gamma spectroscopy system.

Following approval and direction from the AFSC Project Manager and contracting officer, the excavated area may be backfilled roughly to grade using imported or local clean soil; this activity is currently not under contract.

6.0 RADIOLOGICAL FINAL STATUS SURVEY OF NFA

Cabrera will perform a Final Status Survey on the NFA and the RASO Project Manager will review the FSS for approval. The survey is designed to meet the guidance provided in MARSSIM (NRC 2000). The methods and procedures to be used for the FSS are described in this section. The methodology and approach to surveys and sampling are presented in Section 7.0.

6.1 Detection Methods

The following radiation detection methods will be used during the radiological surveys:

- Gross gamma fluence (count rate) measurements
- Systematic soil sampling and analysis
- Biased soil sampling and analysis

Field survey methodology, techniques, and terminology are based on guidance contained in MARSSIM (NRC 2000).

For soil sample data, non-parametric statistical methodologies (i.e., Wilcoxon rank sum [WRS] test), described below, will be utilized to compare the post-remediation site conditions with the naturally occurring background thorium. If all sample results are less than the DCGL, use of the WRS test may not be necessary to prove that a survey unit passes FSS release criteria.

6.2 Representative Reference (Background) Area

The thorium series radionuclides occur naturally and the DCGL is not substantially greater than typical background concentrations; it is necessary to establish background concentrations to identify and evaluate residual contributions from past site operations. Determination of background levels for comparison with Site conditions in specific survey units entails conducting surveys and collecting and analyzing samples from a reference area (RA) to define background radionuclide concentrations. CABRERA will use the RA results from previous FSS work (CABRERA 2003) to establish the typical background concentrations for this remediation effort. Reference area GWS results presented an average of 10,211 counts per minute (cpm), with a standard deviation of 803 cpm. Reference area sample results presented an average of 0.86 pCi/g Th-232 with a standard deviation of 0.10 pCi/g.

The RA features physical, geological, and natural radiological characteristics similar to the NFA. Non-impacted in this context should ideally include an area that was not used for, or potentially affected by previous monazite sand operations and has been disturbed from natural conditions similar to the disturbance of the construction zone (NRC 1998a).

The RA approximates the individual sizes of the NFA Class 1 Survey Units. Figure 3 shows the 2003 RA location on the site base map, with the results of the RA gross gamma survey count rate performed during the 2003 characterization survey. Details justifying the new RA as an appropriate replacement for the original RA are provided in the CABRERA memo to RASO on September 24, 2003 (CABRERA 2003a).

6.3 Survey Units

The NFA is north of the warehouse; the entire area is 2,289 m^2 in size. The majority of the surface of the NFA is bare soil, although some areas are paved or covered with concrete slabs and the southwest portion is grass. One Class 1 and one Class 2 final status survey unit have been established inside the NFA, consistent with MARSSIM guidance. The perimeter of the NFA and the designated Class 1 and Class 2 final status survey units are shown in Figure 3.

MARSSIM provides suggested maximum areas for Class 1 land areas as being up to 2,000 m^2 in size. The NFA Class 1 survey unit will have a survey area of 880 m^2. As a naming convention, this survey unit will be referred to as NFA-SU-1.

A Class 2 survey unit surrounding the NFA Class 1 survey unit has been established, as shown in Figure 3. The Class 2 survey unit is created by including a surrounding parcel of land 4 m in width around the entire Class 1 survey unit. This results in the creation of a Class 2 survey unit of 850 m^2 in size. MARSSIM provides suggested maximum areas for Class 2 land areas as being from 2,000 to 10,000 m^2. This survey unit will be referred to as NFA-SU-2. For the purposes of ensuring the identification of any small areas of elevated radioactivity, a 100% GWS will be performed on NFA-SU-2; this equates to the performance of a Class 1 survey in this Class 2 survey unit.

6.4 Number of Sample Locations and Survey Coverage

6.4.1 Number of Sample Locations for Each Survey Unit

MARSSIM discusses a method to determine the number of data points required in a given survey unit. A minimum number of measurement locations are required in each survey unit to obtain sufficient statistical confidence that the conclusions drawn from the measurements are correct. For the purpose of this survey, the minimum required number of measurements is based on expected radionuclide concentrations in site areas that may be suitable for release for unrestricted use. The following subsections describe the basis for, and derivation of, the minimum required measurement locations per survey unit.

(A) Estimation of Relative Shift

The minimum number of measurements required is dependent on the distribution of site residual radionuclide concentrations relative to the DCGL and acceptable decision error limits (α and β) established in Section 6.9.6. The relative shift describes the relationship of site residual radionuclide concentrations to the DCGL and is calculated using the following equation, from Section 8.4.3 of MARSSIM.

$$\Delta/\sigma = \frac{DCGL_W - LBGR}{\sigma}$$

Where: $DCGL_w$ = the derived concentration guideline level (i.e., release limit)

LBGR = concentration at the lower bound of the gray region. The LBGR is the concentration to which the survey unit must be cleaned in order to have an acceptable probability of passing the statistical tests. The LBGR effectively becomes the survey's action level.

σ = an estimate of the standard deviation of the concentration of residual radioactivity in the survey unit (which includes real spatial variability in the concentration as well as the precision of the measurement system)

(1) DCGL

The soil DCGL for this survey is specified as 1.0 pCi/g for Th-232. This DCGL is assumed to be conservative in nature and is used to calculate the number of samples required in the NFA survey units

(2) LBGR

The LBGR is typically used as a clean-up guideline (or action level), as discussed above. This application of the LBGR is not directly applicable to the survey design, because remediation (clean-up) has not been performed. As such, MARSSIM recommendation of setting the LBGR to 0.5 times the DCGL is used to calculate the number of required measurement locations (i.e., the DCGL = 1.0 pCi/g, so the LBGR = 1.0 pCi/g x 0.5 = 0.5 pCi/g).

(3) Sigma (σ)

For the purposes of this survey, the sigma values are drawn from data collected during the 2003 characterization survey. The standard deviation (σ) of Th-232 concentrations in the reference area (CABRERA 2003) from that survey is 0.1 pCi/g. The observed σ in the Class 2 NFA survey unit is 0.3 pCi/g, which would be expected to be similar to the Class 1 NFA survey unit σ following remediation. Therefore, to ensure that sufficient samples are collected, the more conservative Th-232 σ of 0.3 pCi/g will be assumed.

Based on the preceding, the values for relative shift are calculated for each area to be surveyed. The Δ/σ value for the NFA is 1.7.

(B) Determination of N (Number of Required Measurement Locations)

The WRS statistical test will be used to determine whether portions of the site are suitable for release for unrestricted use, since the contaminants being measured are present in background. The minimum number of systematic measurement locations required in each survey unit for the WRS statistical test is determined using Table 5.3 in MARSSIM. Using the acceptable α and β errors discussed in Section 6.9.6, and the resulting relative shift of 1.7, the N for each NFA survey unit is 15. The α and β values associated with the Type I and Type II errors are five percent (5%).

6.4.2 Required Scan Sensitivity for Class 1 Survey Unit

MARSSIM states that in Class 1 survey units, scanning sensitivity must be sufficient to detect small areas of elevated radioactivity. MARSSIM utilizes an area factor to evaluate the magnitude by which the concentration within a small area of elevated activity can exceed the $DCGL_w$ while maintaining compliance with the release criterion. The following formula is listed in section 5.5.2.4 of MARSSIM for determining the necessary scan sensitivity when incorporating the area factor:

$$\textit{Required Scan MDC (required)} = (DCGL_w) \times (\text{Area Factor})$$

If the actual scan MDC is greater than the required scan MDC, additional samples are required to ensure that the dose-based release criterion is satisfied.

For this investigation, the scan MDC, has been determined to be 1.8 pCi/g for Th-232, using values presented in MARSSIM Table 6.7. The Area Factor described above may be calculated utilizing the 15 samples taken for each survey unit from the NFA. The average area covered by each sampled area in the NFA Class 1 survey unit is calculated by dividing the Class 1 survey unit area (i.e., assumed to be, 880 m^2) by the number of samples in the Class 1 survey unit (i.e., 15); this equals 58 m^2. The Class 1 survey unit area is assumed to be 880 m^2, but could actually be larger once remediation activities are complete. The largest Class 1 survey unit area suggested by MARSSIM is 2,000 m^2. Using the same approach for the 2,000 m^2 area as that described above for the 880 m^2 area yields an average area covered of 133 m^2.

RESRAD version 6.22 was used in the deterministic mode with default parameters and Th-232 in equilibrium with its daughters. The code was used to include the "unlimited area" (i.e., RESRAD 10,000 m^2 area default), the 58 m^2 area (as described above), and the 133 m^2 area (also described above). An area factor of 2.0 is calculated by dividing the maximum RESRAD dose for the "unlimited area" of 15.06 mrem/y by the RESRAD dose for the assumed 58 m^2 area of 7.49 mrem/y. An area factor of 1.7 is calculated by dividing the maximum RESRAD dose for the "unlimited area" of 15.06 mrem/y by the RESRAD dose for the maximum 133 m^2 area of 8.64 mrem/y.

Application of the area factor for the assumed 880 m^2 Class 1 survey area results in a minimum scan MDC sensitivity not greater than 2.0 pCi/g for Th-232 compared to the scan MDC of 1.8. Thus, the scan MDC is adequate for the 880 m^2 Class 1 survey unit area.

Application of the area factor for the MARSSIM maximum suggested Class 1 survey unit area of 2,000 m^2 results in a minimum scan MDC sensitivity not greater than 1.7 pCi/g for Th-232 compared to the MDC of 1.8. Thus, the scan MDC would not be adequate for the maximum suggested area. Therefore, if following remediation activities, the Class 1 area is significantly larger than the assumed 880 m^2, the number of samples in the Class 1 survey unit will be increased, as necessary, until the required MDC is greater than 1.8 pCi/g.

The summary results of the RESRAD code outputs described above are included as Attachment E to this document.

6.4.3 Gamma Walkover Surveys and Biased Samples

NFA-SU-1 and NFA-SU-2 will receive 100% gamma walkover survey (GWS) coverage. The 100% GWS will be performed on NFA-SU-2 for the purposes of ensuring the identification of any small areas of elevated radioactivity; this equates to the performance of a Class 1 survey in this Class 2 survey unit.

If areas of elevated radioactivity are identified during the GWS, biased samples will be collected and analyzed. In addition, biased measurements may be obtained in areas of rough or cracked surfaces, drainage pathways, fence line, windbreaks etc. At a minimum, one biased soil sample will be collected in the NFA survey unit at the location of the highest gamma walkover reading. Biased samples may also be collected at locations where GWS data Z-scores exceed 3.0 (see Section 6.9.5(E)(2)). It is assumed that approximately two biased samples will be collected and analyzed as part of the final status survey from each survey unit.

6.4.4 Area Factors and the EMC Criterion

As discussed previously, 15 systematic soil samples will be obtained in each NFA survey unit. Samples will be obtained at 0 to 0.30 m (0 to 12 in) below ground surface (bgs) after the removal action has occurred.

(A) Class 1 Survey Unit

Results of the NFA Class 1 survey unit (NFA-SU-1) for Th-232 exceeding the DCGL (including background) will be compared to the $DCGL_{EMC}$ for evaluation of acceptability. The $DCGL_{EMC}$ is determined as follows:

$$DCGL_{EMC} = \text{(area factor)} \times (DCGL_W) = 1.7 \times 1 \text{ pCi/g} = 2.7 \text{ pCi/g Th-232}$$

Each sample point will be evaluated to determine if it exceeds the $DCGL_W$ plus background for Th-232. The lowest background Th-232 sample result from the 2003 reference area data will be considered the site “background” for this determination. If a sample result exceeds background by more than the $DCGL_W$, it will be compared to the applicable $DCGL_{EMC}$. Areas that exceed background by more than the $DCGL_{EMC}$ will be considered unacceptable (i.e., will require remediation).

Provided that the results of EMC comparisons are resolved, it is still necessary to evaluate the average residual radioactivity in the survey unit for the purpose of evaluating residual results against risk. If residual radioactivity is found in an isolated area of elevated activity (in addition to residual radioactivity distributed across the survey unit), the unity rule can be used to ensure that the total dose is within the final status survey release criterion. This evaluation is performed using MARSSIM Equation 8-2 as follows:

(d/DCGLw) + ((elevated area average concentration – d)/(Area Factor x DCGLw)) <1

where:

d = average residual radioactivity in the survey unit

If there is more than one elevated area, a separate term (for d over the DCGLw) should be included for each separate area.

(B) Class 2 Survey Unit

If a sample result exceeds background in the Class 2 survey unit (NFA-SU-2) by more than the $DCGL_W$, the survey unit will be reclassified and evaluated as a Class 1 survey unit.

6.5 Survey Instrumentation and Survey Techniques

6.5.1 Gamma Walkover Survey

A 100% GWS will be performed over accessible areas in each Class 1 survey unit, as recommended in MARSSIM. The purpose of the GWS is to identify areas of elevated radioactivity. The approximate detection sensitivity of the GWS is 1.8 pCi/g for Th-232 in secular equilibrium with its radioactive daughter products as presented in Attachment A entitled *2 in x 2 in NaI MDC Technical Memorandum*. The detection sensitivity is based on surficially deposited 0 to 0.30 m (0 to 12 in) isotopes. Equipment required for performing the GWS survey includes the following:

- Trimble Pathfinder Pro - XRS (or equivalent)
- 2 in by 2 in 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 m apart. Data from the ratemeter/scaler will be automatically logged into the GPS unit every one 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 on-site Project Engineer for evaluation.

6.5.2 Soil Sampling

Surface soil samples will be collected in the NFA survey units NFA-SU-1 and NFA-SU-2, and in the onsite reference area to enable statistical evaluation of site radionuclide concentrations relative to the DCGL, in accordance with MARSSIM guidance. Soil samples will be collected using hand augers or equivalent equipment and will be collected from 0 to 0.30 m (0 to 12 in) in the NFA survey units. A total of at least 15 reference area soil samples will be taken. This number is based upon MARSSIM table 5.3 and input as previously described in Section 5.7.1. The following equipment (or equivalent) will be required for this task.

- Hand auger, or other proper sampling method
- Large stainless steel mixing bowl
- Stainless steel utensil for removal of soil core from hand auger after sample is retrieved and for mixing and packaging samples in containers
- Sample containers and chain of custody forms/seals

6.6 Preparation of Survey Units

The NFA survey units may contain debris and equipment, which may obstruct the final status survey. Should such obstructions exist, they will be brought to the attention of RASO and the AFSC. RASO, in consultation with the AFSC, will make the decision on removal of the obstruction or of no action. Should the "no action" scenario be adopted the CABRERA Site Manager will record the area and location of the survey exclusion zone and identify its coordinates using the GPS.

6.7 Establish the Survey Reference Coordinate System

To facilitate both survey measurements and data analysis, a survey reference coordinate system will be developed and installed early in the survey process. Coordinates will be referenced to the Illinois State Plane Coordinate System, Zone 1201, Illinois East. The horizontal datum will be the North American Datum of 1983 (NAD 83) in meters. At a minimum, the corners of survey units will be identified and clearly marked. Additionally, to facilitate the walkover survey process, intermediate markings may be installed to mark the start and end points of planned survey lines. Use of GPS obviates the need for marking small grid intervals.

6.8 Specify Sampling Locations

Systematic sample locations in NFA survey units will be established and marked using survey flags, paint, or equivalent markings, prior to sample collection. A triangular sampling grid will be established for each survey unit based on its area. Actual survey unit areas will be measured in the field, as it is anticipated that minor deviations from the planned survey unit dimensions will be necessary. The triangular grid spacing for each survey unit will be determined, based on the measured area of the survey unit, using the following equation (Equation 5-5 from MARSSIM).

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

Where:	L	=	square grid spacing for survey unit
	A	=	area of survey unit
	N	=	number of sample locations

A random start point will be generated and systematic sample locations will be marked in an equilateral triangular grid using the spacing calculated by the equation shown above.

If the GWS identifies areas of elevated radioactivity, biased samples will be collected to evaluate elevated area radionuclide concentrations against MARSSIM EMC criteria. Biased sample locations will be selected based on the results of the GWS, as well as other factors as described in Section 6.4. At a minimum, one biased sample will be collected in each survey unit at the location of the highest gamma walkover measurement.

6.9 Data Quality Objectives for Final Status Survey

6.9.1 Step 1: State the Problem

(A) Problem Description

The objective of final status survey activities in the NFA is to obtain data of sufficient quality and quantity to support unrestricted release of the areas. The problem is the presence of radioactive material, in the form of monazite sand from former operations. Specific ROPCs present include Th-232 and its radioactive daughter products.

Final Status Survey planning is being performed by a team of CABRERA personnel, with input from RASO and the AFSC.

(B) Primary Decision Maker

The ultimate decision regarding site disposition will rest with RASO, in consultation with its regulators. As such, RASO, in consultation with the AFSC, and CABRERA, will make decisions for the final status survey activities.

(C) Available Resources and Relevant Deadlines

Sufficient resources are available through the combined staff of RASO, the AFSC, CABRERA, and the Naval Station to perform and complete work required to achieve final status survey objectives within the required timeframes.

6.9.2 Step 2: Identify the Decision

(A) Principal Study Question

Do ROPC concentrations in the NFA survey units exceed background concentrations by more than the DCGLw and, if so, what are those concentrations and where in the survey units are they located?

(B) Decision Statement

The following statements assume that ROPC concentrations in Class 1 survey units will be found to exceed background concentrations by more than the DCGLw. Decision Statements should be evaluated sequentially, as shown.

(1) Determine whether ROPC concentrations in the survey units exceed background concentrations by more than the DCGLw.

(2) Based on sample results, if ROPC concentrations exceed background concentrations by more than the DCGLw, evaluate concentrations against the $DCGL_{EMC}$ criterion.

(3) If ROPC concentrations exceed background concentrations by more than the $DCGL_{EMC}$ or fail unity rule comparisons for dose based risk (see Section 6.4.4), perform required remediation.

6.9.3 Step 3: Identify Inputs to the Decision

In order to resolve the decision statements listed in Section 5.12.2 a variety of data is required. This section lists data needs, describes the sources of that data, and discusses the means of obtaining the required data points.

(A) Information Inputs:

The following site characteristics must be determined in order to resolve applicable decision statements:

(1) Concentrations of residual radioactive material in the NFA:

This information will allow determination as to whether or not the survey units are likely to be suitable for unrestricted release. Obtaining this data will facilitate cost effective decision-making about the project's direction and duration.

(B) Information Sources for Above Listed Items:

(1) Concentrations of residual radioactive material in the NFA as determined from Onsite Laboratory analyses:

Volumetric sample analysis and GWS data will provide sufficient information to enable determination of NFA radionuclide concentrations. Duplicate samples will be analyzed at an offsite laboratory and compared to the onsite sample analysis results for 10% of samples analyzed at the Onsite Laboratory.

6.9.4 Step 4: Define the Study Boundaries

(A) Population of Interest Defining Characteristics:

The population of interest for the NFA is the Th-232 concentrations above background in surface and shallow subsurface soils.

(B) Spatial Boundaries of the Decision Statement:

The population of interest study is horizontally limited to land areas located in the survey units (see Figure 3). The vertical study area extends from the land surface to the depth of up to 0.30 m (12 in) bgs for the NFA.

(C) Temporal Boundaries of the Decision Statement

(1) Time frame to which the decision applies:

DCGL values are based on risks to an average member of the Critical Group over a 1000-year period following the study.

(2) Time for data collection:

Data collection and analysis should be performed as soon as practical, as timely completion of the structures and work onsite are contingent upon the results of the final status survey.

(D) Scale of Decision Making:

The NFA Class 1 and 2 survey unit residual radioactivity measurements will be reviewed against the DCGL criteria to assure that no areas exceed the DCGL. Small areas of elevated activity could exist in the Class 1 survey units and could require additional sampling points.

All class 2 survey units must be below the DCGL. Any Class 2 survey unit greater than the DCGL will be flagged for further investigation/remediation.

Decisions will be made for small areas that may exhibit elevated levels of radioactivity, then for individual survey units regarding whether or not they meet the criteria for unrestricted or restricted release.

(E) Constraints on Data Collection:

Data collection activities can be constrained due to excessive moisture or rain, which can have an adverse effect on field instrumentation and volumetric sample collection. Extremely cold weather can also inhibit data collection, due to its effects on both equipment and project personnel. Macrocore refusal and the presence of other obstructions may constrain sample collection. Other constraints may include those related to Naval Station operations, restrictions, and requirements.

6.9.5 Step 5: Develop the Decision Rules

(A) Parameter of Interest

Parameters of interest are the mean, median, and standard deviation of data collected during the study. Based on the data distribution characteristics resulting from characterization data collection, the preceding parameters may be transformed to equivalent descriptive measures (e.g., logarithms, etc.) to allow more representative statistical testing. By using a graded approach to data testing as discussed below, decisions will be made according to the decision rule stated at the end of this section.

(B) Scale of Decision Making

Decisions are made on two fundamental scales, the survey unit and smaller localized areas of elevated activity. Localized areas of elevated radiation levels are evaluated on an ongoing basis throughout the field effort. In cases where clear indications of elevated measurements are observed, decisions on remediation, survey unit subdivision, etc., may be taken as appropriate. On a larger scale, and as a final determination, data will be evaluated on a survey unit-specific basis.

(C) Action Level

Decisions on a survey unit's acceptability for release are based on comparison of the DCGL to the difference between measured residual radioactivity concentrations in survey units and measured radioactivity in the reference area, subject to applicable statistical analyses specified in MARSSIM. Inputs to this decision will be based on a graded approach to data analysis intended to avoid unnecessary analytical and/or remediation efforts, while also ensuring that project DQOs are met. Graphical and statistical approaches to data analysis are included in the Data Quality Assessment (DQA) process, which is the, "… scientific and statistical evaluation of data to determine if the data are of the right type, quality, and quantity to support their intended use."

For the purposes of this Final Status Survey, the action level used for data comparison is 1.0 pCi/g plus the lowest reference area Th-232 sample analysis result. If the action level is exceeded in a Class 1 survey unit, then the result will be evaluated using MARSSIM EMC criterion. If the action level is exceeded in a Class 2 survey unit, the survey unit will be reclassified to a Class 1 survey unit.

(D) Decision Inputs

Geospatial modeling of position-correlated GWS data will provide a graphical view of surface gamma radiation levels and will be updated as the survey progresses. This and results of sample analyses from the Onsite Laboratory will serve as primary decision inputs during performance of the fieldwork, as data will be reduced soon after collection.

Assessment of soil sample data will be as simple as visually inspecting data to identify obvious indicators that the action level has or has not been met. If sample results are below the DCGL, the survey unit will meet the release criteria. If not, the WRS test will be applied to the data.

(1) Spot-Check Gamma Scans During Survey Unit Delineation

Initially, the perimeter of each survey unit will be marked with stakes or survey flags based on the dimensions established in this plan. During this process, the boundary areas will be checked with gross gamma detection instruments to ensure the boundaries surround the areas with observed elevated gamma count rates.

(2) Field Measurements of Survey Unit Dimensions

The dimensions of the survey units will be determined using GPS data, downloaded and interpreted in ArcGIS version 8.0 or greater. At a minimum, the corners of the survey units will be logged using the GPS system. The area of each survey unit will then be calculated in units of m^2. This data will be used to determine grid spacing and ensure that survey units do not exceed the maximum size recommended by MARSSIM.

(3) GWS in NFA Survey Units

The NFA survey unit GWS data will be reduced and evaluated as follows:

- The measurements will be plotted and color-coded for visual review and evaluation. The average and standard deviation of each survey unit will also be calculated. The location of the highest measurement will be located.
- The difference between each data point and the average of the survey unit in which it was obtained will be calculated and divided by the standard deviation of the survey unit. This will convert the measurements to multiples of the survey unit standard deviation above or below the average (Z-scores). The color-coding will be based on multiples of the survey unit standard deviation.
- Areas exceeding three standard deviations (3Z) above the survey unit will be identified. The frequency of these occurrences and the maximum measurement in these areas will be compared to the reference area. The geospatial plot will also be visually inspected to identify anomalies in the distribution of measurement data. Biased samples shall be collected at areas greater than 3Z.

(4) Sample Results: WRS Statistical Test

Comparison of RA (background) radionuclide concentrations with survey unit concentrations will be performed using the two-sample WRS statistical test. This test is selected because the ROPCs are present in the natural background. The two-sample WRS test assumes the RA and survey unit data distributions are similar except for a possible shift in the medians. When the data are severely skewed, the value for the mean difference between survey unit measurements and reference measurements may be above the DCGL, while the median difference is below the DCGL. In such cases, the survey unit does not meet the release criterion regardless of the result of the statistical test. On the other hand, if the difference between the largest survey unit measurement and the smallest RA measurement is less than the DCGL, the WRS test will always show that the survey unit meets the release criterion.

In using this test, the hypotheses being tested are:

Null Hypothesis (H_0): The median concentration in the survey unit exceeds that in the RA by more than the DCGL.

versus the alternative:

Alternative Hypothesis (H_a): The median concentration in the survey unit exceeds that in the RA by less than the DCGL.

The WRS will be applied to the Th-232 concentrations as described in MARSSIM.

(E) Decision Rules

(1) Field Measurements of Survey Unit Dimensions

If the measured dimensions of a survey unit exceed the 2,000 m^2 maximum recommended by MARSSIM, RASO will be contacted. With their concurrence, the survey unit boundaries will be adjusted accordingly. Significantly larger areas may require establishing up additional survey units.

(2) GWS in NFA Survey Units

- A biased soil sample will be collected at the location where the highest GWS data point is observed. Biased samples will not be analyzed by WRS testing.
- A Z-score plot based on survey unit data will be generated. The Z-score plot is a graphical depiction of survey unit standard deviation values. This plot will be examined to determine areas where additional investigation is warranted. Additional investigations include biased sampling followed by Onsite Laboratory analysis.

(3) Sample Results: WRS Statistical Test

- If sample results for the survey unit are less than the DCGL, the survey unit is deemed to meet the release criterion.
- If any of the sample results for the survey unit exceeds the DCGL, perform the WRS test. If W_r, the output from the WRS test, for the survey unit is less than the applicable critical value, the median value for residual radioactivity in the survey unit is less than the DCGL to the specified confidence level as indicated by the acceptable decision error specified (see following section). The survey unit meets the release criterion. If W_r for the survey unit is greater than the applicable critical value, the median value for residual radioactivity in the survey unit is greater than the DCGL and the survey unit does not meet the release criterion. CABRERA will contact RASO and the AFSC for any survey units that do not meet the release criteria (W_r for the survey unit is greater than the applicable critical value).

6.9.6 Step 6: Define Acceptable Decision Errors

NRC guidance (NRC 1998a) provides a discussion regarding decision errors. This discussion includes the concept that acceptable error rates, which balance the need to make appropriate decisions with the financial costs of achieving high degrees of certainty, must be specified.

> *Errors can be made when making site remediation decisions. The use of statistical methods allows for controlling the probability of making decision errors. When designing a statistical test, acceptable error rates for incorrectly determining that a site meets or does not meet the applicable decommissioning criteria must be specified. In determining these error rates, consideration should be given to the number of sample data points that are necessary to achieve them. Lower error rates require more measurements, but result in statistical tests of greater power and higher levels of confidence in the decisions. In setting error rates, it is important to balance the consequences of making a decision error against the cost of achieving greater certainty.*

Acceptability decisions are often made based on acceptance criteria. If the mean and median concentrations of a contaminant are less than the associated acceptance criteria, for example, the results can usually be accepted. In cases where data results are not so clear, statistically based decisions are necessary. Statistical acceptability decisions, however, are always subject to error. Two possible error types are associated with such decisions.

The first type of decision error, called a Type I error, occurs when the null hypothesis is rejected when it is actually true. A Type I error is sometimes called a "false positive." The probability of a Type I error is usually denoted by α. Considered in light of H_0 used for this site (discussed above), this error could result in higher potential doses to future site occupants than prescribed by the dose-based criterion.

The second type of decision error, called a Type II error, occurs when the null hypothesis is not rejected when it is actually false. A Type II error is sometimes called a "false negative." The probability of a Type II error is usually denoted by β. The power of a statistical test is defined as the probability of rejecting the null hypotheses when it is false. It is numerically equal to $1-\beta$ where β is the Type II error rate. Consequences of Type II errors at the Site include unnecessary remediation expense and project delays.

For the purposes of the NFA final status survey, the acceptable error rate for both Type I and Type II errors is five percent (0.05).

7.0 METHODOLOGY AND APPROACH TO PERFORMING SURVEYS

7.1 Gamma Walkover Survey Utilizing GPS

Gamma Walkover Surveys will be performed in order to identify elevated radioactivity in surface and near surface soils.

7.1.1 Estimated Scan Sensitivity

MARSSIM Section 6.7.2.1 describes the methodology used to calculate the Scan Minimum Detectable Concentrations (MDCs) for land areas that are delineated in MARSSIM Table 6.7. The MDC for Th-232 in equilibrium with its progeny in the decay series is 1.8 pCi/g for a 2-inch by 2-inch sodium iodide detector. This methodology is based on a scan speed of 0.5 meters per second and a minimum contaminated area 56 cm in diameter and 15 cm in depth, referenced in Chapter 6 of NUREG-1507 (NRC 1997). Attachment A provides details regarding the calculations used to determine the scan MDC for Th-232.

The gross gamma walkover scan survey in this plan was designed using these parameters. The basic method for performing a GWS is to walk along a path while moving the sodium iodide detector from side to side. A 1-meter path length will be used to perform the survey. The side-to-side motion of the detector must be 0.5 meters per second to meet the design criteria. Therefore, each detector pass will take 2 seconds (i.e. 1 m ÷ 0.5 m/s).

MARSSIM MDC analysis is based on detecting a contaminated area that is 56 cm in diameter. The number of side-to-side detector passes performed per meter must be sufficient to detect this area. Three detector passes per meter, evenly spaced (approximately every 33 centimeters) will ensure that the detector crosses a minimum distance of 45 centimeters across the contaminated area. This provides a minimum observation interval of 0.9 seconds (i.e., 0.45 m ÷ 0.5 m/s) compared to the 1 second used in MARSSIM Section 6.7.2.1. The difference in MDC between a 1 second and 0.9 second observation interval is readily determined as 1 over the square root of 0.9 (i.e., 1 ÷ 0.987) or 1.053, from equations 1 and 2 of MARSSIM Section 6.7.2.1. This demonstrates that the MDC for the minimum 45 centimeter pass across the contaminated area will be 105.3 % of the MDC calculated for the 56 centimeter pass.

The MDC for a 2-inch by 2-inch sodium iodide detector is 1.8 pCi/g for thorium-232 in equilibrium with its progeny in the decay series, based on a 56 centimeter pass (MARSSIM Table 6.7). Section 3.3.3 of this plan demonstrates that additional samples are not required to meet the EMC criterion as long as the scan MDC is less than 2.1 pCi/g, as derived in Section 3.3.3. The MDC for the 45 centimeter pass is 1.9 pCi/g (i.e., 1.053 x 1.8), which is less than 2.1 pCi/g and demonstrates that additional samples are not needed for a scan spacing of 33 centimeters.

7.1.2 GPS Setup

The Global Positioning System (GPS) will provide high quality, precision geospatial positioning data to support characterization, data verification, and remediation. The ratemeter/scalars used for this work plan will be configured to output directly to the GPS unit. The GPS unit will perform all data logging functions.

In order for the GPS unit to achieve sub-meter accuracy, differential position correction is necessary. Two methods for doing this are: (1) post-processing differential correction and (2) real-time differential correction. Essentially, the difference between the two is the time during which the corrections are made. Real-time differential correction is possible if the site being considered is located within range of a United States Coast Guard (USCG) GPS differential correction beacon. These beacons are located in coastal areas of the United States. Real-time correction does not require a GPS base station. Based upon manufacturers' recommendations, the Site is likely to be within range of a USCG beacon, allowing for real-time differential correction. However, if for some reason the USCG beacon cannot be received by the GPS system, post-processing differential correction will be used.

7.1.3 Survey Performance

A survey is performed by walking straight parallel lines over an area while swinging the detector 2-inches to 4-inches above the ground surface. Survey passes will be approximately one meter apart. Once a survey (or series of surveys) is complete, technicians will return the data files to the data processing specialist.

Each survey will be designed to optimize the survey data collection procedure, taking into account the area's configuration, buildings, hazards, and other obstructions. A field map of the survey layout will be produced showing the area's boundary, survey line starting and stopping points, major obstacles, and other pertinent information. Copies of the base map will be available that already identifies on-site structures, roads, or other major features. Technicians will annotate copies of the base map with information relevant to the survey.

Each survey pass will be assigned a line number in the GPS unit's data file and on the field map. The direction of each survey pass will also be noted. Occasionally, non-parallel paths may be required when the surveyor must avoid obstructions such as large bushes, vehicles, or small structures. Deviations from a straight path and non-parallel paths shall be noted on the field map. Starting at the beginning of a line, the surveyor will begin to collect data and walk straight to a designated endpoint at a constant velocity of approximately 0.25 meters per second. The surveyor will stop collecting data once the end point is reached and then position himself at the beginning of the next line. Once in position, the surveyor will again begin to collect data and walk a line parallel to the previous line, stopping at the next designated end point. The survey will continue in this manner until completion.

Elevated radiation levels detected while surveying the path may be flagged at the time of detection without stopping the path in progress or may be investigated when identified. After the traverse is complete, the surveyors may return to the flagged area and collect supplementary data. These supplemental surveys will be designated in the data dictionary, and annotated on the field map.

Using proper survey technique expedites the survey process and assists post-processing specialists. Additional useful instructions include the following:

- Walk along and not into tall obstacles, when possible. Walking into an obstacle may result in a path ending without satellite lock. If it becomes necessary to walk toward a tall obstacle, plan the survey to approach the obstacle from the south side, since the majority of satellites are in the south.

- To avoid confusion, lower or remove markers (e.g., pin flags) from paths already surveyed. A surveyor may become confused about which marker is at the next endpoint.

- When recording supplementary data, hold the sensor at approximately the same distance from the ground as during a normal line survey. Consistency in the detection method is important when interpreting survey results.

- Limit individual survey times (i.e., the file size) to one hour or other time specified by the post-processing specialist.

- Collect enough discrete points to define structure (or other feature) boundaries.

- When collecting discrete points, hold the GPS antenna directly over the designated feature to optimize position data. If using base maps generated from aerial photography, the discrete point should locate the "drip line" of the corner of the roof, not the corner of the structure.

- Do not round corners to avoid obstacles. Deviate from the imaginary line between markers only when necessary and return to the line as soon as possible.

- When surveying in wooded areas or areas with overhead obstructions, attempt to start and stop at known locations. A "known location" is defined here as a location that can be surveyed by some other means (e.g., measured from a discrete point or at a mapped boundary) or to which survey lines can be extended from areas where satellite lock is achieved.

Even though major features such as buildings may appear on base and field maps, position data must still be collected as discrete boundary locations. These discrete points function as mapping control points that facilitate matching and overlaying the GPS positional data collected in the field with the known (previously mapped) locations. All discrete points shall be recorded in the data collector and annotated onto the field map.

7.1.4 Survey Limitations

Although the GPS unit identifies positions using the signals from several satellites, GPS positioning may be affected by overhead obstructions during the course of a survey. A loss of signals from these satellites due to these obstructions will prevent collection of location data. The collection of data will not resume until satellite lock is regained (usually by moving past the obstruction). If the signal is lost during a survey, the operator shall continue to walk at constant velocity in a straight line until satellite lock has been reestablished or until a boundary is reached. Post-processing will enable interpolation of gamma count rate data between pairs of GPS positional data. Erroneous results may be obtained if the survey team varies its velocity and/or direction. The surveyor will need to inform the data processing specialist if the gamma count rate between pairs of GPS positional data changes considerably.

Extrapolation of gamma data positions beyond good GPS locations requires additional post-processing programs or hand editing of data. It is desirable, therefore, to begin and end a survey path with good GPS positions. The survey crew shall extend the beginning or end of a survey path (in a straight line) beyond a designated boundary in order to obtain satellite lock, if necessary. On occasion, it may not be possible to get a good satellite lock because of satellite positions in the sky. In this case, a short wait (e.g., one-half hour) is usually sufficient to regain satellite lock. If necessary, survey paths without good satellite locks will be repeated.

The satellite system consists of many different satellites that are used for national security, air transportation, and various military applications. Although the loss of a particular satellite may occur during the survey, the loss of the entire system is not considered feasible.

7.2 Onsite Gamma Spectroscopy Laboratory

7.2.1 General

The Cabrera Services field team will collect soil samples for subsequent on-site analysis utilizing the Onsite Laboratory. The Onsite Laboratory analyses will be performed using a gamma spectroscopy system with a high purity germanium (HPGe) coaxial detector, or equivalent. This system will be calibrated with a National Institute of Standards and Technology (NIST) traceable multi-line gamma marinelli standard.

Soil samples will be collected at selected locations in the NFA survey units. Personnel collecting samples will ensure each sample is placed into a clean, unused container. Each sample will be labeled and annotated with, as a minimum, a unique (preferably sequential) 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.

7.2.2 Spectroscopic Energy Lines

The site ROPC is Th-232. This radionuclides may be quantified for activity concentrations directly via gamma decays, or inferred via gamma-emitting progeny, assuming secular equilibrium.

Th-232 activity concentrations will be inferred via progeny activity concentrations of Pb-212 at 238.6 keV, Ac-228 at 911.2 keV and others, assuming secular equilibrium.

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. Therefore, Ra-226 will be measured directly by detection of its 186.2 keV energy line. It should be noted that U-235 also has a gamma line of similar energy (185.7 keV) that can cause interference with direct Ra-226 detection via the 186.2 keV gamma line. As uranium is not expected to be detected in significant quantities on this project, the only result from this issue may be minor over reporting of Ra-226.

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.

7.2.3 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 final status survey report.

7.3 Sample Collection and Analysis

Soil sampling will be achieved using hand-augers or powered augers, as appropriate. Soil samples will be extruded from the augers and transferred into a stainless steel bowl where they will be thoroughly mixed or homogenized. 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 either dry decontamination methods or rinsing with water and containing the rinsate for solidification and disposal.

Duplicate sample analyses will be performed by a third party offsite laboratory analyzing the original sample as counted by the onsite laboratory. Field duplicate samples will be collected at the frequency specified in Section 8.3.1, and Z-score results will be utilized to compare the initial results to the duplicate sample results.

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.

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. Samples being analyzed for radium via gamma spectroscopy will be placed in an airtight container and sealed. The sample will then be stored for approximately 21 days to allow radium equilibrium to be reestablished. Each sample will be analyzed for thorium and uranium series radionuclides using gamma spectroscopy for Uranium-238, Radium-226, Th-232 by quantifying their radioactive progeny.

Soil samples will be prepared by drying, sieving and weighing in accordance with the offsite laboratory's Standard Operating Procedure (SOP) 739, Revision 3, 1999. Analysis by gamma spectroscopy will be performed in accordance with Laboratory SOP, if Paragon Analytics, then SOP 713, Revision 5, 2000, which conforms or exceeds the requirements of the Environmental Protection Agency (EPA) Procedure 901.1.

7.4 Final Status Survey Data Evaluation

Because naturally occurring concentrations of the ROPCs are present in background, hypothesis testing will be performed by the WRS test. In this test, the null hypothesis, H_0, is that the median residual Th-232 concentration in each survey unit being tested exceeds background by more than the DCGL. In the WRS test, reference area (background) measurements are adjusted and, along with survey unit measurements, are ranked, summed, and compared to a critical value. If the sum, or W_r, of the ranks of the ranked reference measurements is greater than the critical value, W_{crit}, H_0 is rejected. The general approach to applying the WRS test is summarized below.

- Obtain the adjusted reference area measurements, Z_i, by adding the $DCGL_W$ to each reference area measurement, X_i . $Z_i = X_i + DCGL_W$

- The m adjusted reference sample measurements, Z_i , from the reference area and the n sample measurements, Y_i, from the survey unit are pooled and ranked in order of increasing size from 1 to N, where N = m+n.

- If several measurements are tied (i.e., have the same value), they are all assigned the average rank of that group of tied measurements.

- If there are t "less than" values, they are all given the average of the ranks from 1 to t. Therefore, they are all assigned the rank t(t+1)/(2t) = (t+1)/2, which is the average of the first t integers. If there is more than one detection limit, all observations below the largest detection limit should be treated as "less than" values.

- Sum the ranks of the adjusted measurements from the reference area, W_r.

- Obtain the value of W_{crit} from Table I-4 of MARSSIM for sample sizes less than 20. Since 32 samples were obtained in the reference area at Great Lakes, calculate the critical value, W_{crit}, from the following:

$$W_{crit} = m(n+m+1)/2 + z\sqrt{nm(n+m+1)/12}$$

Where z is the (1-α) percentile of a standard normal distribution, which can be found in Table-1:

Table 1:

Percentiles of Standard Normal Distribution

α	**z**
0.001	3.09
0.005	2.575
0.01	2.326
0.025	1.960
0.05	1.645
0.1	1.282

Note that, for this investigation, the value of W_{crit} value for the NFA survey unit is 444.

- Compare W_r with the critical value for the appropriate values of n, m, and α. If W_r is greater than W_{crit}, reject the hypothesis that the survey unit exceeds the release criterion.

Additional information on the WRS test is found in Section 8 of MARSSIM.

7.5 Field Records

For surveys of all types, it is essential that significant events be documented and retained for future reference. While some types of project events have specific forms on which they are documented, many events occur on a routine basis during survey field activities that must be documented as they occur. Additionally, project data transactions must also be recorded as they occur. To provide a practical means of capturing this information, project logbooks will be used. At a minimum, the two logbooks described below will be initiated upon project commencement.

7.5.1 Project Data Logbook

Data transactions involving electronic project data shall be recorded in the Project Data Logbook. Electronic project data includes GWS data files, GPS files, hand collected gamma data, etc. Data transactions are defined as any transfer, download, export, differential correction, or other significant manipulation performed on project electronic data records. Project Data Logbook records shall be sufficient to allow data transactions to be reconstructed after the project is completed. The Data Processing Specialist shall be responsible for maintaining the Project Data Logbook. The Project Engineer is responsible to ensure Project Data Logbook entries are made as necessary and appropriate. The Project Engineer will review the Project Data Logbook at least daily and will report significant issues to the Project Manager.

The Project Data Logbook is considered a legal record. Logbooks will be permanently bound and the pages will be pre-numbered. Pages may not be removed from the logbook under any circumstances. Entries shall be legible, factual, detailed, and complete and shall be signed and dated by the individual(s) making the entries. If a mistake is made, the individual making the entry shall place a single line through the erroneous entry and shall initial and date the deletion. Under no circumstances shall any previously entered information be completely obliterated. Use of whiteout in the Project Data Logbook is not permitted for any reason. Only one Project Data Logbook will be maintained. If a Project Data Logbook is completely filled, another volume shall be initiated. In this case, each volume shall be sequentially numbered.

7.5.2 Field Survey Logbooks

These logbooks will be carried by each survey team during project operations. If multiple volumes are needed to support multiple field survey teams, each volume will be clearly identified with a unique designation approved by the Project Engineer. Any survey teams collecting project data shall carry a Field Survey Logbook.

Field Survey Logbooks are considered legal records. Logbooks will be permanently bound and the pages will be pre-numbered. Pages may not be removed from logbooks under any circumstances. Entries shall be legible, factual, detailed, and complete and shall be signed and dated by the individual(s) making the entries. If a mistake is made, the individual making the entry shall place a single line through the erroneous entry and shall initial and date the deletion. Under no circumstances shall any previously entered information be completely obliterated. Use of whiteout in a Field Survey Logbook is not permitted for any reason.

7.5.3 Other logbooks

The Project Engineer may initiate additional logbooks as deemed necessary to ensure project activities are adequately documented. Additional logbooks will be considered legal records and will be subject to the same provisions described above for the Project Data Logbook and Field Survey Logbooks.

7.6 Release Limits for Equipment and Tools

The limits in this section are as defined in: "Termination of Byproduct, Source, and Special Nuclear Materials Licenses," Policy and Guidance Directive FC 83-23 (November 1983).

7.6.1 Release Limits for thorium

a) 1,000 dpm/100 cm^2, averaged over not more than 1 m^2

b) 3,000 dpm/100 cm^2, maximum.

c) 200 dpm/100 cm^2 removable

7.7 Project Electronic Data

7.7.1 Data Backup

Electronic data collected during the day will be backed-up at the end of the same day on which it was collected (e.g., to CD, zip drive, or equivalent), before processing or editing. This is an archive of the raw data and, once created, it 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 project data will be backed up weekly, as a minimum. Raw archived data will be stored in a different location from weekly backups. Electronic data will be provided daily to data processing specialists and RASO. The time and date 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 Project Engineer.

7.7.2 Data Processing

Data 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. Data processing specialists will inform the Project Engineer 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.

8.0 SURVEY QUALITY ASSURANCE/QUALITY CONTROL

Activities associated with this work plan shall be performed in accordance with written procedures and/or protocols in order to ensure consistent, repeatable results. Topics covered in project procedures and protocols may include proper use of instrumentation, Quality Control (QC) requirements, equipment limitation, etc. Implementations of Quality Assurance (QA) measures for this work plan are described herein.

8.1 Instrumentation Requirements

(A) Calibration

Equipment and instruments used in the field screening operation will be maintained and calibrated to manufacturer's specifications. A project file will be kept on the equipment used in field screening analysis. Current calibration and or maintenance records for instruments used during the survey will be kept onsite for review and inspection and also presented as an appendix to the final project report. The records will include, at a minimum, the following:

- Name of the equipment
- Equipment identification (model and serial number)
- Manufacturer
- Calibration Data
- Calibration Due Date

Instrumentation will be maintained and calibrated to manufacturer's specifications to ensure that required traceability, sensitivity, accuracy and precision of the equipment/instruments are maintained. Instruments will be calibrated at a facility using NIST traceable sources. Calibration certificates for instruments expected to be used during project activities and calibrator NIST source certificates are provided as Attachment F to this document.

Instruments will be calibrated at a facility possessing appropriate NRC and/or Agreement State licenses for its calibration sources, which shall be NIST traceable. Field instruments will be source-checked periodically throughout the workday according to the latest calibration record. In addition, the instruments will be checked daily in order to ensure that the calibration is current (i.e., not expired). Written records of daily checks will be maintained and filed in the project file.

(B) Source and Background Checks

Prior to and after daily use, instruments will be QC checked by comparing the instrument's response to ambient background and to a designated gamma radiation source. The results of the ambient background and source checks will be recorded in a field logbook.

Instrument response to ambient background will be used to establish a mean background response for each instrument, following the system source check but prior to the commencement of gross gamma survey at the study areas. NaI measurements shall be collected in the selected reference location. Background readings shall be conducted at the beginning of each day prior to collecting data in the field. Results from these surveys will be used to monitor gross fluctuations in background gamma fluence (e.g., from changes due to barometric pressure and other, non-contaminant related causes), and to check detector response. Please note that the background measurements are made solely for the purpose of normalizing each day's survey results and eliminating bias introduced by natural fluctuations in site radiological conditions. Given the qualitative nature of the scanning portion of this study, no attempt will be made to remove naturally occurring radioactivity from survey data to derive net activity.

Source checks will consist of one-minute integrated counts with the designated source position in a reproducible geometry, performed at the designated location. Instrument response to the designated QC check source will be plotted on control charts and evaluated against the average established at the start of the field activities. A performance criterion of +/– 20% of this average will be used as an investigation action level. The Site Radiation Safety Officer (RSO) will investigate results exceeding this criterion and will make appropriate corrections to instrument readings if response is deviated by factors beyond personnel control, such as large humidity or temperature changes. The Site RSO has authority to decide whether or not the instrument is acceptable to use or must be removed from service.

During QC checks, instruments used to obtain radiological data should be inspected for physical damage, current calibration and erroneous readings in accordance with applicable protocols. The individual performing these tasks shall document the results in accordance with the associated instrument protocol. Instrumentation that does not meet the specified requirements of calibration, inspection, or response check will be removed from operation. If the instrument fails the QC response check, any data obtained to that point, but after the last successful QC check will be considered invalid due to faulty instrumentation.

8.2 GPS Requirements and Quality Control

GPS quality control will be accomplished with calibration points, viewing plotted survey data, and keeping detailed field notes. A calibration point is a location with known horizontal and vertical coordinates (e.g., a benchmark) that can be used to check the accuracy of GPS (position) data. Calibration points will ensure that the differential position corrections are being calculated properly, and that equipment is performing to specification. GPS calibrations assist the data processor in correcting errors in the survey data and checking the integrity of the GPS system. GPS calibration points shall be set in convenient locations near the areas to be surveyed. Existing unique features such as manholes, fire hydrants, or other permanent features may serve as calibration points. Calibration points shall be set in areas clear of overhead obstructions.

One or more GPS calibration points will be established prior to beginning this investigation. At each calibration point, ten initial GPS position readings will be collected, each of a one-minute duration or more. Each set of ten readings will be used to develop the average position of the applicable calibration point. Prior to beginning and following completion of a survey, technicians shall collect position data at one of the calibration points. Data may also be collected at a calibration point at any point in a survey if anomalous readings or other indications of potential GPS data quality problems are observed. Additional calibrations may be necessary as determined by the Senior Radiological Engineer in consultation with the Technical Project Manager. Data shall be collected at the calibration point at least two times for each day's survey. Each time calibration point data is collected, the result shall be compared to the average location of that point, as calculated above. Measurements differing from the average by more than one m will be investigated and corrective measures will be implemented as appropriate. This applies to both hand held and vehicle mounted GPS units.

To collect a calibration point the following steps shall be completed:

- Position the GPS unit precisely over the desired calibration point location.
- Ensure the radiation detector is turned off.
- Open the GPS data file.
- Select "Calibration Point" or equivalent in the data dictionary of the rover computer.
- Record the calibration point number (there may be more than one calibration point) in the data file.
- Collect GPS (position) data until the computer indicates the measurement is complete.

8.2.1 Daily Reviews

The following plots may be reviewed by surveyors prior to the beginning of daily surveys and throughout workdays as appropriate:

- Number of Satellites - This plots the number of available satellites versus time for the daily work period.
- Positional Dilution of Precision (PDOP) - This plots PDOP versus time for the daily work period.
- Satellite and Sky plots - These plot GPS position and a polar plot versus time and allow the survey teams to schedule periods of work in areas of specific obstructions.

The noted plots allow the survey teams to plan around times when GPS surveying will be impossible due to the limited number of satellites or high PDOP. Data can only be collected when PDOP (a measure of the geometrical configuration of the available satellites) is less than 4.0 and when receiving signals from five or more satellites.

8.2.2 Quality control of the field survey

Data quality control will be accomplished with mapping control points, viewing plotted survey data, and keeping detailed field notes. Mapping control points (a discrete point at a known location such as in the corner of a base map building) will ensure that the area surveyed will overlay with existing maps. Gamma surveys, when plotted, should exhibit the same configuration as shown in annotated field sketches and field notes. Any anomalies observed by the data processing specialist and/or technicians performing field surveys shall be brought to the attention of the Project Engineer.

8.3 Volumetric Soil Sampling

8.3.1 Duplicate Samples

Volumetric soil sampling will be sent to an independent third party laboratory for gamma spectroscopic analysis. Duplicate samples will be scheduled at a rate of 10% of samples collected. When duplicate analysis is required, the original sample counted by the onsite laboratory will be sent to the third party laboratory. The samples will be numbered using a unique identifier and will be sent to the laboratory for analysis. Additionally, the analytical laboratory should perform duplicate analyses on selected samples as specified in their quality assurance procedures. Duplicate analyses performed by the laboratory will be compared to the initial analytical results by determining a Z-score value for each data set by the following equation:

$$Z = \frac{|S - D|}{\sqrt{\sigma_S^2 + \sigma_D^2}}$$

Where: S, D, $\equiv$ value of (S)ample and (D)uplicate measurements; and,

σ ≡ one sigma error associated with (S)ample and (D)uplicate measurements.

The calculated Z-Score results will be compared to a performance criteria of less than or equal to 2.57. The value of 2.57 corresponds to a 99% confidence level, or, 99% of the Z-Score values will be below 2.57, and only 1% of the values will be above this acceptance criteria, if the sample and the duplicate are truly of the same distribution. Calculated Z-values less than 2.57 will be considered acceptable and values greater than 2.57 will be investigated for possible discrepancies in analytical precision, or for sources of disagreement with the following assumptions of the test:

- The sample measurement and duplicate or replicate measurement are of the same normally distributed population.
- The standard deviations, σ_S and σ_D, represent the true standard deviation of the measured population.

8.3.2 Laboratory Spike Analyses

Spike analyses may be performed by the laboratory and used to estimate the extent of bias in the analytical measurements. The analytical laboratory adds a known quantity of radioactive material, or analyte, to representative media, and analyzes the spiked media. Bias in the results will be quantified by determining percent difference values for spike analyses data provided by the laboratory. Percent difference values will be determined by the following equation:

$$\%\,\text{Difference} = \frac{(C_S - C_M)}{C_S} * 100$$

Where: C_S ≡ Concentration of spike analyte added to sample

C_M ≡ Measured concentration of analyte in sample

Percent differences will be compared to a performance criteria of 20%. Percent differences greater than 20% will be investigated for possible discrepancies in measurement bias. The error associated with the measured values should be a consideration when evaluating percent differences and qualifying data which do not meet these performance criteria.

8.3.3 Laboratory Blanks

The analytical laboratory performs blank analyses to test analytical accuracy and to estimate the extent of bias in the measurements. Laboratory blanks are also used to demonstrate that laboratory contamination is not the cause of reported analytical results. A blank sample is prepared and analyzed by the analytical laboratory and typically consists of a sample of similar media, free of radiological contamination, which remains with the field sample throughout the entire analytical procedure and analyzed to determine the concentration of the radionuclide of concern. Blank analyses should be performed in accordance with the laboratory's quality assurance procedures. If blank results reported by the laboratory indicate the presence of contamination above the detection limit, or results are not qualified, data should not be used.

9.0 REFERENCES

(AEC 1974) Application for Source Material License No. AEC-2, Phillip Brothers, NY, dated May 10, 1974.

(CABRERA 2000) Final Report: *Characterization and Final Status Survey of the Monazite Sand Area of the Great Lakes Naval Training Station – Great Lakes, Illinois*, June 2000.

(CABRERA 2003) Final Report: *Remediation and Final Status Survey Former Monazite Sand Storage Area Soil Pile and North Fence Areas Great Lakes Naval Training Station – Great Lakes, Illinois*, March 2004.

(CABRERA 2003a) Memo Henry W. Siegrist, Cabrera Services Inc., to RASO regarding new reference area at Naval Station Great Lakes, dated September 24, 2003.

(NRC 1997) NUREG-1507, *Minimum detectable concentrations with typical radiation survey instruments for various contaminants and field conditions.* Washington, DC: U.S. Nuclear Regulatory Commission, 1997.

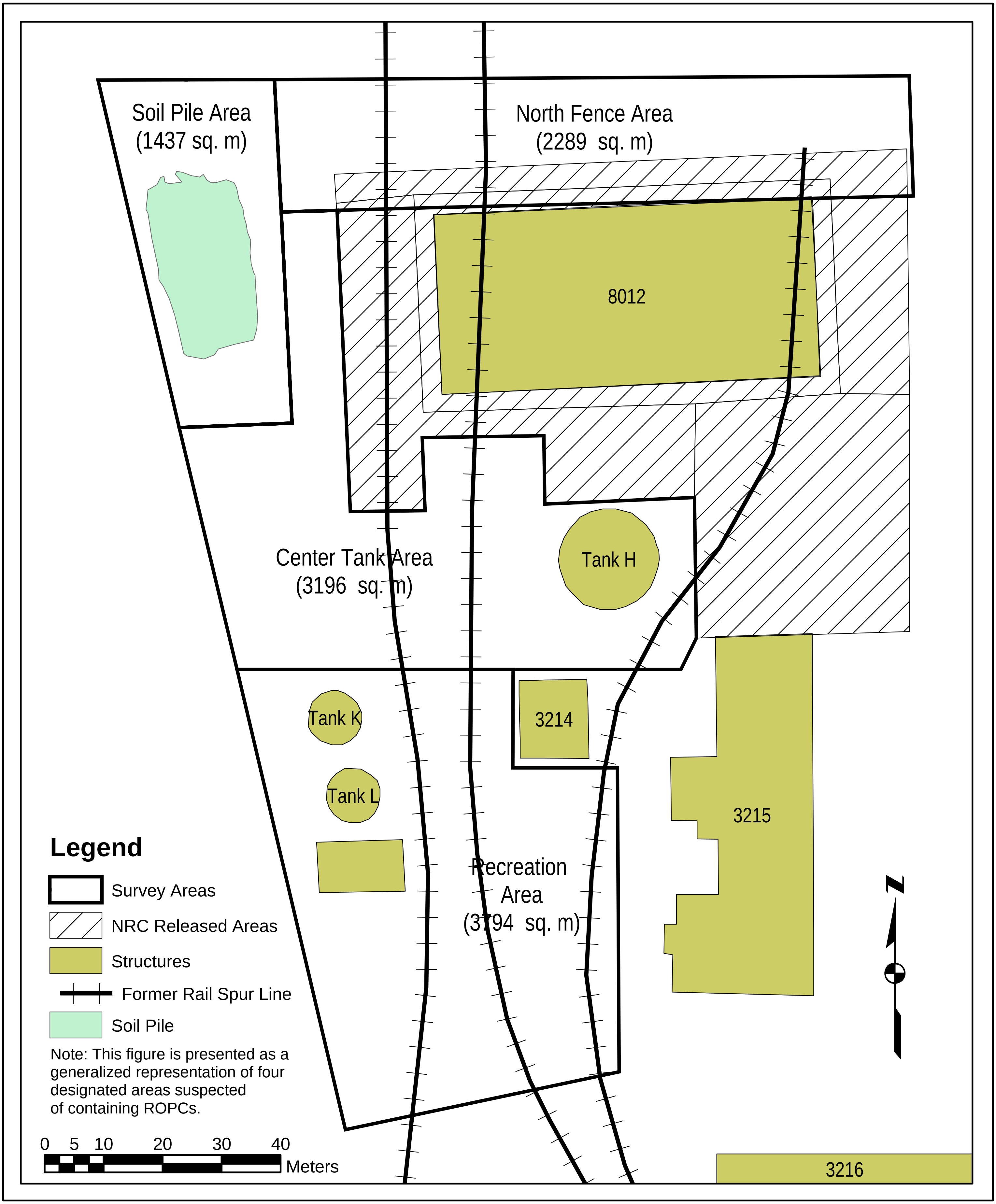
(NRC 1998) Draft Regulatory Guide DG-4006, *Demonstrating Compliance with the Radiological Criteria for License Termination*, August 1998.

(NRC 1998a) NUREG-1505, Rev.1, *A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys*, June 1998.

(NRC 1999) *Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for License Termination*, Federal Register, Volume 64, Number 234, Tuesday, December 7, 1999, 68396-68396.

(NRC 2000) NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), August 2000.

Figures



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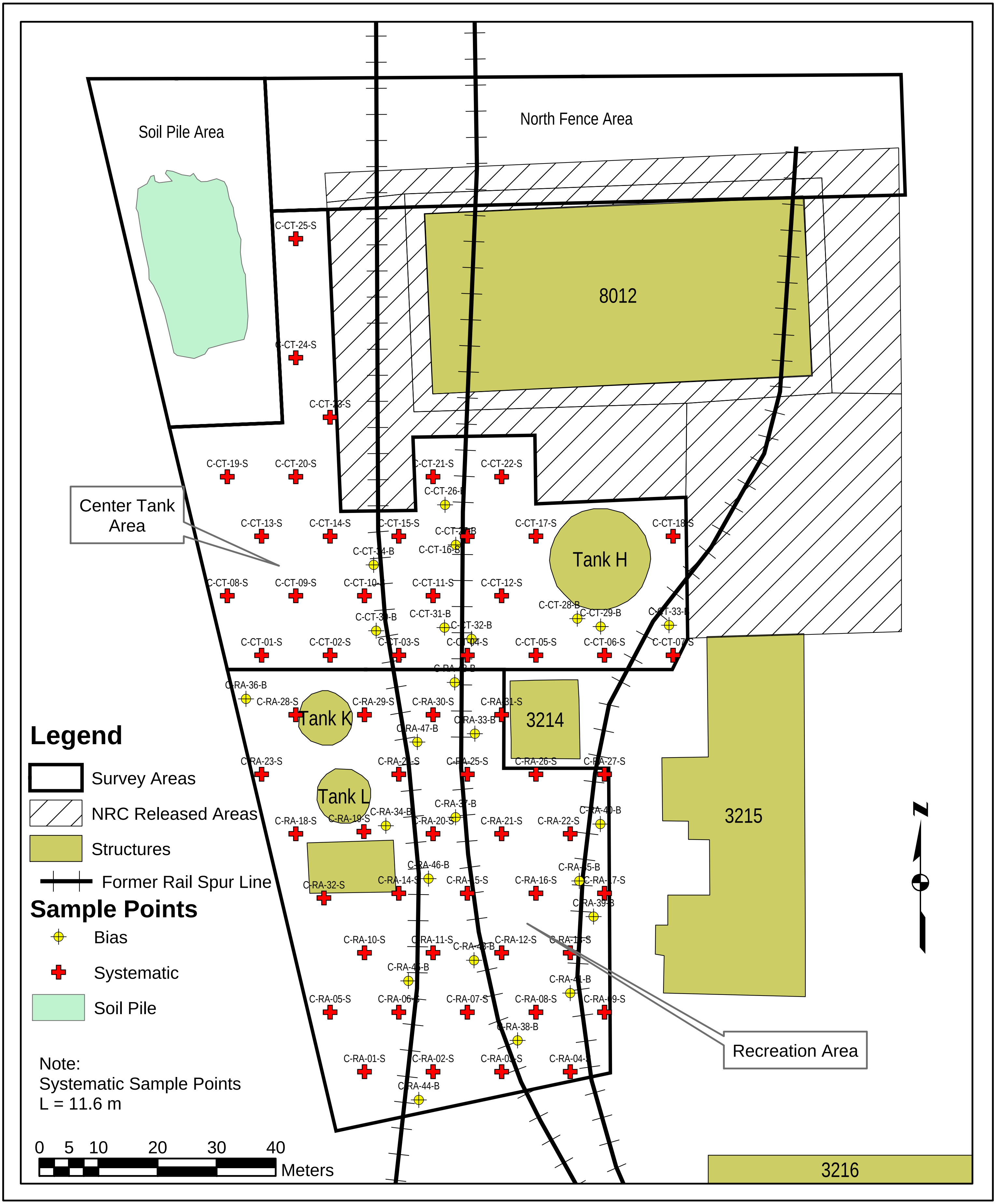
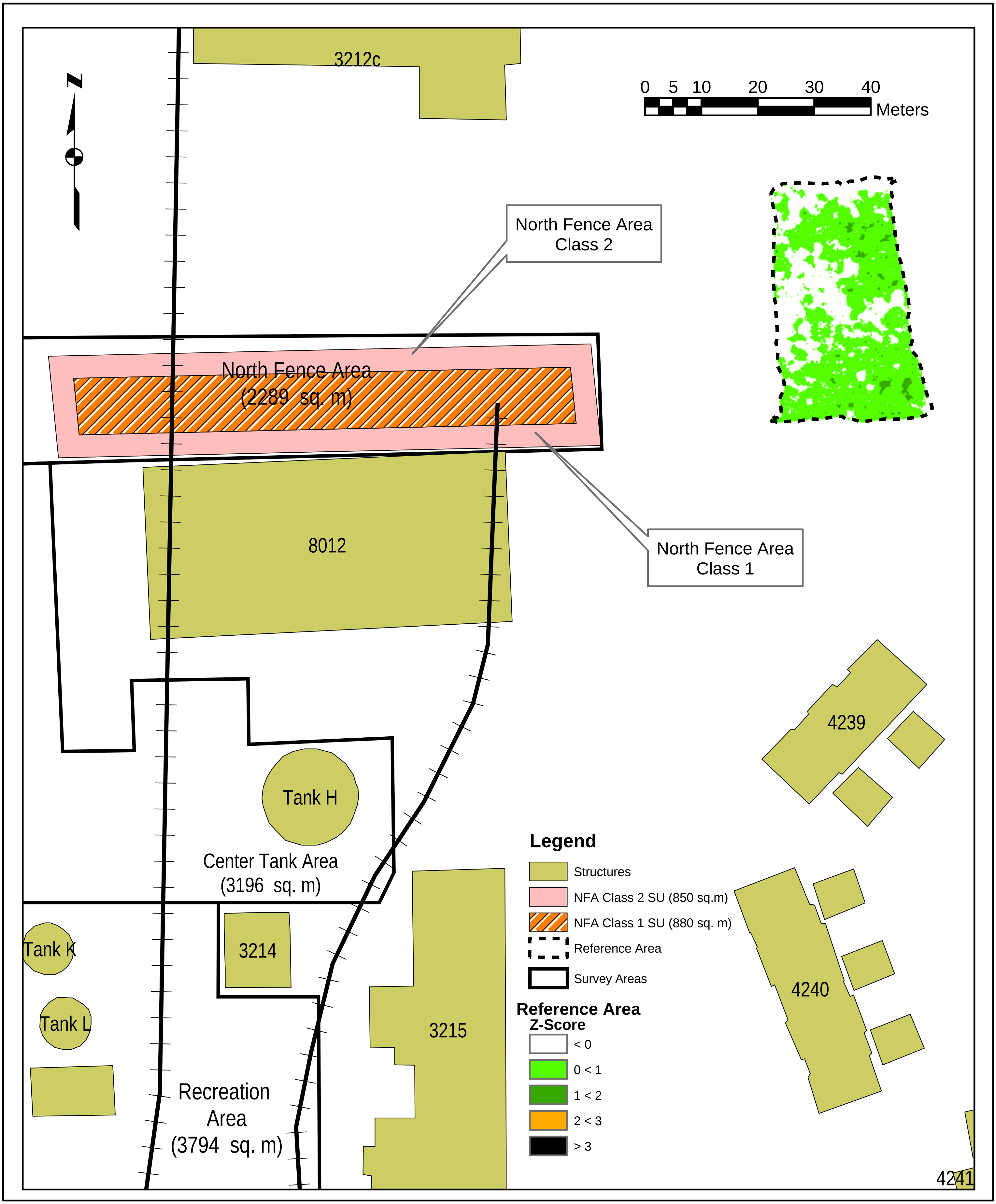
	Site Map	Date: 8-24-04 Project #: 04-3050.17	**Figure 1**
	Naval Station Great Lakes	File Name: Figure 1 Site Map Prepared By: JTM	



Cabrera Services — Radiological · Environmental · Remediation — www.cabreraservices.com	Predetermined Characterization Sample Locations	Date: 8-17-04 Project #: 04-3050.17 File Name: Figure2 Sample Locations Prepared By: JTM	**Figure 2**
	Naval Station Great Lakes		



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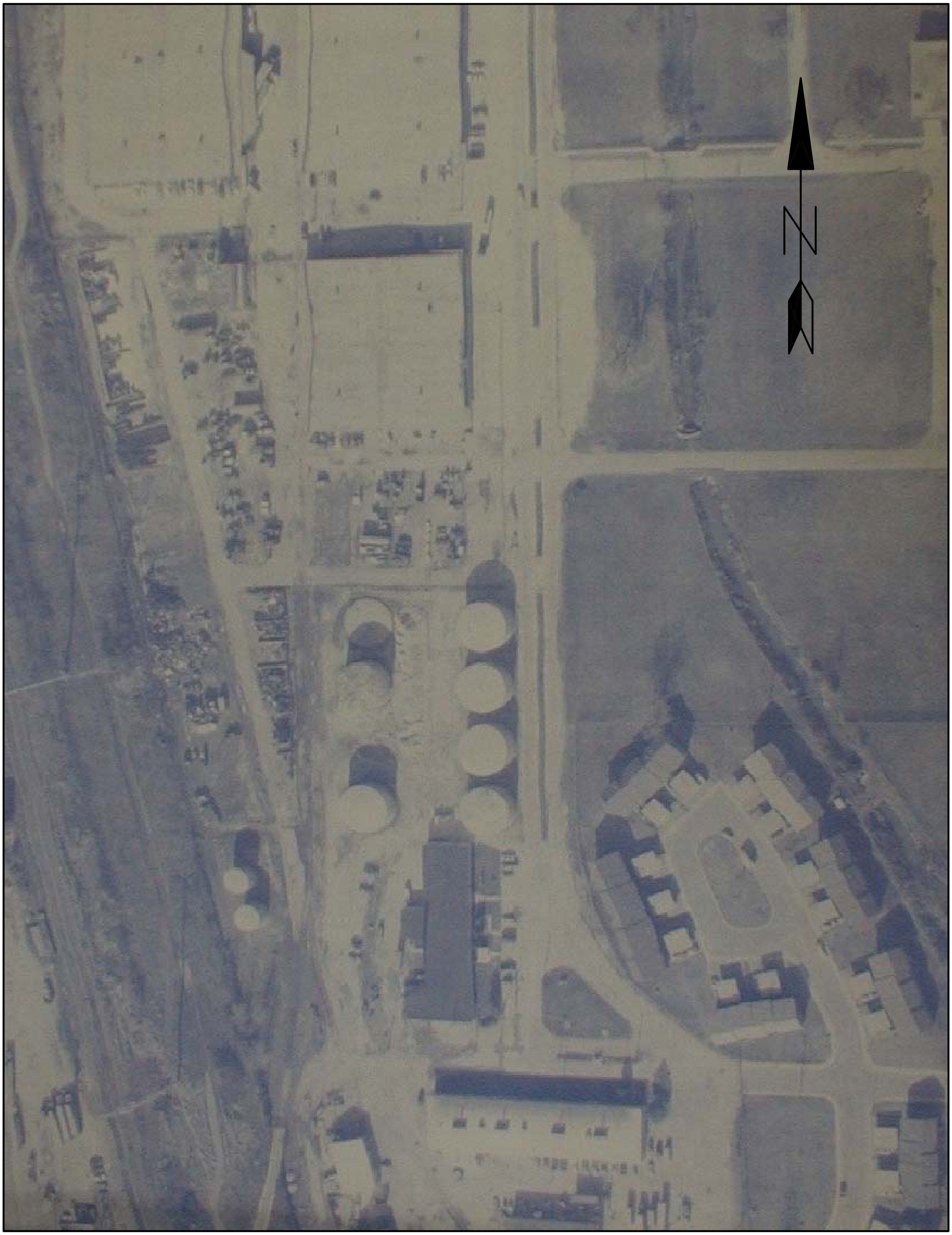
NFA Class 1 & 2 SUs and Reference Area Location Map

Naval Station Great Lakes

Date: 7-9-04
Project #: 04-3050.17
File Name: Figure3 RA&NFA
Prepared By: JTM

Figure 3



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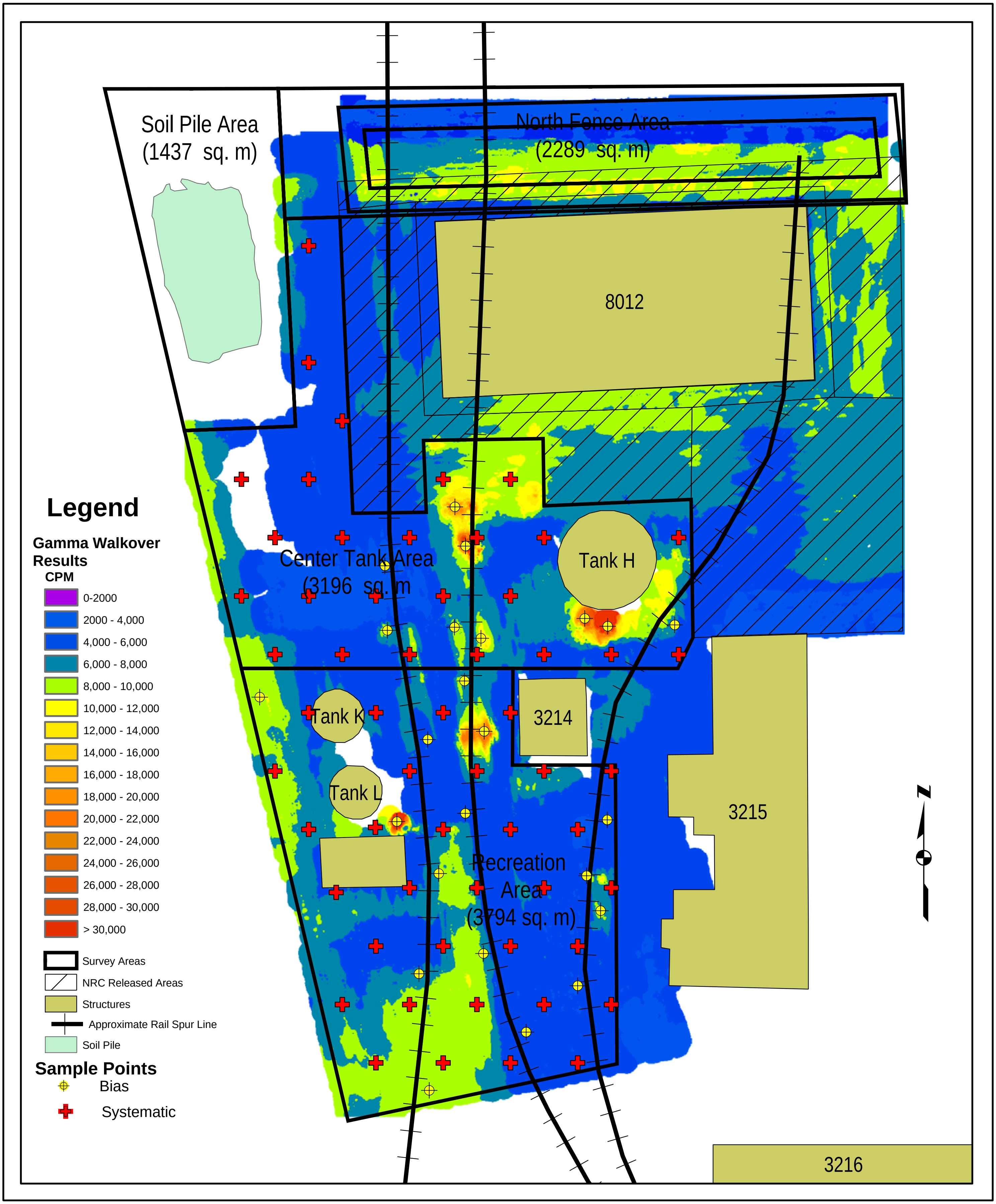
Aerial Site Photo - 1982

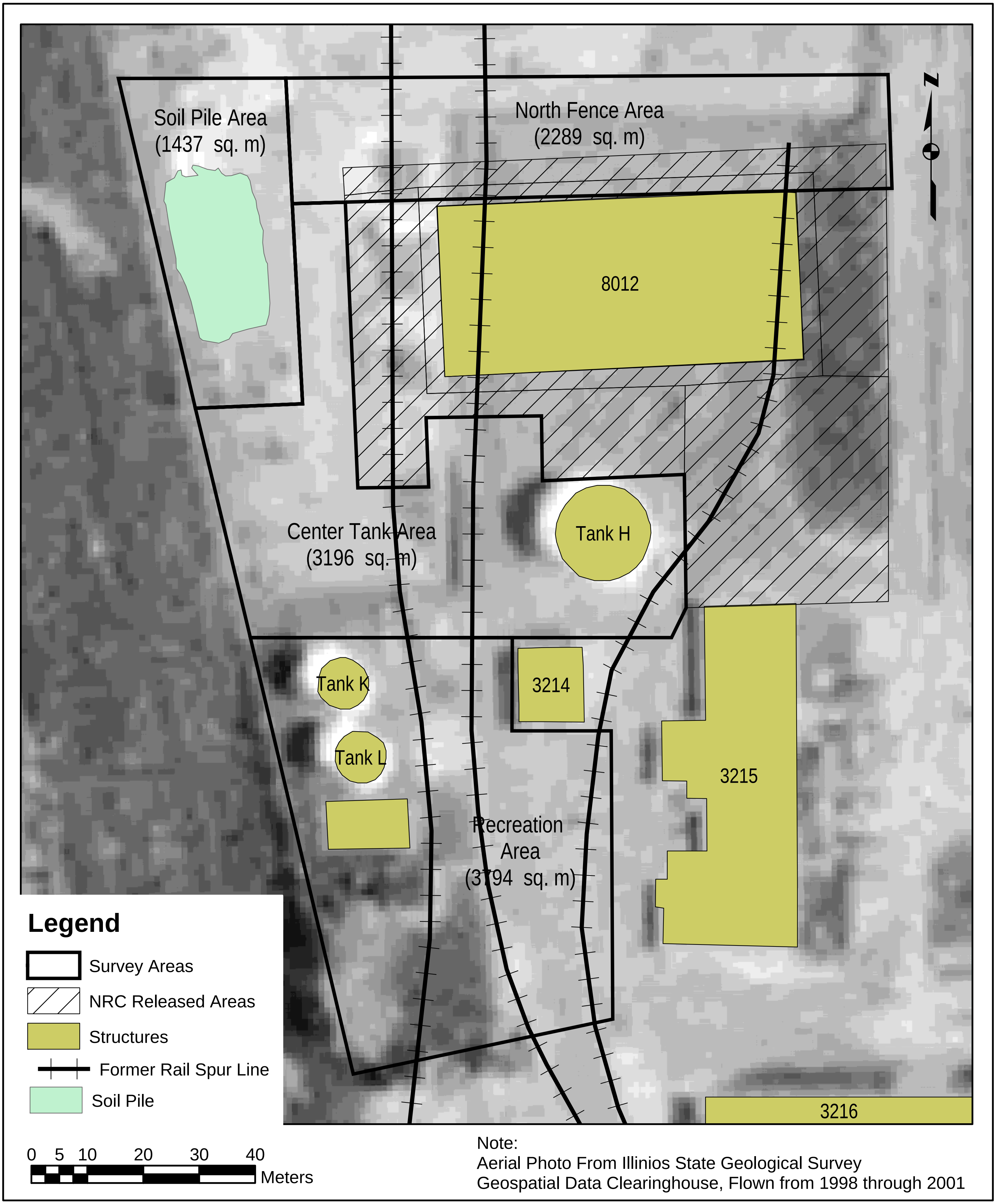
Naval Station Great Lakes

Date: 7-8-04
Project #: 04-3050.17
File Name: Figure4 1982AirPhoto
Prepared By: JTM

Figure 4



CABRERA SERVICES RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION WWW.CABRERASERVICES.COM	2000 Gamma Walkover Survey Results **Naval Station Great Lakes**	Date: 7-9-04 Project #: 04-3050.17 File Name: Figure5 2000GWS Prepared By: JTM	**Figure 5**



Note:
Aerial Photo From Illinios State Geological Survey
Geospatial Data Clearinghouse, Flown from 1998 through 2001

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Site Aerial Photo with Overlay	Date: 8-24-04	Project #: 04-3050.17	**Figure 6**
Naval Station Great Lakes	File Name: Figure6 Aerial Photo	Prepared By: JTM	

Attachment A

2 in X 2 in NaI MDC Technical Memorandum

ATTACHMENT A

2" X 2" NaI MDC TECHNICAL MEMORANDUM

1.0 INTRODUCTION

The U.S. Army Field Support Command (AFSC) has issued Cabrera Services, Inc. (CABRERA) a delivery order to provide a Work Plan describing the methodology, equipment, instrumentation, sample frequency, and sample analysis for the remediation of soils located within the boundaries of the Naval Station Great Lakes (Site), and to perform that remediation. This site was formerly used by the Defense Logistics Agency as a storage area for strategic quantities of monazite sands, a thorium-bearing material. The Scope of Work (SOW) is defined by AFSC Basic Ordering Agreement Document DAAA09-00-G-0002, Delivery Order 0036, dated 30 September 2001.

Thorium present at the site is assumed to be derived from naturally occurring ^{232}Th in 50-year secular equilibrium with its progeny. The Great Lakes site will be scanned for potential thorium contamination utilizing a Ludlum 44-10 (2"x2" NaI scintillation detector). Scans of the subject area will be accomplished by a walking speed (1.5 ft/sec) walkover by the surveyor at a detector height of approximately 2-4 inches above the ground surfaces. Results will be tallied by counts per minute (CPM).

1.1 Objectives

The objective of this technical memorandum is to determine the scan sensitivity of the Ludlum 44-10 (2 inch x 2 inch) NaI scintillation detector utilized for the planned gamma walkover survey for thorium. The evaluation considered a 15 cm-thick layer of contaminated soil with a radius of 28 cm. The scan sensitivity is important for use in interpretation of potential concentrations of thorium in the soil.

2.0 SITE RADIOLOGICAL CONDITIONS

The site area to be surveyed consists of surface soils potentially contaminated with thorium containing sand at various concentrations. Any thorium present will be in equilibrium with its progeny. A 50-year equilibrium has been chosen for the soil containing small amounts of ^{232}Th.

It has been assumed for detection calculations that the contamination is present in a layer on the surface with no cover and that the thorium and progeny contaminants are uniformly mixed with the soil in a volume of soil 56 cm in diameter with a 15 cm or 1 inch thickness.

3.0 SCAN MINIMUM DETECTABLE CONCENTRATION (MDC) CALCULATION AND METHODOLOGY

The methodology used to determine the NaI scintillation detector scan MDC is based on NRC NUREG –1507, titled "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions" December 1997. 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 hot spot, and energy and yield of gamma emissions.

The computer code Microshield was used to model the presence of a normalized 1 pCi/g total thorium with its 50-year decay progeny in soil with the further assumption that the activity is uniformly distributed to a depth of 15 cm and spread over a disk shaped area with a diameter of 56 cm. The uncontaminated soil cover thickness has zero thickness (contamination on the surface) and there is a 0.051 cm aluminum shield simulating the cover of the NaI detector to complete the model source term. This model is consistent with the NUREG-1507 methodology and provides for a count rate to exposure rate ratio (CPM/μR/hr) to be calculated.

The following sections provide tabulated data based upon the NUREG-1507 methodology as applied toward the Ludlum 44-10 2"x2" NaI scintillation detector used in this survey, zero thickness soil cover, and a 56 cm diameter soil uniformly contaminated to a 15 cm thickness. The dose point is centered over the contaminated disk of soil. Additional details and discussion describing the NUREG analysis methodology are described in that publication.

3.1 Fluence Rate to Exposure Rate (FRER, no units)

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

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

Whereas,

E_γ = energy of the gamma photon of concern, keV

$(\mu_{en}/\rho)_{air}$ = the mass energy absorption coefficient for air, cm^2/g

And in tabular form:

TABLE 1

$Energy_\gamma$, keV	$(u_{en}/\rho)_{air}$, cm^2/g	FRER
40	0.064	0.3906
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
800	0.0289	0.0433
1,000	0.0280	0.0357
1,500	0.0255	0.0261
2,000	0.0234	0.0214
3,000	0.0205	0.0163

3.2 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:

$$\text{Probability (P)} = 1\text{-}e^{-(\mu/\rho)NaI(X)(\rho NaI)}$$

Where

$(\mu/\rho)_{NaI}$ = the mass attenuation coefficient for NaI

X = the thickness through the bottom edge (end facing the soil) of the Ludlum 44-10 2”x2” NaI crystal, 5.1 cm

ρ = the density of the NaI crystal, 3.67 g/cm^3

And in tabular form:

TABLE 2

$Energy_{\gamma}$, keV	$(\mu/\rho)_{NaI}$, cm^2/g	P
40	18.3	1.00
60	6.23	1.00
80	2.86	1.00
100	1.58	1.00
150	0.566	1.00
200	0.302	1.00
300	0.153	0.94
400	0.11	0.87
500	0.0904	0.82
600	0.079	0.77
800	0.0657	0.71
1,000	0.0576	0.66
1,500	0.0464	0.58
2,000	0.0412	0.54
3,000	0.0367	0.50

3.3 Relative Detector Response (RDR)

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

$$RDR = FRER \text{ (table 1)} \times P \text{ (table 2)}$$

And in tabular form:

TABLE 3

Energy$_\gamma$, keV	FRER	P	RDR
40	0.3906	1.00	0.3906
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	0.1859
300	0.1157	0.94	0.1091
400	0.0845	0.87	0.0737
500	0.0673	0.82	0.0549
600	0.0563	0.77	0.0435
800	0.0433	0.71	0.0306
1,000	0.0357	0.66	0.0236
1,500	0.0214	0.58	0.0124
2,000	0.0214	0.54	0.0115
3,000	0.0163	0.50	0.0081

3.4 Determination of CPM per μR/hr as a Function of Energy

The equivalent FRER, P, and finally RDR may be calculated for a NaI Scintillation detector at the cesium-137 energy of 662 keV. Manufacturers of this equipment typically provide an instrument response in terms of CPM and μR/hr at the cesium-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.

Based on measured counts in a known field it is estimated that a typical Ludlum 44-10 NaI response is 900 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, Revised Edition January 1970, pages 139, and 140.

FRER	$Energy_{\gamma}$, keV	$(\mu_{en}/\rho)_{air}$, cm^2/g
0.0514	662	0.0294

And

$Energy_{\gamma}$, keV	$(\mu/\rho)_{NaI}$, cm^2/g	P
662	0.0749	0.75

And Cesium-137 RDR (662 keV) = 0.0387

The detector response (CPM) to another energy is based upon the ratio of the RDR at an energy to the known Cs-137 energy RDR

$$CPM/\mu R/hr,\ E_i = (CPM_{Cs\text{-}137}) \times (RDR_{Ei}) / (RDR_{Cs\text{-}137})$$

$$= (900) \times (RDR_{Ei}) / (RDR_{Cs\text{-}137})$$

and in tabular form:

TABLE 4

$Energy_{\gamma}$, keV	RDR_{Ei}	Fidler NaI Detector, E_i, cpm per μR/hr
40	0.3906	9078
60	0.5708	13264
80	0.5297	12309
100	0.4329	10060
150	0.2656	6172
200	0.1859	4320
300	0.1091	2536
400	0.0737	1712
500	0.0549	1277
600	0.0435	1010
662	0.0387	900
800	0.0306	711
1,000	0.0236	548
1,500	0.0124	288
2,000	0.0115	267
3,000	0.0081	188

A “typical”measured background is 10 μR/hr in an uncontaminated area in the U.S. when not near granite outcroppings. Based on a measured background the count rate to exposure rate ratio of 900 CPM/μR/hr, a background value of 9,000 CPM is computed.

Finally, the count rate to exposure rate ratio for each of the thorium isotopes and progeny gamma emissions and their 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 4.

TABLE 5

keV	MicroShield Exposure Rate, μR/hr (with buildup, 1 pCi/g ^{232}Th)	cpm/μR/hr	cpm/μR/hr (weighted)	Percent of NaI detector response
40	4.808E-05	9078	0	0.1%
60	6.721E-05	13264	1	0.1%
80	7.360E-03	12309	94	11.2%
100	1.860E-03	10060	19	2.3%
150	2.169E-03	6172	14	1.7%
200	4.200E-02	4320	187	22.4%
300	3.301E-02	2536	86	10.3%
400	4.090E-03	1712	7	0.9%
500	3.014E-02	1277	40	4.7%
600	8.205E-02	1010	86	10.2%
800	1.070E-01	711	79	9.4%
1000	2.384E-01	548	135	16.1%
1500	7.630E-02	288	23	2.7%
2000	2.154E-03	267	1	0.1%
3000	3.422E-01	188	66	7.9%
Total	9.688E-01		837	100%

3.5 Scan MDC Value

The scan MDC is calculated using the NUREG-1507 methodology where:

The average number of background counts in an interval b_i = CPM/60

And for the Ludlum generic count rate to exposure rate ratio value of 900 CPM/μR/hr and 10 μR/hr assumed background gives

$$b_i = (10\ \mu R/hr) \times (900\ CPM/\mu R/hr) / 60 = 150 \text{ counts}$$

The minimum detectable count rate, MDCR is

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

Where d' is from table 6.1 of NUREG-1507 and represents rate of detections at 95% and a false positive rate of 60%, b_i is the background counts, 60 seconds/1 minute is a conversion factor and

$$MDCR = (1.38) \times (150)^{0.5} \times (60\ sec/1\ min) = 1014\ CPM$$

The Minimum Detectable Count Rate for the surveyor is given as

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

Where

p = Surveyor Efficiency, equal to 0.75 to 0.5 as given by NUREG-1507 (0.5 is chosen as a conservative choice) and

$$MDCR_{surveyor} = 1014/0.707 = 1434\ CPM$$

The Minimum Detectable Exposure Rate for the surveyor is obtained from the $MDCR_{surveyor}$ divided by the Table 5 weighted count rate to exposure rate value of 837 CPM/μR/hr for thorium and its progeny is

$$(1434\ CPM)/(837\ CPM/\mu R/hr) = 1.71\ \mu R/hr$$

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 total thorium and

$$\text{Scan MDC} = (\text{Normalized Th}_{\text{Total Conc}}) \times (\text{Exposure Rate}_{\text{Surveyor}})/(\text{Exposure Rate}_{\text{normalized Th conc}})$$

$$\text{Scan MDC} = (1\ pCi/g) \times (1.71\ \mu R/hr)/(9.688E\text{-}1\ \mu R/hr) = 1.77\ pCi/g$$

4.0 CONCLUSION

The Ludlum 44-10 2”x2” NaI Scintillation scan MDC, for ^{232}Th in 50-year equilibrium with progeny, being uniformly distributed in surface soil with dimensions of 56 cm diameter and 15 cm thick, is estimated to be 1.8 pCi/g.

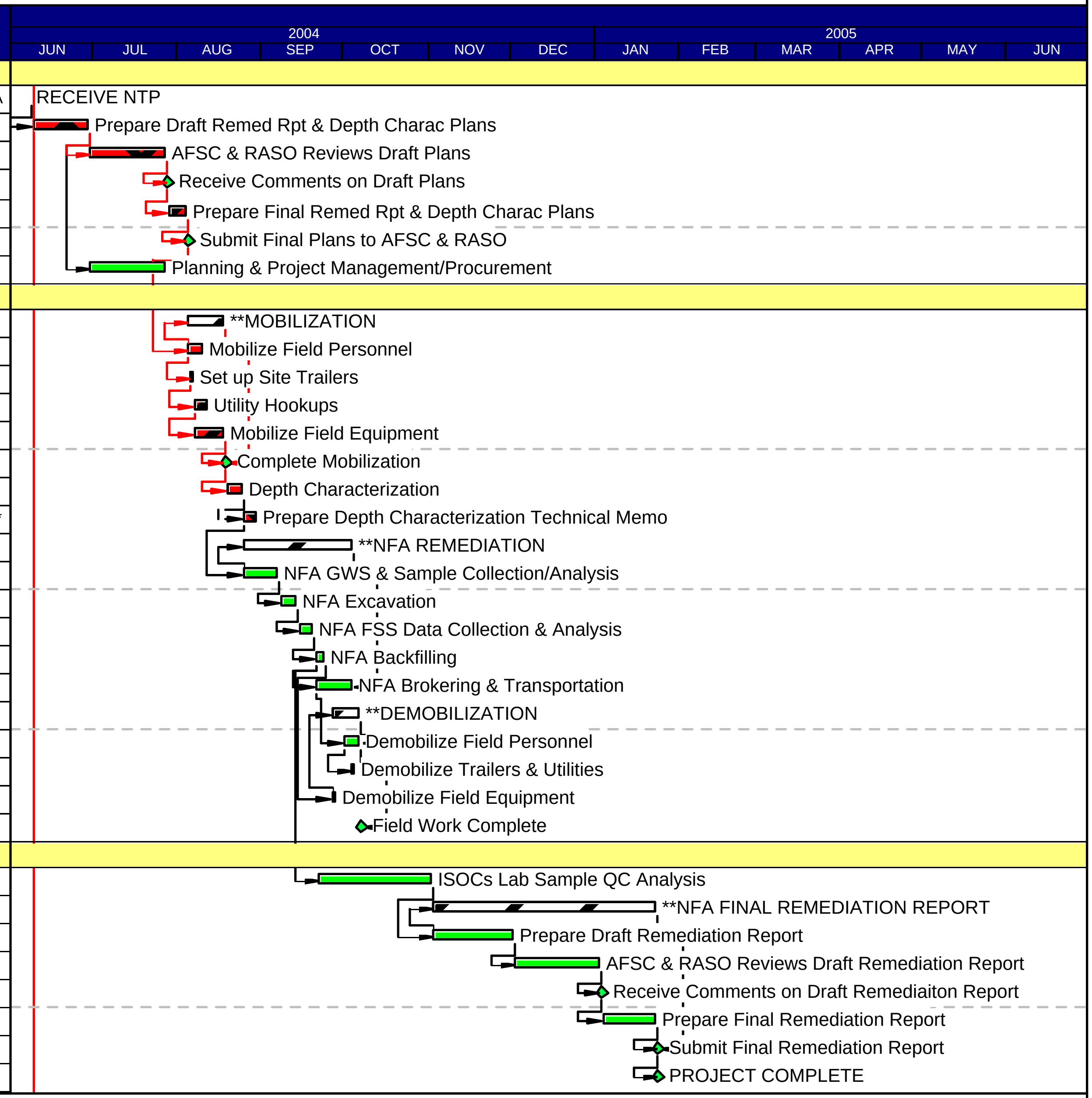
The values computed are indicative of a sensitive instrument and agrees with data presented in MARSSIM Table 6.7.

Attachment B

Schedule

Naval Station Great Lakes
Monazite Sand Storage Area
NFA Remediation
Suspect Area Depth Characterization
Baseline Schedule

Description	Dur	% Complete	Start Date	Finish Date
Characterization Plans & Procurement				
RECEIVE NTP	1d	100	08JUN04 A	08JUN04 A
Prepare Draft Remed Rpt & Depth Charac	15d	0	09JUN04	29JUN04
AFSC & RASO Reviews Draft Plans	20d	0	30JUN04	28JUL04
Receive Comments on Draft Plans	0	0		28JUL04
Prepare Final Remed Rpt & Depth Charac	5d	0	29JUL04	04AUG04
Submit Final Plans to AFSC & RASO	0	0		04AUG04
Planning & Project	20d	0	30JUN04	28JUL04
Field Effort				
**MOBILIZATION	12d	0	05AUG04	18AUG04
Mobilize Field Personnel	5d	0	05AUG04	10AUG04
Set up Site Trailers	2d	0	06AUG04	07AUG04
Utility Hookups	5d	0	07AUG04	12AUG04
Mobilize Field Equipment	10d	0	07AUG04	18AUG04
Complete Mobilization	0	0		18AUG04
Depth Characterization	6d	0	19AUG04	25AUG04
Prepare Depth Characterization Technical	5d	0	25AUG04	30AUG04 *
**NFA REMEDIATION	30d	0	25AUG04	04OCT04
NFA GWS & Sample Collection/Analysis	9d	0	25AUG04	07SEP04
NFA Excavation	6d	0	08SEP04	14SEP04
NFA FSS Data Collection & Analysis	5d	0	15SEP04	20SEP04
NFA Backfilling	4d	0	21SEP04	24SEP04
NFA Brokering & Transportation	10d	0	21SEP04	04OCT04
**DEMOBILIZATION	9d *	0	27SEP04	07OCT04
Demobilize Field Personnel	5d	0	01OCT04	07OCT04
Demobilize Trailers & Utilities	2d	0	04OCT04	05OCT04
Demobilize Field Equipment	2d	0	27SEP04	28SEP04
Field Work Complete	0	0		07OCT04
Final Report				
ISOCs Lab Sample QC Analysis	30d	0	22SEP04	02NOV04
**NFA FINAL REMEDIATION REPORT	55d	0	03NOV04	24JAN05
Prepare Draft Remediation Report	20d	0	03NOV04	02DEC04
AFSC & RASO Reviews Draft Remediation	20d	0	03DEC04	03JAN05
Receive Comments on Draft Remediaiton	0	0		03JAN05
Prepare Final Remediation Report	15d	0	04JAN05	24JAN05
Submit Final Remediation Report	0	0		24JAN05
PROJECT COMPLETE	0	0		24JAN05



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Finish date	24JAN05
Data date	09JUN04
Page number	1A

Prepared By
CABRERA SERVICES
Needham, MA

Early bar
Progress bar
Critical bar
Summary bar
Start milestone point
Finish milestone point

Attachment C

NFA 2003 Survey Results

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GREAT LAKES CHARACTERIZATION SURVEY UNIT NORTH FENCE AREA-SU-1 TRANSMITTAL FORM (November 19, 2003)

SURVEY UNIT: NFA-SU-1

Attachment 1 – Gamma Walkover Survey Z-Score

Attachment 2 – Soil Sample Activity Concentrations

Attachment 3 - Survey Unit Statistics Running Summaries

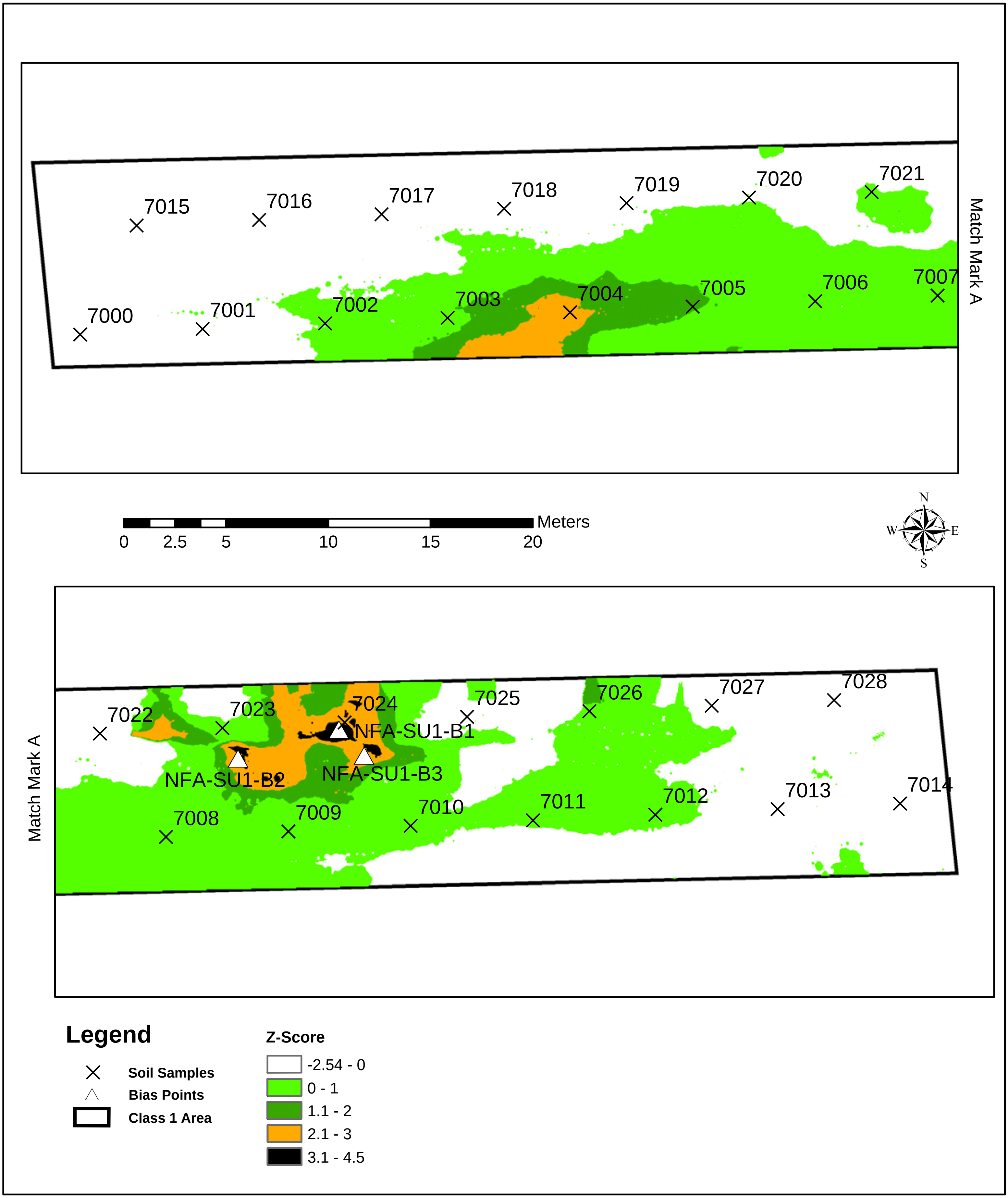
Attachment 4 – Retrospective Power Test

Attachment 5 – WRS Test

The attached information is associated with characterization data from the North Fence Area Survey Unit 1 (class 1 area). This transmittal does not address unrestricted release of this survey unit.

Henry W. Siegrist — 11/19/03
Henry W. Siegrist P.E., CHP — date
Cabrera Corporate Health Physicist

______________________ — ______________
APPROVED — date
NAVSEADET RASO Project Manager



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	Great Lakes **NTC Remediation**	File Name: NF_Class1.mxd Prepared By: JTM	

Attachment 2
Soil Sample Activity Concentrations

Location I/D	Pile Sample Points	Internal ID	Units	K-40 Result		Uncertainty	MDA	Cs-137 Result		Uncertainty	MDA	TL-208 Result		Uncertainty	MDA	BI-211 Result		Uncertainty	MDA
NFASU1-01	7000	id339	(pCi/gram)	1.54E+01	±	1.74E+00	1.04E+00	ND	±	ND	9.38E-02	2.26E-01	±	5.92E-02	7.14E-02	ND	±	ND	6.91E+00
NFASU1-02	7001	id340	(pCi/gram)	1.62E+01	±	1.79E+00	1.01E+00	ND	±	ND	9.90E-02	2.45E-01	±	5.74E-02	6.20E-02	ND	±	ND	7.15E+00
NFASU1-03	7002	id341	(pCi/gram)	6.74E+00	±	1.16E+00	9.76E-01	1.37E-01	±	4.90E-02	6.20E-02	3.29E-01	±	6.59E-02	6.77E-02	ND	±	ND	7.10E+00
NFASU1-04	7003	id342	(pCi/gram)	9.23E+00	±	1.35E+00	1.02E+00	ND	±	ND	8.33E-02	2.43E-01	±	5.75E-02	6.27E-02	ND	±	ND	6.29E+00
NFASU1-05	7004	id343	(pCi/gram)	9.57E+00	±	1.45E+00	1.32E+00	ND	±	ND	1.69E-01	1.86E+00	±	1.54E-01	1.21E-01	ND	±	ND	1.41E+01
NFASU1-06	7005	id344	(pCi/gram)	1.53E+01	±	1.79E+00	1.07E+00	3.90E-02	±	3.21E-02	4.94E-02	4.21E-01	±	7.62E-02	7.53E-02	ND	±	ND	8.21E+00
NFASU1-07	7006	id345	(pCi/gram)	1.39E+01	±	1.62E+00	9.06E-01	ND	±	ND	9.38E-02	2.39E-01	±	5.48E-02	5.58E-02	ND	±	ND	6.62E+00
NFASU1-08	7007	id346	(pCi/gram)	1.46E+01	±	1.69E+00	1.01E+00	ND	±	ND	1.07E-01	2.98E-01	±	6.09E-02	6.65E-02	ND	±	ND	7.27E+00
NFASU1-09	7008	id347	(pCi/gram)	1.82E+01	±	1.96E+00	1.13E+00	ND	±	ND	1.06E-01	3.60E-01	±	6.79E-02	6.41E-02	ND	±	ND	8.48E+00
NFASU1-10	7009	id348	(pCi/gram)	1.35E+01	±	1.71E+00	1.21E+00	4.65E-02	±	2.98E-02	4.13E-02	3.22E-01	±	7.30E-02	8.56E-02	ND	±	ND	8.54E+00
NFASU1-11	7010	id349	(pCi/gram)	1.33E+01	±	1.61E+00	9.63E-01	4.89E-02	±	3.81E-02	5.94E-02	3.32E-01	±	6.89E-02	7.49E-02	ND	±	ND	7.36E+00
NFASU1-12	7011	id350	(pCi/gram)	8.76E+00	±	1.32E+00	1.04E+00	1.36E-01	±	5.76E-02	8.21E-02	5.36E-01	±	8.63E-02	8.91E-02	ND	±	ND	9.51E+00
NFASU1-13	7012	id351	(pCi/gram)	9.45E+00	±	1.36E+00	1.03E+00	ND	±	ND	1.02E-01	3.65E-01	±	6.42E-02	5.74E-02	ND	±	ND	7.93E+00
NFASU1-14	7013	id352	(pCi/gram)	1.60E+01	±	1.78E+00	1.00E+00	ND	±	ND	9.72E-02	1.74E-01	±	5.19E-02	6.30E-02	ND	±	ND	6.98E+00
NFASU1-15	7014	id353	(pCi/gram)	1.44E+01	±	1.73E+00	1.19E+00	6.72E-02	±	4.20E-02	6.27E-02	2.30E-01	±	5.95E-02	7.02E-02	2.881806	±	1.559372	3.72E+00
NFASU1-16	7015	id354	(pCi/gram)	1.00E+01	±	1.38E+00	9.10E-01	ND	±	ND	8.74E-02	1.83E-01	±	4.84E-02	5.16E-02	ND	±	ND	6.34E+00
NFASU1-17	7016	id355	(pCi/gram)	1.13E+01	±	1.48E+00	9.91E-01	ND	±	ND	9.01E-02	1.88E-01	±	4.92E-02	5.27E-02	ND	±	ND	6.06E+00
NFASU1-18	7017	id356	(pCi/gram)	1.53E+01	±	1.75E+00	1.04E+00	ND	±	ND	1.02E-01	3.28E-01	±	6.51E-02	6.50E-02	ND	±	ND	7.79E+00
NFASU1-19	7018	id357	(pCi/gram)	1.50E+01	±	1.75E+00	1.14E+00	ND	±	ND	9.96E-02	1.80E-01	±	4.96E-02	5.50E-02	ND	±	ND	6.78E+00
NFASU1-20	7019	id358	(pCi/gram)	1.45E+01	±	1.71E+00	9.97E-01	ND	±	ND	8.86E-02	1.82E-01	±	4.81E-02	4.85E-02	ND	±	ND	7.06E+00
NFASU1-21	7020	id359	(pCi/gram)	1.34E+01	±	1.66E+00	1.13E+00	ND	±	ND	9.41E-02	1.86E-01	±	5.28E-02	6.22E-02	ND	±	ND	7.00E+00
NFASU1-22	7021	id360	(pCi/gram)	1.42E+01	±	1.71E+00	1.11E+00	ND	±	ND	1.23E-01	3.53E-01	±	7.32E-02	8.27E-02	ND	±	ND	8.05E+00
NFASU1-23	7022	id361	(pCi/gram)	1.25E+01	±	1.60E+00	1.17E+00	ND	±	ND	1.20E-01	6.27E-01	±	9.07E-02	8.45E-02	ND	±	ND	9.60E+00
NFASU1-24	7023	id362	(pCi/gram)	5.97E+00	±	1.19E+00	1.27E+00	4.93E-01	±	8.85E-02	9.65E-02	1.69E+00	±	1.45E-01	1.15E-01	ND	±	ND	1.39E+01
NFASU1-25	7024	id363	(pCi/gram)	5.55E+00	±	1.14E+00	1.21E+00	1.39E-01	±	7.28E-02	1.13E-01	2.67E+00	±	1.96E-01	1.64E-01	ND	±	ND	1.65E+01
NFASU1-26	7025	id364	(pCi/gram)	7.92E+00	±	1.25E+00	9.99E-01	5.59E-02	±	3.35E-02	4.76E-02	2.65E-01	±	5.92E-02	7.00E-02	ND	±	ND	6.79E+00
NFASU1-27	7026	id365	(pCi/gram)	1.49E+01	±	1.75E+00	1.07E+00	ND	±	ND	9.26E-02	1.96E-01	±	5.09E-02	5.82E-02	ND	±	ND	6.90E+00
NFASU1-28	7027	id366	(pCi/gram)	4.88E+00	±	1.02E+00	1.00E+00	1.89E-01	±	5.61E-02	6.79E-02	6.14E-01	±	8.47E-02	7.75E-02	ND	±	ND	8.91E+00
NFASU1-29	7028	id367	(pCi/gram)	5.24E+00	±	1.10E+00	1.16E+00	4.29E-01	±	7.46E-02	6.71E-02	8.20E-01	±	9.54E-02	7.66E-02	ND	±	ND	9.98E+00
NFASU1-B1		id368	(pCi/gram)	1.07E+01	±	1.56E+00	1.43E+00	1.84E-01	±	8.61E-02	1.33E-01	2.57E+00	±	1.88E-01	1.45E-01	ND	±	ND	1.65E+01
NFASU1-B2		id369	(pCi/gram)	1.76E+01	±	1.90E+00	1.07E+00	ND	±	ND	1.27E-01	7.62E-01	±	9.58E-02	9.34E-02	ND	±	ND	9.99E+00
NFASU1-B3		id370	(pCi/gram)	1.29E+01	±	1.58E+00	9.50E-01	ND	±	ND	1.26E-01	8.01E-01	±	9.67E-02	9.12E-02	ND	±	ND	1.03E+01

Attachment 2
Soil Sample Activity Concentrations

Location I/D	Pile Sample Points	PB-211 Result		Uncertainty	MDA	BI-212 Result		Uncertainty	MDA	PB-212 Result		Uncertainty	MDA	BI-214 Result		Uncertainty	MDA
NFASU1-01	7000	ND	±	ND	1.82E+00	9.75E-01	±	5.26E-01	7.38E-01	7.80E-01	±	1.27E-01	1.60E-01	5.64E-01	±	1.13E-01	1.35E-01
NFASU1-02	7001	ND	±	ND	1.72E+00	9.62E-01	±	5.01E-01	6.82E-01	7.78E-01	±	1.17E-01	1.23E-01	6.26E-01	±	1.20E-01	1.14E-01
NFASU1-03	7002	ND	±	ND	1.67E+00	ND	±	ND	1.36E+00	8.24E-01	±	1.17E-01	1.27E-01	4.05E-01	±	9.40E-02	8.65E-02
NFASU1-04	7003	ND	±	ND	1.54E+00	ND	±	ND	1.17E+00	6.71E-01	±	1.21E-01	1.60E-01	3.41E-01	±	9.82E-02	1.17E-01
NFASU1-05	7004	ND	±	ND	3.04E+00	6.18E+00	±	1.18E+00	1.51E+00	6.01E+00	±	4.13E-01	1.78E-01	1.07E+00	±	1.62E-01	2.15E-01
NFASU1-06	7005	ND	±	ND	1.82E+00	ND	±	ND	1.55E+00	9.57E-01	±	1.52E-01	1.83E-01	6.93E-01	±	1.23E-01	8.70E-02
NFASU1-07	7006	ND	±	ND	1.66E+00	8.85E-01	±	5.09E-01	7.24E-01	6.43E-01	±	9.11E-02	9.18E-02	5.98E-01	±	1.21E-01	1.25E-01
NFASU1-08	7007	ND	±	ND	1.64E+00	ND	±	ND	1.52E+00	7.80E-01	±	1.34E-01	1.65E-01	6.49E-01	±	1.11E-01	1.25E-01
NFASU1-09	7008	ND	±	ND	1.85E+00	ND	±	ND	1.45E+00	7.09E-01	±	1.30E-01	1.62E-01	6.54E-01	±	1.21E-01	1.33E-01
NFASU1-10	7009	ND	±	ND	1.92E+00	ND	±	ND	1.69E+00	1.14E+00	±	1.54E-01	1.80E-01	6.60E-01	±	1.16E-01	1.38E-01
NFASU1-11	7010	ND	±	ND	1.82E+00	1.59E+00	±	5.47E-01	5.79E-01	9.58E-01	±	1.37E-01	1.46E-01	5.69E-01	±	1.19E-01	1.23E-01
NFASU1-12	7011	ND	±	ND	1.96E+00	2.18E+00	±	7.55E-01	9.77E-01	1.59E+00	±	1.86E-01	2.07E-01	1.01E+00	±	1.33E-01	1.43E-01
NFASU1-13	7012	ND	±	ND	1.73E+00	ND	±	ND	1.52E+00	9.78E-01	±	1.35E-01	1.55E-01	5.04E-01	±	1.13E-01	1.23E-01
NFASU1-14	7013	ND	±	ND	1.78E+00	7.67E-01	±	4.98E-01	7.34E-01	6.24E-01	±	1.17E-01	1.44E-01	6.21E-01	±	1.11E-01	1.14E-01
NFASU1-15	7014	ND	±	ND	1.80E+00	ND	±	ND	1.49E+00	8.07E-01	±	1.03E-01	9.76E-02	5.78E-01	±	1.28E-01	1.46E-01
NFASU1-16	7015	ND	±	ND	1.50E+00	ND	±	ND	1.38E+00	5.47E-01	±	9.89E-02	1.12E-01	3.99E-01	±	9.05E-02	1.03E-01
NFASU1-17	7016	ND	±	ND	1.49E+00	ND	±	ND	1.35E+00	5.24E-01	±	1.07E-01	1.37E-01	3.80E-01	±	1.00E-01	1.14E-01
NFASU1-18	7017	ND	±	ND	1.85E+00	1.24E+00	±	5.31E-01	6.62E-01	9.44E-01	±	1.50E-01	1.81E-01	6.63E-01	±	1.13E-01	1.10E-01
NFASU1-19	7018	ND	±	ND	1.60E+00	ND	±	ND	1.35E+00	5.95E-01	±	1.08E-01	1.28E-01	5.01E-01	±	1.06E-01	9.90E-02
NFASU1-20	7019	ND	±	ND	1.65E+00	ND	±	ND	1.43E+00	4.89E-01	±	1.06E-01	1.37E-01	4.68E-01	±	1.04E-01	1.24E-01
NFASU1-21	7020	ND	±	ND	1.66E+00	ND	±	ND	1.29E+00	6.67E-01	±	9.35E-02	9.92E-02	6.11E-01	±	1.02E-01	1.07E-01
NFASU1-22	7021	ND	±	ND	1.80E+00	1.04E+00	±	4.56E-01	5.27E-01	9.74E-01	±	1.35E-01	1.50E-01	5.97E-01	±	1.18E-01	1.39E-01
NFASU1-23	7022	ND	±	ND	2.09E+00	2.51E+00	±	8.16E-01	1.05E+00	1.87E+00	±	1.87E-01	1.62E-01	6.69E-01	±	1.22E-01	1.35E-01
NFASU1-24	7023	ND	±	ND	3.12E+00	6.46E+00	±	1.19E+00	1.28E+00	5.70E+00	±	3.98E-01	1.56E-01	7.41E-01	±	1.28E-01	1.72E-01
NFASU1-25	7024	ND	±	ND	3.59E+00	8.93E+00	±	1.35E+00	1.69E+00	8.77E+00	±	5.65E-01	2.01E-01	9.93E-01	±	1.66E-01	2.54E-01
NFASU1-26	7025	ND	±	ND	1.60E+00	1.36E+00	±	5.54E-01	6.91E-01	1.04E+00	±	1.18E-01	8.72E-02	4.17E-01	±	9.23E-02	9.86E-02
NFASU1-27	7026	ND	±	ND	1.70E+00	6.33E-01	±	4.89E-01	7.51E-01	6.59E-01	±	1.18E-01	1.40E-01	5.22E-01	±	1.05E-01	1.11E-01
NFASU1-28	7027	ND	±	ND	1.97E+00	2.13E+00	±	6.87E-01	8.18E-01	1.85E+00	±	1.89E-01	1.46E-01	4.70E-01	±	1.05E-01	1.05E-01
NFASU1-29	7028	ND	±	ND	2.21E+00	2.78E+00	±	7.93E-01	9.40E-01	2.22E+00	±	2.19E-01	2.15E-01	6.28E-01	±	1.17E-01	1.43E-01
NFASU1-B1		ND	±	ND	3.55E+00	7.60E+00	±	1.55E+00	2.03E+00	7.88E+00	±	5.14E-01	2.03E-01	1.16E+00	±	2.02E-01	2.49E-01
NFASU1-B2		ND	±	ND	2.31E+00	2.42E+00	±	7.93E-01	1.00E+00	1.93E+00	±	2.04E-01	2.02E-01	6.71E-01	±	1.26E-01	1.48E-01
NFASU1-B3		ND	±	ND	2.15E+00	3.44E+00	±	8.44E-01	9.18E-01	2.24E+00	±	2.14E-01	1.83E-01	7.22E-01	±	1.43E-01	1.66E-01

Attachment 2
Soil Sample Activity Concentrations

Location I/D	Pile Sample Points	PB-214 Result		Uncertainty	MDA	RA-226 Result		Uncertainty	MDA	AC-228 Result		Uncertainty	MDA	PA-234M Result		Uncertainty	MDA
NFASU1-01	7000	7.52E-01	±	9.37E-02	9.78E-02	ND	±	ND	1.90E+00	9.22E-01	±	1.46E-01	2.23E-01	ND	±	ND	1.10E+01
NFASU1-02	7001	6.65E-01	±	1.01E-01	1.32E-01	2.16E+00	±	9.33E-01	1.42E+00	7.78E-01	±	1.50E-01	2.52E-01	ND	±	ND	1.18E+01
NFASU1-03	7002	3.86E-01	±	7.68E-02	1.29E-01	ND	±	ND	1.80E+00	1.06E+00	±	1.58E-01	2.21E-01	ND	±	ND	9.95E+00
NFASU1-04	7003	3.92E-01	±	7.39E-02	1.16E-01	ND	±	ND	1.66E+00	7.72E-01	±	1.41E-01	2.40E-01	ND	±	ND	1.06E+01
NFASU1-05	7004	1.08E+00	±	1.26E-01	2.19E-01	ND	±	ND	3.33E+00	6.07E+00	±	3.23E-01	3.78E-01	ND	±	ND	1.46E+01
NFASU1-06	7005	7.24E-01	±	1.10E-01	1.51E-01	1.81E+00	±	8.85E-01	1.36E+00	1.13E+00	±	1.98E-01	2.66E-01	ND	±	ND	1.31E+01
NFASU1-07	7006	6.73E-01	±	8.94E-02	1.15E-01	ND	±	ND	1.93E+00	7.30E-01	±	1.35E-01	2.53E-01	ND	±	ND	1.01E+01
NFASU1-08	7007	6.75E-01	±	9.73E-02	1.13E-01	1.79E+00	±	8.87E-01	1.38E+00	9.70E-01	±	1.61E-01	2.25E-01	ND	±	ND	1.22E+01
NFASU1-09	7008	7.81E-01	±	1.11E-01	1.41E-01	3.19E+00	±	1.16E+00	1.75E+00	1.07E+00	±	1.93E-01	1.93E-01	ND	±	ND	1.29E+01
NFASU1-10	7009	6.63E-01	±	9.88E-02	1.43E-01	ND	±	ND	2.17E+00	1.20E+00	±	1.83E-01	2.22E-01	ND	±	ND	1.16E+01
NFASU1-11	7010	6.28E-01	±	9.59E-02	1.16E-01	1.29E+00	±	8.75E-01	1.41E+00	1.05E+00	±	1.89E-01	2.47E-01	ND	±	ND	1.05E+01
NFASU1-12	7011	1.00E+00	±	1.19E-01	1.75E-01	1.76E+00	±	9.38E-01	1.48E+00	2.06E+00	±	2.01E-01	3.03E-01	ND	±	ND	1.08E+01
NFASU1-13	7012	5.38E-01	±	8.15E-02	1.07E-01	ND	±	ND	1.98E+00	1.01E+00	±	1.63E-01	2.04E-01	ND	±	ND	1.02E+01
NFASU1-14	7013	5.65E-01	±	9.46E-02	1.25E-01	1.66E+00	±	8.09E-01	1.24E+00	8.02E-01	±	1.42E-01	1.55E-01	ND	±	ND	1.10E+01
NFASU1-15	7014	6.58E-01	±	9.27E-02	1.21E-01	1.24E+00	±	9.27E-01	1.51E+00	9.30E-01	±	1.52E-01	1.84E-01	ND	±	ND	1.19E+01
NFASU1-16	7015	3.80E-01	±	8.04E-02	1.08E-01	ND	±	ND	1.65E+00	6.77E-01	±	1.38E-01	2.06E-01	ND	±	ND	9.05E+00
NFASU1-17	7016	4.61E-01	±	7.94E-02	9.29E-02	ND	±	ND	1.70E+00	4.92E-01	±	1.43E-01	2.42E-01	ND	±	ND	1.03E+01
NFASU1-18	7017	5.88E-01	±	9.41E-02	1.20E-01	1.11E+00	±	7.46E-01	1.19E+00	7.75E-01	±	1.55E-01	2.80E-01	ND	±	ND	1.20E+01
NFASU1-19	7018	5.65E-01	±	8.98E-02	1.04E-01	1.90E+00	±	9.10E-01	1.41E+00	6.09E-01	±	1.60E-01	2.46E-01	ND	±	ND	1.21E+01
NFASU1-20	7019	4.75E-01	±	8.81E-02	1.12E-01	1.47E+00	±	7.96E-01	1.24E+00	5.57E-01	±	1.40E-01	2.31E-01	ND	±	ND	1.04E+01
NFASU1-21	7020	5.82E-01	±	8.73E-02	1.14E-01	ND	±	ND	1.91E+00	6.86E-01	±	1.32E-01	1.94E-01	ND	±	ND	1.18E+01
NFASU1-22	7021	6.30E-01	±	9.19E-02	1.22E-01	2.43E+00	±	9.61E-01	1.45E+00	9.83E-01	±	1.63E-01	2.47E-01	ND	±	ND	1.06E+01
NFASU1-23	7022	5.08E-01	±	9.25E-02	1.69E-01	ND	±	ND	2.16E+00	1.98E+00	±	2.06E-01	2.84E-01	ND	±	ND	1.12E+01
NFASU1-24	7023	8.43E-01	±	1.25E-01	2.38E-01	ND	±	ND	3.09E+00	5.33E+00	±	3.04E-01	3.63E-01	ND	±	ND	1.24E+01
NFASU1-25	7024	1.17E+00	±	1.42E-01	2.35E-01	2.63E+00	±	1.90E+00	3.14E+00	8.65E+00	±	3.99E-01	4.15E-01	ND	±	ND	1.47E+01
NFASU1-26	7025	4.77E-01	±	7.56E-02	8.67E-02	ND	±	ND	1.72E+00	8.77E-01	±	1.38E-01	2.34E-01	ND	±	ND	8.64E+00
NFASU1-27	7026	5.44E-01	±	9.31E-02	1.16E-01	2.10E+00	±	9.80E-01	1.52E+00	8.12E-01	±	1.59E-01	2.03E-01	ND	±	ND	1.18E+01
NFASU1-28	7027	3.85E-01	±	8.96E-02	1.40E-01	ND	±	ND	1.95E+00	1.84E+00	±	1.76E-01	2.35E-01	ND	±	ND	9.95E+00
NFASU1-29	7028	6.40E-01	±	9.44E-02	1.35E-01	ND	±	ND	2.40E+00	2.45E+00	±	2.10E-01	2.90E-01	ND	±	ND	9.82E+00
NFASU1-B1		1.20E+00	±	1.54E-01	2.91E-01	2.18E+00	±	1.40E+00	2.29E+00	7.54E+00	±	3.69E-01	3.76E-01	ND	±	ND	1.67E+01
NFASU1-B2		8.33E-01	±	1.12E-01	1.70E-01	1.60E+00	±	9.14E-01	1.45E+00	2.35E+00	±	2.09E-01	2.39E-01	ND	±	ND	1.30E+01
NFASU1-B3		7.73E-01	±	1.05E-01	1.58E-01	1.67E+00	±	9.07E-01	1.43E+00	2.45E+00	±	2.31E-01	3.41E-01	ND	±	ND	1.11E+01

Sample Average	**1.63E+00**
Sample SD	**1.87E+00**
Sample Count	**29**
Sample Maximum	**8.65E+00**
Sample Minimum	**4.92E-01**

Attachment 2
Soil Sample Activity Concentrations

Location I/D	Pile Sample Points	TH-234 Result		Uncertainty	MDA	U-235 Result		Uncertainty	MDA	Sample Type	Volume	Sample Analysis Date/Time	Duration	Dead Time
NFASU1-01	7000	ND	±	ND	1.66E+00	ND	±	ND	5.62E-01	DET 6185	1.494E+003 gram	10/22/2003 16:39	600.0 seconds	0.14%
NFASU1-02	7001	ND	±	ND	1.71E+00	ND	±	ND	5.58E-01	DET 6185	1.490E+003 gram	10/22/2003 16:55	600.0 seconds	0.13%
NFASU1-03	7002	ND	±	ND	1.69E+00	ND	±	ND	5.31E-01	DET 6185	1.473E+003 gram	10/22/2003 17:19	600.0 seconds	0.12%
NFASU1-04	7003	ND	±	ND	1.39E+00	ND	±	ND	4.91E-01	DET 6185	1.488E+003 gram	10/22/2003 17:31	600.0 seconds	0.11%
NFASU1-05	7004	ND	±	ND	3.05E+00	ND	±	ND	1.01E+00	DET 6185	1.495E+003 gram	10/23/2003 8:17	600.0 seconds	0.35%
NFASU1-06	7005	ND	±	ND	1.93E+00	ND	±	ND	5.93E-01	DET 6185	1.382E+003 gram	10/23/2003 8:36	600.0 seconds	0.14%
NFASU1-07	7006	ND	±	ND	1.64E+00	ND	±	ND	5.22E-01	DET 6185	1.494E+003 gram	10/23/2003 8:49	600.0 seconds	0.13%
NFASU1-08	7007	ND	±	ND	1.64E+00	ND	±	ND	5.56E-01	DET 6185	1.492E+003 gram	10/23/2003 9:01	600.0 seconds	0.14%
NFASU1-09	7008	ND	±	ND	2.05E+00	ND	±	ND	6.17E-01	DET 6185	1.407E+003 gram	10/23/2003 9:14	600.0 seconds	0.15%
NFASU1-10	7009	ND	±	ND	2.05E+00	ND	±	ND	6.01E-01	DET 6185	1.381E+003 gram	10/23/2003 9:27	600.0 seconds	0.15%
NFASU1-11	7010	ND	±	ND	1.64E+00	ND	±	ND	5.48E-01	DET 6185	1.461E+003 gram	10/23/2003 9:45	600.0 seconds	0.14%
NFASU1-12	7011	ND	±	ND	2.11E+00	ND	±	ND	6.91E-01	DET 6185	1.492E+003 gram	10/23/2003 9:56	600.0 seconds	0.18%
NFASU1-13	7012	ND	±	ND	1.94E+00	ND	±	ND	5.81E-01	DET 6185	1.499E+003 gram	10/23/2003 10:08	600.0 seconds	0.14%
NFASU1-14	7013	ND	±	ND	1.63E+00	ND	±	ND	5.25E-01	DET 6185	1.464E+003 gram	10/23/2003 10:22	600.0 seconds	0.13%
NFASU1-15	7014	ND	±	ND	1.90E+00	ND	±	ND	5.75E-01	DET 6185	1.446E+003 gram	10/23/2003 10:34	600.0 seconds	0.14%
NFASU1-16	7015	ND	±	ND	1.64E+00	ND	±	ND	4.94E-01	DET 6185	1.487E+003 gram	10/23/2003 10:46	600.0 seconds	0.11%
NFASU1-17	7016	ND	±	ND	1.48E+00	ND	±	ND	4.97E-01	DET 6185	1.481E+003 gram	10/23/2003 11:03	600.0 seconds	0.11%
NFASU1-18	7017	ND	±	ND	1.90E+00	ND	±	ND	5.96E-01	DET 6185	1.460E+003 gram	10/23/2003 11:22	600.0 seconds	0.15%
NFASU1-19	7018	ND	±	ND	1.64E+00	ND	±	ND	4.96E-01	DET 6185	1.460E+003 gram	10/23/2003 11:34	600.0 seconds	0.12%
NFASU1-20	7019	ND	±	ND	1.59E+00	ND	±	ND	5.32E-01	DET 6185	1.413E+003 gram	10/23/2003 11:47	600.0 seconds	0.12%
NFASU1-21	7020	ND	±	ND	1.58E+00	ND	±	ND	5.25E-01	DET 6185	1.442E+003 gram	10/23/2003 12:50	600.0 seconds	0.12%
NFASU1-22	7021	ND	±	ND	1.88E+00	ND	±	ND	5.78E-01	DET 6185	1.443E+003 gram	10/23/2003 13:02	600.0 seconds	0.14%
NFASU1-23	7022	ND	±	ND	2.25E+00	ND	±	ND	6.69E-01	DET 6185	1.461E+003 gram	10/23/2003 13:16	600.0 seconds	0.18%
NFASU1-24	7023	ND	±	ND	3.02E+00	ND	±	ND	9.53E-01	DET 6185	1.487E+003 gram	10/23/2003 13:32	600.0 seconds	0.33%
NFASU1-25	7024	ND	±	ND	3.56E+00	ND	±	ND	1.16E+00	DET 6185	1.494E+003 gram	10/23/2003 13:44	600.0 seconds	0.45%
NFASU1-26	7025	ND	±	ND	1.46E+00	ND	±	ND	5.00E-01	DET 6185	1.499E+003 gram	10/23/2003 13:56	600.0 seconds	0.11%
NFASU1-27	7026	ND	±	ND	1.56E+00	ND	±	ND	5.21E-01	DET 6185	1.416E+003 gram	10/23/2003 14:18	600.0 seconds	0.12%
NFASU1-28	7027	ND	±	ND	1.81E+00	ND	±	ND	6.48E-01	DET 6185	1.495E+003 gram	10/23/2003 14:31	600.0 seconds	0.16%
NFASU1-29	7028	ND	±	ND	2.17E+00	ND	±	ND	7.22E-01	DET 6185	1.493E+003 gram	10/23/2003 14:45	600.0 seconds	0.19%
NFASU1-B1		ND	±	ND	3.60E+00	ND	±	ND	1.16E+00	DET 6185	1.489E+003 gram	10/23/2003 14:57	600.0 seconds	0.44%
NFASU1-B2		ND	±	ND	2.29E+00	ND	±	ND	7.44E-01	DET 6185	1.431E+003 gram	10/23/2003 15:10	600.0 seconds	0.19%
NFASU1-B3		ND	±	ND	2.25E+00	ND	±	ND	7.42E-01	DET 6185	1.480E+003 gram	10/23/2003 15:23	600.0 seconds	0.21%

Attachment 3
Survey Unit Statistics Running Summaries

Survey Unit Statistic[a]	SP-SU-1	SP-SU-2	SP-SU-3	SP-SU-4	SP-SU-5	SP-SU-6	SP-SU-7	SP-SU-8	SP-SU-9	SP-SU-10	NFA-SU-1	NFA-SU-2
Reference Area Sample Size, m	34	34	34	34	34	34	34	34	34	34	34	
Lift Sample Size, n	29	28	28	23	28	27	28	27	28	28	29	
DCGL (^{232}Th), pCi/g	1	1	1	1	1	1	1	1	1	1	1	
Alpha	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	
Z-score for 0.05	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	
Calculated W_{crit} (retrospective power test)	1207	1187	1187	1087	1187	1167	1187	1167	1187	1187	1207	
Prospective Assumed Sigma	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
Lift Sample Average, pCi/g ^{232}Th	0.86	0.94	1.03	0.96	1.01	0.96	0.89	0.88	0.47	0.43	1.63	
Lift Sample Maximum, pCi/g ^{232}Th	1.03	1.37	1.51	1.44	1.56	1.65	1.20	1.46	1.13	0.82	8.65	
Lift Sample Minimum, pCi/g ^{232}Th	0.60	0.64	0.73	0.74	0.69	0.65	0.45	0.59	-0.13	0.09	0.49	
Lift Sample Retrospective Sigma	0.10	0.18	0.20	0.17	0.21	0.24	0.15	0.20	0.31	0.19	1.87	
Lift Bias CPM_{max}	13453	12857	12855	< 11308[e]	11443	< 10446[f]	11373	< 10378[f]	9204	N/A	14713	
Lift CPM_{avg}	9110	8840	8758	< 8969[e]	9262	< 8773[f]	9532	< 8761[f]	6742	N/A	8139	
Lift Bias Sample Maximum, pCi/g ^{232}Th	1.43	1.43	1.42	1.15	1.75	1.34	0.94	1.14	0.82	0.47	7.54	
Lift Bias Sample Minimum, pCi/g ^{232}Th	0.68	b	0.98	b	b	b	b	b	0.61	-0.21	2.35	
Reference Area Average, pCi/g ^{232}Th	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	
Reference Area Retrospective Sigma	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
Reference Area CPM_{avg}	10211	10211	10211	10211	10211	10211	10211	10211	10211	10211	10211	
Lift Bias CPM_{max} per Bias pCi/g $^{232}Th_{max}$[c]	9408	8991	9053	9833	6539	7796	12099	9104	11224	N/A	1951	
Net CPM_{avg} per pCi/g $^{232}Th_{avg}$[d]	-1280	-1459	-1411	-1294	-940	-1498	-765	-1644	-7381	N/A	-1271	

[a] Following NUREG-1575 (Marssim) Criteria

[b] Only one bias sample was necessary since no contoured z-score > 3.0; lowest is the same as highest

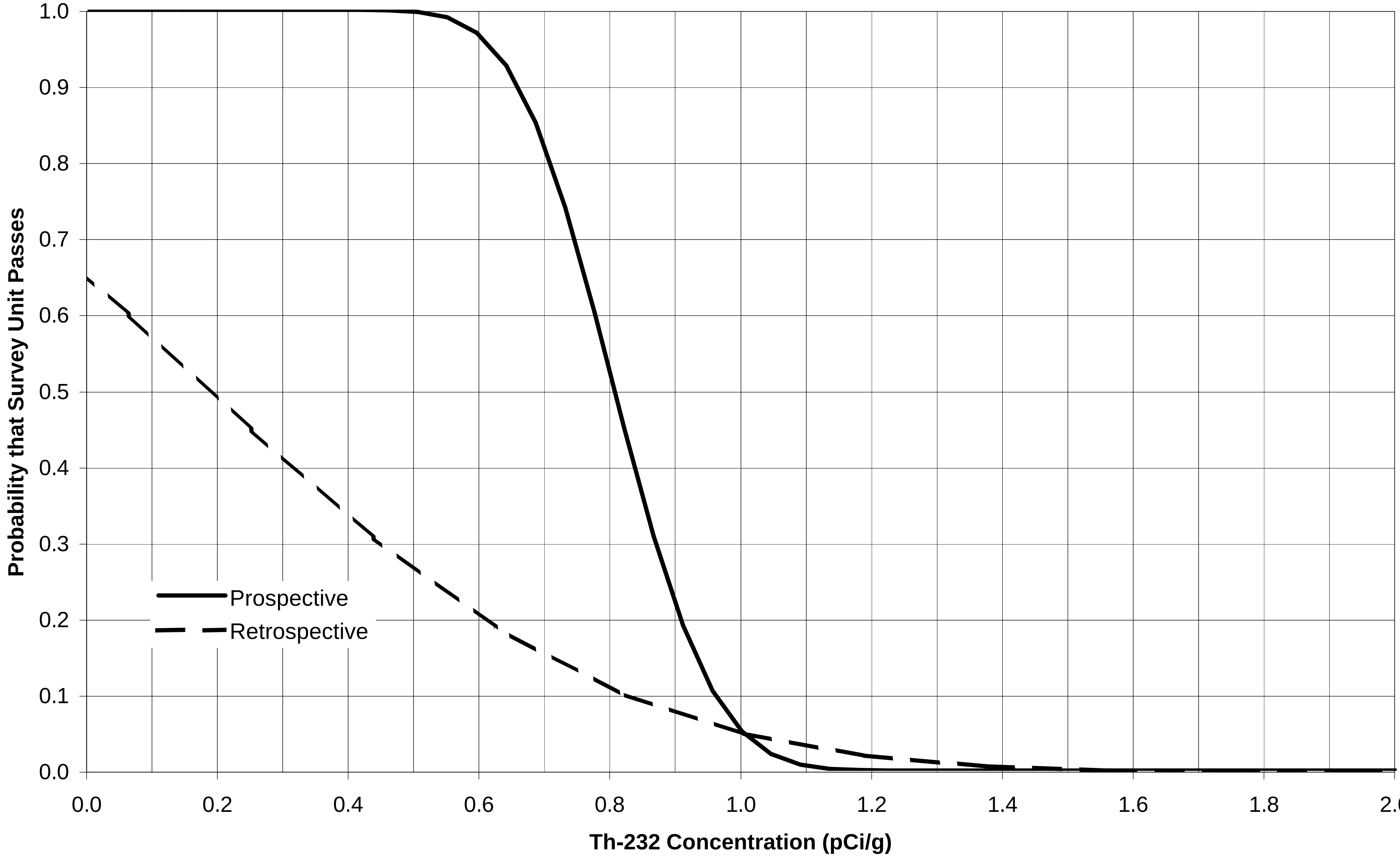
[c] Lift Bias CPM_{max} /Bias pCi/g_{max} ^{232}Th

[d] (Lift CPM_{avg} -Reference Area CPM_{avg})/Lift $^{232}Th_{avg}$

[e] Less than, since approximately 20-25% of lift NOT included with unrestricted release portion of lift was contaminated and had higher general count rate than the average

[f] Less than, since approximately 5-10% of lift NOT included with unrestricted release portion of lift was contaminated and had higher general count rate than the average

Attachment 4
Great Lakes North Fence Area SU-1
Retrospective Power Test



Attachment 5
Great Lakes North Fence Area SU-1
WRS Test

Results (pCi/g)	Survey Area	Adjusted Data	Ranks	References Area Ranks
0.89	R	1.89	50.5	50.5
0.68	R	1.68	29.5	29.5
0.82	R	1.82	44	44
0.67	R	1.67	28	28
0.68	R	1.68	29.5	29.5
0.66	R	1.66	26.5	26.5
0.91	R	1.91	53	53
1.04	R	2.04	58	58
0.89	R	1.89	50.5	50.5
0.69	R	1.69	32	32
0.70	R	1.70	34	34
0.81	R	1.81	42.5	42.5
0.69	R	1.69	32	32
0.66	R	1.66	26.5	26.5
0.69	R	1.69	32	32
0.79	R	1.79	40.5	40.5
0.61	R	1.61	23	23
0.86	R	1.86	49	49
0.79	R	1.79	40.5	40.5
0.65	R	1.65	25	25
1.02	R	2.02	57	57
0.85	R	1.85	47	47
0.81	R	1.81	42.5	42.5
0.91	R	1.91	53	53
0.91	R	1.91	53	53
0.71	R	1.71	35	35
0.85	R	1.85	47	47
0.63	R	1.63	24	24
0.75	R	1.75	37	37
0.73	R	1.73	36	36
0.85	R	1.85	47	47
0.95	R	1.95	55	55
0.76	R	1.76	38	38
0.78	R	1.78	39	39
0.92	S	0.92	13	0
0.78	S	0.78	9	0
1.06	S	1.06	19	0
0.77	S	0.77	7	0
6.07	S	6.07	62	0
1.13	S	1.13	21	0
0.73	S	0.73	6	0
0.97	S	0.97	15	0
1.07	S	1.07	20	0
1.20	S	1.20	22	0
1.05	S	1.05	18	0
2.06	S	2.06	59	0
1.01	S	1.01	17	0
0.80	S	0.80	10	0
0.93	S	0.93	14	0
0.68	S	0.68	4	0
0.49	S	0.49	1	0
0.78	S	0.78	8	0
0.61	S	0.61	3	0
0.56	S	0.56	2	0
0.69	S	0.69	5	0
0.98	S	0.98	16	0
1.98	S	1.98	56	0
5.33	S	5.33	61	0
8.65	S	8.65	63	0
0.88	S	0.88	12	0
0.81	S	0.81	11	0
1.84	S	1.84	45	0
2.45	S	2.45	60	0
		Sum =	2016	1357

Notes: S represents samples collected in Survey Unit.
R represents samples collected in Reference Unit.

CABRERA SERVICES
RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

GREAT LAKES CHARACTERIZATION SURVEY UNIT NORTH FENCE AREA –SU-2 TRANSMITTAL FORM (November 19, 2003)

SURVEY UNIT: NFA-SU-2

Attachment 1 – Gamma Walkover Survey Z-Score

Attachment 2 – Soil Sample Activity Concentrations

Attachment 3 - Survey Unit Statistics Running Summaries

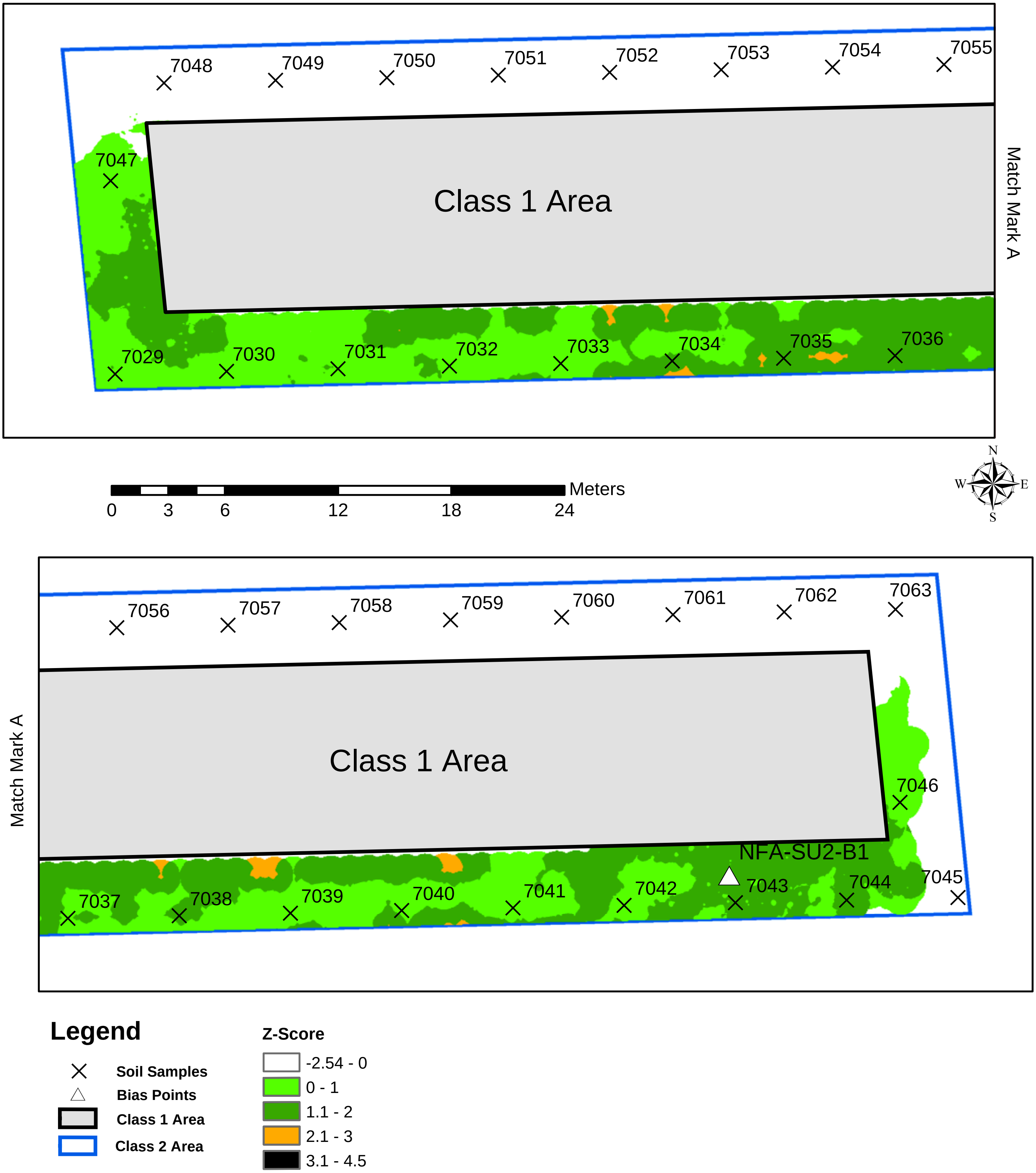
Attachment 4 – Retrospective Power Test

Attachment 5 – WRS Test

The attached information is associated with characterization data from the North Fence Area Survey Unit 2 (class 2 area). This transmittal does not address unrestricted release of this survey unit.

Henry W. Siegrist ______ 11/19/03
Henry W. Siegrist P.E., CHP — date
Cabrera Corporate Health Physicist

______ ______
APPROVED — date
NAVSEADET RASO Project Manager



CABRERA SERVICES RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION WWW.CABRERASERVICES.COM	Gamma Walkover Survey Soil Samples NFA-SU-2	Date: 11-18-03 Project #: 01-3030.36	**Attachment 1**
	Great Lakes **NTC Remediation**	File Name: NF_Class1.mxd Prepared By: JTM	

Attachment 2
Soil Sample Activity Concentrations

Location I/D	NFA Sample Points	Internal ID	Units	K-40 Result		Uncertainty	MDA	Cs-137 Result		Uncertainty	MDA	TL-208 Result		Uncertainty	MDA	BI-211 Result		Uncertainty	MDA
NFASU2-01	7029	id371	(pCi/gram)	7.50E+00	±	1.22E+00	1.00E+00	ND	±	ND	8.51E-02	1.76E-01	±	4.78E-02	5.16E-02	ND	±	ND	5.73E+00
NFASU2-02	7030	id372	(pCi/gram)	1.06E+01	±	1.45E+00	1.07E+00	ND	±	ND	8.98E-02	1.95E-01	±	5.10E-02	5.61E-02	ND	±	ND	6.41E+00
NFASU2-03	7031	id373	(pCi/gram)	1.43E+01	±	1.73E+00	1.10E+00	6.38E-02	±	3.71E-02	5.24E-02	2.26E-01	±	5.43E-02	5.38E-02	ND	±	ND	7.14E+00
NFASU2-04	7032	id374	(pCi/gram)	1.59E+01	±	1.85E+00	1.13E+00	7.01E-02	±	3.86E-02	5.36E-02	1.96E-01	±	6.07E-02	7.79E-02	ND	±	ND	6.88E+00
NFASU2-05	7033	id375	(pCi/gram)	1.51E+01	±	1.81E+00	1.23E+00	4.70E-02	±	3.26E-02	4.77E-02	2.34E-01	±	5.96E-02	6.74E-02	ND	±	ND	6.95E+00
NFASU2-06	7034	id376	(pCi/gram)	1.35E+01	±	1.67E+00	1.04E+00	ND	±	ND	1.02E-01	2.19E-01	±	5.23E-02	4.97E-02	ND	±	ND	7.01E+00
NFASU2-07	7035	id377	(pCi/gram)	1.61E+01	±	1.87E+00	1.13E+00	ND	±	ND	9.85E-02	2.10E-01	±	5.87E-02	6.93E-02	ND	±	ND	7.26E+00
NFASU2-08	7036	id378	(pCi/gram)	1.70E+01	±	1.92E+00	1.14E+00	ND	±	ND	1.13E-01	2.35E-01	±	5.93E-02	6.55E-02	ND	±	ND	7.28E+00
NFASU2-09	7037	id379	(pCi/gram)	1.34E+01	±	1.64E+00	1.03E+00	ND	±	ND	1.01E-01	1.39E-01	±	5.19E-02	6.99E-02	ND	±	ND	6.09E+00
NFASU2-10	7038	id380	(pCi/gram)	1.37E+01	±	1.75E+00	1.24E+00	ND	±	ND	1.25E-01	1.92E-01	±	5.29E-02	5.73E-02	ND	±	ND	6.58E+00
NFASU2-11	7039	id381	(pCi/gram)	9.83E+00	±	1.41E+00	1.05E+00	ND	±	ND	8.30E-02	1.47E-01	±	4.83E-02	5.95E-02	ND	±	ND	5.83E+00
NFASU2-12	7040	id382	(pCi/gram)	1.00E+01	±	1.39E+00	9.51E-01	ND	±	ND	7.89E-02	1.02E-01	±	3.95E-02	4.96E-02	ND	±	ND	5.37E+00
NFASU2-13	7041	id383	(pCi/gram)	1.48E+01	±	1.81E+00	1.13E+00	1.13E-01	±	4.54E-02	5.59E-02	2.74E-01	±	6.01E-02	5.49E-02	ND	±	ND	6.93E+00
NFASU2-14	7042	id384	(pCi/gram)	1.67E+01	±	1.94E+00	1.24E+00	1.05E-01	±	4.98E-02	6.91E-02	2.33E-01	±	5.90E-02	6.38E-02	ND	±	ND	7.57E+00
NFASU2-15	7043	id385	(pCi/gram)	1.79E+01	±	2.02E+00	1.23E+00	ND	±	ND	1.29E-01	3.15E-01	±	6.19E-02	5.30E-02	ND	±	ND	7.45E+00
NFASU2-16	7044	id386	(pCi/gram)	1.69E+01	±	1.93E+00	1.19E+00	8.57E-02	±	4.58E-02	6.53E-02	2.65E-01	±	6.17E-02	6.47E-02	ND	±	ND	6.97E+00
NFASU2-17	7045	id387	(pCi/gram)	1.71E+01	±	1.87E+00	1.08E+00	ND	±	ND	1.09E-01	3.08E-01	±	5.98E-02	6.05E-02	ND	±	ND	7.05E+00
NFASU2-18	7046	id388	(pCi/gram)	1.62E+01	±	1.80E+00	1.04E+00	6.33E-02	±	3.64E-02	5.16E-02	2.42E-01	±	5.48E-02	5.36E-02	ND	±	ND	6.66E+00
NFASU2-19	7047	id389	(pCi/gram)	3.08E+00	±	8.49E-01	9.49E-01	ND	±	ND	8.78E-02	1.21E-01	±	3.78E-02	3.89E-02	ND	±	ND	5.01E+00
NFASU2-20	7048	id390	(pCi/gram)	1.88E+00	±	7.40E-01	9.66E-01	ND	±	ND	4.61E-02	ND	±	ND	6.70E-02	ND	±	ND	3.01E+00
NFASU2-21	7049	id391	(pCi/gram)	1.88E+00	±	7.30E-01	9.45E-01	ND	±	ND	5.06E-02	ND	±	ND	6.41E-02	ND	±	ND	2.70E+00
NFASU2-23	7051	id392	(pCi/gram)	4.07E+00	±	1.00E+00	1.12E+00	1.27E-01	±	4.47E-02	5.28E-02	3.11E-01	±	6.28E-02	6.07E-02	ND	±	ND	6.58E+00
NFASU2-25	7053	id393	(pCi/gram)	4.57E+00	±	9.75E-01	9.33E-01	ND	±	ND	7.94E-02	7.10E-02	±	3.03E-02	3.56E-02	ND	±	ND	4.17E+00
NFASU2-27	7055	id394	(pCi/gram)	4.11E+00	±	9.37E-01	9.34E-01	ND	±	ND	7.15E-02	1.30E-01	±	3.86E-02	3.79E-02	ND	±	ND	4.32E+00
NFASU2-29	7057	id395	(pCi/gram)	5.73E+00	±	1.07E+00	9.24E-01	ND	±	ND	7.17E-02	1.02E-01	±	3.78E-02	4.51E-02	ND	±	ND	5.05E+00
NFASU2-31	7059	id396	(pCi/gram)	7.42E+00	±	1.22E+00	9.74E-01	ND	±	ND	8.43E-02	ND	±	ND	1.00E-01	ND	±	ND	4.92E+00
NFASU2-33	7061	id397	(pCi/gram)	6.43E+00	±	1.15E+00	9.96E-01	ND	±	ND	9.43E-02	1.52E-01	±	4.70E-02	5.51E-02	ND	±	ND	5.52E+00
NFASU2-35	7063	id398	(pCi/gram)	2.76E+00	±	8.05E-01	9.09E-01	ND	±	ND	5.46E-02	ND	±	ND	6.90E-02	ND	±	ND	3.43E+00
NFASU2-B1		id399	(pCi/gram)	1.67E+01	±	1.87E+00	1.15E+00	9.11E-02	±	4.39E-02	6.06E-02	2.73E-01	±	6.10E-02	6.39E-02	ND	±	ND	6.99E+00

Note: Samples from locations 7050, 7052, 7054, 7056, 7058, 7060, and 7062 were not collected due to active roadway on the northern portion of NFA-SU-2; sufficient samples were collected to meet MARSSIM sampling requirements

Attachment 2
Soil Sample Activity Concentrations

Location I/D	NFA Sample Points	PB-211 Result		Uncertainty	MDA	BI-212 Result		Uncertainty	MDA	PB-212 Result		Uncertainty	MDA	BI-214 Result		Uncertainty	MDA
NFASU2-01	7029	ND	±	ND	1.44E+00	7.12E-01	±	4.01E-01	5.25E-01	4.92E-01	±	9.48E-02	1.11E-01	2.85E-01	±	7.41E-02	5.85E-02
NFASU2-02	7030	ND	±	ND	1.48E+00	ND	±	ND	1.35E+00	4.86E-01	±	9.86E-02	1.22E-01	4.58E-01	±	9.91E-02	8.97E-02
NFASU2-03	7031	ND	±	ND	1.63E+00	ND	±	ND	1.32E+00	6.72E-01	±	1.14E-01	1.28E-01	7.73E-01	±	1.24E-01	1.16E-01
NFASU2-04	7032	ND	±	ND	1.71E+00	ND	±	ND	1.50E+00	7.55E-01	±	1.01E-01	9.69E-02	5.75E-01	±	1.12E-01	1.17E-01
NFASU2-05	7033	ND	±	ND	1.64E+00	ND	±	ND	1.53E+00	5.98E-01	±	1.14E-01	1.48E-01	5.54E-01	±	1.23E-01	1.32E-01
NFASU2-06	7034	ND	±	ND	1.81E+00	ND	±	ND	1.55E+00	6.35E-01	±	1.21E-01	1.49E-01	6.00E-01	±	1.20E-01	1.12E-01
NFASU2-07	7035	ND	±	ND	1.82E+00	8.00E-01	±	4.87E-01	6.84E-01	7.20E-01	±	1.01E-01	1.07E-01	7.43E-01	±	1.21E-01	1.37E-01
NFASU2-08	7036	ND	±	ND	1.84E+00	1.16E+00	±	5.72E-01	7.68E-01	6.35E-01	±	1.12E-01	1.26E-01	5.97E-01	±	1.20E-01	1.10E-01
NFASU2-09	7037	ND	±	ND	1.37E+00	ND	±	ND	1.27E+00	5.45E-01	±	1.07E-01	1.31E-01	6.09E-01	±	1.13E-01	1.19E-01
NFASU2-10	7038	ND	±	ND	1.63E+00	ND	±	ND	1.52E+00	4.72E-01	±	1.04E-01	1.32E-01	4.17E-01	±	1.19E-01	1.46E-01
NFASU2-11	7039	ND	±	ND	1.51E+00	ND	±	ND	1.26E+00	3.61E-01	±	8.39E-02	1.03E-01	5.48E-01	±	1.03E-01	9.46E-02
NFASU2-12	7040	ND	±	ND	1.38E+00	ND	±	ND	1.13E+00	4.46E-01	±	7.13E-02	7.45E-02	4.65E-01	±	9.42E-02	9.86E-02
NFASU2-13	7041	ND	±	ND	1.72E+00	7.66E-01	±	5.08E-01	7.39E-01	6.72E-01	±	1.12E-01	1.17E-01	5.08E-01	±	1.19E-01	1.24E-01
NFASU2-14	7042	ND	±	ND	1.83E+00	ND	±	ND	1.50E+00	6.75E-01	±	1.33E-01	1.70E-01	6.26E-01	±	1.12E-01	1.30E-01
NFASU2-15	7043	ND	±	ND	1.83E+00	ND	±	ND	1.67E+00	8.20E-01	±	1.08E-01	9.81E-02	5.26E-01	±	1.20E-01	1.23E-01
NFASU2-16	7044	ND	±	ND	1.86E+00	ND	±	ND	1.51E+00	7.44E-01	±	1.22E-01	1.34E-01	6.87E-01	±	1.27E-01	1.08E-01
NFASU2-17	7045	ND	±	ND	1.59E+00	ND	±	ND	1.45E+00	7.66E-01	±	1.01E-01	1.00E-01	5.33E-01	±	1.04E-01	1.10E-01
NFASU2-18	7046	ND	±	ND	1.79E+00	7.82E-01	±	4.65E-01	6.53E-01	6.88E-01	±	9.56E-02	9.64E-02	5.25E-01	±	1.07E-01	1.26E-01
NFASU2-19	7047	ND	±	ND	1.25E+00	ND	±	ND	1.08E+00	3.46E-01	±	7.90E-02	9.59E-02	2.66E-01	±	7.45E-02	6.90E-02
NFASU2-20	7048	ND	±	ND	1.01E+00	ND	±	ND	8.44E-01	4.10E-02	±	3.87E-02	6.27E-02	ND	±	ND	1.34E-01
NFASU2-21	7049	ND	±	ND	8.25E-01	ND	±	ND	6.90E-01	9.66E-02	±	4.04E-02	5.27E-02	ND	±	ND	1.15E-01
NFASU2-23	7051	ND	±	ND	1.61E+00	ND	±	ND	1.38E+00	7.76E-01	±	1.21E-01	1.30E-01	2.71E-01	±	7.74E-02	7.37E-02
NFASU2-25	7053	ND	±	ND	1.28E+00	ND	±	ND	1.03E+00	2.55E-01	±	7.21E-02	9.48E-02	1.25E-01	±	6.17E-02	8.24E-02
NFASU2-27	7055	ND	±	ND	1.13E+00	ND	±	ND	1.06E+00	3.13E-01	±	7.83E-02	9.95E-02	1.99E-01	±	6.70E-02	7.00E-02
NFASU2-29	7057	ND	±	ND	1.19E+00	ND	±	ND	9.92E-01	3.21E-01	±	8.19E-02	1.06E-01	1.89E-01	±	7.20E-02	8.73E-02
NFASU2-31	7059	ND	±	ND	1.14E+00	ND	±	ND	1.11E+00	2.62E-01	±	6.96E-02	8.66E-02	2.81E-01	±	7.65E-02	6.67E-02
NFASU2-33	7061	ND	±	ND	1.40E+00	ND	±	ND	1.12E+00	4.91E-01	±	1.02E-01	1.28E-01	3.01E-01	±	8.52E-02	9.03E-02
NFASU2-35	7063	ND	±	ND	8.79E-01	ND	±	ND	8.20E-01	1.32E-01	±	4.85E-02	6.32E-02	ND	±	ND	1.54E-01
NFASU2-B1		ND	±	ND	1.84E+00	ND	±	ND	1.40E+00	7.46E-01	±	1.01E-01	1.04E-01	6.22E-01	±	1.19E-01	1.04E-01

Note: Samples from locations 7050, 7052, 7054, 7056, 7058, 7060, and 7062 were not collected due to active roadway on the northern portion of NFA-SU-2; sufficient samples were collected to meet MARSSIM sampling requirements

Attachment 2
Soil Sample Activity Concentrations

Location I/D	NFA Sample Points	PB-214 Result		Uncertainty	MDA	RA-226 Result		Uncertainty	MDA	AC-228 Result		Uncertainty	MDA	PA-234M Result		Uncertainty	MDA
NFASU2-01	7029	3.62E-01	±	7.57E-02	9.88E-02	ND	±	ND	1.60E+00	6.42E-01	±	ND	4.74E-01	ND	±	ND	9.06E+00
NFASU2-02	7030	4.94E-01	±	8.20E-02	9.73E-02	1.73E+00	±	7.21E-01	1.06E+00	6.28E-01	±	1.54E-01	1.94E-01	ND	±	ND	9.31E+00
NFASU2-03	7031	6.93E-01	±	9.99E-02	1.30E-01	ND	±	ND	1.99E+00	7.91E-01	±	1.50E-01	2.31E-01	ND	±	ND	1.15E+01
NFASU2-04	7032	6.54E-01	±	9.72E-02	1.34E-01	1.59E+00	±	8.85E-01	1.39E+00	7.80E-01	±	1.66E-01	1.96E-01	ND	±	ND	1.32E+01
NFASU2-05	7033	6.12E-01	±	9.32E-02	1.39E-01	1.81E+00	±	8.69E-01	1.33E+00	6.97E-01	±	1.73E-01	2.63E-01	ND	±	ND	1.26E+01
NFASU2-06	7034	6.94E-01	±	9.99E-02	1.08E-01	1.87E+00	±	9.84E-01	1.55E+00	7.04E-01	±	1.45E-01	2.99E-01	ND	±	ND	1.24E+01
NFASU2-07	7035	7.06E-01	±	9.71E-02	1.19E-01	1.87E+00	±	9.36E-01	1.45E+00	8.10E-01	±	1.51E-01	1.53E-01	ND	±	ND	1.19E+01
NFASU2-08	7036	6.00E-01	±	1.00E-01	1.28E-01	1.73E+00	±	8.73E-01	1.35E+00	6.83E-01	±	1.52E-01	2.69E-01	ND	±	ND	1.38E+01
NFASU2-09	7037	4.91E-01	±	8.38E-02	1.09E-01	ND	±	ND	1.73E+00	5.76E-01	±	1.58E-01	2.20E-01	ND	±	ND	1.07E+01
NFASU2-10	7038	4.93E-01	±	9.35E-02	1.33E-01	ND	±	ND	1.84E+00	7.09E-01	±	1.47E-01	1.70E-01	ND	±	ND	1.11E+01
NFASU2-11	7039	4.56E-01	±	8.48E-02	1.23E-01	1.40E+00	±	6.91E-01	1.05E+00	4.74E-01	±	1.26E-01	1.69E-01	ND	±	ND	9.04E+00
NFASU2-12	7040	5.50E-01	±	8.02E-02	1.04E-01	1.05E+00	±	7.24E-01	1.16E+00	2.98E-01	±	ND	4.41E-01	ND	±	ND	9.37E+00
NFASU2-13	7041	5.38E-01	±	9.71E-02	1.43E-01	1.43E+00	±	8.53E-01	1.34E+00	8.19E-01	±	1.46E-01	2.29E-01	ND	±	ND	1.21E+01
NFASU2-14	7042	5.81E-01	±	1.02E-01	1.30E-01	2.19E+00	±	8.36E-01	1.21E+00	7.35E-01	±	1.55E-01	2.38E-01	ND	±	ND	1.30E+01
NFASU2-15	7043	6.18E-01	±	9.65E-02	1.37E-01	2.09E+00	±	8.79E-01	1.31E+00	7.92E-01	±	1.65E-01	3.11E-01	ND	±	ND	1.25E+01
NFASU2-16	7044	6.33E-01	±	1.03E-01	1.34E-01	1.45E+00	±	9.29E-01	1.49E+00	9.23E-01	±	ND	6.06E-01	ND	±	ND	1.08E+01
NFASU2-17	7045	6.84E-01	±	9.76E-02	1.28E-01	ND	±	ND	1.91E+00	6.62E-01	±	1.46E-01	2.20E-01	ND	±	ND	1.22E+01
NFASU2-18	7046	6.61E-01	±	9.23E-02	1.31E-01	ND	±	ND	1.97E+00	8.05E-01	±	1.66E-01	1.66E-01	ND	±	ND	1.23E+01
NFASU2-19	7047	1.94E-01	±	6.06E-02	9.42E-02	6.58E-01	±	5.32E-01	8.54E-01	3.05E-01	±	ND	3.90E-01	ND	±	ND	8.31E+00
NFASU2-20	7048	ND	±	ND	1.19E-01	ND	±	ND	9.69E-01	-8.91E-02	±	ND	2.22E-01	ND	±	ND	6.73E+00
NFASU2-21	7049	ND	±	ND	1.23E-01	ND	±	ND	8.92E-01	1.18E-01	±	ND	2.72E-01	ND	±	ND	5.94E+00
NFASU2-23	7051	2.67E-01	±	6.72E-02	9.78E-02	ND	±	ND	1.66E+00	1.03E+00	±	1.49E-01	1.99E-01	ND	±	ND	8.23E+00
NFASU2-25	7053	1.26E-01	±	5.25E-02	6.52E-02	ND	±	ND	1.13E+00	2.54E-01	±	8.98E-02	1.53E-01	ND	±	ND	7.52E+00
NFASU2-27	7055	2.07E-01	±	6.52E-02	7.41E-02	ND	±	ND	1.27E+00	3.14E-01	±	8.90E-02	1.12E-01	ND	±	ND	8.15E+00
NFASU2-29	7057	2.56E-01	±	8.10E-02	1.02E-01	ND	±	ND	1.29E+00	6.14E-01	±	ND	4.30E-01	ND	±	ND	8.66E+00
NFASU2-31	7059	3.15E-01	±	6.93E-02	1.03E-01	ND	±	ND	1.34E+00	3.62E-01	±	ND	4.08E-01	ND	±	ND	9.85E+00
NFASU2-33	7061	2.94E-01	±	7.10E-02	9.98E-02	ND	±	ND	1.51E+00	5.09E-01	±	1.26E-01	1.30E-01	ND	±	ND	9.03E+00
NFASU2-35	7063	ND	±	ND	1.41E-01	ND	±	ND	1.02E+00	1.59E-01	±	ND	2.94E-01	ND	±	ND	8.52E+00
NFASU2-B1		5.65E-01	±	9.05E-02	1.40E-01	2.29E+00	±	8.23E-01	1.18E+00	7.47E-01	±	1.85E-01	3.09E-01	ND	±	ND	1.24E+01

Note: Samples from locations 7050, 7052, 7054, 7056, 7058, 7060, and 7062 were not collected due to active roadway on the northern portion of NFA-SU-2; sufficient samples were collected to meet MARSSIM sampling requirements

Sample Average	**5.75E-01**
Sample SD	**2.68E-01**
Sample Count	**28**
Sample Maximum	**1.03E+00**
Sample Minimum	**-8.91E-02**

Attachment 2
Soil Sample Activity Concentrations

Location I/D	NFA Sample Points	TH-234 Result		Uncertainty	MDA	U-235 Result		Uncertainty	MDA	Sample Type	Volume	Sample Analysis Date/Time	Duration	Dead Time
NFASU2-01	7029	ND	±	ND	1.31E+00	ND	±	ND	4.40E-01	DET 6185	1.485E+003 gram	10/23/2003 15:49	600.0 seconds	0.09%
NFASU2-02	7030	ND	±	ND	1.41E+00	ND	±	ND	4.94E-01	DET 6185	1.499E+003 gram	10/23/2003 16:13	600.0 seconds	0.11%
NFASU2-03	7031	6.86E-01	±	8.40E-01	1.34E+00	ND	±	ND	5.31E-01	DET 6185	1.385E+003 gram	10/24/2003 9:29	600.0 seconds	0.12%
NFASU2-04	7032	ND	±	ND	1.70E+00	ND	±	ND	5.73E-01	DET 6185	1.355E+003 gram	10/24/2003 9:41	600.0 seconds	0.12%
NFASU2-05	7033	ND	±	ND	1.57E+00	ND	±	ND	5.13E-01	DET 6185	1.381E+003 gram	10/24/2003 10:00	600.0 seconds	0.12%
NFASU2-06	7034	ND	±	ND	1.68E+00	ND	±	ND	5.59E-01	DET 6185	1.386E+003 gram	10/24/2003 10:14	600.0 seconds	0.12%
NFASU2-07	7035	ND	±	ND	1.73E+00	ND	±	ND	5.80E-01	DET 6185	1.343E+003 gram	10/24/2003 10:43	600.0 seconds	0.13%
NFASU2-08	7036	ND	±	ND	1.75E+00	ND	±	ND	5.37E-01	DET 6185	1.348E+003 gram	10/24/2003 10:55	600.0 seconds	0.12%
NFASU2-09	7037	ND	±	ND	1.53E+00	ND	±	ND	5.09E-01	DET 6185	1.438E+003 gram	10/24/2003 11:07	600.0 seconds	0.11%
NFASU2-10	7038	ND	±	ND	1.75E+00	ND	±	ND	5.18E-01	DET 6185	1.324E+003 gram	10/24/2003 11:19	600.0 seconds	0.11%
NFASU2-11	7039	ND	±	ND	1.44E+00	ND	±	ND	4.73E-01	DET 6185	1.432E+003 gram	10/24/2003 11:32	600.0 seconds	0.10%
NFASU2-12	7040	ND	±	ND	1.30E+00	ND	±	ND	4.22E-01	DET 6185	1.489E+003 gram	10/24/2003 11:45	600.0 seconds	0.10%
NFASU2-13	7041	ND	±	ND	1.73E+00	ND	±	ND	5.41E-01	DET 6185	1.297E+003 gram	10/24/2003 12:13	600.0 seconds	0.11%
NFASU2-14	7042	ND	±	ND	1.70E+00	ND	±	ND	5.72E-01	DET 6185	1.309E+003 gram	10/24/2003 12:31	600.0 seconds	0.12%
NFASU2-15	7043	ND	±	ND	1.72E+00	ND	±	ND	5.65E-01	DET 6185	1.297E+003 gram	10/24/2003 12:53	600.0 seconds	0.12%
NFASU2-16	7044	ND	±	ND	1.73E+00	ND	±	ND	5.55E-01	DET 6185	1.341E+003 gram	10/24/2003 13:14	600.0 seconds	0.12%
NFASU2-17	7045	ND	±	ND	1.68E+00	ND	±	ND	5.39E-01	DET 6185	1.438E+003 gram	10/24/2003 13:46	600.0 seconds	0.12%
NFASU2-18	7046	ND	±	ND	1.64E+00	ND	±	ND	5.19E-01	DET 6185	1.453E+003 gram	10/24/2003 14:06	600.0 seconds	0.12%
NFASU2-19	7047	ND	±	ND	1.13E+00	ND	±	ND	4.01E-01	DET 6185	1.494E+003 gram	10/24/2003 14:20	600.0 seconds	0.09%
NFASU2-20	7048	ND	±	ND	8.57E-01	ND	±	ND	2.86E-01	DET 6185	1.476E+003 gram	10/24/2003 14:40	600.0 seconds	0.06%
NFASU2-21	7049	ND	±	ND	6.77E-01	ND	±	ND	2.76E-01	DET 6185	1.481E+003 gram	10/24/2003 15:08	600.0 seconds	0.06%
NFASU2-23	7051	ND	±	ND	1.42E+00	ND	±	ND	4.64E-01	DET 6185	1.439E+003 gram	10/24/2003 15:56	600.0 seconds	0.10%
NFASU2-25	7053	ND	±	ND	1.09E+00	ND	±	ND	3.55E-01	DET 6185	1.497E+003 gram	10/24/2003 16:18	600.0 seconds	0.07%
NFASU2-27	7055	ND	±	ND	1.12E+00	ND	±	ND	3.64E-01	DET 6185	1.489E+003 gram	10/24/2003 16:33	600.0 seconds	0.07%
NFASU2-29	7057	ND	±	ND	1.03E+00	ND	±	ND	3.86E-01	DET 6185	1.465E+003 gram	10/24/2003 16:49	600.0 seconds	0.07%
NFASU2-31	7059	ND	±	ND	1.17E+00	ND	±	ND	3.72E-01	DET 6185	1.440E+003 gram	10/24/2003 17:19	600.0 seconds	0.07%
NFASU2-33	7061	ND	±	ND	1.20E+00	ND	±	ND	3.94E-01	DET 6185	1.463E+003 gram	10/24/2003 17:37	600.0 seconds	0.08%
NFASU2-35	7063	ND	±	ND	8.82E-01	ND	±	ND	3.18E-01	DET 6185	1.488E+003 gram	10/24/2003 17:51	600.0 seconds	0.06%
NFASU2-B1		ND	±	ND	1.71E+00	ND	±	ND	5.60E-01	DET 6185	1.414E+003 gram	10/24/2003 18:07	600.0 seconds	0.13%

Note: Samples from locations 7050, 7052, 7054, 7056, 7058, 7060, and 7062 were not collected due to active roadway on the northern portion of NFA-SU-2; sufficient samples were collected to meet MARSSIM sampling requirements

Attachment 3
Survey Unit Statistics Running Summaries

Survey Unit Statistic[a]	SP-SU-1	SP-SU-2	SP-SU-3	SP-SU-4	SP-SU-5	SP-SU-6	SP-SU-7	SP-SU-8	SP-SU-9	SP-SU-10	NFA-SU-1	NFA-SU-2
Reference Area Sample Size, m	34	34	34	34	34	34	34	34	34	34	34	34
Lift Sample Size, n	29	28	28	23	28	27	28	27	28	28	29	28
DCGL (^{232}Th), pCi/g	1	1	1	1	1	1	1	1	1	1	1	1
Alpha	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Z-score for 0.05	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
Calculated W_{crit} (retrospective power test)	1207	1187	1187	1087	1187	1167	1187	1167	1187	1187	1207	1187
Prospective Assumed Sigma	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Lift Sample Average, pCi/g ^{232}Th	0.86	0.94	1.03	0.96	1.01	0.96	0.89	0.88	0.47	0.43	1.63	0.58
Lift Sample Maximum, pCi/g ^{232}Th	1.03	1.37	1.51	1.44	1.56	1.65	1.20	1.46	1.13	0.82	8.65	1.03
Lift Sample Minimum, pCi/g ^{232}Th	0.60	0.64	0.73	0.74	0.69	0.65	0.45	0.59	-0.13	0.09	0.49	-0.09
Lift Sample Retrospective Sigma	0.10	0.18	0.20	0.17	0.21	0.24	0.15	0.20	0.31	0.19	1.87	0.27
Lift Bias CPM_{max}	13453	12857	12855	< 11308[e]	11443	< 10446[f]	11373	< 10378[f]	9204	N/A	14713	10825
Lift CPM_{avg}	9110	8840	8758	< 8969[e]	9262	< 8773[f]	9532	< 8761[f]	6742	N/A	8139	5430
Lift Bias Sample Maximum, pCi/g ^{232}Th	1.43	1.43	1.42	1.15	1.75	1.34	0.94	1.14	0.82	0.47	7.54	0.75
Lift Bias Sample Minimum, pCi/g ^{232}Th	0.68	b	0.98	b	b	b	b	b	0.61	-0.21	2.35	b
Reference Area Average, pCi/g ^{232}Th	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Reference Area Retrospective Sigma	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Reference Area CPM_{avg}	10211	10211	10211	10211	10211	10211	10211	10211	10211	10211	10211	1021
Lift Bias CPM_{max} per Bias pCi/g $^{232}Th_{max}$[c]	9408	8991	9053	9833	6539	7796	12099	9104	11224	N/A	1951	14491
Net CPM_{avg} per pCi/g $^{232}Th_{avg}$[d]	-1280	-1459	-1411	-1294	-940	-1498	-765	-1644	-7381	N/A	-1271	7668

[a] Following NUREG-1575 (Marssim) Criteria

[b] Only one bias sample was necessary since no contoured z-score > 3.0; lowest is the same as highest

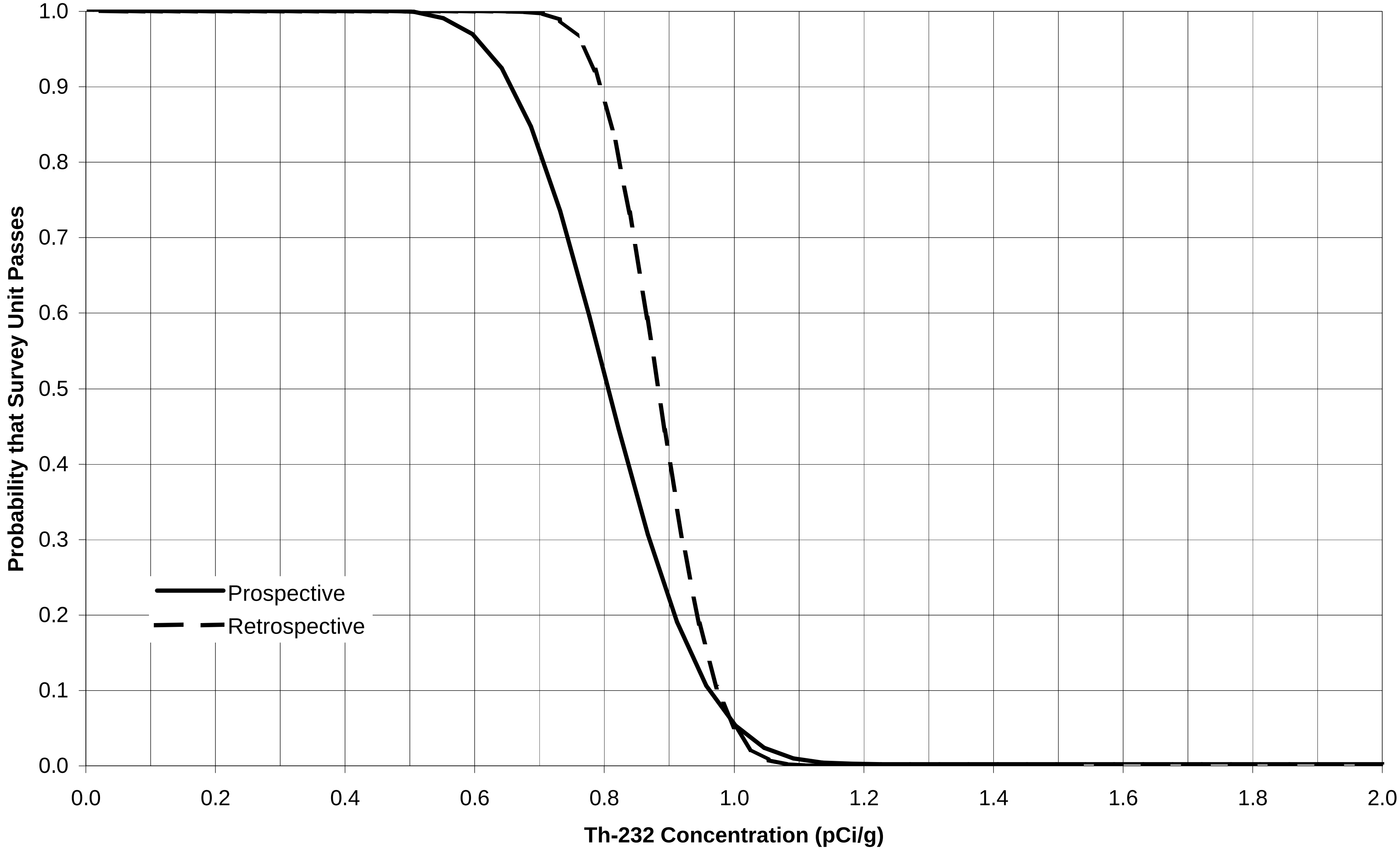
[c] Lift Bias CPM_{max} /Bias pCi/g_{max} ^{232}Th

[d] (Lift CPM_{avg} -Reference Area CPM_{avg})/Lift $^{232}Th_{avg}$

[e] Less than, since approximately 20-25% of lift NOT included with unrestricted release portion of lift was contaminated and had higher general count rate than the average

[f] Less than, since approximately 5-10% of lift NOT included with unrestricted release portion of lift was contaminated and had higher general count rate than the average

Attachment 4
Great Lakes North Fence Area SU-2
Retrospective Power Test



Attachment 5
Great Lakes Noth Fence Area SU-2
WRS Test

Results (pCi/g)	Survey Area	Adjusted Data	Ranks	References Area Ranks
0.89	R	1.89	55.5	55.5
0.68	R	1.68	35.5	35.5
0.82	R	1.82	50	50
0.67	R	1.67	34	34
0.68	R	1.68	35.5	35.5
0.66	R	1.66	32.5	32.5
0.91	R	1.91	58	58
1.04	R	2.04	62	62
0.89	R	1.89	55.5	55.5
0.69	R	1.69	38	38
0.70	R	1.70	40	40
0.81	R	1.81	48.5	48.5
0.69	R	1.69	38	38
0.66	R	1.66	32.5	32.5
0.69	R	1.69	38	38
0.79	R	1.79	46.5	46.5
0.61	R	1.61	29	29
0.86	R	1.86	54	54
0.79	R	1.79	46.5	46.5
0.65	R	1.65	31	31
1.02	R	2.02	61	61
0.85	R	1.85	52	52
0.81	R	1.81	48.5	48.5
0.91	R	1.91	58	58
0.91	R	1.91	58	58
0.71	R	1.71	41	41
0.85	R	1.85	52	52
0.63	R	1.63	30	30
0.75	R	1.75	43	43
0.73	R	1.73	42	42
0.85	R	1.85	52	52
0.95	R	1.95	60	60
0.76	R	1.76	44	44
0.78	R	1.78	45	45
0.64	S	0.64	14	0
0.63	S	0.63	13	0
0.79	S	0.79	22	0
0.78	S	0.78	21	0
0.70	S	0.70	17	0
0.70	S	0.70	18	0
0.81	S	0.81	25	0
0.68	S	0.68	16	0
0.58	S	0.58	11	0
0.71	S	0.71	19	0
0.47	S	0.47	9	0
0.30	S	0.30	5	0
0.82	S	0.82	26	0
0.74	S	0.74	20	0
0.79	S	0.79	23	0
0.92	S	0.92	27	0
0.66	S	0.66	15	0
0.81	S	0.81	24	0
0.30	S	0.30	6	0
-0.09	S	-0.09	1	0
0.12	S	0.12	2	0
1.03	S	1.03	28	0
0.25	S	0.25	4	0
0.31	S	0.31	7	0
0.61	S	0.61	12	0
0.36	S	0.36	8	0
0.51	S	0.51	10	0
0.16	S	0.16	3	0
		Sum =	1953	1547

Notes: S represents samples collected in Survey Unit.
R represents samples collected in Reference Unit.

Attachment D

DandD Run Results

DandD Residential Scenario

DandD Version: 2.1.0
Run Date/Time: 7/7/2004 10:17:29 AM
Site Name: Naval Station Great Lakes
Description: Default Run for Th-232
FileName:C:\Documents and Settings\dwatters\Desktop\Great Lakes Run.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are NOT distributed among all progeny
Number of simulations: 100
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON
Agricultural Pathway is ON
Drinking Water Pathway is ON
Irrigation Pathway is ON
Surface Water Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
232Th+C	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Assumed DCGL of 1 pCi/g		Value 1.00E+00

Chain Data:

Number of chains: **1**

Chain No. 1: **232Th+C**
Nuclides in chain: **11**

Nuclide	Chain Position	Half Life	First Parent	Fractional Yield	Second Parent	Fractional Yield	Ingestion CEDE Factor (Sv/Bq)	Inhalation CEDE Factor (Sv/Bq)	Surface Dose Rate Factor ((Sv/d)/(Bq/m^2))	1 Do F ((Sv/d
232Th+C	1	5.13E+12								
228Ra	2	2.10E+03	1	1	0	0	3.88E-07	1.29E-06	0.00E+00	0.00E
228Ac	Implicit		2	1			5.85E-10	8.33E-08	8.01E-11	2.38E
228Th	3	6.99E+02	2	1	0	0	1.07E-07	9.23E-05	2.03E-13	3.60E

224Ra	4	3.66E+00	3	1	0	0	9.89E-08	8.53E-07	8.26E-13	2.26E
220Rn	Implicit		4	1			0.00E+00	0.00E+00	3.29E-14	9.52E
216Po	Implicit		4	1			0.00E+00	0.00E+00	1.43E-15	4.21E
212Pb	5	4.43E-01	4	1	0	0	1.23E-08	4.56E-08	1.23E-11	3.13E
212Bi	Implicit		5	1			2.87E-10	5.83E-09	1.54E-11	4.63E
212Po	Implicit		5	0.6407			0.00E+00	0.00E+00	0.00E+00	0.00E
208Tl	Implicit		5	0.3593			0.00E+00	0.00E+00	2.58E-10	8.36E

Initial Concentrations:

Note: All reported values are the upper bound of the symmetric 95% confidence interval for the 0.9 **quantile value**

Nuclide	Soil Concentration (pCi/g)
232Th	1.00E+00
228Ra	1.00E+00
228Ac	1.00E+00
228Th	1.00E+00
224Ra	1.00E+00
220Rn	1.00E+00
216Po	1.00E+00
212Pb	1.00E+00
212Bi	1.00E+00
212Po	6.41E-01
208Tl	3.59E-01

Model Parameters:

General Parameters:

Parameter Name	Description	Distribution
Tv (1):Translocation:Leafy	Translocation factor for leafy vegetables	CONSTANT(none)
Default value used		Value 1.00E+00
Tv(2):Translocation:Root	Translocation factor for other vegetables	CONSTANT(none)
Default value used		Value 1.00E-01
Tv (3):Translocation:Fruit	Translocation factor for fruit	CONSTANT(none)
Default value used		Value 1.00E-01
Tv (4):Translocation:Grain	Translocation factor for grain	CONSTANT(none)
Default value used		Value 1.00E-01
Tf(1):Translocation:Beef Forage	Translocation factor for forage consumed by beef cattle	CONSTANT(none)

Default value used		Value 1.00E+00
Tf (2):Translocation:Poultry Forage	Translocation factor for forage consumed by poultry	CONSTANT(none)
Default value used		Value 1.00E+00
Tf(3):Translocation:Milk Cow	Translocatioin factor for forage consumed by milk cows	CONSTANT(none)
Default value used		Value 1.00E+00
Tf (4):Translocation:Layer Hen Forage	Translocation factor for forage consumed by layer hens	CONSTANT(none)
Default value used		Value 1.00E+00
Tg(1):Translocation:Beef Grain	Translocation factor for stored grain consumed by beef cattle	CONSTANT(none)
Default value used		Value 1.00E-01
Tg (2):Translocation:Poultry Grain	Translocation factor for stored grain consumed by poultry	CONSTANT(none)
Default value used		Value 1.00E-01
Tg(3):Translocation:Milk Cow Grain	Translocation factor for stored grain consumed by milk cows	CONSTANT(none)
Default value used		Value 1.00E-01
Tg (4):Translocation:Layer Hen Grain	Translocation factor for stored grain consumed by layer hens	CONSTANT(none)
Default value used		Value 1.00E-01
Th(1):Translocation:Beef Hay	Translocation factor for stored hay consumed by beef cattle	CONSTANT(none)
Default value used		Value 1.00E+00
Th (2):Translocation:Poultry Hay	Translocation factor for stored hay consumed by poultry	CONSTANT(none)
Default value used		Value 1.00E+00
Th (3):Translocation:Milk Cow Hay	Translocation factor for stored hay consumed by milk cows	CONSTANT(none)
Default value used		Value 1.00E+00
Th (4):Translocation:Layer Hen Hay	Translocation factor for stored hay consumed by layer hens	CONSTANT(none)
Default value used		Value 1.00E+00
fca(1):Beef Carbon Fraction	Mass fraction of beef cattle that is carbon	CONSTANT(none)
Default value used		Value 3.60E-01
fca(2):Poultry Carbon Fraction	Mass fraction of poultry that is carbon	CONSTANT(none)
Default value used		

		Value 1.80E-01
fca(3):Milk Carbon Fraction	Mass fraction of milk that is carbon	CONSTANT(none)
Default value used		Value 6.00E-02
fca(4):Eggs Carbon Fraction	Mass fraction of an egg that is carbon	CONSTANT(none)
Default value used		Value 1.60E-01
fcf(1):Beef Forage Carbon Fraction	Mass fraction of wet forage consumed by beef cattle that is carbon	CONSTANT(none)
Default value used		Value 1.10E-01
fcf(2):Poultry Forage Carbon Fraction	Mass fraction of wet forage consumed by poultry that is carbon	CONSTANT(none)
Default value used		Value 1.10E-01
fcf(3):Milk Cow Forage Carbon Fraction	Mass fraction of wet forage consumed by milk cows that is carbon	CONSTANT(none)
Default value used		Value 1.10E-01
fcf(4):Layer Hen Forage Carbon Fraction	Mass fraction of wet forage consumed by layer hens that is carbon	CONSTANT(none)
Default value used		Value 1.10E-01
fcg(1):Beef Grain Carbon Fraction	Mass fraction of wet stored grain consumed by beef cattle that is carbon	CONSTANT(none)
Default value used		Value 4.00E-01
fcg(2):Poultry Grain Carbon Fraction	Mass fraction of wet stored grain consumed by poultry that is carbon	CONSTANT(none)
Default value used		Value 4.00E-01
fcg(3):Milk Cow Grain Carbon Fraction	Mass fraction of wet stored grain consumed by milk cows that is carbon	CONSTANT(none)
Default value used		Value 4.00E-01
fcg(4):Layer Hen Grain Carbon Fraction	Mass fraction of wet stored grain consumed by layer hens that is carbon	CONSTANT(none)
Default value used		Value 4.00E-01
fch(1):Beef Hay Carbon Fraction	Mass fraction of wet stored hay consumed by beef cattle that is carbon	CONSTANT(none)
Default value used		Value 7.00E-02
fch(2):Poultry Hay Carbon Fraction	Mass fraction of wet stored hay consumed by poultry that is carbon	CONSTANT(none)
Default value used		Value 7.00E-02
fch(3):Milk Cow Hay Carbon Fraction	Mass fraction of wet stored hay consumed by milk cows that is carbon	CONSTANT(none)
Default value used		Value 7.00E-02
fch(4):Layer Hen Hay Carbon Fraction	Mass fraction of wet stored hay consumed by layer hens that is carbon	CONSTANT(none)
Default value used		Value 7.00E-02
fCd:Soil Carbon Fraction	Mass fraction of dry soil that is carbon	CONSTANT(none)
Default value used		Value 3.00E-02

SATac:Animal Product Specific Activity	Specific activity equivalence of animal product and specific activity of animal feed, forage, and soil	CONSTANT(none)
Default value used		Value 1.00E+00
xf(1):Beef Forage Contaminated Fraction	Fraction of forage consumed by beef cattle that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xf(2):Poultry Forage Contaminated Fraction	Fraction of forage consumed by poultry that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xf(3):Milk Cow Forage Contaminated Fraction	Fraction of forage consumed by milk cows that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xf(4):Layer Hen Forage Contaminated Fraction	Fraction of forage consumed by layer hens that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xg(1):Beef Grain Contaminated Fraction	Fraction of stored grain consumed by beef cattle that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xg(2):Poultry Grain Contaminated Fraction	Fraction of stored grain consumed by poultry that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xg(3):Milk Cow Grain Contaminated Fraction	Fraction of stored grain consumed by milk cows that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xg(4):Layer Hen Grain Contaminated Fraction	Fraction of stored grain that is consumed by layer hens that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xh(1):Beef Hay Contaminated Fraction	Fraction of stored hay consumed by beef cattle that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xh(2):Poultry Hay Contaminated Fraction	Fraction of stored hay consumed by poultry that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xh(3):Milk Cow Hay Contaminated Fraction	Fraction of stored hay consumed by milk cows that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xh(4):Layer Hen Hay Contaminated Fraction	Fraction of stored hay consumed by layer hens that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xw(1):Beef Water Contaminated Fraction	Fraction of water that is consumed by beef cattle that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xw(2):Poultry Water Contaminated Fraction	Fraction of water consumed by poultry that is contaminated	CONSTANT(none)

Default value used		Value 1.00E+00
xw(3):Milk Cow Water Contaminated Fraction	Fraction of water consumed by milk cows that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
xw(4):Layer Hen Water Contaminated Fraction	Fraction of water consumed by layer hens that is contaminated	CONSTANT(none)
Default value used		Value 1.00E+00
DIET:Garden Diet	Fraction of human diet grown onsite	CONSTANT(none)
Default value used		Value 1.00E+00
Uv(1):Diet - Leafy	Yearly human consumption of leafy vegetables	CONSTANT(kg/y)
Default value used		Value 2.14E+01
Uv(2):Diet - Roots	Yearly human consumption of other vegetables	CONSTANT(kg/y)
Default value used		Value 4.46E+01
Uv(3):Diet - Fruit	Yearly human consumption of fruits	CONSTANT(kg/y)
Default value used		Value 5.28E+01
Uv(4):Diet - Grain	Yearly human consumption of grains	CONSTANT(kg/y)
Default value used		Value 1.44E+01
Ua(1):Diet - Beef	Yearly human consumption of beef	CONSTANT(kg/y)
Default value used		Value 3.98E+01
Ua(2):Diet - Poultry	Yearly human consumption of poultry	CONSTANT(kg/y)
Default value used		Value 2.53E+01
Ua(3):Diet - Milk	Yearly human consumption of milk	CONSTANT(L/y)
Default value used		Value 2.33E+02
Ua(4):Diet - Egg	Yearly human consumption of eggs	CONSTANT(kg/y)
Default value used		Value 1.91E+01
Uf:Diet - Fish	Yearly human consumption of fish produced from an onsite pond	CONSTANT(kg/y)
Default value used		Value 2.06E+01
tf:Consumption Period	Consumption period for fish	CONSTANT(days)
Default value used		Value 3.65E+02
tcv(1):Consumption Period - Leafy	Food consumption period for leafy vegetables	CONSTANT(days)
Default value used		Value 3.65E+02
tcv(2):Consumption Period - Roots	Food consumption period for other vegetables	CONSTANT(days)
Default value used		Value 3.65E+02
tcv(3):Consumption Period - Fruit	Food consumption period for fruits	CONSTANT(days)
Default value used		Value 3.65E+02
tcv(4):Consumption Period - Grain	Food consumption period for grains	CONSTANT(days)
Default value used		Value 3.65E+02

tca(1):Consumption Period - Beef	Food consumption period for beef	CONSTANT(days)
Default value used		Value 3.65E+02
tca(2):Consumption Period - Poultry	Food consumption period for poultry	CONSTANT(days)
Default value used		Value 3.65E+02
tca(3):Consumption Period - Milk	Food consumption period for milk	CONSTANT(days)
Default value used		Value 3.65E+02
tca(4):Consumption Period - Egg	Food consumption period for eggs	CONSTANT(days)
Default value used		Value 3.65E+02
Nunsat:Number of Unsaturated Layers	Number of model layers used to represent the unsaturated zone	CONSTANT(none)
Default value used		Value 1.00E+01
TstartR:Start Time	The start time of the scenario in days	CONSTANT(days)
Default value used		Value 0.00E+00
TendR:End Time	The ending time of the scenario in days	CONSTANT(days)
Default value used		Value 3.65E+05
dtR:Time Step Size	The time step size	CONSTANT(days)
Default value used		Value 3.65E+02
PstepR:Print Step Size	The time steps for the history file. Doses will be written to the history file every n time steps	CONSTANT(none)
Default value used		Value 1.00E+00
TI:Indoor Exposure Period	The time the resident spends indoors	CONSTANT(days/year)
Default value used		Value 2.40E+02
TX:Outdoor Exposure Period	The time the resident spends outdoors	CONSTANT(days/year)
Default value used		Value 4.02E+01
TG:Gardening Period	The time the resident spends gardening	CONSTANT(days/year)
Default value used		Value 2.92E+00
TTR:Total time in period	Total time in the one year exposure period	CONSTANT(days/year)
Default value used		Value 3.65E+02
SFI:Indoor Shielding Factor	Shielding factor for the residence	CONSTANT(none)
Default value used		Value 5.52E-01
SFO:Outdoor Shielding Factor	Shielding factor for the cover soil	CONSTANT(none)
Default value used		Value 1.00E+00
PD:Floor dust loading	Floor dust loading	UNIFORM(g/m**2)
Default value used		Lower Limit 2.00E-02 Upper Limit 3.00E-01

RFR:Indoor Resuspension Factor	Resuspension factor for indoor dust	LOGUNIFORM(1/m)
Default value used		Lower Limit 1.00E-07 Upper Limit 8.00E-05
CDO:Outdoor Dust Loading	Average dust loading outdoors	LOGUNIFORM(g/m**3)
Default value used		Lower Limit 1.00E-07 Upper Limit 1.00E-04
CDI:Indoor Dust Loading	Average dust loading indoors	DERIVED(g/m**3)
Default value used		
PF:Indoor/Outdoor Penetration Factor	Fraction of outdoor dust in indoor air	UNIFORM(none)
Default value used		Lower Limit 2.00E-01 Upper Limit 7.00E-01
CDG:Gardening Dust Loading	Average dust loading while gardening	UNIFORM(g/m**3)
Default value used		Lower Limit 1.00E-04 Upper Limit 7.00E-04
VR:Indoor Breathing Rate	Breathing rate while indoors	CONSTANT(m**3/hr)
Default value used		Value 9.00E-01
VX:Outdoor Breathing Rate	Breathing rate while outdoors	CONSTANT(m**3/hr)
Default value used		Value 1.40E+00
VG:Gardening Breathing Rate	Breathing rate while gardening	CONSTANT(m**3/hr)
Default value used		Value 1.70E+00
GR:Soil Ingestion Transfer Rate	Average rate of soil ingestion	CONSTANT(g/d)
Default value used		Value 5.00E-02
UW:Diet - Water	Drinking water ingestion rate	CONSTANT(L/d)
Default value used		Value 1.26E+00
H1:Surface Soil Thickness	Thickness of the surface soil layer	CONSTANT(m)
Default value used		Value 1.50E-01
H2:Unsaturated Zone Thickness	Thickness of the unsaturated zone	CONTINUOUS LINEAR(m)
Default value used		Value Probability 3.05E-01 0.00E+00 6.68E-01 4.76E-03 8.11E-01 9.52E-03 9.21E-01 1.43E-02 9.94E-01 1.91E-02 1.03E+00 2.38E-02 1.07E+00 2.86E-02 1.14E+00 3.33E-02 1.21E+00 3.81E-02

1.30E+00	4.29E-02
1.31E+00	4.76E-02
1.32E+00	5.24E-02
1.56E+00	5.71E-02
1.58E+00	6.19E-02
1.61E+00	6.67E-02
1.69E+00	7.62E-02
1.78E+00	8.57E-02
1.80E+00	9.05E-02
1.81E+00	9.52E-02
1.84E+00	1.00E-01
1.87E+00	1.05E-01
1.92E+00	1.10E-01
2.04E+00	1.14E-01
2.10E+00	1.19E-01
2.11E+00	1.24E-01
2.32E+00	1.29E-01
2.36E+00	1.33E-01
2.37E+00	1.38E-01
2.39E+00	1.43E-01
2.44E+00	1.48E-01
2.44E+00	1.52E-01
2.45E+00	1.57E-01
2.59E+00	1.62E-01
2.63E+00	1.67E-01
2.69E+00	1.71E-01
2.79E+00	1.76E-01
2.81E+00	1.81E-01
2.90E+00	1.86E-01
2.95E+00	1.91E-01
3.07E+00	1.95E-01
3.18E+00	2.00E-01
3.22E+00	2.05E-01
3.30E+00	2.10E-01
3.34E+00	2.14E-01
3.37E+00	2.19E-01
3.44E+00	2.24E-01
3.58E+00	2.29E-01
3.62E+00	2.33E-01
3.66E+00	2.38E-01
3.74E+00	2.43E-01
3.86E+00	2.48E-01
3.88E+00	2.52E-01
4.17E+00	2.57E-01
4.26E+00	2.62E-01
4.44E+00	2.71E-01
4.63E+00	2.76E-01
4.87E+00	2.81E-01
5.13E+00	2.86E-01
5.18E+00	2.91E-01
5.54E+00	2.95E-01
5.83E+00	3.00E-01
5.86E+00	3.05E-01
5.86E+00	3.10E-01
5.90E+00	3.14E-01
6.06E+00	3.19E-01
6.13E+00	3.24E-01
6.17E+00	3.29E-01
6.22E+00	3.33E-01

6.31E+00	3.38E-01
6.36E+00	3.43E-01
6.40E+00	3.48E-01
6.46E+00	3.52E-01
6.51E+00	3.57E-01
6.55E+00	3.62E-01
6.60E+00	3.67E-01
6.86E+00	3.71E-01
6.93E+00	3.76E-01
6.95E+00	3.86E-01
6.97E+00	3.91E-01
7.09E+00	3.95E-01
7.18E+00	4.00E-01
7.35E+00	4.05E-01
7.36E+00	4.10E-01
7.40E+00	4.14E-01
7.43E+00	4.19E-01
7.46E+00	4.24E-01
7.59E+00	4.29E-01
7.60E+00	4.33E-01
7.64E+00	4.38E-01
7.87E+00	4.43E-01
8.10E+00	4.48E-01
8.28E+00	4.52E-01
8.35E+00	4.57E-01
8.71E+00	4.62E-01
8.71E+00	4.67E-01
8.73E+00	4.71E-01
8.79E+00	4.76E-01
8.80E+00	4.81E-01
8.82E+00	4.86E-01
8.85E+00	4.91E-01
8.89E+00	4.95E-01
8.90E+00	5.00E-01
8.99E+00	5.05E-01
9.00E+00	5.10E-01
9.13E+00	5.14E-01
9.14E+00	5.19E-01
9.21E+00	5.24E-01
9.31E+00	5.29E-01
9.55E+00	5.33E-01
9.60E+00	5.38E-01
9.63E+00	5.43E-01
9.86E+00	5.48E-01
1.05E+01	5.52E-01
1.07E+01	5.57E-01
1.13E+01	5.62E-01
1.15E+01	5.67E-01
1.17E+01	5.71E-01
1.20E+01	5.76E-01
1.26E+01	5.81E-01
1.26E+01	5.86E-01
1.28E+01	5.91E-01
1.32E+01	5.95E-01
1.32E+01	6.00E-01
1.34E+01	6.05E-01
1.34E+01	6.10E-01
1.36E+01	6.14E-01
1.37E+01	6.19E-01

	1.38E+01	6.24E-01
	1.41E+01	6.29E-01
	1.45E+01	6.33E-01
	1.51E+01	6.38E-01
	1.52E+01	6.43E-01
	1.61E+01	6.48E-01
	1.62E+01	6.52E-01
	1.65E+01	6.57E-01
	1.66E+01	6.62E-01
	1.69E+01	6.67E-01
	1.74E+01	6.71E-01
	1.82E+01	6.76E-01
	1.84E+01	6.81E-01
	1.84E+01	6.86E-01
	1.87E+01	6.91E-01
	1.95E+01	6.95E-01
	2.01E+01	7.00E-01
	2.07E+01	7.05E-01
	2.08E+01	7.10E-01
	2.17E+01	7.14E-01
	2.24E+01	7.19E-01
	2.27E+01	7.24E-01
	2.29E+01	7.29E-01
	2.29E+01	7.33E-01
	2.40E+01	7.38E-01
	2.47E+01	7.43E-01
	2.60E+01	7.48E-01
	2.65E+01	7.52E-01
	2.72E+01	7.57E-01
	2.73E+01	7.62E-01
	2.76E+01	7.67E-01
	2.77E+01	7.71E-01
	2.78E+01	7.76E-01
	2.80E+01	7.81E-01
	2.86E+01	7.86E-01
	2.94E+01	7.91E-01
	3.01E+01	7.95E-01
	3.03E+01	8.00E-01
	3.06E+01	8.10E-01
	3.08E+01	8.14E-01
	3.11E+01	8.19E-01
	3.17E+01	8.24E-01
	3.17E+01	8.29E-01
	3.17E+01	8.33E-01
	3.22E+01	8.38E-01
	3.39E+01	8.43E-01
	3.48E+01	8.48E-01
	3.54E+01	8.52E-01
	3.60E+01	8.57E-01
	3.68E+01	8.62E-01
	4.03E+01	8.67E-01
	4.07E+01	8.71E-01
	4.24E+01	8.76E-01
	4.29E+01	8.81E-01
	4.42E+01	8.86E-01
	4.72E+01	8.91E-01
	4.97E+01	8.95E-01
	5.12E+01	9.00E-01
	6.13E+01	9.05E-01

		6.19E+01 9.10E-01 6.23E+01 9.14E-01 6.32E+01 9.19E-01 6.59E+01 9.24E-01 6.73E+01 9.29E-01 7.47E+01 9.33E-01 7.92E+01 9.38E-01 8.12E+01 9.43E-01 8.28E+01 9.48E-01 8.47E+01 9.52E-01 8.96E+01 9.57E-01 9.47E+01 9.62E-01 1.08E+02 9.67E-01 1.13E+02 9.71E-01 1.15E+02 9.76E-01 1.42E+02 9.81E-01 1.77E+02 9.86E-01 1.78E+02 9.91E-01 1.80E+02 9.95E-01 3.16E+02 1.00E+00
N1:Surface Soil Porosity	Porosity of the surface soil layer	DERIVED(none)
Default value used		
N2:Unsaturated Zone Porosity	Porosity of the unsaturated zone	DERIVED(none)
Default value used		
F1:Surface Soil Saturation	Saturation ratio of the surface soil layer	DERIVED(none)
Default value used		
F2:Unsaturated Zone Saturation	Saturation ratio of the unsaturated zone	DERIVED(none)
Default value used		
INFIL:Infiltration Rate	Net rate of infiltration to aquifer	DERIVED(m/y)
Default value used		
SCSST:Soil Classification	SCS soil classification ID	DISCRETE CUMULATIVE(none)
Default value used		Value Probability 1.00E+00 1.00E-04 2.00E+00 1.34E-03 3.00E+00 1.06E-02 4.00E+00 2.51E-02 5.00E+00 6.17E-02 6.00E+00 1.09E-01 7.00E+00 1.62E-01 8.00E+00 2.12E-01 9.00E+00 2.85E-01 1.00E+01 5.10E-01 1.10E+01 7.58E-01 1.20E+01 1.00E+00
NDEV:Porosity Probability	Relative porosity value within the distribution for this soil type	UNIFORM(none)
Default value used		Lower Limit 0.00E+00 Upper Limit 1.00E+00

KSDEV:Permeability Probability	Relative permeability value within the distribution for this soil type	UNIFORM(none)
Default value used		Lower Limit 0.00E+00 Upper Limit 1.00E+00
BDEV:Parameter "b" Probability	Relative value of "b" parameter within the distribution for this soil type	UNIFORM(none)
Default value used		Lower Limit 0.00E+00 Upper Limit 1.00E+00
AP:Water Application Rate	Total water application rate on cultivated area	CONTINUOUS LINEAR(m/y)
Default value used		Value / Probability 6.07E-01 / 0.00E+00 6.10E-01 / 4.62E-01 6.35E-01 / 4.76E-01 7.62E-01 / 5.40E-01 8.89E-01 / 6.29E-01 1.02E+00 / 7.05E-01 1.14E+00 / 8.04E-01 1.27E+00 / 8.79E-01 1.40E+00 / 9.41E-01 1.52E+00 / 9.82E-01 1.65E+00 / 9.98E-01 1.78E+00 / 1.00E+00
IR:Irrigation Rate	Annual average irrigation rate	CONSTANT(L/m**2-d)
Default value used		Value 1.29E+00
RHO1:Surface Soil Density	Bulk density of soil in the surface soil layer	DERIVED(g/mL)
Default value used		
RHO2:Unsaturated Zone Density	Bulk density of soil in the unsaturated zone	DERIVED(g/mL)
Default value used		
Ksat1:Surface Soil Permeabiliy	Saturated permeability of the surface soil layer	DERIVED(cm/sec)
Default value used		
VDR:Volume of Water Consumed	Volume of water withdrawn for consumptive use	CONSTANT(L)
Default value used		Value 1.18E+05
VSW:Volume of Water in Pond	Volume of water in the pond	CONSTANT(L)
Default value used		Value 1.30E+06
AR:Cultivated Area	Area of land cultivated	DERIVED(m**2)
Default value used		
sh:Soil Moisture Content	Moisture content of soil	DERIVED(none)
Default value used		
TTG:Gardening Period	Total time in gardening period	CONSTANT(days)
Default value used		Value 9.00E+01
TD:Drinking-water consumption period	Drinking-water consumption period	CONSTANT(days)

Default value used		Value 3.65E+02
THV(1):Holdup Period : Leafy	Holdup period for leafy vegetables	CONSTANT(days)
Default value used		Value 1.00E+00
THV(2):Holdup Period : Other vegetables	Holdup period for other vegetables	CONSTANT(days)
Default value used		Value 1.40E+01
THV(3):Holdup Period : Fruits	Holdup period for fruits	CONSTANT(days)
Default value used		Value 1.40E+01
THV(4):Holdup Period : Grains	Holdup period for grains	CONSTANT(days)
Default value used		Value 1.40E+01
THA(1):Holdup Period : Beef	Holdup period for beef	CONSTANT(days)
Default value used		Value 2.00E+01
THA(2):Holdup Period : Poultry	Holdup period for poultry	CONSTANT(days)
Default value used		Value 1.00E+00
THA(3):Holdup Period : Milk	Holdup period for milk	CONSTANT(days)
Default value used		Value 1.00E+00
THA(4):Holdup Period : Eggs	Holdup period for eggs	CONSTANT(days)
Default value used		Value 1.00E+00
TGV(1):Growing Period : Leafy	Minimum growing period for leafy vegetables	CONSTANT(days)
Default value used		Value 4.50E+01
TGV(2):Growing Period : Other vegetables	Minimum growing period for other vegetables	CONSTANT(days)
Default value used		Value 9.00E+01
TGV(3):Growing Period : Fruits	Minimum growing period for fruits	CONSTANT(days)
Default value used		Value 9.00E+01
TGV(4):Growing Period : Grains	Minimum growing period for grains	CONSTANT(days)
Default value used		Value 9.00E+01
TGF(1):Growing Period : Beef Forage	Minimum growing period for forage consumed by beef cattle	CONSTANT(days)
Default value used		Value 3.00E+01
TGF(2):Growing Period : Poultry Forage	Minimum growing period for forage consumed by poultry	DERIVED(days)
Default value used		
TGF(3):Growing Period : Milk Cow Forage	Minimum growing period for forage consumed by milk cows	DERIVED(days)

Default value used		
TGF(4):Growing Period : Layer Hen Forage	Minimum growing period for forage consumed by layer hens	DERIVED(days)
Default value used		
TGG(1):Growing Period : Beef Cow Grain	Minimum growing period for stored grain consumed by beef cattle	CONSTANT(days)
Default value used		Value 9.00E+01
TGG(2):Growing Period : Poultry Grain	Minimum growing period for stored grain consumed by poultry	DERIVED(days)
Default value used		
TGG(3):Growing Period : Milk Cow Grain	Minimum growing period for stored grain consumed by milk cows	DERIVED(days)
Default value used		
TGG(4):Growing Period : Layer Hen Grain	Minimum growing period for stored grain consumed by layer hens	DERIVED(days)
Default value used		
TGH(1):Growing Period : Beef Cow Hay	Minimum growing period for stored hay consumed by beef cattle	CONSTANT(days)
Default value used		Value 4.50E+01
TGH(2):Growing Period : Poultry Hay	Minimum growing period for stored hay consumed by poultry	DERIVED(days)
Default value used		
TGH(3):Growing Period : Milk Cow Hay	Minimum growing period for stored hay consumed by milk cows	DERIVED(days)
Default value used		
TGH(4):Growing Period : Layer Hen Hay	Minimum growing period for stored hay consumed by layer hens	DERIVED(days)
Default value used		
RV(1):Interception Fraction : Leafy	Interception fraction for leafy vegetables	UNIFORM(none)
Default value used		Lower Limit 1.00E-01 Upper Limit 6.00E-01
RV(2):Interception Fraction : Other vegetables	Interception fraction for other vegetables	UNIFORM(none)
Default value used		Lower Limit 1.00E-01 Upper Limit 6.00E-01
RV(3):Interception Fraction : Fruits	Interception fraction for fruits	UNIFORM(none)
Default value used		Lower Limit 1.00E-01 Upper Limit 6.00E-01
RV(4):Interception Fraction : Grains	Interception fraction for grains	UNIFORM(none)
Default value used		Lower Limit 1.00E-01 Upper Limit 6.00E-01
RF(1):Interception	Interception fraction for beef cattle	

Fraction : Beef Forage	forage	UNIFORM(none)
Default value used		Lower Limit 1.00E-01 Upper Limit 6.00E-01
RF(2):Interception Fraction : Poultry forage	Interception fraction for poultry forage	DERIVED(none)
Default value used		
RF(3):Interception Fraction : Milk Cow Forage	Interception fraction for milk cow forage	DERIVED(none)
Default value used		
RF(4):Interception Fraction : Layer Hen Forage	Interception fraction for layer hen forage	DERIVED(none)
Default value used		
RG(1):Interception Fraction : Beef Cow Grain	Interception fraction for beef cattle grain	UNIFORM(none)
Default value used		Lower Limit 1.00E-01 Upper Limit 6.00E-01
RG(2):Interception Fraction : Poultry Grain	Interception fraction for poultry grain	DERIVED(none)
Default value used		
RG(3):Interception Fraction : Milk Cow Grain	Interception fraction for milk cow grain	DERIVED(none)
Default value used		
RG(4):Interception Fraction : Layer Hen Grain	Interception fraction for layer hen grain	DERIVED(none)
Default value used		
RH(1):Interception Fraction : Beef Cow Hay	Interception fraction for beef cattle hay	DERIVED(none)
Default value used		
RH(2):Interception Fraction : Poultry Hay	Interception fraction for poultry hay	DERIVED(none)
Default value used		
RH(3):Interception Fraction : Milk Cow Hay	Interception fraction for milk cow hay	DERIVED(none)
Default value used		
RH(4):Interception Fraction : Layer Hen Hay	Interception fraction for layer hen hay	DERIVED(none)
Default value used		
YV(1):Crop Yield : Leafy	Crop yield for leafy vegetables	CONTINUOUS LINEAR(kg wet wt/m**2)
Default value used		Value Probability 2.70E+00 0.00E+00 2.71E+00 1.60E-03 2.74E+00 6.00E-03

		2.76E+00	1.76E-02
		2.78E+00	4.36E-02
		2.80E+00	8.48E-02
		2.82E+00	1.56E-01
		2.85E+00	2.57E-01
		2.87E+00	3.64E-01
		2.89E+00	5.00E-01
		2.91E+00	6.39E-01
		2.93E+00	7.46E-01
		2.96E+00	8.42E-01
		2.98E+00	9.09E-01
		3.00E+00	9.60E-01
		3.02E+00	9.84E-01
		3.04E+00	9.94E-01
		3.07E+00	9.97E-01
		3.09E+00	9.99E-01
		3.11E+00	1.00E+00
		3.13E+00	1.00E+00
		3.15E+00	1.00E+00
YV(2):Crop Yield : Other	Crop yield for other vegetables	CONTINUOUS LINEAR(kg wet wt/m**2)	
Default value used		Value	Probability
		2.26E+00	0.00E+00
		2.29E+00	8.00E-04
		2.30E+00	1.20E-03
		2.31E+00	6.40E-03
		2.33E+00	1.52E-02
		2.34E+00	3.28E-02
		2.35E+00	7.44E-02
		2.36E+00	1.40E-01
		2.38E+00	2.49E-01
		2.39E+00	3.80E-01
		2.40E+00	5.30E-01
		2.42E+00	6.61E-01
		2.43E+00	7.88E-01
		2.44E+00	8.86E-01
		2.45E+00	9.42E-01
		2.47E+00	9.75E-01
		2.48E+00	9.88E-01
		2.49E+00	9.96E-01
		2.51E+00	9.97E-01
		2.52E+00	9.99E-01
		2.53E+00	1.00E+00
		2.54E+00	1.00E+00
YV(3):Crop Yield : Fruits	Crop yield for fruits	CONTINUOUS LINEAR(kg wet wt/m**2)	
Default value used		Value	Probability
		2.17E+00	0.00E+00
		2.20E+00	1.20E-03
		2.21E+00	2.40E-03
		2.23E+00	6.80E-03
		2.25E+00	1.80E-02
		2.27E+00	4.36E-02
		2.29E+00	7.64E-02
		2.31E+00	1.38E-01
		2.32E+00	2.14E-01
		2.34E+00	3.27E-01

		2.36E+00 4.50E-01 2.38E+00 5.76E-01 2.40E+00 6.87E-01 2.42E+00 7.88E-01 2.43E+00 8.68E-01 2.45E+00 9.25E-01 2.47E+00 9.60E-01 2.49E+00 9.81E-01 2.51E+00 9.92E-01 2.53E+00 9.98E-01 2.54E+00 1.00E+00 2.56E+00 1.00E+00
YV(4):Crop Yield : Grains	Crop yield for grains	CONTINUOUS LINEAR(kg wet wt/m**2)
Default value used		Value Probability 2.85E-01 0.00E+00 2.90E-01 6.00E-04 3.02E-01 2.80E-03 3.14E-01 9.40E-03 3.26E-01 2.14E-02 3.38E-01 5.42E-02 3.50E-01 1.08E-01 3.62E-01 2.02E-01 3.74E-01 3.15E-01 3.86E-01 4.50E-01 3.98E-01 5.92E-01 4.10E-01 7.20E-01 4.23E-01 8.26E-01 4.35E-01 9.03E-01 4.47E-01 9.51E-01 4.59E-01 9.77E-01 4.71E-01 9.91E-01 4.83E-01 9.96E-01 4.95E-01 9.99E-01 5.07E-01 1.00E+00 5.19E-01 1.00E+00 5.31E-01 1.00E+00
YF(1):Crop Yield : Beef Forage	Crop yield for beef cattle forage	BETA(kg dry wt forage/m**2)
Default value used		Lower Limit 3.70E-01 Upper Limit 5.24E-01 p 2.36E+00 q 1.40E+00
YF(2):Crop Yield : Poultry Forage	Crop yield for poultry forage	DERIVED(kg wet wt forage/m**2)
Default value used		
YF(3):Crop Yield : Milk Cow Forage	Crop yield for milk cow forage	DERIVED(kg wet wt forage/m**2)
Default value used		
YF(4):Crop Yield : Layer Hen Forage	Crop yield for layer hen forage	DERIVED(kg wet wt forage/m**2)
Default value used		
YG(1):Crop Yield : Beef Cow Grain	Crop yield for beef cattle grain	NORMAL(kg dry wt grain /m**2)

Default value used		Mean 5.78E-01 Standard Deviation 7.77E-02
YG(2):Crop Yield : Poultry Grain	Crop yield for poultry grain	DERIVED(kg wet wt grain /m**2)
Default value used		
YG(3):Crop Yield : Milk Cow Grain	Crop yield for milk cow grain	DERIVED(kg wet wt grain /m**2)
Default value used		
YG(4):Crop Yield : Layer Hen Grain	Crop yield for layer hen grain	DERIVED(kg wet wt grain /m**2)
Default value used		
YH(1):Crop Yield : Beef Cow Hay	Crop yield for beef cattle hay	DERIVED(kg wet wt/m**2)
Default value used		
YH(2):Crop Yield : Poultry Hay	Crop yield for poultry hay	DERIVED(kg wet wt/m**2)
Default value used		
YH(3):Crop Yield : Milk Cow Hay	Crop yield for milk cow hay	DERIVED(kg wet wt/m**2)
Default value used		
YH(4):Crop Yield : Layer Hen Hay	Crop yield for layer hen hay	DERIVED(kg wet wt/m**2)
Default value used		
WV(1):Wet/dry : Leafy Vegetables	Wet/dry conversion factor for leafy vegetables	CONTINUOUS LINEAR(none)
Default value used		Value / Probability 3.32E-02 0.00E+00 4.89E-02 3.45E-02 5.47E-02 6.91E-02 5.96E-02 1.04E-01 6.36E-02 1.38E-01 6.70E-02 1.73E-01 7.05E-02 2.07E-01 7.38E-02 2.42E-01 7.48E-02 2.50E-01 7.72E-02 2.76E-01 8.03E-02 3.11E-01 8.34E-02 3.45E-01 8.66E-02 3.80E-01 9.00E-02 4.15E-01 9.36E-02 4.49E-01 9.73E-02 4.84E-01 9.91E-02 4.99E-01 1.01E-01 5.18E-01 1.05E-01 5.53E-01 1.09E-01 5.87E-01 1.13E-01 6.22E-01 1.18E-01 6.56E-01 1.23E-01 6.91E-01 1.29E-01 7.25E-01 1.33E-01 7.50E-01 1.35E-01 7.60E-01

		1.42E-01 7.94E-01 1.50E-01 8.29E-01 1.59E-01 8.64E-01 1.70E-01 8.98E-01 1.85E-01 9.33E-01 2.10E-01 9.67E-01 2.56E-01 9.91E-01 3.24E-01 1.00E+00
WV(2):Wet/dry : Other Vegetables	Wet/dry conversion factor for other vegetables	CONTINUOUS LINEAR(none)
Default value used		Value Probability 3.58E-02 0.00E+00 4.87E-02 3.45E-02 5.46E-02 6.91E-02 5.90E-02 1.04E-01 6.29E-02 1.38E-01 6.69E-02 1.73E-01 7.02E-02 2.07E-01 7.34E-02 2.42E-01 7.41E-02 2.50E-01 7.65E-02 2.76E-01 7.99E-02 3.11E-01 8.32E-02 3.45E-01 8.66E-02 3.80E-01 9.05E-02 4.15E-01 9.41E-02 4.49E-01 9.82E-02 4.84E-01 9.98E-02 4.99E-01 1.02E-01 5.18E-01 1.06E-01 5.53E-01 1.09E-01 5.87E-01 1.14E-01 6.22E-01 1.19E-01 6.56E-01 1.24E-01 6.91E-01 1.29E-01 7.25E-01 1.33E-01 7.50E-01 1.35E-01 7.60E-01 1.42E-01 7.94E-01 1.50E-01 8.29E-01 1.59E-01 8.64E-01 1.70E-01 8.98E-01 1.87E-01 9.33E-01 2.12E-01 9.67E-01 2.62E-01 9.91E-01 3.13E-01 1.00E+00
WV(3):Wet/dry : Fruit	Wet/dry conversion factor for fruits	CONTINUOUS LINEAR(none)
Default value used		Value Probability 3.66E-02 0.00E+00 4.87E-02 3.45E-02 5.45E-02 6.91E-02 5.93E-02 1.04E-01 6.31E-02 1.38E-01 6.72E-02 1.73E-01 7.10E-02 2.07E-01 7.44E-02 2.42E-01 7.52E-02 2.50E-01 7.78E-02 2.76E-01

		8.13E-02 3.11E-01 8.45E-02 3.45E-01 8.78E-02 3.80E-01 9.11E-02 4.15E-01 9.46E-02 4.49E-01 9.82E-02 4.84E-01 9.97E-02 4.99E-01 1.02E-01 5.18E-01 1.06E-01 5.53E-01 1.10E-01 5.87E-01 1.14E-01 6.22E-01 1.19E-01 6.56E-01 1.24E-01 6.91E-01 1.29E-01 7.25E-01 1.34E-01 7.50E-01 1.35E-01 7.60E-01 1.42E-01 7.94E-01 1.49E-01 8.29E-01 1.58E-01 8.64E-01 1.70E-01 8.98E-01 1.87E-01 9.33E-01 2.14E-01 9.67E-01 2.58E-01 9.91E-01 3.25E-01 1.00E+00
WV(4):Wet/dry : Grain	Wet/dry conversion factor for grains	CONSTANT(none)
Default value used		Value 8.80E-01
WF(1):Wet/dry : Beef Cow Forage	Wet/dry conversion factor for beef cattle forage	BETA(none)
Default value used		Lower Limit 1.83E-01 Upper Limit 3.23E-01 p 1.15E+00 q 1.18E+00
WF(2):Wet/dry : Poultry Forage	Wet/dry conversion factor for poultry forage	DERIVED(none)
Default value used		
WF(3):Wet/dry : Milk Cow Forage	Wet/dry conversion factor for milk cow forage	DERIVED(none)
Default value used		
WF(4):Wet/dry : Layer Hen Forage	Wet/dry conversion factor for layer hen forage	DERIVED(none)
Default value used		
WG(1):Wet/dry : Beef Cow Grain	Wet/dry conversion factor for beef cattle grain	CONSTANT(none)
Default value used		Value 8.80E-01
WG(2):Wet/dry : Poultry Grain	Wet/dry conversion factor for poultry grain	DERIVED(none)
Default value used		
WG(3):Wet/dry : Milk Cow Grain	Wet/dry conversion factor for milk cow grain	DERIVED(none)
Default value used		
WG(4):Wet/dry : Layer Hen Grain	Wet/dry conversion factor for layer hen grain	DERIVED(none)

Default value used		
WH(1):Wet/dry : Beef Cow Hay	Wet/dry conversion factor for beef cattle hay	DERIVED(none)
Default value used		
WH(2):Wet/dry : Poultry Hay	Wet/dry conversion factor for poultry hay	DERIVED(none)
Default value used		
WH(3):Wet/dry : Milk Cow Hay	Wet/dry conversion factor for milk cow hay	DERIVED(none)
Default value used		
WH(4):Wet/dry : Layer Hen Hay	Wet/dry conversion factor for layer hen hay	DERIVED(none)
Default value used		
QF(1):Ingestion Rate : Beef Cow Forage	Ingestion rate for beef cattle forage	BETA(kg dry wt forage/d)
Default value used		Lower Limit 1.69E+00 Upper Limit 2.29E+00 p 1.99E+00 q 9.11E-01
QF(2):Ingestion Rate : Poultry Forage	Ingestion rate for poultry forage	BETA(kg dry wt forage/d)
Default value used		Lower Limit 3.48E-03 Upper Limit 2.82E-02 p 1.51E+00 q 1.41E+00
QF(3):Ingestion Rate : Milk Cow Forage	Ingestion rate for milk cow forage	CONTINUOUS LINEAR(kg dry wt forage/d)
Default value used		Value Probability 6.35E+00 0.00E+00 6.77E+00 3.45E-02 6.96E+00 6.91E-02 7.10E+00 1.04E-01 7.24E+00 1.38E-01 7.35E+00 1.73E-01 7.47E+00 2.07E-01 7.57E+00 2.42E-01 7.60E+00 2.50E-01 7.67E+00 2.76E-01 7.77E+00 3.11E-01 7.87E+00 3.45E-01 7.98E+00 3.80E-01 8.08E+00 4.15E-01 8.18E+00 4.49E-01 8.31E+00 4.84E-01 8.37E+00 4.99E-01 8.42E+00 5.18E-01 8.54E+00 5.53E-01 8.67E+00 5.87E-01 8.81E+00 6.22E-01 8.95E+00 6.56E-01 9.10E+00 6.91E-01 9.26E+00 7.25E-01 9.38E+00 7.50E-01

		9.45E+00 7.60E-01 9.68E+00 7.94E-01 9.93E+00 8.29E-01 1.02E+01 8.64E-01 1.06E+01 8.98E-01 1.11E+01 9.33E-01 1.20E+01 9.67E-01 1.33E+01 9.91E-01 1.53E+01 1.00E+00
QF(4):Ingestion Rate : Layer Hen Forage	Ingestion rate for layer hen forage	BETA(kg dry wt forage/d)
Default value used		Lower Limit 1.19E-02 Upper Limit 2.22E-02 p 1.45E+00 q 7.92E-01
QG(1):Ingestion Rate : Beef Cattle Grain	Ingestion rate for beef cattle grain	BETA(kg dry wt grain/d)
Default value used		Lower Limit 1.69E+00 Upper Limit 2.29E+00 p 1.99E+00 q 9.11E-01
QG(2):Ingestion Rate : Poultry Grain	Ingestion rate for poultry grain	BETA(kg dry wt grain/d)
Default value used		Lower Limit 1.04E-02 Upper Limit 8.45E-02 p 1.51E+00 q 1.41E+00
QG(3):Ingestion Rate : Milk Cow Grain	Ingestion rate for milk cow grain	NORMAL(kg dry wt grain/d)
Default value used		Mean 1.71E+00 Standard Deviation 2.62E-01
QG(4):Ingestion Rate : Layer Hen Grain	Ingestion rate for layer hen grain	BETA(kg dry wt grain/d)
Default value used		Lower Limit 3.58E-02 Upper Limit 6.67E-02 p 1.43E+00 q 7.92E-01
QH(1):Ingestion Rate : Beef Cattle Hay	Ingestion rate for beef cattle hay	BETA(kg dry wt hay/d)
Default value used		Lower Limit 3.38E+00 Upper Limit 4.58E+00 p 1.99E+00 q 9.11E-01
QH(2):Ingestion Rate : Poultry Hay	Ingestion rate for poultry hay	CONSTANT(kg dry wt hay/d)
Default value used		Value 0.00E+00
QH(3):Ingestion Rate : Milk Cow Hay	Ingestion rate for milk cow hay	CONTINUOUS LINEAR(kg dry wt hay/d)
Default value used		Value Probability 5.12E+00 0.00E+00 5.43E+00 3.45E-02

		5.57E+00 6.91E-02 5.68E+00 1.04E-01 5.79E+00 1.38E-01 5.89E+00 1.73E-01 5.98E+00 2.07E-01 6.06E+00 2.42E-01 6.08E+00 2.50E-01 6.14E+00 2.76E-01 6.22E+00 3.11E-01 6.30E+00 3.45E-01 6.38E+00 3.80E-01 6.46E+00 4.15E-01 6.54E+00 4.49E-01 6.63E+00 4.84E-01 6.67E+00 4.99E-01 6.72E+00 5.18E-01 6.81E+00 5.53E-01 6.92E+00 5.87E-01 7.03E+00 6.22E-01 7.13E+00 6.56E-01 7.26E+00 6.91E-01 7.39E+00 7.25E-01 7.49E+00 7.50E-01 7.56E+00 7.60E-01 7.70E+00 7.94E-01 7.89E+00 8.29E-01 8.11E+00 8.64E-01 8.39E+00 8.98E-01 8.75E+00 9.33E-01 9.44E+00 9.67E-01 1.05E+01 9.91E-01 1.27E+01 1.00E+00
QH(4):Ingestion Rate : Layer Hen Hay	Ingestion rate for layer hen hay	CONSTANT(kg dry wt hay/d)
Default value used		Value 0.00E+00
QW(1):Water Rate : Beef Cattle	Water ingestion rate for beef cattle	CONSTANT(L/d)
Default value used		Value 5.00E+01
QW(2):Water Rate : Poultry	Water ingestion rate for poultry	CONSTANT(L/d)
Default value used		Value 3.00E-01
QW(3):Water Rate : Milk Cows	Water ingestion rate for milk cows	CONSTANT(L/d)
Default value used		Value 6.00E+01
QW(4):Water Rate : Layer Hens	Water ingestion rate for layer hens	CONSTANT(L/d)
Default value used		Value 3.00E-01
QD(1):Soil Fraction : Beef Cattle	Soil intake fraction for beef cattle	CONSTANT(none)
Default value used		Value 2.00E-02
QD(2):Soil Fraction : Poultry	Soil intake fraction for poultry	CONSTANT(none)
Default value used		Value 1.00E-01

QD(3):Soil Fraction : Milk Cows	Soil intake fraction for milk cows	CONSTANT(none)
Default value used		Value 2.00E-02
QD(4):Soil Fraction : Layer Hens	Soil intake fraction for layer hens	CONSTANT(none)
Default value used		Value 1.00E-01
MLV(1):Mass-Loading : Leafy Vegetables	Mass-loading factor for leafy vegetables	CONSTANT(none)
Default value used		Value 1.00E-01
MLV(2):Mass-Loading : Other Vegetables	Mass-loading factor for other vegetables	CONSTANT(none)
Default value used		Value 1.00E-01
MLV(3):Mass-Loading : Fruits	Mass-loading factor for fruits	CONSTANT(none)
Default value used		Value 1.00E-01
MLV(4):Mass-Loading : Grains	Mass-loading factor for grains	CONSTANT(none)
Default value used		Value 1.00E-01
LAMBDW:Weathering Rate	Weathering rate for activity removal from plants	CONSTANT(1/d)
Default value used		Value 4.95E-02
MLF(1):Mass-Loading : Beef Cow Forage	Mass-loading factor for beef cattle forage	CONSTANT(none)
Default value used		Value 1.00E-01
MLF(2):Mass-Loading : Poultry Forage	Mass-loading factor for poultry forage	CONSTANT(none)
Default value used		Value 1.00E-01
MLF(3):Mass-Loading : Milk Cow Forage	Mass-loading factor for milk cow forage	CONSTANT(none)
Default value used		Value 1.00E-01
MLF(4):Mass-Loading : Layer Hen Forage	Mass-loading factor for layer hen forage	CONSTANT(none)
Default value used		Value 1.00E-01
MLG(1):Mass-Loading : Beef Cattle Grain	Mass-loading factor for beef cattle grain	CONSTANT(none)
Default value used		Value 1.00E-01
MLG(2):Mass-Loading : Poultry Grain	Mass-loading factor for poultry grain	CONSTANT(none)
Default value used		Value 1.00E-01
MLG(3):Mass-Loading : Milk Cow Grain	Mass-loading factor for milk cow grain	CONSTANT(none)
Default value used		Value 1.00E-01
MLG(4):Mass-Loading : Layer Hen Grain	Mass-loading factor for layer hen grain	CONSTANT(none)
Default value used		Value 1.00E-01

MLH(1):Mass-Loading : Beef Cattle Hay	Mass-loading factor for beef cattle hay	CONSTANT(none)
Default value used		Value 1.00E-01
MLH(2):Mass-Loading : Poultry Hay	Mass-loading factor for poultry hay	CONSTANT(none)
Default value used		Value 1.00E-01
MLH(3):Mass-Loading : Milk Cow Hay	Mass-loading factor for milk cow hay	CONSTANT(none)
Default value used		Value 1.00E-01
MLH(4):Mass-Loading : Layer Hen Hay	Mass-loading factor for layer hen hay	CONSTANT(none)
Default value used		Value 1.00E-01
TFF(1):Feeding Period : Beef Cow Forage	Feeding period for beef cattle forage	CONSTANT(days)
Default value used		Value 3.65E+02
TFF(2):Feeding Period : Poultry Forage	Feeding period for poultry forage	CONSTANT(days)
Default value used		Value 3.65E+02
TFF(3):Feeding Period : Milk Cow Forage	Feeding period for milk cow forage	CONSTANT(days)
Default value used		Value 3.65E+02
TFF(4):Feeding Period : Layer Hen Forage	Feeding period for layer hen forage	CONSTANT(days)
Default value used		Value 3.65E+02
TFG(1):Feeding Period : Beef Cattle Grain	Feeding period for beef cattle grain	CONSTANT(days)
Default value used		Value 3.65E+02
TFG(2):Feeding Period : Poultry Grain	Feeding period for poultry grain	CONSTANT(days)
Default value used		Value 3.65E+02
TFG(3):Feeding Period : Milk Cow Grain	Feeding period for milk cow grain	CONSTANT(days)
Default value used		Value 3.65E+02
TFG(4):Feeding Period : Layer Hen Grain	Feeding period for layer hen grain	CONSTANT(days)
Default value used		Value 3.65E+02
TFH(1):Feeding Period : Beef Cattle Hay	Feeding period for beef cattle hay	CONSTANT(days)
Default value used		Value 3.65E+02
TFH(2):Feeding Period : Poultry Hay	Feeding period for poultry hay	CONSTANT(days)
Default value used		Value 3.65E+02
TFH(3):Feeding Period : Milk Cow Hay	Feeding period for milk cow hay	CONSTANT(days)
Default value used		Value 3.65E+02

TFH(4):Feeding Period : Layer Hen Hay	Feeding period for layer hen hay	CONSTANT(days)
Default value used		Value 3.65E+02
TFW(1):Water Period : Beef Cattle	Water ingestion period for beef cattle	CONSTANT(days)
Default value used		Value 3.65E+02
TFW(2):Water Period : Poultry	Water ingestion period for poultry	CONSTANT(days)
Default value used		Value 3.65E+02
TFW(3):Water Period : Milk Cows	Water ingestion period for milk cows	CONSTANT(days)
Default value used		Value 3.65E+02
TFW(4):Water Period : Layer Hens	Water ingestion period for layer hens	CONSTANT(days)
Default value used		Value 3.65E+02
fha(1):Hydrogen Fraction : Beef Cattle	Hydrogen fraction for beef cattle	CONSTANT(none)
Default value used		Value 1.00E-01
fha(2):Hydrogen Fraction : Poultry	Hydrogen fraction for poultry	CONSTANT(none)
Default value used		Value 1.00E-01
fha(3):Hydrogen Fraction : Milk Cows	Hydrogen fraction for milk cows	CONSTANT(none)
Default value used		Value 1.10E-01
fha(4):Hydrogen Fraction : Eggs	Hydrogen fraction for eggs	CONSTANT(none)
Default value used		Value 1.10E-01
fhv(1):Hydrogen Fraction : Leafy Vegetables	Hydrogen fraction for leafy vegetables	CONSTANT(none)
Default value used		Value 1.00E-01
fhv(2):Hydrogen Fraction : Other Vegetables	Hydrogen fraction for other vegetables	CONSTANT(none)
Default value used		Value 1.00E-01
fhv(3):Hydrogen Fraction : Fruits	Hydrogen fraction for fruits	CONSTANT(none)
Default value used		Value 1.00E-01
fhv(4):Hydrogen Fraction : Grains	Hydrogen fraction for grains	CONSTANT(none)
Default value used		Value 6.80E-02
fhf(1):Hydrogen Fraction : Beef Cow Forage	Hydrogen fraction for beef cattle forage	CONSTANT(none)
Default value used		Value 1.00E-01
fhf(2):Hydrogen		

Fraction : Poultry Forage	Hydrogen fraction for poultry forage	CONSTANT(none)
Default value used		Value 1.00E-01
fhf(3):Hydrogen Fraction : Milk Cow Forage	Hydrogen fraction for milk cow forage	CONSTANT(none)
Default value used		Value 1.00E-01
fhf(4):Hydrogen Fraction : Layer Hen Forage	Hydrogen fraction for layer hen forage	CONSTANT(none)
Default value used		Value 1.00E-01
fhh(1):Hydrogen Fraction : Beef Cattle Hay	Hydrogen fraction for beef cattle hay	CONSTANT(none)
Default value used		Value 1.00E-01
fhh(2):Hydrogen Fraction : Poultry Hay	Hydrogen fraction for poultry hay	CONSTANT(none)
Default value used		Value 1.00E-01
fhh(3):Hydrogen Fraction : Milk Cow Hay	Hydrogen fraction for milk cow hay	CONSTANT(none)
Default value used		Value 1.00E-01
fhh(4):Hydrogen Fraction : Layer Hen Hay	Hydrogen fraction for layer hen hay	CONSTANT(none)
Default value used		Value 1.00E-01
fhg(1):Hydrogen Fraction : Beef Cattle Grain	Hydrogen fraction for beef cattle grain	CONSTANT(none)
Default value used		Value 6.80E-02
fhg(2):Hydrogen Fraction : Poultry Grain	Hydrogen fraction for poultry grain	CONSTANT(none)
Default value used		Value 6.80E-02
fhg(3):Hydrogen Fraction : Milk Cow Grain	Hydrogen fraction for milk cow grain	CONSTANT(none)
Default value used		Value 6.80E-02
fhg(4):Hydrogen Fraction : Layer Hen Grain	Hydrogen fraction for layer hen grain	CONSTANT(none)
Default value used		Value 6.80E-02
fhd016:Hydrogen Fraction : Soil	Fraction of hydrogen in soil	DERIVED(none)
Default value used		
sasvh:Tritium Equivalence: Plant/Soil	Tritium equivalence: plant/soil	CONSTANT(none)
Default value used		Value 1.00E+00
sawvh:Tritium Equivalence:	Tritium equivalence: plant/water	CONSTANT(none)

Plant/Water		
Default value used		Value 1.00E+00
satah:Tritium Equivalence: Animal Products	Tritium equivalence: animal product intake	CONSTANT(none)
Default value used		Value 1.00E+00
YA(1):Animal Product Yield : Beef Cattle	Annual yield of beef per individual animal	CONSTANT(kg/y)
Default value used		Value 2.09E+02
YA(2):Animal Product Yield : Poultry	Annual yield of chicken per individual animal	CONSTANT(kg/y)
Default value used		Value 1.53E+00
YA(3):Animal Product Yield : Milk Cows	Annual yield of milk per individual animal	CONSTANT(L/y)
Default value used		Value 7.41E+03
YA(4):Animal Product Yield : Layer Hens	Annual yield of eggs per individual animal	CONSTANT(kg/y)
Default value used		Value 1.26E+01
ARExt:External Exposure Area	Minimum surface area to which resident is exposed via external radiation during residential period	CONSTANT(m**2)
Default value used		Value 1.00E+02
ARInh:Inhalation Exposure Area	Minimum surface area to which resident is exposed via inhalation during residential period	CONSTANT(m**2)
Default value used		Value 1.00E+02
ARIng:Secondary Ingestion Exposure Area	Minimum surface area to which resident is exposed via secondary ingestion during residential period	CONSTANT(m**2)
Default value used		Value 1.00E+02
ARAgr:Agricultural Exposure Area	Minimum surface area to which resident is exposed via any agricultural product during residential period	DERIVED(m**2)
Default value used		
ARH2O:Groundwater Exposure Area	Minimum surface area to which resident is exposed via groundwater during residential period	DERIVED(m**2)
Default value used		
ARAll:Exposure Area	Minimum surface area to which resident is exposed via any pathway during the residential period	DERIVED(m**2)
Default value used		

Element Dependant Parameters

Parameter Name	Description	Distribution
Tl:Coefficient	Partition coefficient for Tl	NORMAL(Log10(mL/g))
Default value used		Mean 2.20E+00

		Standard Deviation	1.40E+00
Pb:Coefficient	Partition coefficient for Pb	NORMAL(Log10(mL/g))	
Default value used		Mean Standard Deviation	3.38E+00 1.20E+00
Bi:Coefficient	Partition coefficient for Bi	NORMAL(Log10(mL/g))	
Default value used		Mean Standard Deviation	2.65E+00 1.40E+00
Po:Coefficient	Partition coefficient for Po	NORMAL(Log10(mL/g))	
Default value used		Mean Standard Deviation	2.26E+00 7.30E-01
Rn:Coefficient	Partition coefficient for Rn	CONSTANT(mL/g)	
Default value used		Value	0.00E+00
Ra:Coefficient	Partition coefficient for Ra	NORMAL(Log10(mL/g))	
Default value used		Mean Standard Deviation	3.55E+00 7.40E-01
Ac:Coefficient	Partition coefficient for Ac	NORMAL(Log10(mL/g))	
Default value used		Mean Standard Deviation	3.24E+00 1.40E+00
Th:Coefficient	Partition coefficient for Th	NORMAL(Log10(mL/g))	
Default value used		Mean Standard Deviation	3.77E+00 1.57E+00
Tl:Leafy	Leafy plant concentration factor for Tl	LOGNORMAL-N(pCi/kg dry-wt leafy per pCi/kg soil)	
Default value used		Mean of Ln(X) Standard Deviation of Ln	-5.52E+00 9.04E-01
Pb:Leafy	Leafy plant concentration factor for Pb	LOGNORMAL-N(pCi/kg dry-wt leafy per pCi/kg soil)	
Default value used		Mean of Ln(X) Standard Deviation of Ln	-3.10E+00 9.04E-01
Bi:Leafy	Leafy plant concentration factor for Bi	LOGNORMAL-N(pCi/kg dry-wt leafy per pCi/kg soil)	
Default value used		Mean of Ln(X) Standard Deviation of Ln	-3.35E+00 9.04E-01
Po:Leafy	Leafy plant concentration factor for Po	LOGNORMAL-N(pCi/kg dry-wt leafy per pCi/kg soil)	
Default value used		Mean of Ln(X) Standard Deviation of Ln	-5.99E+00 9.04E-01
Rn:Leafy	Leafy plant concentration factor for Rn	CONSTANT(pCi/kg dry-wt leafy per pCi/kg soil)	
Default value used		Value	0.00E+00
Ra:Leafy	Leafy plant concentration factor for Ra	LOGNORMAL-N(pCi/kg dry-wt leafy per pCi/kg soil)	
Default value used		Mean of Ln(X) Standard Deviation of Ln	-4.20E+00 9.04E-01
Ac:Leafy	Leafy plant concentration factor for Ac	LOGNORMAL-N(pCi/kg dry-wt leafy per pCi/kg soil)	
Default value used		Mean of Ln(X) Standard Deviation of Ln	-5.65E+00 9.04E-01
		LOGNORMAL-N(pCi/kg dry-wt leafy per	

Th:Leafy	Leafy plant concentration factor for Th	pCi/kg soil)
Default value used		Mean of Ln(X) -7.07E+00 Standard Deviation of Ln 9.04E-01
Tl:Root	Root plant concentration factor for Tl	LOGNORMAL-N(pCi/kg dry-wt roots per pCi/kg soil)
Default value used		Mean of Ln(X) -7.82E+00 Standard Deviation of Ln 9.04E-01
Pb:Root	Root plant concentration factor for Pb	LOGNORMAL-N(pCi/kg dry-wt roots per pCi/kg soil)
Default value used		Mean of Ln(X) -4.71E+00 Standard Deviation of Ln 9.04E-01
Bi:Root	Root plant concentration factor for Bi	LOGNORMAL-N(pCi/kg dry-wt roots per pCi/kg soil)
Default value used		Mean of Ln(X) -5.30E+00 Standard Deviation of Ln 9.04E-01
Po:Root	Root plant concentration factor for Po	LOGNORMAL-N(pCi/kg dry-wt roots per pCi/kg soil)
Default value used		Mean of Ln(X) -7.82E+00 Standard Deviation of Ln 9.04E-01
Rn:Root	Root plant concentration factor for Rn	CONSTANT(pCi/kg dry-wt roots per pCi/kg soil)
Default value used		Value 0.00E+00
Ra:Root	Root plant concentration factor for Ra	LOGNORMAL-N(pCi/kg dry-wt roots per pCi/kg soil)
Default value used		Mean of Ln(X) -6.50E+00 Standard Deviation of Ln 9.04E-01
Ac:Root	Root plant concentration factor for Ac	LOGNORMAL-N(pCi/kg dry-wt roots per pCi/kg soil)
Default value used		Mean of Ln(X) -7.96E+00 Standard Deviation of Ln 9.04E-01
Th:Root	Root plant concentration factor for Th	LOGNORMAL-N(pCi/kg dry-wt roots per pCi/kg soil)
Default value used		Mean of Ln(X) -9.37E+00 Standard Deviation of Ln 9.04E-01
Tl:Fruit	Fruit concentration factor for Tl	LOGNORMAL-N(pCi/kg dry-wt fruit per pCi/kg soil)
Default value used		Mean of Ln(X) -7.82E+00 Standard Deviation of Ln 9.04E-01
Pb:Fruit	Fruit concentration factor for Pb	LOGNORMAL-N(pCi/kg dry-wt fruit per pCi/kg soil)
Default value used		Mean of Ln(X) -4.71E+00 Standard Deviation of Ln 9.04E-01
Bi:Fruit	Fruit concentration factor for Bi	LOGNORMAL-N(pCi/kg dry-wt fruit per pCi/kg soil)
Default value used		Mean of Ln(X) -5.30E+00 Standard Deviation of Ln 9.04E-01
Po:Fruit	Fruit concentration factor for Po	LOGNORMAL-N(pCi/kg dry-wt fruit per pCi/kg soil)
Default value used		Mean of Ln(X) -7.82E+00 Standard Deviation of Ln 9.04E-01
Rn:Fruit	Fruit concentration factor for Rn	CONSTANT(pCi/kg dry-wt fruit per pCi/kg soil)

Default value used		Value 0.00E+00
Ra:Fruit	Fruit concentration factor for Ra	LOGNORMAL-N(pCi/kg dry-wt fruit per pCi/kg soil)
Default value used		Mean of Ln(X) -6.50E+00 Standard Deviation of Ln 9.04E-01
Ac:Fruit	Fruit concentration factor for Ac	LOGNORMAL-N(pCi/kg dry-wt fruit per pCi/kg soil)
Default value used		Mean of Ln(X) -7.96E+00 Standard Deviation of Ln 9.04E-01
Th:Fruit	Fruit concentration factor for Th	LOGNORMAL-N(pCi/kg dry-wt fruit per pCi/kg soil)
Default value used		Mean of Ln(X) -9.37E+00 Standard Deviation of Ln 9.04E-01
Tl:Grain	Grain concentration factor for Tl	LOGNORMAL-N(pCi/kg dry-wt grain per pCi/kg soil)
Default value used		Mean of Ln(X) -7.82E+00 Standard Deviation of Ln 9.04E-01
Pb:Grain	Grain concentration factor for Pb	LOGNORMAL-N(pCi/kg dry-wt grain per pCi/kg soil)
Default value used		Mean of Ln(X) -4.71E+00 Standard Deviation of Ln 9.04E-01
Bi:Grain	Grain concentration factor for Bi	LOGNORMAL-N(pCi/kg dry-wt grain per pCi/kg soil)
Default value used		Mean of Ln(X) -5.30E+00 Standard Deviation of Ln 9.04E-01
Po:Grain	Grain concentration factor for Po	LOGNORMAL-N(pCi/kg dry-wt grain per pCi/kg soil)
Default value used		Mean of Ln(X) -7.82E+00 Standard Deviation of Ln 9.04E-01
Rn:Grain	Grain concentration factor for Rn	CONSTANT(pCi/kg dry-wt grain per pCi/kg soil)
Default value used		Value 0.00E+00
Ra:Grain	Grain concentration factor for Ra	LOGNORMAL-N(pCi/kg dry-wt grain per pCi/kg soil)
Default value used		Mean of Ln(X) -6.50E+00 Standard Deviation of Ln 9.04E-01
Ac:Grain	Grain concentration factor for Ac	LOGNORMAL-N(pCi/kg dry-wt grain per pCi/kg soil)
Default value used		Mean of Ln(X) -7.96E+00 Standard Deviation of Ln 9.04E-01
Th:Grain	Grain concentration factor for Th	LOGNORMAL-N(pCi/kg dry-wt grain per pCi/kg soil)
Default value used		Mean of Ln(X) -9.37E+00 Standard Deviation of Ln 9.04E-01
Tl:Beef	Beef transfer factor for Tl	CONSTANT(d/kg)
Default value used		Value 4.00E-02
Pb:Beef	Beef transfer factor for Pb	CONSTANT(d/kg)
Default value used		Value 3.00E-04
Bi:Beef	Beef transfer factor for Bi	CONSTANT(d/kg)
Default value used		Value 4.00E-04

Po:Beef	Beef transfer factor for Po	CONSTANT(d/kg)
Default value used		Value 3.00E-04
Rn:Beef	Beef transfer factor for Rn	CONSTANT(d/kg)
Default value used		Value 0.00E+00
Ra:Beef	Beef transfer factor for Ra	CONSTANT(d/kg)
Default value used		Value 2.50E-04
Ac:Beef	Beef transfer factor for Ac	CONSTANT(d/kg)
Default value used		Value 2.50E-05
Th:Beef	Beef transfer factor for Th	CONSTANT(d/kg)
Default value used		Value 6.00E-06
Tl:Poultry	Poultry transfer factor for Tl	CONSTANT(d/kg)
Default value used		Value 3.00E-01
Pb:Poultry	Poultry transfer factor for Pb	CONSTANT(d/kg)
Default value used		Value 2.00E-01
Bi:Poultry	Poultry transfer factor for Bi	CONSTANT(d/kg)
Default value used		Value 1.00E-01
Po:Poultry	Poultry transfer factor for Po	CONSTANT(d/kg)
Default value used		Value 9.00E-01
Rn:Poultry	Poultry transfer factor for Rn	CONSTANT(d/kg)
Default value used		Value 0.00E+00
Ra:Poultry	Poultry transfer factor for Ra	CONSTANT(d/kg)
Default value used		Value 3.00E-02
Ac:Poultry	Poultry transfer factor for Ac	CONSTANT(d/kg)
Default value used		Value 4.00E-03
Th:Poultry	Poultry transfer factor for Th	CONSTANT(d/kg)
Default value used		Value 4.00E-03
Tl:Milk	Milk transfer factor for Tl	CONSTANT(d/L)
Default value used		Value 2.00E-03
Pb:Milk	Milk transfer factor for Pb	CONSTANT(d/L)
Default value used		Value 2.50E-04
Bi:Milk	Milk transfer factor for Bi	CONSTANT(d/L)
Default value used		Value 5.00E-04
Po:Milk	Milk transfer factor for Po	CONSTANT(d/L)
Default value used		Value 3.50E-04
Rn:Milk	Milk transfer factor for Rn	CONSTANT(d/L)
Default value used		Value 0.00E+00
Ra:Milk	Milk transfer factor for Ra	CONSTANT(d/L)
Default value used		Value 4.50E-04
Ac:Milk	Milk transfer factor for Ac	CONSTANT(d/L)
Default value used		Value 2.00E-05
Th:Milk	Milk transfer factor for Th	CONSTANT(d/L)

Default value used		Value 5.00E-06
Tl:Eggs	Egg transfer factor for Tl	CONSTANT(d/kg)
Default value used		Value 8.00E-01
Pb:Eggs	Egg transfer factor for Pb	CONSTANT(d/kg)
Default value used		Value 8.00E-01
Bi:Eggs	Egg transfer factor for Bi	CONSTANT(d/kg)
Default value used		Value 8.00E-01
Po:Eggs	Egg transfer factor for Po	CONSTANT(d/kg)
Default value used		Value 7.00E+00
Rn:Eggs	Egg transfer factor for Rn	CONSTANT(d/kg)
Default value used		Value 0.00E+00
Ra:Eggs	Egg transfer factor for Ra	CONSTANT(d/kg)
Default value used		Value 2.00E-05
Ac:Eggs	Egg transfer factor for Ac	CONSTANT(d/kg)
Default value used		Value 2.00E-03
Th:Eggs	Egg transfer factor for Th	CONSTANT(d/kg)
Default value used		Value 2.00E-03
Tl:Factor	Bioaccumulation factor for Tl in fish	CONSTANT(pCi/kg wet-wt fish per pCi/L water)
Default value used		Value 0.00E+00
Pb:Factor	Bioaccumulation factor for Pb in fish	CONSTANT(pCi/kg wet-wt fish per pCi/L water)
Default value used		Value 1.00E+02
Bi:Factor	Bioaccumulation factor for Bi in fish	CONSTANT(pCi/kg wet-wt fish per pCi/L water)
Default value used		Value 1.50E+01
Po:Factor	Bioaccumulation factor for Po in fish	CONSTANT(pCi/kg wet-wt fish per pCi/L water)
Default value used		Value 5.00E+02
Rn:Factor	Bioaccumulation factor for Rn in fish	CONSTANT(pCi/kg wet-wt fish per pCi/L water)
Default value used		Value 0.00E+00
Ra:Factor	Bioaccumulation factor for Ra in fish	CONSTANT(pCi/kg wet-wt fish per pCi/L water)
Default value used		Value 7.00E+01
Ac:Factor	Bioaccumulation factor for Ac in fish	CONSTANT(pCi/kg wet-wt fish per pCi/L water)
Default value used		Value 2.50E+01
Th:Factor	Bioaccumulation factor for Th in fish	CONSTANT(pCi/kg wet-wt fish per pCi/L water)
Default value used		Value 1.00E+02

Correlation Coefficients:

Parameter One	Parameter Two	Correlation

		Coefficient
KSDEV:Permeability Probability	**BDEV:Parameter "b" Probability**	-0.35
Default value used		
NDEV:Porosity Probability	**BDEV:Parameter "b" Probability**	-0.35
Default value used		

Summary Results:

90.00% **of the** 100 **calculated TEDE values are** < 2.30E+01 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 2.24E+01 **to** 2.59E+01 **mrem/year**

Detailed Results:

Note: All reported values are the upper bound of the symmetric 95% confidence interval for the 0.9 **quantile value**

Concentration at Time of Peak Dose:

Nuclide	Soil Concentration (pCi/g)	Water Concentration (pCi/g)
232Th	1.00E+00	4.15E-12
228Ra	1.00E+00	1.09E-08
228Ac	1.00E+00	1.09E-08
228Th	1.00E+00	2.89E-09
224Ra	1.00E+00	3.03E-09
220Rn	1.00E+00	3.03E-09
216Po	1.00E+00	3.03E-09
212Pb	1.00E+00	3.03E-09
212Bi	1.00E+00	3.03E-09
212Po	6.41E-01	1.94E-09
208Tl	3.59E-01	1.09E-09

Pathway Dose from All Nuclides (mrem)

All Pathways Dose	Agricultural	Drinking Water	Surface Water	External	Inhalation	Secondary Ingestion	Irrigation
2.59E+01	1.67E+01	8.33E-09	1.28E-08	6.53E+00	6.65E-01	7.05E-02	1.39E-08

Radionuclide Dose through All Active Pathways (mrem)

Nuclide	All Pathways Dose
232Th	1.04E+01
228Ra	5.24E+00

228Ac	2.52E+00
228Th	1.53E+00
224Ra	1.44E+00
220Rn	1.01E-03
216Po	4.44E-05
212Pb	5.08E-01
212Bi	4.92E-01
212Po	0.00E+00
208Tl	3.17E+00
All Nuclides	2.59E+01

Dose from Each Nuclide through Each Active Pathway (mrem)

Nuclide	Agricultural	Drinking Water	Surface Water	External	Inhalation	Secondary Ingestion	Irrigation
232Th	8.87E+00	5.23E-12	1.21E-11	2.53E-04	5.48E-01	3.87E-02	1.07E-11
228Ra	5.21E+00	7.22E-09	1.08E-08	0.00E+00	1.60E-03	2.03E-02	1.15E-08
228Ac	7.86E-03	1.09E-11	1.63E-11	2.51E+00	1.03E-04	3.06E-05	1.73E-11
228Th	1.30E+00	5.29E-10	1.13E-09	3.80E-03	1.14E-01	5.60E-03	1.16E-09
224Ra	1.23E+00	5.12E-10	7.65E-10	2.39E-02	1.05E-03	5.18E-03	1.09E-09
220Rn	0.00E+00	0.00E+00	0.00E+00	1.01E-03	0.00E+00	0.00E+00	0.00E+00
216Po	0.00E+00	0.00E+00	0.00E+00	4.44E-05	0.00E+00	0.00E+00	0.00E+00
212Pb	1.54E-01	6.37E-11	1.36E-10	3.30E-01	5.64E-05	6.44E-04	1.36E-10
212Bi	3.60E-03	1.49E-12	3.17E-12	4.89E-01	7.21E-06	1.50E-05	3.17E-12
212Po	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
208Tl	0.00E+00	0.00E+00	0.00E+00	3.17E+00	0.00E+00	0.00E+00	0.00E+00

Attachment E

RESRAD Results

Attachment F

Instrumentation Calibration Certificates