US Army Corps of Engineers®
Buffalo District

FINAL

REMEDIAL INVESTIGATION REPORT

TONAWANDA LANDFILL VICINITY PROPERTY

TONAWANDA, NEW YORK

APRIL 2005

EXECUTIVE SUMMARY

SITE DESCRIPTION AND BACKGROUND

The Tonawanda Landfill Vicinity Property is located approximately 1.5 miles north of the Linde (Praxair) Site in the Town of Tonawanda. It is comprised of two main parcels – the Town of Tonawanda Landfill (Landfill) and the Mudflats. Both properties are owned by the Town of Tonawanda, NY and the area is essentially zoned commercial/industrial, except for the bordering residential area to the north.

The Landfill parcel comprises approximately 55 acres, is located at the northern end of East Park Drive, and is bounded by residential developments to the north and northwest, a railroad line to the east, and an easement owned by the Niagara Mohawk Power Corporation (NMPC) to the south. The Mudflats parcel is approximately 115 acres in size and is bordered by the NMPC easement to the north, a railroad line to the east, on the west by the incinerator access road, and to the south by Interstate 290.

The Landfill was operated as a municipal landfill by the Town of Tonawanda from the mid-1930's through October 1989. Wastes disposed in the landfill included ash generated by the incinerators (formerly located just west of the mudflats), construction/demolition debris, and yard refuse (leaves, branches, etc.) collected from Town residents. On occasion, the landfill accepted municipal solid waste and wastewater sludge (formerly incinerated at the incinerators), but only when the incinerators were temporarily inoperable. The incinerators were demolished in 2002. Other than the incinerators, the Mudflats have always been vacant.

A previous investigation conducted by the Town of Tonawanda in 1988 indicated the presence of a non-MED-like radionuclide, americium-241 (Am-241), in material in two locations in the Landfill portion of the Site. The source of the Am-241 was found to be a nearby former manufacturing facility, which used radioactive components, that discharged Am-241 contaminated material to the sanitary sewer, which ultimately ended up in the wastewater sludge generated at the municipal wastewater treatment plant. In 1989, a New York State Task Force approved capping the Am-241 in place with an additional 3 feet of fill placed over the material before the final cap is constructed.

The Town of Tonawanda is in the process of closing the Landfill in accordance with the New York State regulations. Cover material is being placed in areas of the Landfill (primarily at the eastern end) in preparation for capping and closure.

The Town of Tonawanda's plans for the Mudflats area include industrial development of the area. Portions of the Mudflats area are being used as debris collection locations for the Town of Tonawanda Department of Public Works. Street sweepings, mulch, tree limbs, etc., are stored on portions of the site. Part of the closure plan for the Landfill calls for the Mudflats being used as the borrow source for much of the final cover material in the Landfill.

PREVIOUS INVESTIGATIONS

Initial radioactive material surveys for the presence of MED-like contaminants at the Landfill and Mudflats were conducted by DOE in 1990 as part of the Linde FUSRAP Site investigation. A limited radiological investigation was later conducted by ORNL for DOE in September 1991. The results of the investigation showed some area soils in the Landfill and Mudflats exceeding the radionuclide guideline concentrations established by the DOE for the Tonawanda FUSRAP Sites. Laboratory results indicated some soil samples exhibited characteristics similar to the MED product formerly produced at the Linde

facility and others were consistent with the by-products of the refinery process conducted at the same Linde facility. As a result of these investigations, the impacted areas of the Landfill and Mudflats were subsequently designated as a Vicinity Property of the Linde FUSRAP Site due to the discovery of materials that appeared to have characteristics similar to MED materials originating at the Linde Site.

DOE conducted additional soil sampling activities at the Landfill and Mudflats in 1994 to determine the vertical extent of the radiological contamination at the site. Analytical results obtained for subsurface soil, sediment, surface water, and groundwater samples indicated the radiological contamination was essentially limited to the upper 1.5 feet of soil. However, contamination above the DOE guideline concentrations was detected in one sample collected 11.5 feet below existing grade.

USACE INVESTIGATION IN 2001

To supplement information available from prior investigations, USACE conducted a field investigation at the Tonawanda Landfill Vicinity Property in 2001. The 2001 investigation included collection and analyses of over 500 soil samples, from borings at varying depths in the Landfill and Mudflats OUs, including samples in non-impacted areas to determine background levels of radionuclides in vicinity soils. Surface water and sediment samples were also collected. Groundwater samples from existing monitoring wells installed by the Town of Tonawanda were also collected for analyses. The field investigation also included preliminary walkovers to identify areas of elevated gamma radiation (gamma walkover surveys [GWS]), site survey and mapping, groundwater elevation level measurements to determine the direction of groundwater flow, and related field activities as described in the *Sampling and Analysis Plan (SAP), Tonawanda FUSRAP Site, Tonawanda, New York* and detailed in the RI report. A detailed discussion of the sampling efforts and results is contained in Section 4 of the RI report. The following provide a brief summary of the efforts and the results.

SOILS INVESTIGATION – MUDFLATS OU

Soil samples were collected at 96 locations in the Mudflats Operable Unit (OU) in 2001. From these 96 sampling locations, including Quality Control/Quality Assurance (QA/QC) samples, a total of 224 soil samples collected from the Mudflats OU. These samples were analyzed primarily for uranium, thorium, radium, and americium.

To define the nature and extent of radiologically-impacted material (MED-like material) in the Mudflats OU, screening levels for U-238, Th-230 and Ra-226 were developed based on the Mudflats OU background reference data set. Of the 224 soil samples that were analyzed, concentrations of Th-230, U-238 and/or Ra-226 exceeded the screening criteria in only four soils samples from two locations in the Mudflats OU. Trace amounts of Am-241 were detected and were most likely due to physical transfer (on vehicles, etc.) from the landfill. There were no exceedances of the screening level for the MED-like materials at those locations.

Soil sample results from previous investigations in the Mudflats were also compared to screening levels established for the Mudflats reference area in 2001. Th-230, U-238, and/or Ra-226 detected in previous investigations above the screening levels were not detected at concentrations above their respective screening criteria in the soil samples collected in 2001 from corresponding locations. It is believed that between the previous and the 2001 investigations significant re-contouring and general disturbance of soils has taken place that either buried or blended the soils with previous elevated results.

SOILS INVESTIGATION – LANDFILL OU

Soil samples were collected at 114 locations in the Landfill OU in 2001. A total of 280 soil samples (including QA/QC samples) were collected at these 114 locations. The radiological analyses of these samples was the same as the analyses performed on the Mudflats OU soil samples as described above.

To define the nature and extent of radiologically-impacted material (MED-like material) in the Landfill OU, screening levels for U-238, Th-230 and Ra-226 were developed based on the Landfill OU background reference data set. For the 2001 data set, within the Landfill OU, the majority of the screening level exceedances were detected in Area A. Soil sample results from previous investigations were also compared to screening levels from the Landfill reference area. The locations where the screening levels were exceeded in previous or 2001 samples are discussed in Section 4 of the RI report. Sample results from the 2001 investigation as well as the historical investigations exceeding the screening criteria are compiled in Table 4-20 of the RI report. Both the 2001 and the historical exceedances of the screening levels in soil were plotted for Areas A and B in Figures 4-11 and 4-13, respectively of the RI report. In general, the lateral extent of MED-like material as defined by the 2001 soil investigation is within the footprint of the MED-like material as defined by the historical investigations.

The detections of Am-241 in soil during the 2001 investigation are consistent with the detections of Am-241 during previous investigations within the Landfill OU. In the soil samples in which Am-241 was detected, there were no exceedances of the screening levels for U-238, Th-230, and/or Ra-226, indicating that at those locations the potentially MED-like soil and Am-241-impacted soil are not commingled.

SEDIMENT AND SURFACE WATER – LANDFILL OU

During the 2001 investigation, surface water/sediment samples were collected from several locations within the landfill as shown in Figure 4-16 of the RI report. The radiological analyses of the sediment and surface water samples was the same as the analyses of soil samples except total uranium analyses was performed on the surface water samples only. The analytical results for the surface water and sediment samples are shown in Table 4-24 of the RI report. Soils screening levels for radionuclides were exceeded in sediment samples collected at only two locations. Surface water sample results were screened using the groundwater standards of 40 CFR Part 192, Subpart A. All of the surface water samples collected had exceedances of one or more of the 40 CFR Part 192, Subpart A groundwater standards.

GROUNDWATER – TONAWANDA LANDFILL VICINITY PROPERTY

As part of the USACE RI, groundwater samples were collected from eleven existing shallow monitoring wells and three deeper contact-zone aquifer monitoring wells located at the Tonawanda Landfill Vicinity Property. The locations of the monitoring wells sampled are shown in Figure 2-2 of the RI report.

Both total (unfiltered) and dissolved (filtered with a 0.45 µm filter) samples were collected from each well and analyzed primarily for uranium, thorium and radium. The results (Table 4-11 of the RI report) were compared to the groundwater standards of 40 CFR Part 192, Subpart A. The results at only one well, which is screened directly within the landfill waste material, exceeded the uranium standards.

CONTAMINANT FATE AND TRANSPORT

Potential release and transport scenarios for the MED-like material at the Site identified in the RI report include (1) displacement and transport by the action of humans or animals; (2) displacement and transport by wind and air; and (3) release and transport by water.

The physical displacement of contaminated material is possible when activities such as construction are inadvertently conducted in contaminated areas. The potential for displacement of contaminants by the wind (fugitive dust emissions), with subsequent transport in the air as particulate material, is always present where soils are directly exposed to the wind. Fugitive dust emissions potentials are highest in hot and dry conditions and may be persistent or short term during intrusive activities such as construction or other activities involving vehicles (trucks, dirt bikes, etc.). While most of the landfill areas where MED-like material has been identified are vegetated, bare areas exist and access to these areas is not totally precluded. Thus, the potential for dust generation from off-road vehicles and other intrusive activities is not precluded.

One potential pathway for water transport of contamination evaluated in the RI report for the landfill is by runoff. The migration of radionuclides from soil to groundwater is also addressed. The principal means for facilitating any releases from the Landfill OU source areas is by dissolving the contaminants in the source area, with subsequent potential for transport of the contaminants in the liquid phase. The principal mechanism for potential release of MED-like contaminants at the Tonawanda Landfill Vicinity Property is by leaching of uranium from source areas. Closure of the Landfill in accordance with current conceptual plans would significantly reduce precipitation into the landfilled waste and mounding in the water table in the Landfill would be decreased, resulting in a potential reduction in uranium leaching.

RADIOLOGICAL BASELINE RISK ASSESSMENT

The radiological Baseline Risk Assessment (BRA) for the Tonawanda Landfill Vicinity Property is included in Section 6 of the RI report. It provides an analysis of baseline human health risks that would result from exposure to possible MED-like contaminants at the Tonawanda Landfill Vicinity Property. In addition, the BRA contains a screening level ecological risk assessment for exposure to the possible MED-like contaminants. The approach used for the Tonawanda BRA is based on EPA *Risk Assessment Guidance for Superfund* and prior USACE reports. The risk to human health is determined using the RESidual RADioactivity (RESRAD) code. This code was developed by Argonne National Laboratory (ANL) and is a widely accepted methodology for determining the radiological dose and carcinogenic risk to human health due to radioactive contaminants.

The BRA includes the evaluation of potential radiological carcinogenic risk for the areas of the Tonawanda Landfill Vicinity Property which may have been impacted by MED-like contaminants. The BRA is limited to possible MED-like materials. It is an evaluation of radiological dose and carcinogenic risks from exposure to radionuclides. It does, however, also include the non-carcinogenic risk estimates for uranium.

In the BRA, human exposures are evaluated under current and future central tendency (CT-mean or average) and reasonable maximum exposure (RME) conditions for various site-specific exposure scenarios and receptors. Exposure scenarios were developed based on existing conditions and potential future uses. Exposure scenarios examined for the Landfill OU include: baseline conditions (recreational use - current), a worker who constructs the landfill cap for closure (construction worker), and a recreational user who utilizes the Landfill following closure (recreational user – future). The post-closure exposure scenarios assume that the Landfill is closed in accordance with the closure plans submitted by

Malcolm Pirnie, the Town of Tonawanda's contractor, without removal of radioactive material. Exposure scenarios for the Mudflats OU include a recreational user, a construction worker, and an industrial worker. Residential future use is believed to be unlikely; however, residential scenarios (adult and child) were developed for the Mudflats.

In summary, the BRA for the Tonawanda Landfill Vicinity Property utilized soil contamination data from prior and 2001 investigations by USACE to identify Contaminants of Potential Concern (COPCs). These COPCs were determined using screening techniques detailed in Section 6.2 of the RI report, and include U-238, U-235, Th-232 and their long-lived daughter products (including Th-230 and Ra-226).

The property was divided into six exposure units to facilitate the calculation of exposure point concentrations and risks. Current and plausible future use scenarios were considered and evaluated, as detailed in Section 6.3. Completed pathways for exposure were also assessed in Section 6.3. Pathways identified as complete included exposure to external gamma radiation; exposure via inhalation of airborne particles; ingestion of soil; and ingestion of homegrown produce (for residential scenarios). EU 6, site groundwater, was eliminated because no complete pathway existed, since the site groundwater is non-potable. The remaining exposure units were assessed for exposure to radioactive contaminants in surface and subsurface soils.

Finally, an ecological risk screening was performed, to assess the impact of contamination on terrestrial and aquatic biota. This assessment is detailed in Section 6.6, and summarized in Section 6.7.5 of the RI report.

Uranium, in soluble form, is a kidney toxin at concentrations slightly above background levels, and is the only radionuclide for which the chemical toxicity has been identified to be comparable to or greater than the radiotoxicity. Only uranium is considered as both a carcinogenic and non-carcinogenic hazard. Uranium toxicity did not exceed a Hazard Index of one for any scenarios for both the Landfill and Mudflats operable units.

The ecological risk screening identified limited areas that pose a threat to terrestrial receptors. These areas are located within one area of the Landfill operable unit. Capping that portion of the landfill in accordance with the Town of Tonawanda's closure plans would address the ecological risk. Also, note that the terrestrial and wetland areas at the site are of poor quality and are not currently managed for ecological purposes, nor are there any plans to manage these areas for ecological purposes in the future. These current and future land uses will allow for minimal habitat for ecological receptors and thus minimal exposure to ecological receptors.

CONCLUSION

The radiological risks results for both the Landfill and Mudflats operable units indicate that for current and plausible future scenarios, all excess cancer risks except one are less than the 10^{-4} CERCLA risk threshold. The risk for the recreational user, under current conditions (i.e., with no further capping of contaminated areas) in the Landfill operable unit is at the CERCLA risk threshold. The recreational receptor producing the risk of 1×10^{-4} is conservatively assumed to visit the site 350 days per year for 30 years. This exposure includes 15 minutes per weekday and 46 minutes per weekend assuming all time on-site is spent within the contaminated zone. This risk is driven by a few hot spots derived from historical data which was not confirmed in the 2001 investigation and sampling. After the landfill is closed under NYSDEC regulations, including completion of the cap, all risks are expected to be well below the CERCLA threshold.

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TONAWANDA, NEW YORK

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LIST OF ACRONYMS, ABBREVIATIONS AND SYMBOLS

μg/L	micrograms per liter
μm	micron
σ	Standard Deviation
A	Atomic Weight
Ac	actinium
AEC	Atomic Energy Commission
Am	Americium
ANL	Argonne National Laboratory
ARARs	Applicable and Relevant and Appropriate Requirements
ATSDR	Agency for Toxic Substances and Disease Registry
B	background
BAF	Bioaccumulation Factor
BEIR	Biological Effects of Ionizing Radiation
bgs	below ground surface
BNI	Bechtel National, Incorporated
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as Amended
CFR	Code of Federal Regulations
Ci	curie
CL	Lean Clay
cm/s	centimeter(s) per second
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern
Cs	cesium
CSF	Cancer Slope Factor
CT	Central Tendency
cpm	counts per minute
DCF	dose conversion factor
DOE	U.S. Department of Energy
DSR	Dose/Source Ratio
ECWA	Erie County Water Authority
EFH	Exposure Factors Handbook
EPA	U.S. Environmental Protection Agency
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
EU	Exposure Unit
FBDU	Ford, Bacon, and Davis Utah
FGR	Federal Guidance Report
FS	Feasibility Study
FSP	Field Sampling Plan
ft	foot or feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
FWS	United States Fish and Wildlife Service
g/cm^3	grams per cubic centimeter
g/kg/day	gram(s) per kilogram per day
g/m^3	grams per cubic meter
gpm	gallon(s) per minute

GPS	Global Positioning System
g/yr	grams per year
GWS	Gamma Walkover Survey
HEAST	Health Effects Summary Tables
HELP	Hydrologic Evaluation of Landfill Performance
HHA	Human Health Assessment
HI	Hazard Index
HQ	Hazard Quotient
h	hour
ha	hectare
hrs/day	hours per day
hrs/wk	hours per week
ICRP	International Commission on Radiation Protection
ILCR	Incremental Lifetime Cancer Risk
in	inch
in^2	square inch
IRIS	Integrated Risk Information System
(J)	estimated
K	potassium
k	Hydraulic Conductivity
K_d	distribution coefficient
kg	kilograms
kg/yr	kilograms per year
KPA	Kinetic Phosphorescence Analysis
L	limiting concentration
m	meter(s)
m/yr	meters per year
m^2	square meter(s)
m^3	cubic meter
m^3/hr	cubic meter(s) per hour
m^3/yr	cubic meters per year
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	Minimum Detectable Activity
MDCR	minimum detectable count rate
MED	Manhattan Engineer District
MeV	mega electron-volts
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/kg/d	milligrams per kilogram per day
mg/yr	milligrams per year
mi	mile(s)
mg/L	milligrams per liter
ML	Silt
mL/g	milliliters per gram
mrem	millirem
mrem/yr	millirem(s) per year
msl	Mean Sea Level
NaI	sodium iodide
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCRP	National Council on Radiation Protection
NMPC	Niagara Mohawk Power Corporation

NORM	Naturally Occurring Radioactive Material
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
Pa	protactinium
Pb	lead
PCB	Polychlorinated Biphenyl
pCi/g	picocuries per gram
pCi/L	picocuries per liter
pCi/µg	picocuries per microgram
PL	Public Law
PP	Proposed Plan
PRG	Preliminary Remediation Goals
PS	Performance Standards
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
(R)	rejected
Ra	Radium
rad/d	rads per day
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act of 1976
RESRAD	RESidual RADioactivity Computer Code
R_f	retardation factor
Rfd	Reference Dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RL	Reporting Limit
RME	Reasonable Maximum Exposure
Rn	Radon
ROD	Record of Decision
ROPC	Radionuclide of Potential Concern
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedures
SVOC	Semi-Volatile Organic Compound(s)
t	time
$T_{1/2}$	half-life
TAL	Target Analyte List
Tc	Technetium
TCL	Target Contaminant List
TCLP	Toxicity Characteristic Leaching Procedure
Th	Thorium
U	Uranium
(U)	undetected
UCL95	95th percentile of the upper confidence limit
USACE	United States Army Corps of Engineers
USCS	United Soil Classification System
USNRC	United States Nuclear Regulatory Commission
UTL95	95th Percentile upper tolerance limit

UTL 99/99.9	99 Percentile upper tolerance limit, with 99.9 percent coverage
Utotal	Total Uranium (U-234 + U-235 + U-238)
VOC	Volatile Organic Compound(s)
WWTP	Wastewater Treatment Plant

REMEDIAL INVESTIGATION REPORT
TONAWANDA LANDFILL VICINITY PROPERTY,
TONAWANDA, NEW YORK

1.0 INTRODUCTION

The Formerly Utilized Sites Remedial Action Program (FUSRAP) was initiated in 1974 to identify, investigate and cleanup or otherwise control sites throughout the United States that became contaminated as a result of the nation's early atomic energy program. Many of the sites became contaminated during activities of private contractors under contract to the Manhattan Engineer District (MED) and/or the Atomic Energy Commission (AEC).

The United States Department of Energy (DOE) and its predecessor, the AEC, were responsible for FUSRAP from its inception until October 1997, when the Energy and Water Development Appropriations Act for Fiscal Year 1998, Public Law (PL) 105-62, transferred responsibility for the administration and execution of FUSRAP from DOE to the United States Army Corps of Engineers (USACE).

Early FUSRAP investigations by DOE in the Town of Tonawanda, New York found that during the early to mid-1940s, portions of the property formerly owned by Linde Air Products Corp., a subsidiary of Union Carbide Industrial Gas (Linde), now owned by Praxair, Inc., were used for the processing of uranium ores. The processing activities, conducted under an MED contract, resulted in elevated radionuclide levels in portions of the Linde property. Subsequent disposal and relocation of the processing wastes from the Linde property resulted in elevated levels of radionuclides at three nearby properties in the Town of Tonawanda: the Ashland 1 property; the Seaway property; and the Ashland 2 property. The Linde property was designated as a FUSRAP site by DOE in 1980 and the Ashland 1, Ashland 2, and Seaway Sites were designated as FUSRAP Sites in 1984.

In 1992, following an investigation by Oak Ridge National Laboratory (ORNL), DOE designated the Tonawanda Landfill as a FUSRAP Vicinity Property for the Linde Site due to the discovery of materials that appeared to have characteristics similar to MED materials originating at the Linde Site (DOE 1992). The Town of Tonawanda Landfill Vicinity Property (Tonawanda Landfill Vicinity Property) includes portions of the areas known as the Town of Tonawanda Landfill (Landfill) and the Mudflats Area (Mudflats). FUSRAP Sites in the Town of Tonawanda are shown in Figures 1-1 and 1-2. This report presents the findings of a remedial investigation (RI) of the Tonawanda Landfill Vicinity Property conducted by USACE (Figure 1-3).

To facilitate the investigation, and future decisions about the Tonawanda Landfill Vicinity Property, two Operable Units (OUs) were identified for the RI – one for the Mudflats and one for the Landfill. These OUs limited the investigations to the areas of the Landfill and Mudflats where previous investigations had indicated the presence of MED-like material, and the vicinity of those areas. The OUs are outlined in Figure 1-4. The Landfill OU does not encompass the entire Landfill, nor does the Mudflats OU encompass the entire Mudflats. References to Landfill and Mudflats results throughout this document are generally limited to the OUs depicted in Figure 1-4.

The Energy and Water Development Appropriations Act for Fiscal Year 2000, PL 106-60, requires that USACE comply with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), in conducting FUSRAP cleanup work. Therefore, USACE is conducting FUSRAP investigations and cleanups in accordance with CERCLA.

1.1 Overview of the Remedial Investigation

In accordance with CERCLA and its principal implementing regulation, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), USACE conducted a Remedial Investigation (RI) for the Tonawanda Landfill Vicinity Property. In the CERCLA process, the RI is conducted to characterize the site and determine the nature and extent of site contamination. A Baseline Risk Assessment (BRA) is also performed to assess current and future risks to human health and the environment posed by site contamination.

1.1.1 Purpose/Objectives of the RI for the Tonawanda Landfill Vicinity Property

The principal objective of the RI was to determine the nature and extent of potential MED-like radiological contamination present at the Tonawanda Landfill Vicinity Property in accordance with the requirements of CERCLA. The following project goals were established (USACE 2001b):

- determine the extent of MED-like constituents in onsite soils and groundwater;
- acquire information to describe the fate and transport of contaminants within and from the Site;
- collect data of sufficient quality and quantity to be legally defensible under regulatory requirements;
- gather sufficient information to complete a BRA, including an assessment of both human health and ecological risk;
- determine whether MED-like contaminants present constitute a threat to human health.

This document is the RI report for the Tonawanda Landfill Vicinity Property. It summarizes the USACE 2001 investigations and previous site investigations [Oak Ridge National Laboratory (ORNL) 1992, Bechtel National Inc. (BNI) 1995)]. This report also assesses the fate and transport of site contaminants and describes the conceptual site model, and also includes the radiological BRA for the Site.

1.2 Site Background

1.2.1 Site Description

The Tonawanda Landfill Vicinity Property is located approximately 1.5 miles north of the Linde (Praxair) FUSRAP Site in the Town of Tonawanda, New York. It is comprised of two main parcels – the Town of Tonawanda Landfill (Landfill) and the Mudflats (see Figure 1-3). Both properties are owned by the Town of Tonawanda, NY and the area is essentially zoned as commercial/ industrial except for the bordering residential area described below.

The Landfill parcel comprises approximately 55 acres, is located at the northern end of East Park Drive, and is bounded by the residential developments to the north and northwest, a railroad line to the east, and an easement owned by the Niagara Mohawk Power Corporation (NMPC) to the south. The Mudflats portion of the property is located on the opposite side (south) of the NMPC easement that borders the Landfill. The Mudflats parcel is approximately 115 acres in size and is bordered by the NMPC easement to the north, a railroad line to the east, on the west by the incinerator access road, and to the south by Interstate 290 (Youngmann Expressway).

A 48-inch diameter Erie County Water Authority (ECWA) water transmission line traverses through the NMPC easement. ECWA also has another easement for a second parallel 48-inch diameter water line through the NMPC easement, for future use. Refer to Figure 1-3 for details. An abandoned 36-inch diameter sanitary sewer line, as well as a 42-inch diameter sanitary sewer line transect the Mudflats, as do

a 24-inch diameter water line and several abandoned sewer lines (Figure 1-3). The 42-inch diameter sanitary sewer line conveys flow to the Town of Tonawanda wastewater treatment plant (WWTP) to the west. As further discussed in Section 4.1.2.1, during the installation of the 42-inch sanitary sewer line through the Mudflats, the construction activities appear to have disturbed the MED-like material that was identified during previous investigations (ORNL 1992).

1.2.2 Site History

The Landfill was operated as a municipal landfill by the Town of Tonawanda from the mid-1930's through October 1989. In the early 1900's a quarry was located in the western portion of the Landfill property. In the 1920's, the quarry was reportedly abandoned at a depth of 60 feet when water was encountered. Wastes disposed in the landfill included ash generated by the incinerators (formerly located just west of the mudflats), construction/demolition debris, and yard refuse (leaves, branches, etc.) collected from Town residents. On occasion, the landfill accepted municipal solid waste and wastewater sludge (formerly incinerated at the incinerators), but only when the incinerators were temporarily inoperable.

The incinerators, operated by the Town of Tonawanda between the 1940s and early 1980s, were used to burn municipal solid waste and sludge generated at the Town of Tonawanda's WWTP. The incinerators were located at the western edge of the Mudflats area (see Figure 1-3) until they were demolished in 2002. Other than the incinerators, the Mudflats have always been vacant.

Although neither the Landfill nor Mudflats were known to be directly involved with MED activities, the Landfill and Mudflats were designated a FUSRAP Vicinity Property (DOE 1992) due to the potential for MED material from the Linde Site having been placed in the Landfill. As described above, the Linde Site is the former location of uranium ore processing activities. The operator of the Linde site performed these activities under contract to MED.

In addition to the potential MED-like material identified in the Landfill and Mudflats areas of the Tonawanda Landfill Vicinity Property, a previous investigation conducted by the DOE in 1984 indicated the presence of a non-MED-like radionuclide, americium-241 (Am-241), in material in two locations in the Landfill portion of the Site, to the east of the suspected MED areas (EG&G 1984) (refer to Figure 1-4). The aerial radiological survey of the Tonawanda Landfill Vicinity Property was conducted by the DOE in 1984 at the request of the New York State Department of Health (NYSDOH) as part of the NYSDOH investigation of Am-241 contamination. The source of the Am-241 was found to be a nearby former radioactive components manufacturing facility that discharged Am-241 contaminated material to the sanitary sewer, which ultimately ended up in the wastewater sludge generated at the municipal water treatment plant. Wastewater sludge was commonly brought to the incinerator for incineration and then interned at the Landfill. The Am-241 material in the Landfill was attributed to the spread of contaminated ash generated by the incinerators (EG&G 1984). Subsequent investigations by the Town of Tonawanda and others confirm the presence of a third area of Am-241 contaminated material (TMA/Eberline 1988). To date, there have been no removal or remedial actions associated with the Am-241 contaminated material identified in the Landfill. In 1989, a New York State Task Force approved capping the Am-241 in place with an additional 3 feet of fill placed over the material before the final cap is constructed.

1.2.3 Site Status

The Town of Tonawanda is in the process of closing the Landfill in accordance with the current Title 6 of the New York Code of Rules and Regulations (6 NYCRR) Part 360 and Part 380 (Malcolm Pirnie 1999). This action is being undertaken by the Town of Tonawanda, with regulatory oversight from the New York State Department of Environmental Conservation (NYSDEC). Cover material is being placed in areas of the Landfill (primarily at the eastern end) in preparation for capping and closure. A revised Closure Investigation Plan was prepared for the Town of Tonawanda by Malcolm Pirnie Inc., and submitted to NYSDEC in March 2002. This latest revision addressed NYSDEC comments on the earlier report (Malcolm Pirnie 1999), but did not substantively change the closure plan or the parameters from the earlier report that are utilized in this RI report.

The Town of Tonawanda's plans for the Mudflats area include demolition of the former incinerator, and industrial development of the area. The demolition of the former incinerator was completed by the Town of Tonawanda in 2002. Portions of the Mudflats area are being used as debris collection locations for the Town of Tonawanda Department of Public Works. Street sweepings, mulch, tree limbs, etc., are stored on portions of the site. Part of the closure plan for the Landfill calls for the Mudflats being used as the borrow source for much of the final cover material in the Landfill.

1.2.4 Previous Investigative Studies

Initial radioactive material surveys for the presence of MED-like contaminants at the Landfill and Mudflats were conducted by the DOE in 1990 as part of the Linde FUSRAP Site investigation. The intent of the survey was to assess whether any radioactive material had been transported and disposed of off-site in the general area surrounding the Linde facility. The preliminary survey was completed using a mobile gamma scanning van. An anomaly in the survey detected in the Mudflats during the mobile scanning activities was verified using handheld gamma screening devices. Subsequent soil samples collected from the area around the anomaly indicated elevated levels of uranium-238 (U-238) and radium-226 (Ra-226) - two isotopes consistent with material expected to be in ore processing byproducts generated at the Linde Site (ORNL 1990).

A limited radiological investigation was conducted by DOE in September, 1991 (ORNL 1992). The survey focused on the Landfill and Mudflats and consisted of gamma walkover and scans, measurement of radiation levels, and the collection and analysis of more than 170 systematic and biased soil samples to a maximum depth of 2.5 feet. The results of the investigation detected soils in the Landfill and Mudflats exceeding the radionuclide guideline concentrations established by the DOE for the Tonawanda FUSRAP Sites. The DOE guideline concentrations for radionuclides are: Ra-226, Th-230, and Th-232, 5 pCi/g, averaged over the first 15 cm of soil below the surface and 15 pCi/g for any 15 cm thick soil layer below the surface layer. For total uranium, the guideline concentration cited is 60 pCi/g for any 15 cm thick soil layer, which equates to a U-238 concentration of approximately 30 pCi/g. Laboratory results indicated some soil samples exhibited characteristics similar to the MED product formerly produced at the Linde facility and others were consistent with the by-products of the refinery process conducted at the same Linde facility. As a result of these investigations, the impacted areas of the Landfill and Mudflats were subsequently designated as a Vicinity Property of the Linde FUSRAP Site due to the discovery of materials that appeared to have characteristics similar to MED materials originating at the Linde Site (DOE 1992).

DOE conducted additional soil sampling activities at the Landfill and Mudflats in 1994 to determine the vertical extent of the radiological contamination at the site. Analytical results obtained for subsurface soil, sediment, surface water, and groundwater samples indicated the radiological contamination was

essentially limited to the upper 1.5 feet of soil. However, contamination above the DOE guideline concentrations was detected in one sample collected 11.5 feet below existing grade (BNI 1995).

The USACE completed a Radiological Human Health Assessment (HHA) for the Landfill and Mudflats site in February 1999. For the baseline (current) recreational scenario, risks were within the acceptable CERCLA risk range of 10^{-4} to 10^{-6}. After reviewing several closure scenarios and the radiation doses and health risks associated with each alternative, the USACE concluded that if the Landfill was closed with radiologically impacted soil left in place and if the Landfill is properly maintained after closure, risk of exposure to the public would be well within the acceptable CERCLA risk range of 10^{-4} to 10^{-6}. The assessment also concluded that if the Mudflats area is developed for industrial use it could pose a public health risk. Closure scenarios for the Landfill addressed during the assessment included capping the contaminated soil in place and excavation and removal of the impacted soil. Closure alternatives evaluated for the Mudflats area included no action, covering the impacted area with clean soil, and excavation and removal of impacted soil (USACE 1999a).

1.2.5 USACE Investigation in 2001

To supplement information available from prior investigations, USACE conducted a field investigation at the Tonawanda Landfill Vicinity Property in 2001. The 2001 investigation was conducted to further delineate the extent of MED-like contamination present at the Tonawanda Landfill Vicinity Property, acquire information sufficient to describe the fate and transport of Tonawanda Landfill Vicinity Property contaminants and gather information sufficient to complete a BRA and Feasibility Study (FS) for the Site. The findings of the 2001 investigation are provided in this RI report.

The 2001 investigation included the collection and analyses of over 500 soil samples, from borings at varying depths in the Landfill and Mudflats OUs, including samples in non-impacted areas to determine background levels of radionuclides in vicinity soils. Surface water and sediment samples were also collected. Water samples from existing monitoring wells installed by the Town of Tonawanda were also collected for analyses. The field investigation also included preliminary walkovers to identify areas of elevated gamma radiation (gamma walkover surveys (GWS)), site survey and mapping, groundwater elevation level measurements to determine the direction of groundwater flow, and related field activities as described in the *Sampling and Analysis Plan (SAP), Tonawanda FUSRAP Site, Tonawanda, New York* (USACE 2001a), and this RI report.

The RI investigations at the Tonawanda Landfill Vicinity Property were based on the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (USNRC 2000). The MARSSIM provides detailed guidance for planning, implementing, and evaluating environmental and facility radiological surveys conducted to demonstrate compliance with a dose- or risk-based regulation. The MARSSIM guidance focuses on the demonstration of compliance during the final status survey following scoping, characterization, and any necessary remedial actions.

While MARSSIM guidance is not designed for subsurface explorations, its methodology can be used as a rationale for selecting sampling locations and number of samples. Methodology corresponding to a MARSSIM Final Status Survey was used. The methodology was consistent with a Final Status Survey so that the site, or portions of the site, may be closed without a removal action or further investigations, if that is the selected path forward.

The historical site assessments performed by ORNL and others were used to aid in the classification of areas, to determine impacted and non-impacted areas, and to provide reference concentrations for health and safety planning.

1.3 Report Organization

This section (1.0) is an introductory chapter that briefly describes the RI, the Site, and its history. Section 2.0 briefly summarizes the 2001 investigation activities conducted by the USACE. The physical characteristics of the Landfill and Mudflats are discussed in Section 3.0. Section 4.0 describes the nature and extent of contamination in the Mudflats OU and the Landfill OU. The contaminant fate and transport and conceptual site model for the potentially MED-like contaminants are presented in Section 5.0. The radiological BRA is included in Section 6.0. Section 7.0 presents the summary and conclusions of the RI report.

The 2001 USACE investigation activities and analytical results are presented in greater detail in Appendix A, Field Investigation Details, which is bound separately. A report summarizing the data validation activities conducted is presented in Appendix B. A copy of the database that was generated following data validation activities is also included in Appendix B on CD-ROM.

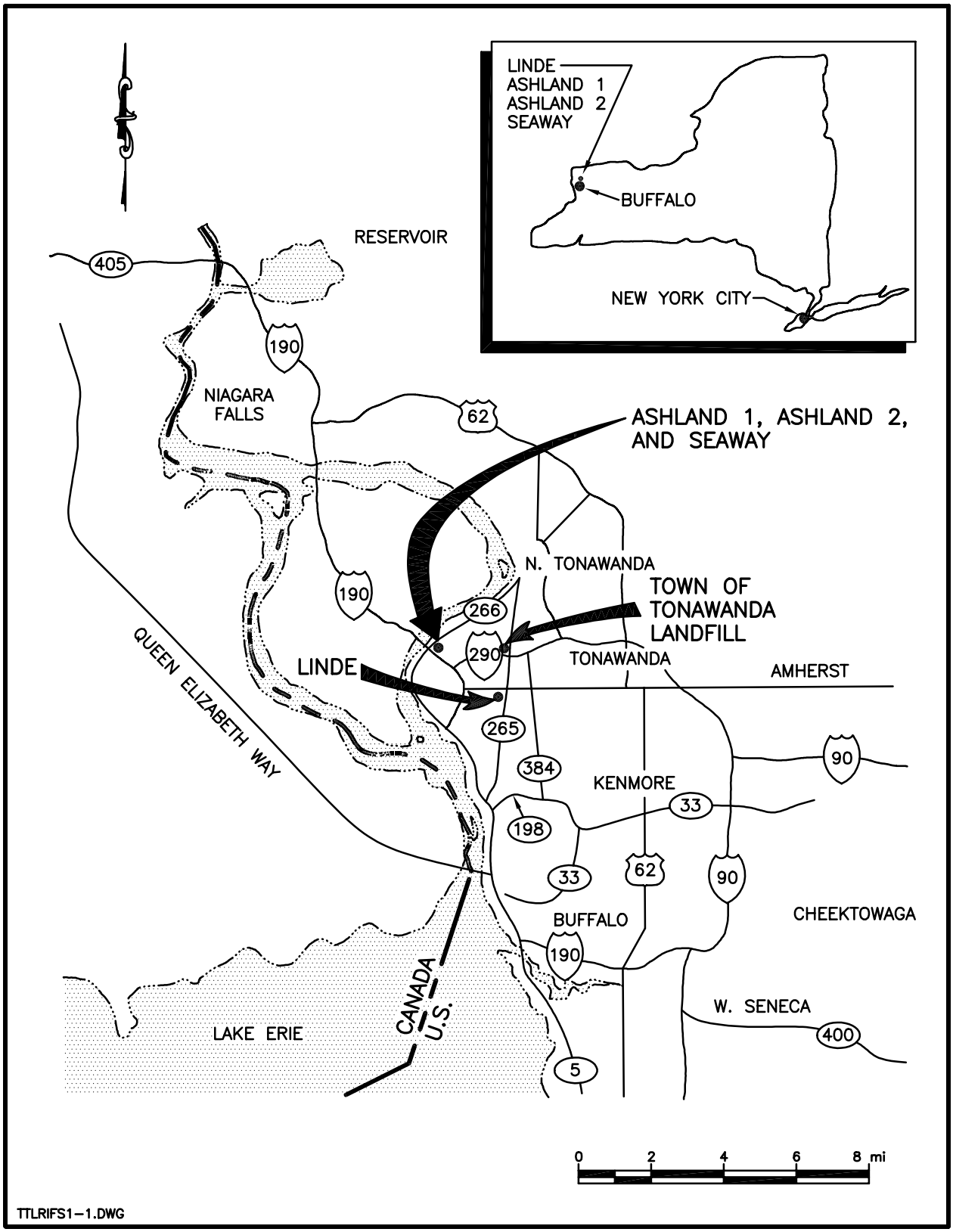
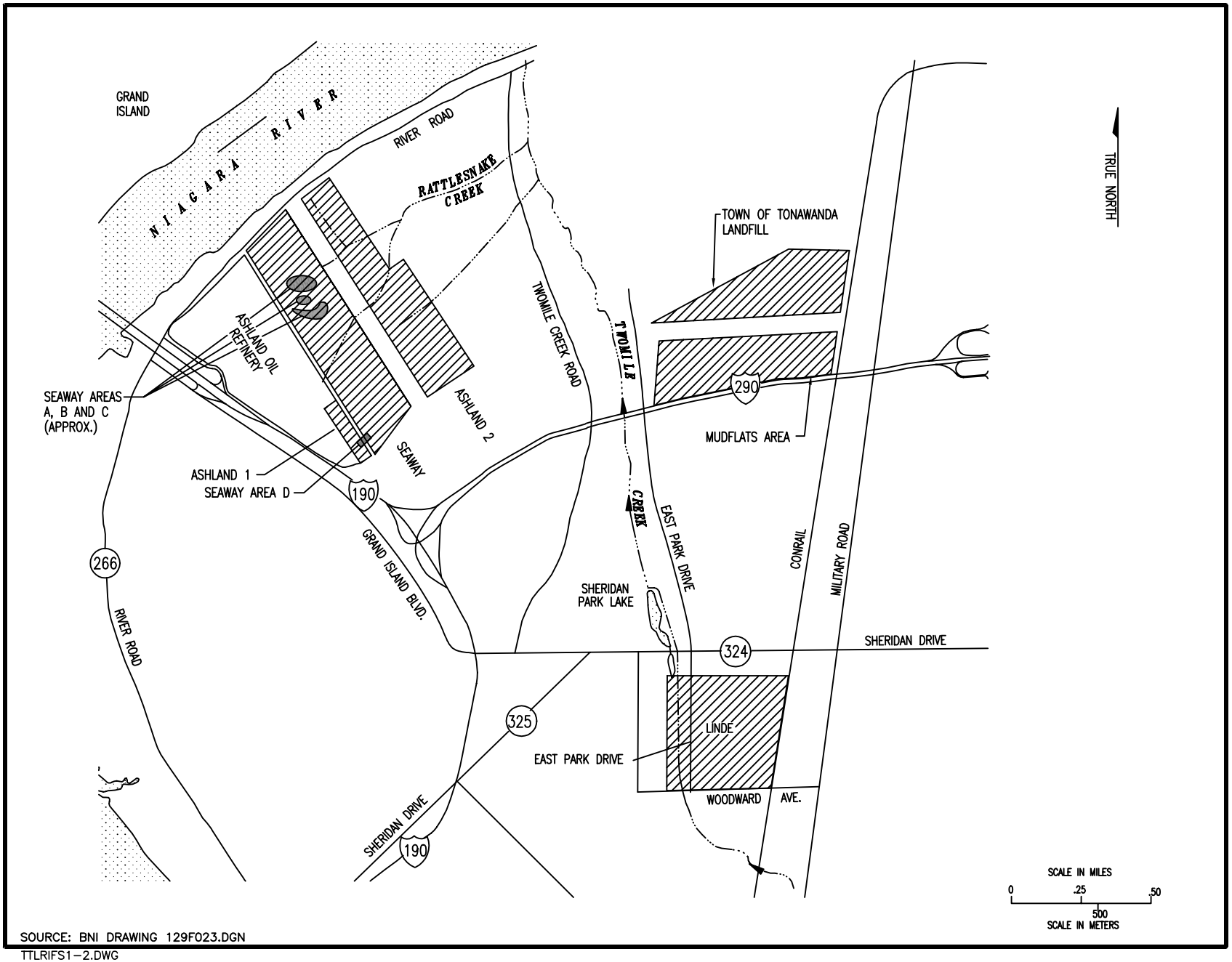


FIGURE 1-1

REGIONAL LOCATION OF THE TOWN OF TONAWANDA, NEW YORK AND THE ASHLAND 1, ASHLAND 2, SEAWAY AND LINDE SITES AND TONAWANDA LANDFILL VICINITY PROPERTY



SOURCE: BNI DRAWING 129F023.DGN
TTLRIFS1-2.DWG

FIGURE 1-2
LOCATIONS OF ASHLAND 1, ASHLAND 2, SEAWAY AND LINDE SITES AND TONAWANDA LANDFILL VICINITY PROPERTY

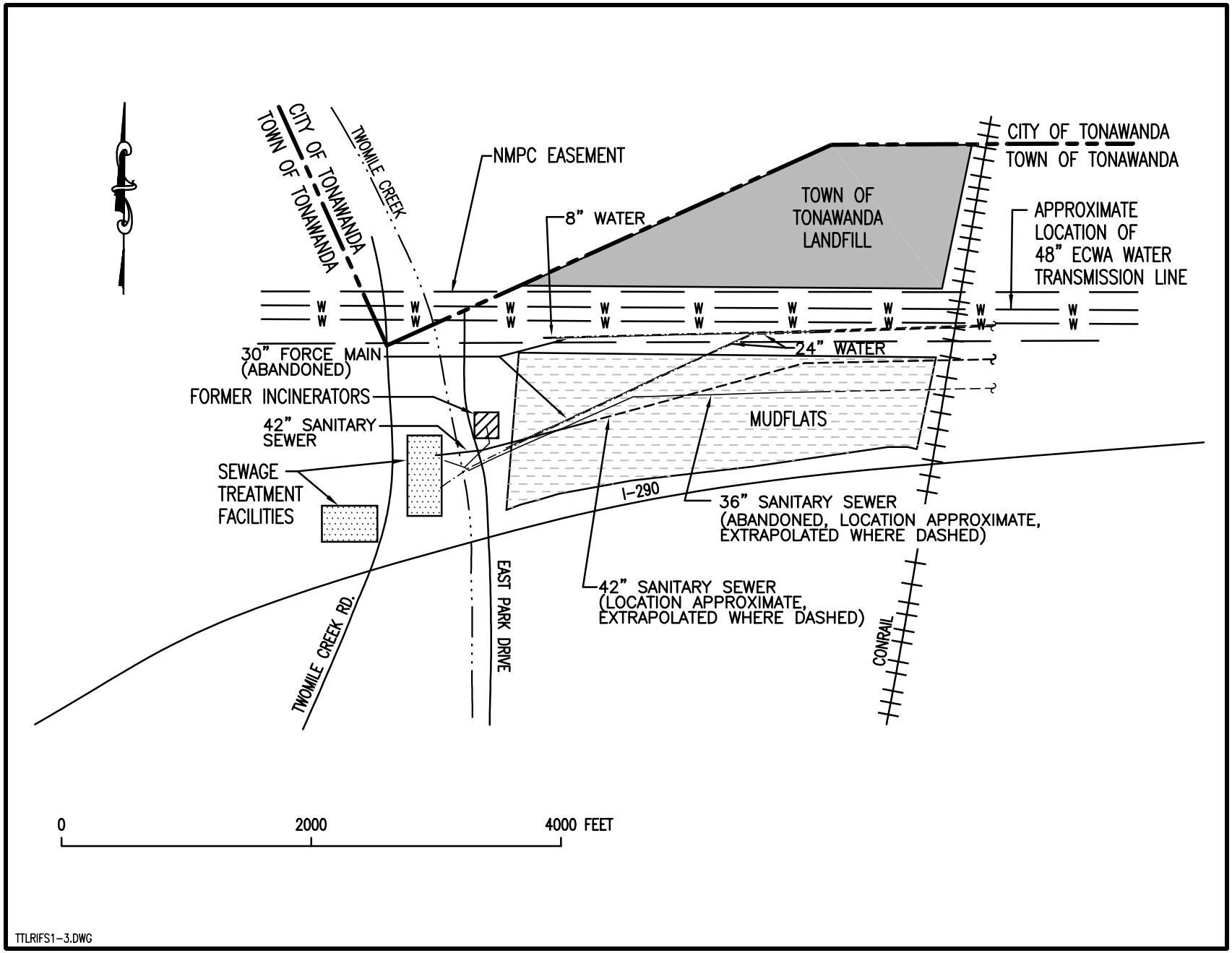
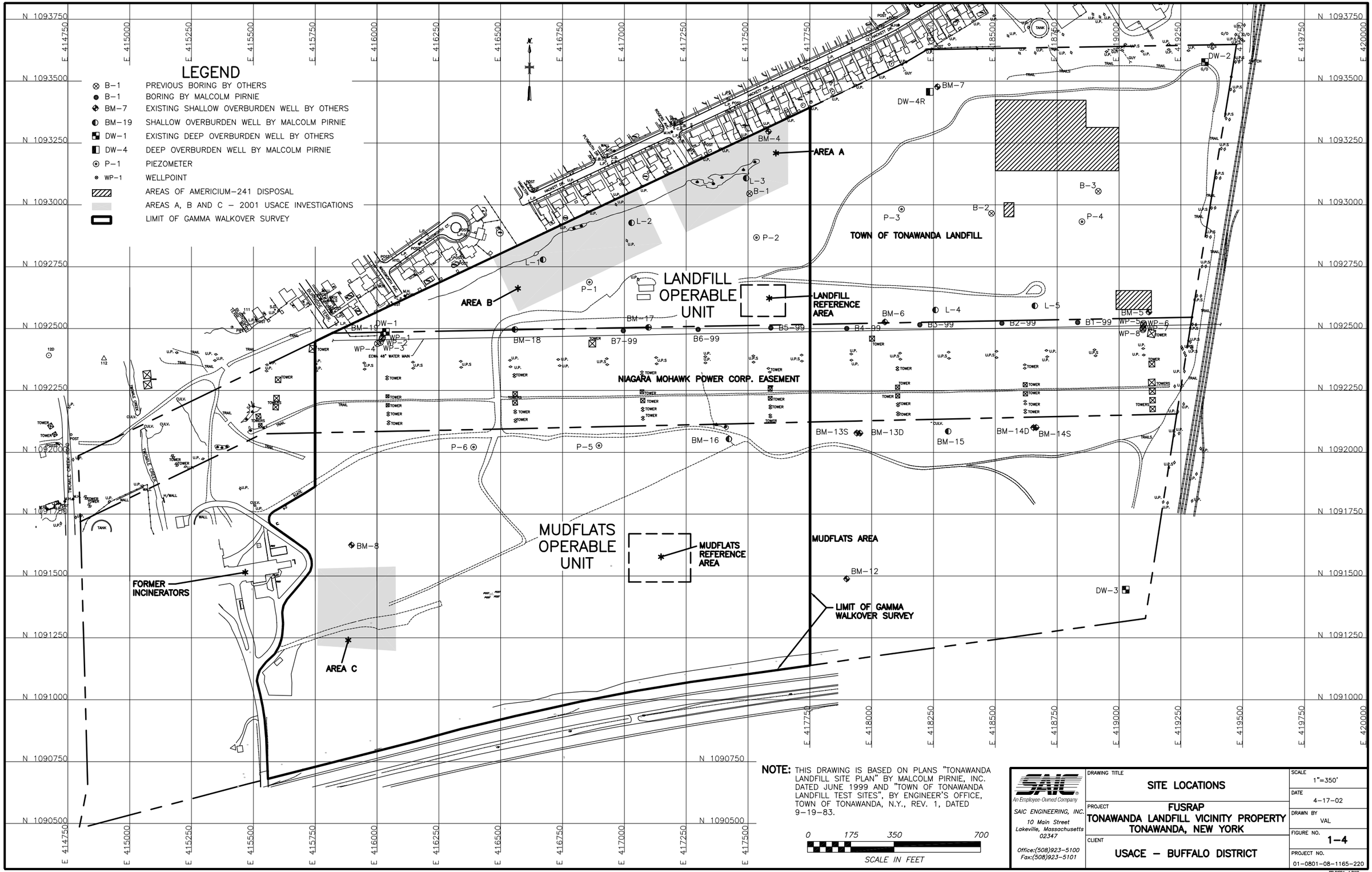


FIGURE 1-3
TONAWANDA LANDFILL VICINITY PROPERTY APPROXIMATE LOCATIONS



NOTE: THIS DRAWING IS BASED ON PLANS "TONAWANDA LANDFILL SITE PLAN" BY MALCOLM PIRNIE, INC. DATED JUNE 1999 AND "TOWN OF TONAWANDA LANDFILL TEST SITES", BY ENGINEER'S OFFICE, TOWN OF TONAWANDA, N.Y., REV. 1, DATED 9-19-83.

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SCALE IN FEET

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DRAWING TITLE	SITE LOCATIONS
PROJECT	FUSRAP TONAWANDA LANDFILL VICINITY PROPERTY TONAWANDA, NEW YORK
CLIENT	USACE – BUFFALO DISTRICT
SCALE	1"=350'
DATE	4-17-02
DRAWN BY	VAL
FIGURE NO.	1-4
PROJECT NO.	01-0801-08-1165-220

TTLRIFS1-4.DWG

2.0 DESCRIPTION OF THE 2001 INVESTIGATION

The purpose of the 2001 investigation was to further delineate the extent of potential MED-like contamination detected during previous investigations at the Tonawanda Landfill Vicinity Property. This section summarizes the data collection methods used by the USACE during its 2001 investigation. The 2001 field investigation included a GWS, surface water and sediment sampling, surface and subsurface sample collection, and water sampling. The details of the procedures used to collect each of these types of data are outlined in greater detail in Appendix A (Field Investigation Details). Therefore, these details are not discussed in this volume of the RI report.

The field activities were conducted by the USACE between June and September, 2001. All sampling procedures and protocols were performed in accordance with the *Sampling and Analysis Plan (SAP), Tonawanda FUSRAP Site, Tonawanda, New York* (USACE 2001a). The SAP consisted of the following three volumes:

- Volume 1 - The Field Sampling Plan (FSP);
- Volume 2 - The Quality Assurance Project Plan (QAPP); and
- Volume 3 - The Field Standard Operating Procedures (SOPs).

Prior to conducting the 2001 investigation, the historical site assessments conducted by ORNL and BNI (ORNL 1992 and BNI 1995), were reviewed to classify areas for contamination potential within the Mudflats and Landfill OUs. MARSSIM designations were used to classify the areas. Based on the review, the Mudflats and Landfill OUs areas were divided into the following three classifications (Figure 2-1):

- Class 1 units that encompass areas of suspected contamination;
- Class 2 units were established in the immediate vicinity of the Class 1 areas, but outside the limits of suspected contamination; and
- Class 3 units that are outside of any areas of suspected contamination and are not believed to be impacted.

Based on historical data, one area of potential contamination was identified within the Mudflats OU. This was designated as Area C (Figure 2-1). The area of contamination within Area C was designated as a Class 1 area. The Mudflats OU, Class 1, Area C is approximately 2,485 square meters (m^2) in area. The area immediately surrounding the Class 1 area was designated as a Class 2 area. Due to the size of the remaining area of the Mudflats OU, it was broken into two Class 3 units, designated as 3A and 3B. Additionally, a reference area (for determining background levels) was identified in the Mudflats OU, at a location within the Class 3 area, away from Area C.

MARSSIM guidance suggests limiting the size of a Class 1 area to 2,000 square meters (m^2). Therefore, three separate areas of contamination (Class 1 areas) were identified in the Landfill OU based on historical data. Two of these were located in close proximity, and so were grouped together in Area B. Therefore, Area B consists of two Class 1 areas (B1A and B1B), and a Class 2 area, which encompasses the two Class 1 areas. The other area of contamination is designated as Area A. One Class 1 area and a Class 2 area which encompasses it were identified in Area A. The remainder of the Landfill OU was designated as a Class 3 unit. Additionally, a reference area (for determining background levels) was identified in the Landfill OU, at a location within the Class 3 area, away from Areas A and B. The three

Class 1 areas in the Landfill OU, Area A, Area B1A and Area B1B, are all approximately 1,936 m^2 in area.

The limits of the Class 1, 2, and 3 units within the Mudflats and Landfill OUs are delineated in Figure 2-1.

2.1 Gamma Walkover Survey

Prior to conducting intrusive soil sampling activities, a gamma walkover survey (GWS) was conducted. The purpose of the GWS was to identify elevated concentrations of gamma-emitting radionuclides (e.g., radium-226) in surface soils. The GWS was performed to meet the following objectives:

- to confirm previously identified areas of interest based on previous investigations [(due to activity measurements equal to or greater than background plus two standard deviations (B + 2s) to two times (2x) background)];
- to evaluate the potential for more MED-like material at the Tonawanda Landfill Vicinity Property not identified by previous investigations; and
- to focus the limits of the direct-push sampling activities conducted with the Geoprobe® drill rig.

The general approach was to measure gamma radiation levels using gamma radiation detectors, which were linked to global positioning system (GPS) instruments. The radiation instruments indicated relative levels of radionuclide concentrations while the GPS instruments provided coordinate (and time) information for each radiation measurement.

2.2 Surface Water and Sediment Investigation

Sediment samples were collected from three locations within Landfill OU Class 1, Area A. At two of those locations, surface water samples also were collected. The sampling locations were selected from areas where elevated concentrations of MED-like residuals were detected during previous investigations. In addition, a sediment and associated surface water sample were also collected from a location in the Landfill OU (Class 2, Area B) to assess a seep outside of the areas of interest. The locations are discussed in Section 4.0. The surface water and sediment samples collected during this phase of the investigation were analyzed for the suite of radiological analytes, summarized in Table 2-1.

2.3 Soil Investigation/Downhole Geophysical Survey

Soil samples were collected at 210 boring locations at the Tonawanda Landfill Vicinity Property with a Geoprobe® probe-drive sampler that utilizes direct-push drilling methods. The soil borings and associated sample identification numbers for soils submitted for laboratory analysis are listed in Table 2-2. The soil samples were analyzed for the same suite of radiological analytes as the sediment samples (Table 2-1). In addition, to determine if chemical wastes may be commingled with the MED-like materials, seven soil samples were analyzed for the presence of chemical analytes.

The soil field measurements performed during drilling were limited to scanning for beta activity. The retrieved soil core was scanned with a shielded pancake Geiger-Mueller (GM) probe. Radioactivity was measured as cpm and recorded on the boring logs, which are presented in Attachment C of Appendix A. A description of the calibration requirements and performance checks for the field instruments used for field measurements during the 2001 investigation is presented in the Town of Tonawanda Landfill FUSRAP Site QAPP (USACE 2001c).

The GM data collected in each of the two reference areas was used to calculate the background gamma levels for the Mudflats OU and Landfill OU investigation areas.

The background activity for each reference area was calculated by averaging all of the shielded pancake GM probe measurements, which were collected at 0.5-foot intervals in each reference boring.

For the Mudflats OU reference area, an average GM measurement of 52 cpm was calculated for the gamma measurements collected from the 20 borings (TMFR1-001 through TMFR1-020). For the Landfill OU reference area, an average of 45 cpm was calculated for the gamma measurements collected from the 18 borings (TLFR3-001, TLFR3-002, TLFR3-004 through TLFR3-008, and TLFR3-010 through TLFR3-0020). For each of the investigation areas, the background GM levels were used to establish the criteria for selecting 6-inch intervals from which soil samples were collected for radiological analysis.

The GM criterion was background plus two standard deviations (B+ 2σ?to twice background (2B), which was established as 100 cpm for the Mudflats OU and 90 cpm for the Landfill OU. In most cases, the 6-inch long continuous region exhibiting the highest count rate was selected as the soil sample for radiological analysis. In situations where the same elevated reading was encountered at two distinct intervals of a given core, the soil sample was collected from the deepest interval. When there was no variation in count rate across the soil core, the soil sample was collected from the bottom 6 inches of the soil core. The soil core radioactivity measurements, soil sample intervals, and associated sample identification numbers are presented on the boring logs (Attachment C of Appendix A).

Soil sample locations were either designated “random” or “biased.” Random sample locations were selected by generating random coordinates within the area of interest, or by establishing a grid. Random coordinates were used to select the boring locations in the Class 3 areas (Landfill Class 3 and Mudflats Class 3A and 3B). Grids were established in the Class 2 areas (Areas A, B and C).

Biased sample locations were selected in the Class 3 areas, where borings were performed around the perimeter of the Class 2 areas. These borings were performed to ensure that any contamination was bounded. In the Class 1 areas, borings were performed at locations where the GWS indicated the potential for surficial contamination, or at areas where previous investigations had encountered radiological contamination. Borings were also performed as offsets of investigation locations where field screening indicated that contamination had been encountered. These are also considered to be biased locations.

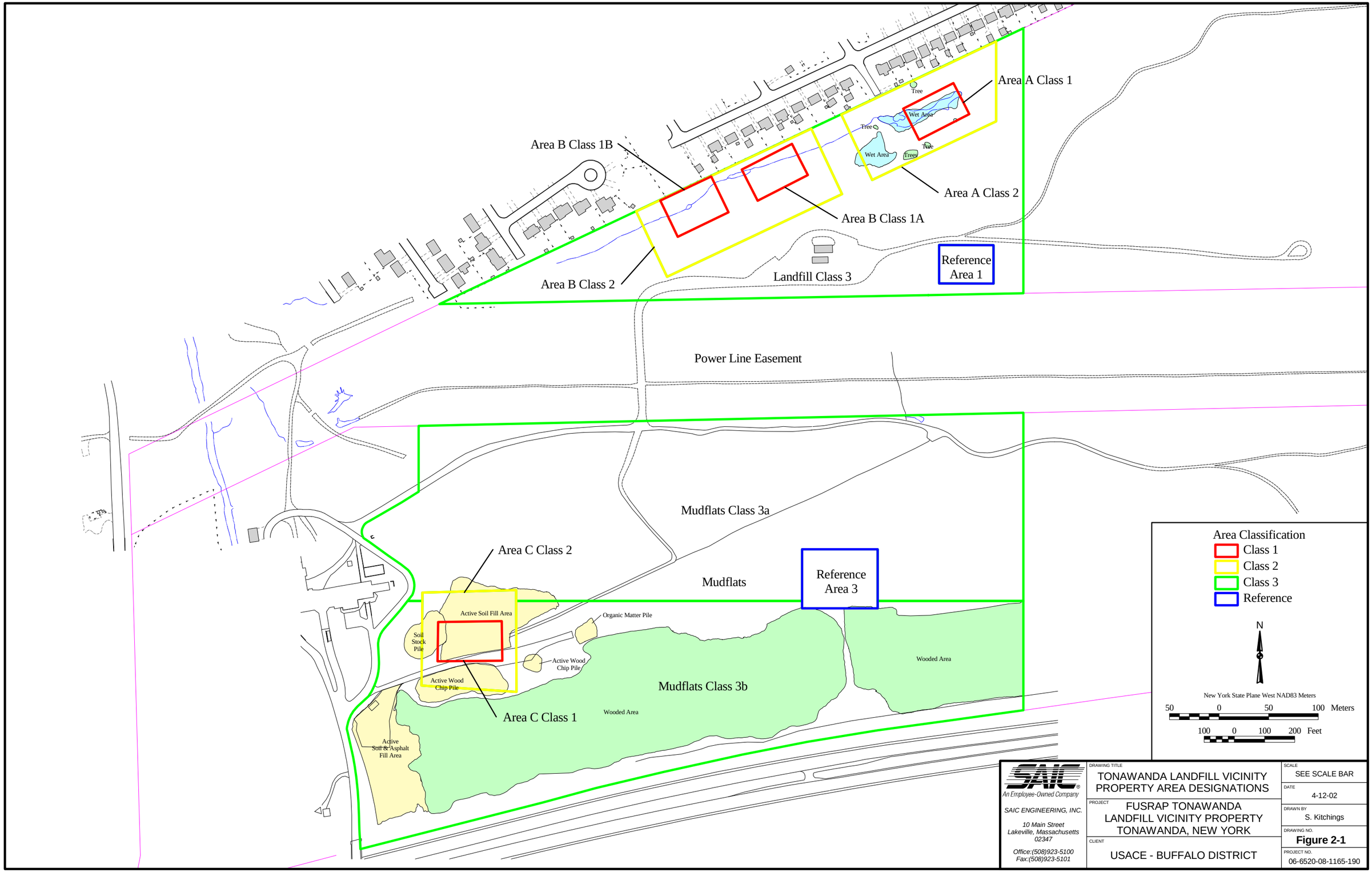
At each of the soil boring locations, downhole gamma logging was used to make a qualitative determination of the vertical profile of any radioactive materials in the subsurface. Primarily, the downhole gamma was used in conjunction with core scans to delineate any “peak” areas, and also to identify when the radiation levels returned to background levels.

2.4 Groundwater Sampling

Groundwater[1] samples were collected from existing groundwater monitoring wells as part of the Town of Tonawanda's semi-annual compliance sampling activities at the Tonawanda Landfill (Landfill and Mudflats parcels). Samples were collected by Malcolm Pirnie, Inc. (Malcolm Pirnie) under subcontract to Science Applications International Corporation (SAIC). During the September 2001 sampling event, in addition to their standard groundwater samples, Malcolm Pirnie collected split samples for radiological analyses as part of the USACE investigation. The results of this sampling were used to evaluate the radiological quality of shallow water located within the Landfill material and shallow and deep groundwater in the vicinity.

Groundwater samples were collected for radiological analysis from a total of 12 existing monitoring wells located on the perimeter of the Landfill parcel of the site. Two of these perimeter wells are located along the northern boundary of the Mudflats OU. Samples were also collected from two existing monitoring wells located within the Mudflats parcel of the Site. The locations of these 14 monitoring wells are shown in Figure 2-2.

[1] For consistency, any samples taken from monitoring wells are referred to as groundwater samples. The "groundwater" from monitoring wells within the Landfill reflect conditions in the landfilled material where the "groundwater" occurs as a mound at higher elevations than the groundwater in the surrounding native material. Samples of landfill water have also been referred to as "leachate samples" in reports prepared by Malcolm Pirnie. These conditions are further described in Section 3.6.



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DRAWING TITLE
TONAWANDA LANDFILL VICINITY PROPERTY AREA DESIGNATIONS

PROJECT
FUSRAP TONAWANDA LANDFILL VICINITY PROPERTY TONAWANDA, NEW YORK

CLIENT
USACE - BUFFALO DISTRICT

SCALE
SEE SCALE BAR

DATE
4-12-02

DRAWN BY
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DRAWING NO.
Figure 2-1

PROJECT NO.
06-6520-08-1165-190

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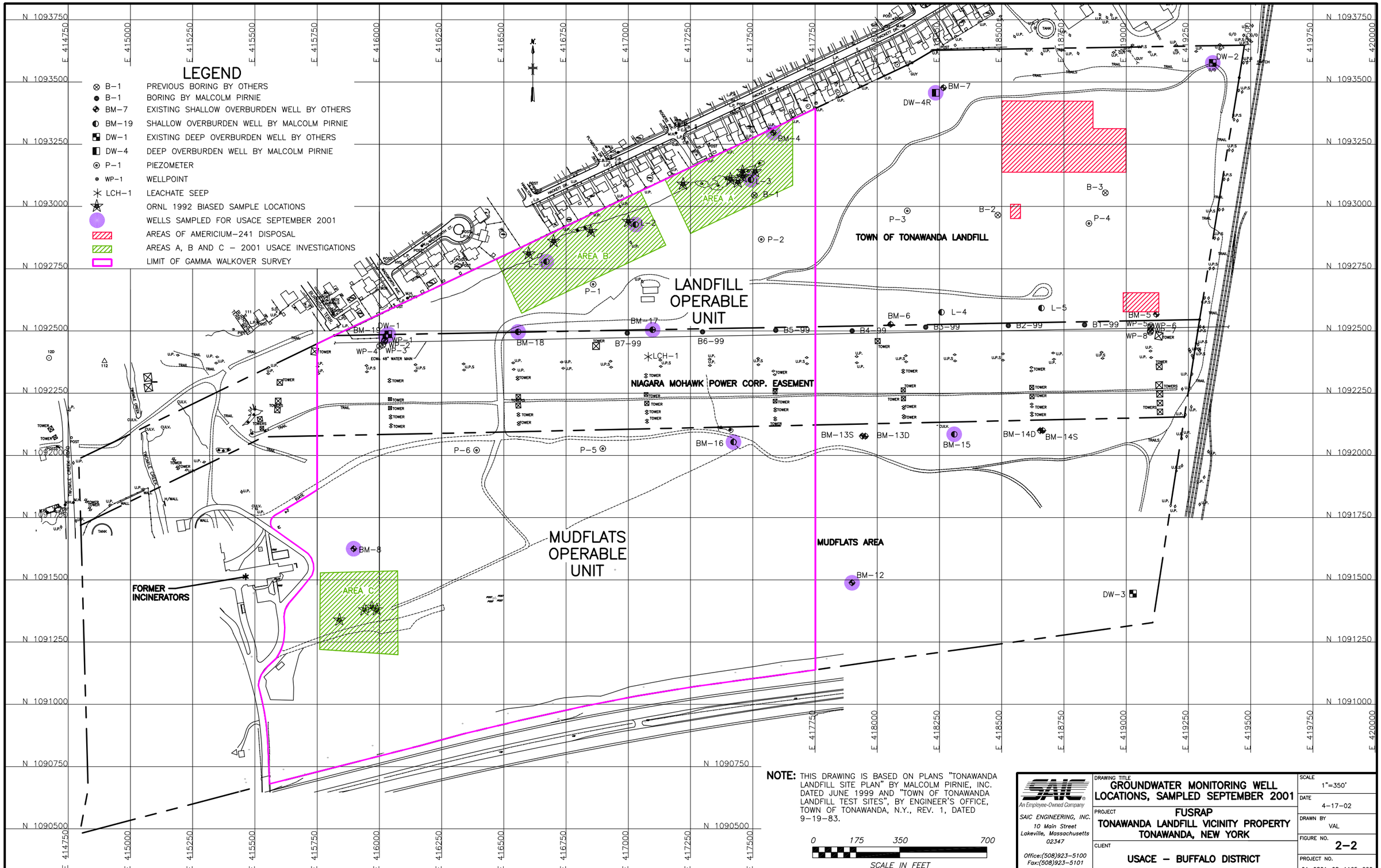

NOTE: THIS DRAWING IS BASED ON PLANS "TONAWANDA LANDFILL SITE PLAN" BY MALCOLM PIRNIE, INC. DATED JUNE 1999 AND "TOWN OF TONAWANDA LANDFILL TEST SITES", BY ENGINEER'S OFFICE, TOWN OF TONAWANDA, N.Y., REV. 1, DATED 9-19-83.

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DRAWING TITLE
GROUNDWATER MONITORING WELL LOCATIONS, SAMPLED SEPTEMBER 2001

PROJECT
FUSRAP
TONAWANDA LANDFILL VICINITY PROPERTY
TONAWANDA, NEW YORK

CLIENT
USACE – BUFFALO DISTRICT

SCALE	1"=350'
DATE	4-17-02
DRAWN BY	VAL
FIGURE NO.	2-2
PROJECT NO.	01-0801-08-1165-220

TTLRIFS2-2.DWG

Table 2-1
Radiological Analytical Methods and Parameters

Parameters	Analytical Methods	
	Water	**Soil/Solid**
Iso-Uranium 234, 235, 238	Radiochemical Separation/Alpha Spectrometry	Radiochemical Separation/Alpha Spectrometry
Iso-Thorium 228, 230, 232	Radiochemical Separation/Alpha Spectrometry	Radiochemical Separation/Alpha Spectrometry
Radium-226	Radon Emanation Method	Radon Emanation Method
Radium-228	Gas Proportional Counting	Gamma Spectrometry
Gross Alpha	Gas Proportional Counting	N/A
Gamma Spectroscopy (Isotope identification) (Including Am-241)	Gamma Spectrometry	Gamma Spectrometry
Total Uranium	Kinetic Phosphorescence Analysis (KPA)	N/A

N/A – Not Analyzed

Table 2-2
Summary of Soil Boring and Soil Sample Information

Area	Number of Borings	Boring ID Numbers	Sample ID Numbers	Number of Samples	Number of QA Samples	Total Number of Samples
Tonawanda Landfill - Mudflats Area						
Mudflats - Reference Area	20	TMFR1-001 - TMFR1-020	TMF-0001 - TMF-0050, TMF-9019, TMF-9020, TMF-9043, TMF-9044	40	4	44
Mudflats - Class 3A (Random)	18	TMFR3A-001 - 004, TMFR3A-006 - 012, TMFR3A-014, TMFR3A-017, TMFR3A-020 - 024	TMF-0051 - TMF-0099, TMF-9087 - TMF-9090	36	4	40
Mudflats - Class 3B (Random)	18	TMF3B-001, TMF3B-003 - 004, TMF3B-006, TMF3B-008 - 009, TMF3B-011 - 013, TMF3B-015 - 020, TMF3B-022- 024	TMF-0101 - TMF-0150, TMF-9119, TMF-9120, TMF-9139, TMF-9140	36	4	40
Mudflats - Class 3B (Biased)	15	TMF3B-050 - 058, TMF3B-060 - 065	TMF-0151 - TMF-0209, TMF-9196, TMF-9197, TMF-9199, TMF-91200	30	4	34
Mudflats - Class 2 (Area C)	18	TMFC2-001 - 006, TMFC2-008 - 019	TMF-0210 - TMF-0269, TMF-9246 - TMF-9250	36	5	41
Mudflats - Class 1 (Area C)	7	TMFC1-001 - 005, TMFC1-009, TMFC1-013	TMF-0270 - TMF-0399, TMF-9342 - TMF-9344	22	3	25
Total Mudflats	**96**			**200**	**24**	**224**

Table 2-2
Summary of Soil Boring and Soil Sample Information

Area	Number of Borings	Boring ID Numbers	Sample ID Numbers	Number of Samples	Number of QA Samples	Total Number of Samples
Tonawanda Landfill - Landfill Area						
Landfill - Reference Area	18	TLFR3-001 - 002, TLFR3-004 - 008, TLFR3-010 - 020	TLF-0400 - TLF-0449, TLF-9418, TLF-9419, TLF-9438, TLF-9439	36	4	40
Landfill - Class 3 (Random)	19	TLF3-001, TLF3-003 - 009, TLF3-012 - 013, TLF3-015 - 017, TLF3-019, TLF3-021 - 024, TLF3-S4	TLF-0450 - TLF-0499, TLF-9468, TLF-9469, TLF-9488, TLF-9489	38	4	42
Landfill - Class 3 (Biased)	15	TLF3-050 - 064	TLF-0500 - TLF-0559, TLF-9547 - TLF-9550	30	4	34
Landfill - Class 2 (Area B)	18	TLFB2-001 - 018	TLF-0730 - TLF-0779, TLF-9545, TLF-9546, TLF-9768, TLF-9769	37	4	41
Landfill - Class 2 (Area A)	19	TLFA2-001 - 018, TLFA2-020	TLF-0570 - TLF-0639, TLF-9606 - TLF-9609	38	4	42
Landfill - Class 1 (Area B1A)	2	TLFB1A-001, TLFB1A-005	TLF-0860 - TLF-0900	4	0	4
Landfill - Class 1 (Area B1B)	3	TLFB1B-001, TLFB1B-005, TLFB1B-009	TLF-0780 - TLF-0800	6	0	6
Landfill - Class 1 (Area A)	20	TLFA1-S1, TLFA1-002 - 004, TLFA1-S2, TLFA1-006 - 008, TLFA1-S3, TLFA1-010 - 020	TLF-0640 - TLF-0729, TLF-9712 - TLF-9717	64	7	71
Total Landfill	**114**			**253**	**27**	**280**
TOTAL SOIL	**210**			**453**	**51**	**504**

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

The Tonawanda Landfill Vicinity is approximately 170 acres in size and is divided into two parcels – the former Town of Tonawanda Landfill (Landfill parcel), which is approximately 55 acres in area, and the Mudflats portion (Mudflats parcel) that is approximately 115 acres in area (Figure 1-3). Both parcels are owned by and located within the Town of Tonawanda.

The following sections describe the physical and environmental characteristics of the Tonawanda Landfill Vicinity Property that are relevant to identifying and evaluating potential exposure pathways, transport mechanisms, and receptors. Much of the regional information presented in this section was derived directly from the February 1993 report titled *Remedial Investigation Report for the Tonawanda Site, Tonawanda New York* (BNI 1993) (hereafter referred to as the 1993 RI report), which focuses on other nearby FUSRAP sites also located in Tonawanda. Site information is generally derived from studies conducted by the Town of Tonawanda relative to the operation of the landfill.

3.1 Surface Topography

3.1.1 Regional Topography

The Site study area is located in the western portion of New York, within the metropolitan area of Buffalo, New York. This area is generally described as broad lowlands with little topographic relief that are bordered by bedrock escarpments.

3.1.2 Tonawanda Landfill (Mudflats and Landfill Parcels) Topography

Closure of the landfill has not been completed and the current surface of the landfill is irregular (refer to Figure 3-1). The western portion of the Landfill parcel has some hills and mounds but generally slopes towards the west/northwest. The eastern portion of the landfill is gently sloping to the north/northeast with plateaued regions along the southern border of the parcel adjacent to the NMPC easement. Maximum change in elevation over the Landfill parcel is estimated to be to be about 30 feet, from a high elevation of approximately 638 feet relative to mean sea level (msl) at the eastern end to a low elevation of approximately 606 feet msl at the western end (Malcolm Pirnie 1999).

The Mudflats parcel is located south of the Landfill parcel on the opposite side of the NMPC easement. The topography of the mudflats parcel is also irregular with soil mounds located along the northern boundary near the NMPC easement. Two large mounds of fill material exist in the western portion of the Mudflats, in the vicinity of Area C (refer to Figure 3-1) as a result of more recent filling.

3.2 Meteorology

The climate for the area can be generally be described as moderate. Based on a 30-year monthly average from 1951 to 1980 for the nearby City of Buffalo, the mean daily air temperature ranges from a low of 23.5 degrees Fahrenheit in the month of January, to a high of 70.7 degrees Fahrenheit in the month of July. Precipitation is fairly uniform in distribution throughout the year, with an average annual precipitation value of approximately 37.5 inches (Wehran 1994).

3.3 Surface-Water Hydrology

The surface water hydrology at the Tonawanda Landfill (Landfill and Mudflats parcels) is controlled by the man-made features that characterize both parcels. On the Landfill parcel runoff flows radially from the top of the Landfill and is collected in intermittent swales along the northwestern, northeastern, and eastern edges of the Landfill. The northeastern swale discharges to the marshy area northeast of the site, and the eastern swale discharges to a drainage ditch along the railroad tracks (Malcolm Pirnie 1999).

The northwestern swale collects runoff from the northern portion of the Landfill parcel, west and northwest of the highest point of the Landfill (Figures 3-1 and 3-2). During storm events surface water collected in this northeast to southwest trending swale eventually flows towards the former incinerator building, where it is collected in a storm water piping system. This storm water collection system eventually drains into the Twomile Creek, which is located along the western border of the Tonawanda Landfill. The Twomile Creek flows to the north and empties into the Niagara River, which is located approximately one mile north of the Tonawanda Landfill (Malcolm Pirnie 1999).

Runoff along the southern border of the Landfill parcel occurs as sheet flow into the wet area in the NMPC easement. Surface water is held in the NMPC easement by a berm along the southern boundary until it discharges from the wet area of the NMPC easement into a culvert beneath the Landfill access road. This culvert discharges into a east-west trending drainage ditch that flows to the west to the storm water collection system that pipes the surface water to the Twomile Creek to the west.

This east-west trending drainage ditch also collects the surface water from the western and central portions of the Mudflats parcel. However, the Mudflats parcel is poorly drained, and therefore much of the surface water ponds on top of the relatively impermeable silts and clays of the underlying sediments, hence the name “Mudflats”.

Within the Tonawanda Landfill, no perennial streams have been identified. However, seeps have been observed on the perimeter of the landfill. These seeps occur at the edge of the Landfill waste material where permeable waste meets less permeable silts and clays. It does not appear that surface water flows from these seeps (Wehran 1994 and Malcolm Pirnie 1999).

3.4 Geology

3.4.1 Regional Geologic Setting

The Tonawanda Landfill (mudflats and landfill parcels) is located near the Niagara River within the Erie-Ontario Lowland Physiographic Unit of New York (Muller 1965; from BNI 1993). The Erie-Ontario Lowland has significant relief characterized by the following two major escarpments: the Niagara and the Onondaga. The Onondaga escarpment is a north-facing, east-northeast trending topographic rise that extends parallel to and immediately north of the Allegheny plateau, which is part of the Appalachian Upland. The Niagara escarpment exists approximately two-thirds of the distance between the Onondaga escarpment and Lake Ontario. The Niagara escarpment separates the Erie-Ontario Lowland into the following two segments: a northern, topographically-lower segment and a southern, topographically-higher segment (BNI 1993). The Tonawanda Landfill is located between the Niagara and Onondaga escarpments.

The subsurface geology of the area can generally be described as consisting of a relatively thin layer of unconsolidated, glacial deposits (varying from 75 feet to 95 feet in thickness). These glacial deposits consist of silts and clays overlying a coarser sand and gravel unit that directly overlays bedrock. Bedrock

in the area is the Camillus Shale, which is a thin-bedded shale or massive mudstone with large intervals of bedded gypsum and anhydrite (Malcolm Pirnie 1999).

3.4.2 Site Geology

3.4.2.1 Glacial Deposits (Unconsolidated Sediments)

Unconsolidated sediments at the Tonawanda Landfill are composed of glacial tills, glaciofluvial deposits, and glaciolacustrine silts and clays. Test borings indicate that the unconsolidated fine-grained glacial deposits range in thickness between 56 feet (well DW-2) and 95.5 feet (well DW-1) at the Tonawanda Landfill. The deposits increase in thickness from east to west across the site as the elevation of the underlying bedrock also decreases. Three distinct geologic units within the unconsolidated sediments were encountered during previous site drilling activities (Malcolm Pirnie 1999 and Wehran 1994). The uppermost layer is composed of red/brown silty clay glacial till with layered thickness between 48 to 63 feet. Lacustrine silt and clay was encountered beneath the silty clay till layer in some locations throughout the site. Lacustrine silt and clay lenses ranged up to 25 feet in thickness.

Several other locations where lacustrine material was not detected indicated layers of silty sand and gravel ranging between 8 feet and 12 feet thick (Wehran 1994). A sand and gravel unit ranging in thickness from 6.5 feet (well DW-4) to 13 feet (well DW-1) was encountered below the silt and clay material and directly above bedrock (Malcolm Pirnie 1999). Four cross sections were constructed that depict the subsurface conditions at the Tonawanda Landfill Vicinity Property. The locations of these cross sections are shown in Figure 3-2. Cross Sections A-A', B-B', C-C' and D-D' are presented in Figures 3-3, 3-4, 3-5 and 3-6, respectively.

3.4.2.2 Bedrock Geology

The bedrock encountered in the Erie-Ontario Lowland is composed of dolomites, limestones, shales, and sandstones ranging in age from Lower Cambrian to Silurian in age (BNI 1993a). The Camillus Shale underlies the unconsolidated glacial sediments at the Tonawanda Landfill (Wehran 1994 and Malcolm Pirnie 1999). This Silurian age unit is composed of gray shale and mudstone with abundant gypsum (encountered in thin layers), solution cavities and fracture zones within the upper 10 to 15 feet (BNI 1993a).

During previous investigations conducted at the Tonawanda Landfill bedrock (shale) was encountered in the three deep monitoring wells (DW-1, DW-2, and DW-4) at elevations of 513 feet msl, 550 ft msl, and 548 feet msl, respectively (Malcolm Pirnie 1999). The elevation of the top of bedrock indicates that there is an apparent slope of the bedrock surface from east to west at the Tonawanda Landfill. The locations of these three deep monitoring wells are shown in Figure 2-2.

3.5 Hydrogeology

3.5.1 Regional Hydrology

The groundwater resources of Erie-Niagara basin, the groundwater basin that contains Tonawanda Landfill was characterized by La Sala who identified the following four hydrostratigraphic units that transmit groundwater (La Sala 1968; from BNI 1993):

- Unconsolidated materials, consisting of glacial tills, glaciofluvial deposits, and glaciolacustrine silts and clay;

- Soluble limestones and dolomites of the Salina Group (Akron Dolomite and Bertie Formation) and the Onondaga Formation;
- Shales of the Salina Group (Vernon Shale, Syracuse Formation, and the Camillus Shale); and
- Dolomites of the Lockport Formation.

However, the previous investigations at, and in the vicinity of the Tonawanda Landfill, concentrated on the following two distinct hydrogeologic systems:

- The semi-confined sand and silty sand lenses that are present within the fine-grained glacial till and glaciolacustrine deposits (silts and clays); and
- The "contact zone aquifer" consisting of the coarser-grained sand and gravel basal unit overlying the bedrock and the shallow portion of the bedrock aquifer that contains fractures, joints, and solution cavities (BNI 1993).

3.5.2 Site Hydrogeology

3.5.2.1 Overburden Deposits

The majority of the overburden deposits encountered at the Tonawanda Landfill are fine-grained silts and clays interbedded with thin (less than 4 feet thick) sand and silty sand lenses that are not considered laterally extensive. These coarse-grained sand units are considered limited in areal extent and previous studies did not consider these deposits as providing extensive pathways for groundwater flow (Malcolm Pirnie 1999). The horizontal hydraulic conductivity (K) of the clayey silt and silty clay units (as calculated from slug tests) ranges from 1.1×10^{-5} centimeters per second (cm/s) in well BM-4 to 1.2×10^{-7} cm/s in well BM-15 (Table 3-1). Results of laboratory permeability tests conducted on two soil samples collected from the glacial till indicate the vertical hydraulic conductivity for the clayey silt and silty clay to be about 1.7×10^{-8} cm/s. This indicates that the ratio of vertical to horizontal conductivity is roughly 1:10 suggesting that these glacial till sediments do not readily transmit water vertically (Wehran 1994).

Monitoring wells installed by the Town of Tonawanda as part of investigations associated with the operation of the landfill were used to obtain water level measurements. These monitoring wells were installed within and immediately adjacent to the landfill; therefore, do not provide information to evaluate groundwater flow patterns in the vicinity of the site. Contours of the water level data obtained from the monitoring wells are shown on Figure 3-7. These contours suggest that the shallow groundwater flow direction within the Mudflats parcel, is to the south. However, it is believed that this groundwater flow direction is probably affected by the water mound that is present within the landfill material (piezometers with identification labels "L-" and "P-"). Regionally the direction of groundwater flow in the unconsolidated sediments is probably to the north towards the Niagara River, similar to flow direction in the contact-zone aquifer as described in the following subsection.

3.5.2.2 Contact-Zone Aquifer

The contact-zone aquifer is a confined, water-bearing zone that has been extensively investigated and documented in the 1993 RI report. The contact-zone aquifer, is described in the 1993 RI report as the coarse-grained sand and gravel basal unit overlying the bedrock and the shallow portion of the bedrock aquifer that contains fractures, joints, and solution cavities (BNI 1993). Groundwater flow within the contact-zone aquifer is in a generally northward direction toward the Niagara River, which is the principal discharge zone for regional groundwater flow (Wehran 1994 and Malcolm Pirnie 1999). The hydraulic

conductivity (K) of the contact-zone aquifer (as calculated from slug tests) ranges from 6.2 x 10^{-3} cm/s in well DW-2 to 2.9 x 10^{-5} cm/s in well DW-1, which is one to three orders of magnitude higher than the overlying silty clay and clayey silt units (Table 3-1).

3.5.2.3 Groundwater Usage

Information presented in the 1993 RI report indicates that there are no private wells located within an approximate 3-mile radius of the Tonawanda Landfill (BNI 1993). In addition, even though the Camillus Shale is the most productive bedrock aquifer in the region, it also contains the poorest water quality due to high salinity and total dissolved solids (BNI 1993). Therefore, it is unlikely that the groundwater from the Camillus Shale is currently, or will be in the future, used for drinking water purposes (BNI 1993).

3.6 Characteristics of the Landfill Waste Material

The approximate lateral extent of the landfill (as defined by landfill waste material and fill) is presented in Figure 3-2, with the southern boundary of the landfill encroaching onto the NMPC easement (Malcolm Pirnie 1999). As shown in geologic cross-sections A-A', B-B', and C-C' (refer to Figures 3-3, 3-4, and 3-5) the landfill waste was placed in a depression or excavation in the surrounding fine-grained, silty clays and clayey silts. Historical information suggest that the landfill waste may have been placed within an abandoned quarry that was operated in the early 1900's in the western portion of the Landfill parcel. However, the footprint and vertical extent of this quarry are not known (Malcolm Pirnie 1999).

Based on slug tests conducted on monitoring wells completed within the landfill waste material (piezometers P-1 through 4 and BM-6), it appears that the saturated landfill wastes have a hydraulic conductivity approximately four orders of magnitude higher than the adjacent and underlying fine-grained glacial deposits ($K=10^{-2}$ cm/s for the landfill wastes vs. $K=10^{-6}$ cm/s for the glacial deposits) (Table 3-1). This difference in hydraulic conductivity between the adjacent and underlying fine-grained sediments (silts and clays) and the overlying landfill waste has created what Malcolm Pirnie has referred to as the "bathtub effect" (Malcolm Pirnie 1999). The landfill leachate, recharged by rainfall, essentially becomes isolated within the landfill depression with some leachate migrating out of the landfill cell in the following main three pathways (Malcolm Pirnie 1999):

- In seeps located along the edges of the landfill boundaries;
- Along the trench of the buried ECWA 48-inch water main where the pipeline is within the landfill waste in the southern portion of the landfill; and
- Through vertical migration of the leachate down through the underlying fine-grained unconsolidated sediments.

As shown in Figure 3-7, the water elevation contours in the landfill water indicate a mound that exists in the central-eastern portion of the Landfill parcel in the vicinity of piezometer P-3. This mound is beneath the highest point of the Landfill parcel (Figures 3-1 and 3-7), which is covered with permeable material (Malcolm Pirnie 1999). As indicated by the contoured data, the water level in the landfill is about 20 feet higher than groundwater levels in the native material. Due to the differences in the hydraulic conductivity of the landfill waste and the native material, seepage at the contact between the waste material and native material is the path of least resistance for any leachate transported with the water mounded within the landfill.

3.7 Demography and Land Use

The 1993 RI presents extensive descriptions on Demography and Land Use. The majority of the descriptions presented in the 1993 RI report also apply to the Tonawanda Landfill Vicinity Property except for the sections on access to the property and land use, which are discussed below.

3.7.1 Access to the Property and Adjacent Areas

The border of the Tonawanda Landfill is fenced along the northern, eastern, western, and southern property boundaries. Along the northern boundary, which is adjacent to a residential neighborhood, there are breaks in the fence where some of the property owners have pushed back the fence to gain access to the site. Easy access to the landfill property is also afforded in the northeast corner near the public water supply tank where there is no fence in place. In addition, even though most of the western boundary, is fenced, there are also some breaks that allow access to trespassers on foot and on motorcycles. Vehicular traffic is controlled by a gate that is locked after operating hours.

3.7.2 Land Use

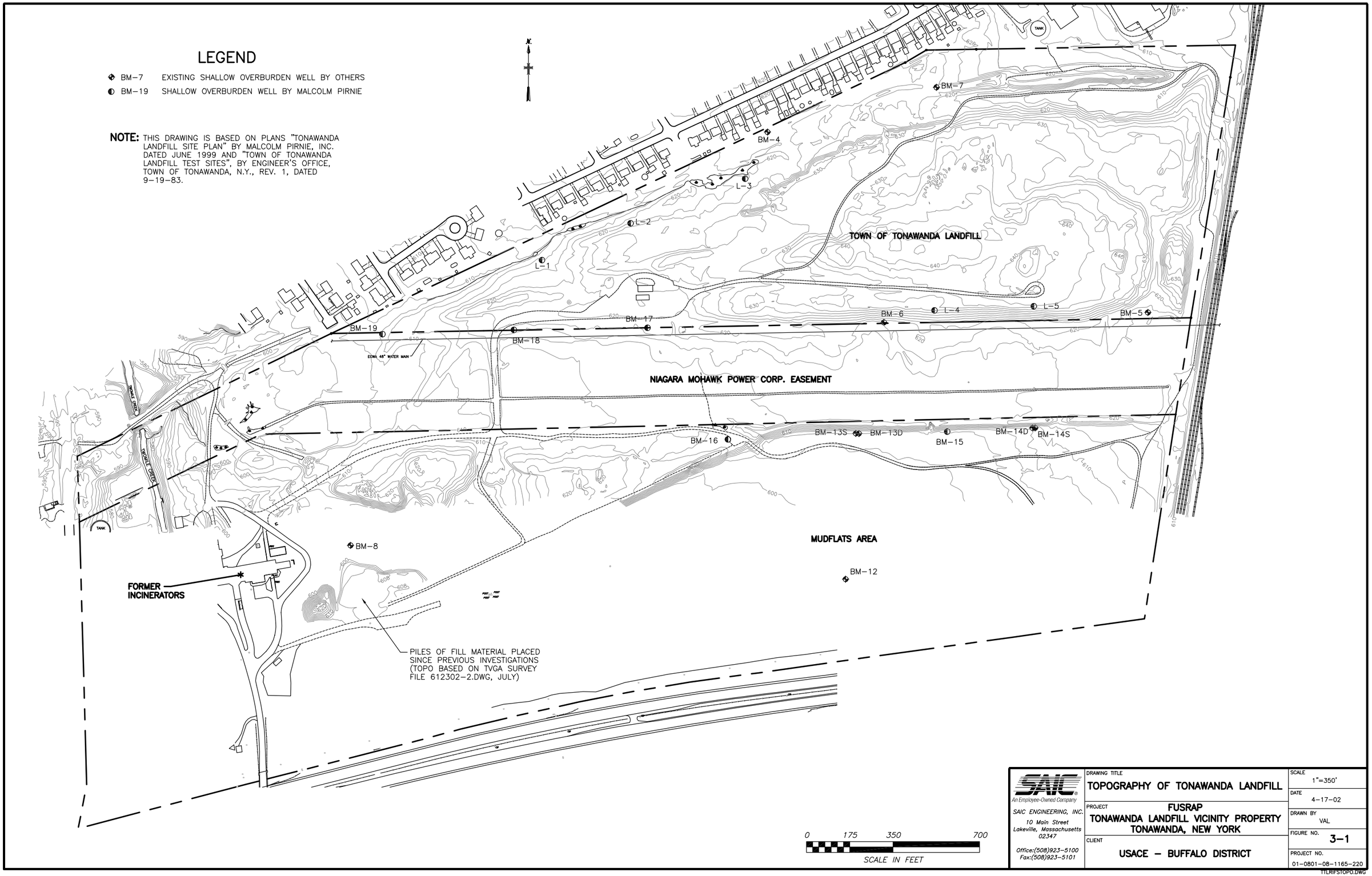
The Tonawanda Landfill is located in a Performance Standards ("PS") Use District as defined by the Town of Tonawanda Town zoning law. The Tonawanda Town Code defines the purpose of the Performance Standards Use as follows: "The purpose of this district is to encourage and allow the most appropriate use of the land available now as well as approaching future commercial and industrial uses unhampered by restrictive categorizing, thus extending the desirability of flexible zoning, subject to change with changing condition" (Town of Tonawanda 1990).

For the eastern portion of the Landfill parcel, the Town of Tonawanda is preparing for the eventual closure of the landfill by bringing in soils and select waste to use as alternate grading material. The NYSDEC specifically requested that the Town's contractor avoid placing alternate material in the Am-241 areas until a final decision is made on the disposition of this waste and the alternative grading material and soils are not currently being placed over the Am-241 areas. In the western portion of the Landfill, no site activities are being conducted, except for mowing of the grasses as part of site maintenance.

Currently the only site activities conducted at the Mudflats consist of use of the western portion of the property for disposal of street sweeping debris, compost material, and staging of road maintenance materials.

3.8 Ecology

Both the Landfill and Mudflats areas of the Tonawanda Landfill Vicinity Property are characterized as highly disturbed areas. The habitat and ecological conditions are described in Section 6.6.2.



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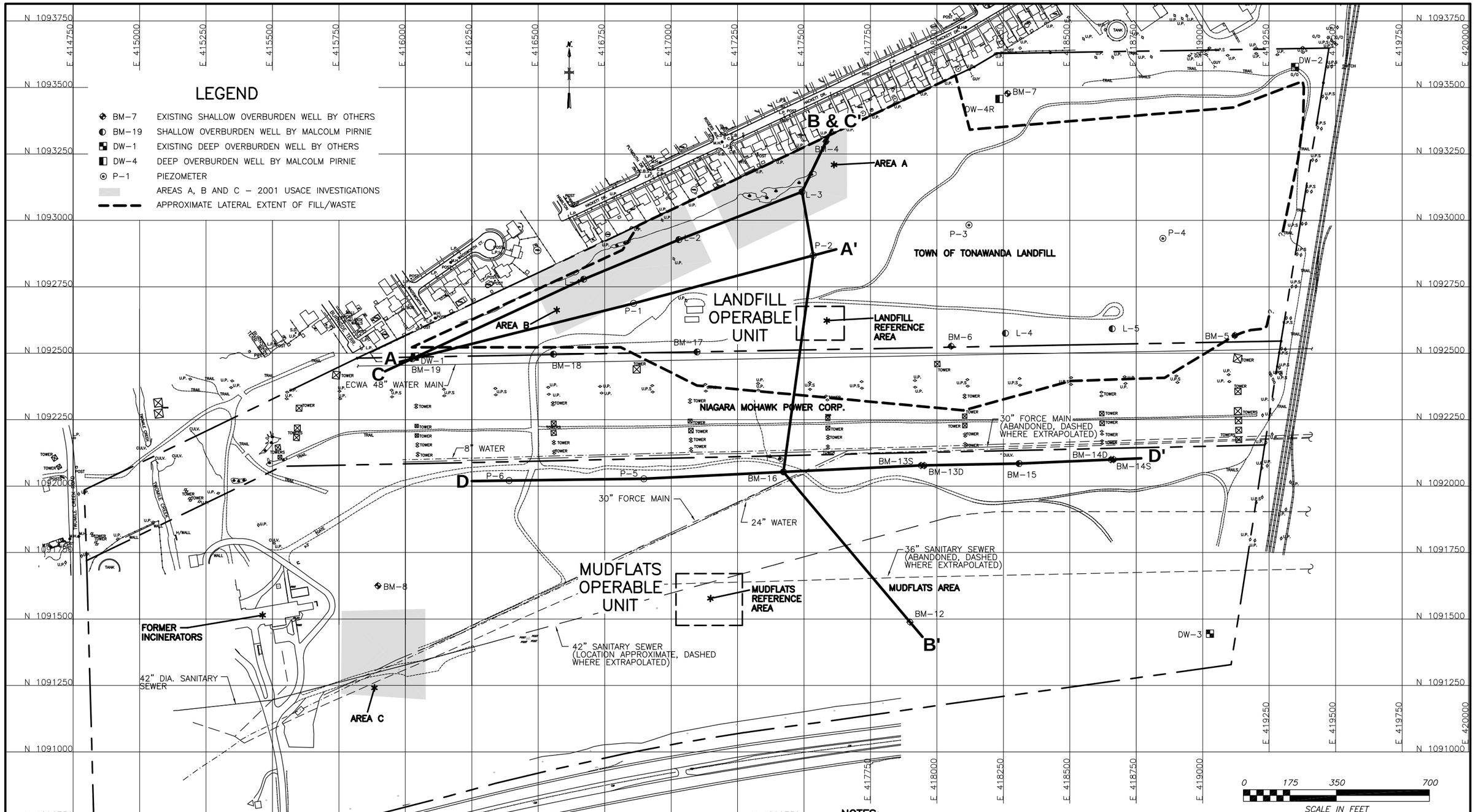
DRAWING TITLE: TOPOGRAPHY OF TONAWANDA LANDFILL

PROJECT: FUSRAP
TONAWANDA LANDFILL VICINITY PROPERTY
TONAWANDA, NEW YORK

CLIENT: USACE – BUFFALO DISTRICT

SCALE: 1"=350'
DATE: 4-17-02
DRAWN BY: VAL
FIGURE NO.: 3-1
PROJECT NO.: 01-0801-08-1165-220

TITLRIFSTOPO.DWG



NOTES:

1. THIS DRAWING IS BASED ON PLANS "TONAWANDA LANDFILL SITE PLAN" BY MALCOLM PIRNIE, INC. DATED JUNE 1999 AND "TOWN OF TONAWANDA LANDFILL TEST SITES", BY ENGINEER'S OFFICE, TOWN OF TONAWANDA, N.Y., REV. 1, DATED 9–19–83.
2. LOCATIONS OF UTILITIES IN THE MUDFLATS AREA APPROXIMATE. BASED ON EXCERPTS OF DRAWINGS FROM THE TOWN OF TONAWANDA INCLUDING: NORTH YOUNGMANN COMMERCE CENTER TOPOGRAPHICAL SURVEY SHEETS 3, 4 AND 6 OF 6.

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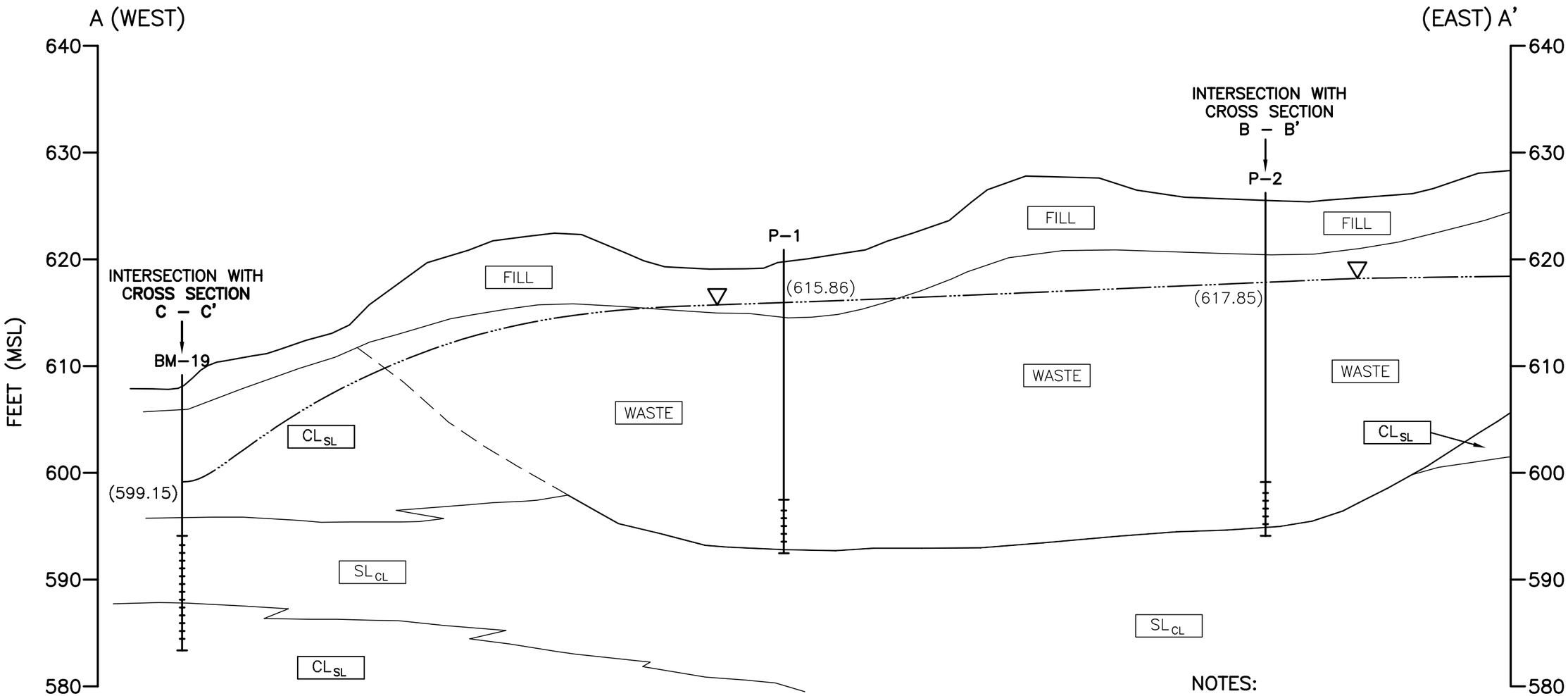
DRAWING TITLE: SITE FEATURES AND CROSS SECTION LOCATIONS

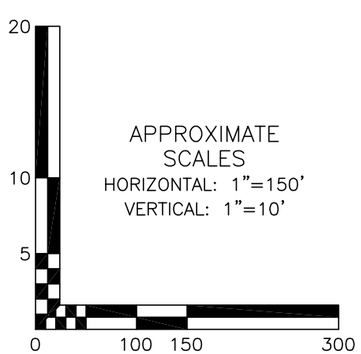
PROJECT: FUSRAP
TONAWANDA LANDFILL VICINITY PROPERTY
TONAWANDA, NEW YORK

CLIENT: USACE – BUFFALO DISTRICT

SCALE	1"=350'
DATE	7–9–02
DRAWN BY	VAL
FIGURE NO.	3–2
PROJECT NO.	01–1504–08–1165–280

TTLRIFS3–2A.DWG





KEY

FILL	FILL
WASTE	LANDFILLED WASTE
CL_{SL}	SILTY CLAY
SL_{CL}	CLAYEY SILT
▽	WATER TABLE SURFACE

BOREHOLE TRACE

(615.86) WATER LEVEL ELEVATION (SEPTEMBER 2001)

SCREENED INTERVAL OF WELL

NOTES:

1. THIS FIGURE WAS CONSTRUCTED, IN PART, BY USING INFORMATION PROVIDED ON CROSS–SECTION A–A' FROM G SHEET, PLATE 2 OF 4 TITLED "TONAWANDA LANDFILL HYDROGEOLOGIC CROSS SECTIONS", PREPARED BY MALCOLM PIRNIE, INC., DATED MARCH 1998.
2. IN THE KEY FOR SOIL TYPES, THE MAJOR CONSTITUENT IS LISTED FIRST AND THE MINOR CONSTITUENT IS LISTED SECOND. FOR EXAMPLE, A SILTY CLAY (CL_{SL}) IS PRIMARILY COMPOSED OF CLAY. THIS FOLLOWS THE NOMENCLATURE USED BY MALCOLM PIRNIE (1998) IN THEIR CROSS SECTIONS.
3. GROUNDWATER ELEVATIONS ARE BASED ON SEPTEMBER 2001 MEASUREMENTS.
4. REFER TO FIGURE 3–2 FOR CROSS SECTION LOCATIONS.

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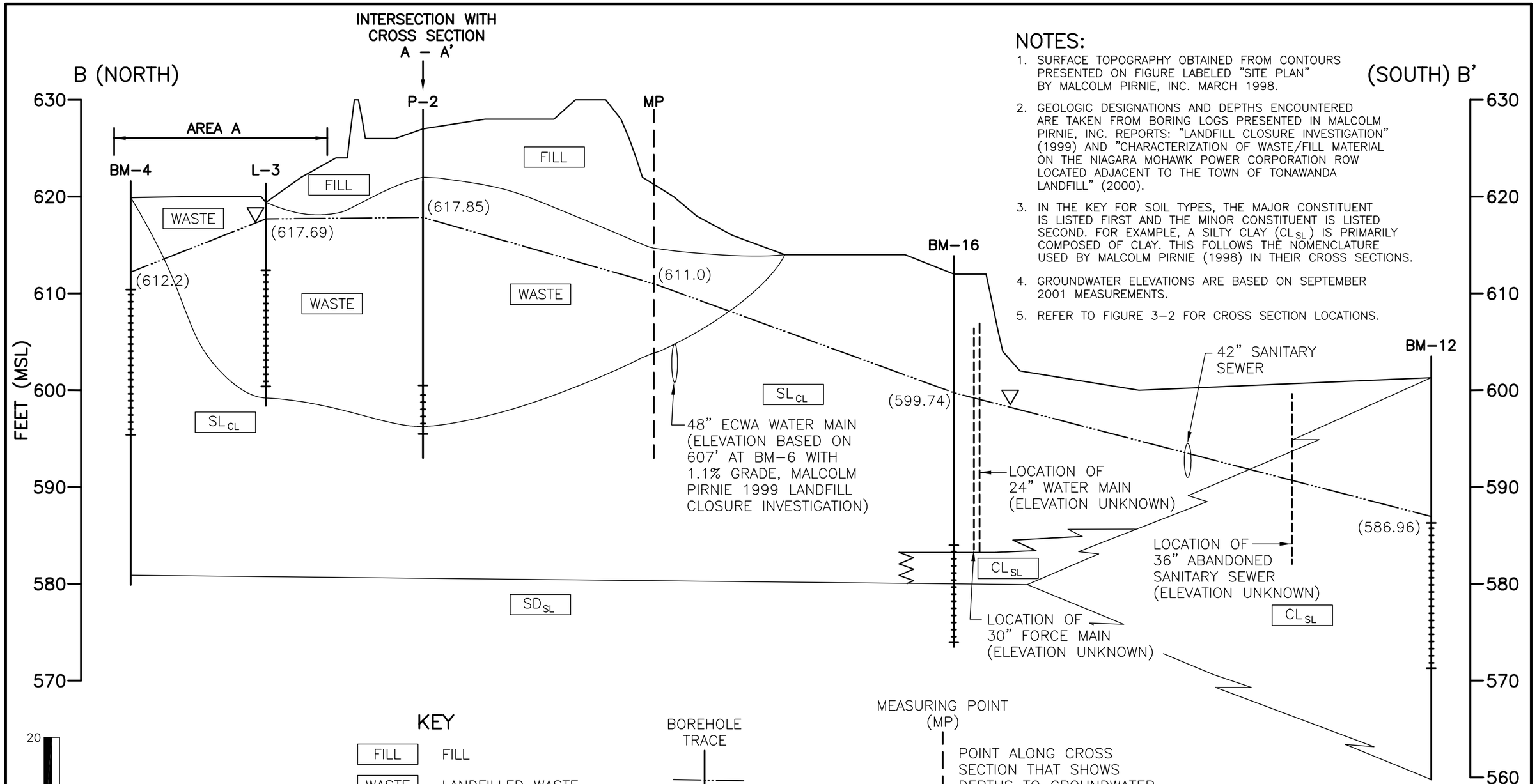
DRAWING TITLE	CROSS SECTION A – A'
PROJECT	FUSRAP TONAWANDA LANDFILL VICINITY PROPERTY TONAWANDA, NEW YORK
CLIENT	USACE – BUFFALO DISTRICT
SCALE	AS SHOWN
DATE	7–9–02
DRAWN BY	VAL
FIGURE NO.	3–3
PROJECT NO.	01–1504–08–1165–280

TTLRIFSWECSA.DWG



NOTES:

1. SURFACE TOPOGRAPHY OBTAINED FROM CONTOURS PRESENTED ON FIGURE LABELED "SITE PLAN" BY MALCOLM PIRNIE, INC. MARCH 1998.
2. GEOLOGIC DESIGNATIONS AND DEPTHS ENCOUNTERED ARE TAKEN FROM BORING LOGS PRESENTED IN MALCOLM PIRNIE, INC. REPORTS: "LANDFILL CLOSURE INVESTIGATION" (1999) AND "CHARACTERIZATION OF WASTE/FILL MATERIAL ON THE NIAGARA MOHAWK POWER CORPORATION ROW LOCATED ADJACENT TO THE TOWN OF TONAWANDA LANDFILL" (2000).
3. IN THE KEY FOR SOIL TYPES, THE MAJOR CONSTITUENT IS LISTED FIRST AND THE MINOR CONSTITUENT IS LISTED SECOND. FOR EXAMPLE, A SILTY CLAY (CL_{SL}) IS PRIMARILY COMPOSED OF CLAY. THIS FOLLOWS THE NOMENCLATURE USED BY MALCOLM PIRNIE (1998) IN THEIR CROSS SECTIONS.
4. GROUNDWATER ELEVATIONS ARE BASED ON SEPTEMBER 2001 MEASUREMENTS.
5. REFER TO FIGURE 3–2 FOR CROSS SECTION LOCATIONS.

APPROXIMATE SCALES
HORIZONTAL: 1"=150'
VERTICAL: 1"=10'

20 10 5 0 100 150 300

KEY

FILL	FILL
WASTE	LANDFILLED WASTE
CL_{SL}	SILTY CLAY
SD_{SL}	SILTY SAND
SL_{CL}	CLAYEY SILT
▽	WATER TABLE SURFACE

BOREHOLE TRACE

(606.5) WATER LEVEL ELEVATION (SEPTEMBER 2001)

SCREENED INTERVAL OF WELL

MEASURING POINT (MP)

POINT ALONG CROSS SECTION THAT SHOWS DEPTHS TO GROUNDWATER, FILL, AND WASTE AS INTERPOLATED BETWEEN MONITORING WELLS BM–17 AND BM–6

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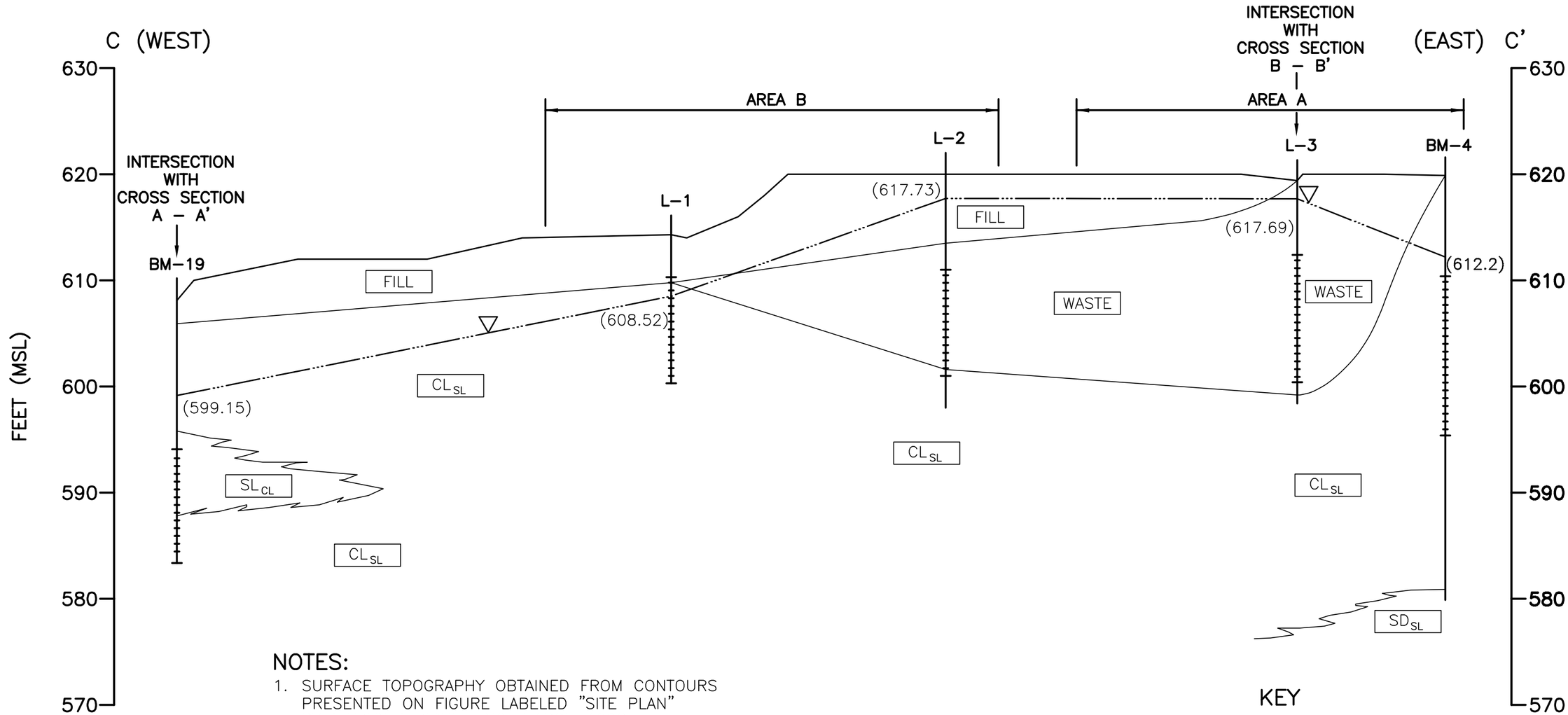
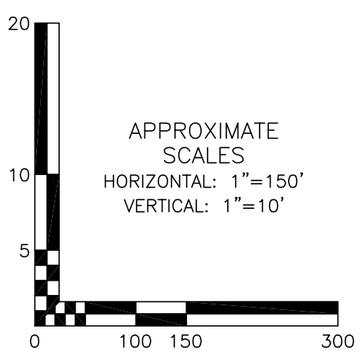
DRAWING TITLE	CROSS SECTION B – B'
PROJECT	FUSRAP TONAWANDA LANDFILL VICINITY PROPERTY TONAWANDA, NEW YORK
CLIENT	USACE – BUFFALO DISTRICT
SCALE	AS SHOWN
DATE	7–9–02
DRAWN BY	VAL
FIGURE NO.	3–4
PROJECT NO.	01–1504–08–1165–280

TTLRIFSWECSA.DWG



NOTES:

1. SURFACE TOPOGRAPHY OBTAINED FROM CONTOURS PRESENTED ON FIGURE LABELED "SITE PLAN" BY MALCOLM PIRNIE, INC. MARCH 1998.
2. GEOLOGIC DESIGNATIONS AND DEPTHS ENCOUNTERED ARE TAKEN FROM BORING LOGS PRESENTED IN MALCOLM PIRNIE, INC. REPORTS: "LANDFILL CLOSURE INVESTIGATION" (1999) AND "CHARACTERIZATION OF WASTE/FILL MATERIAL ON THE NIAGARA MOHAWK POWER CORPORATION ROW LOCATED ADJACENT TO THE TOWN OF TONAWANDA LANDFILL" (2000).
3. IN THE KEY FOR SOIL TYPES, THE MAJOR CONSTITUENT IS LISTED FIRST AND THE MINOR CONSTITUENT IS LISTED SECOND. FOR EXAMPLE, A SILTY CLAY (CL_{SL}) IS PRIMARILY COMPOSED OF CLAY. THIS FOLLOWS THE NOMENCLATURE USED BY MALCOLM PIRNIE (1998) IN THEIR CROSS SECTIONS.
4. GROUNDWATER ELEVATIONS ARE BASED ON SEPTEMBER 2001 MEASUREMENTS.
5. REFER TO FIGURE 3–2 FOR CROSS SECTION LOCATIONS.



BOREHOLE TRACE

(606.5) WATER LEVEL ELEVATION (SEPTEMBER 2001)

SCREENED INTERVAL OF WELL

KEY

FILL	FILL
WASTE	LANDFILLED WASTE
CL_{SL}	SILTY CLAY
SD_{SL}	SILTY SAND
SL_{CL}	CLAYEY SILT
▽	WATER TABLE SURFACE

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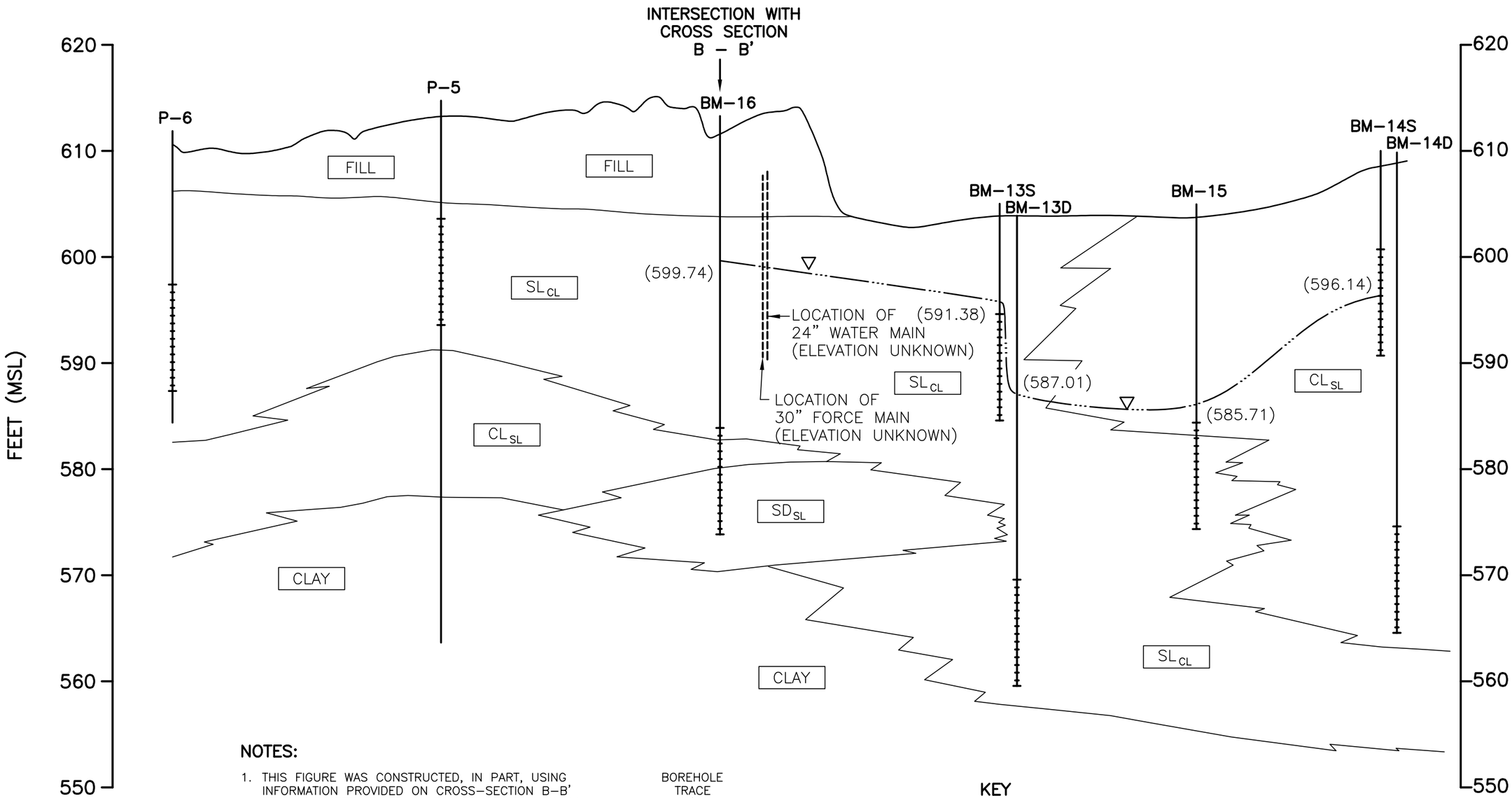
DRAWING TITLE: CROSS SECTION C – C'

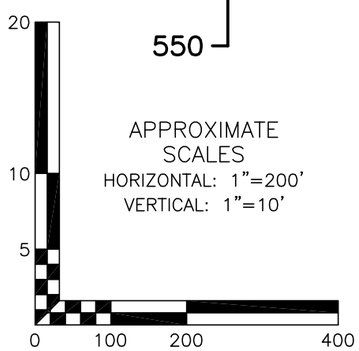
PROJECT: FUSRAP
TONAWANDA LANDFILL VICINITY PROPERTY
TONAWANDA, NEW YORK

CLIENT: USACE – BUFFALO DISTRICT

SCALE: AS SHOWN
DATE: 7–9–03
DRAWN BY: VAL
FIGURE NO.: 3–5
PROJECT NO.: 01–1504–08–1165–280

TTLRIFSWECSA.DWG





NOTES:

1. THIS FIGURE WAS CONSTRUCTED, IN PART, USING INFORMATION PROVIDED ON CROSS–SECTION B–B' FROM G SHEET, PLATE 2 OF 4 TITLED "TONAWANDA LANDFILL HYDROGEOLOGIC CROSS SECTIONS", PREPARED BY MALCOLM PIRNIE, INC., DATED MARCH 1998.
2. IN THE KEY FOR SOIL TYPES, THE MAJOR CONSTITUENT IS LISTED FIRST AND THE MINOR CONSTITUENT IS LISTED SECOND. FOR EXAMPLE, A SILTY CLAY (CL_{SL}) IS PRIMARILY COMPOSED OF CLAY. THIS FOLLOWS THE NOMENCLATURE USED BY MALCOLM PIRNIE (1998) IN THEIR CROSS SECTIONS.
3. GROUNDWATER ELEVATIONS ARE BASED ON SEPTEMBER 2001 MEASUREMENTS.
4. REFER TO FIGURE 3–2 FOR CROSS SECTION LOCATIONS.

BOREHOLE TRACE

(599.74) WATER LEVEL ELEVATION (SEPTEMBER 2001)

SCREENED INTERVAL OF WELL

KEY

FILL	FILL
CLAY	GLACOLACUSTERINE CLAY
CL_{SL}	SILTY CLAY
SD_{SL}	SILTY SAND
SL_{CL}	CLAYEY SILT
▽	WATER TABLE SURFACE

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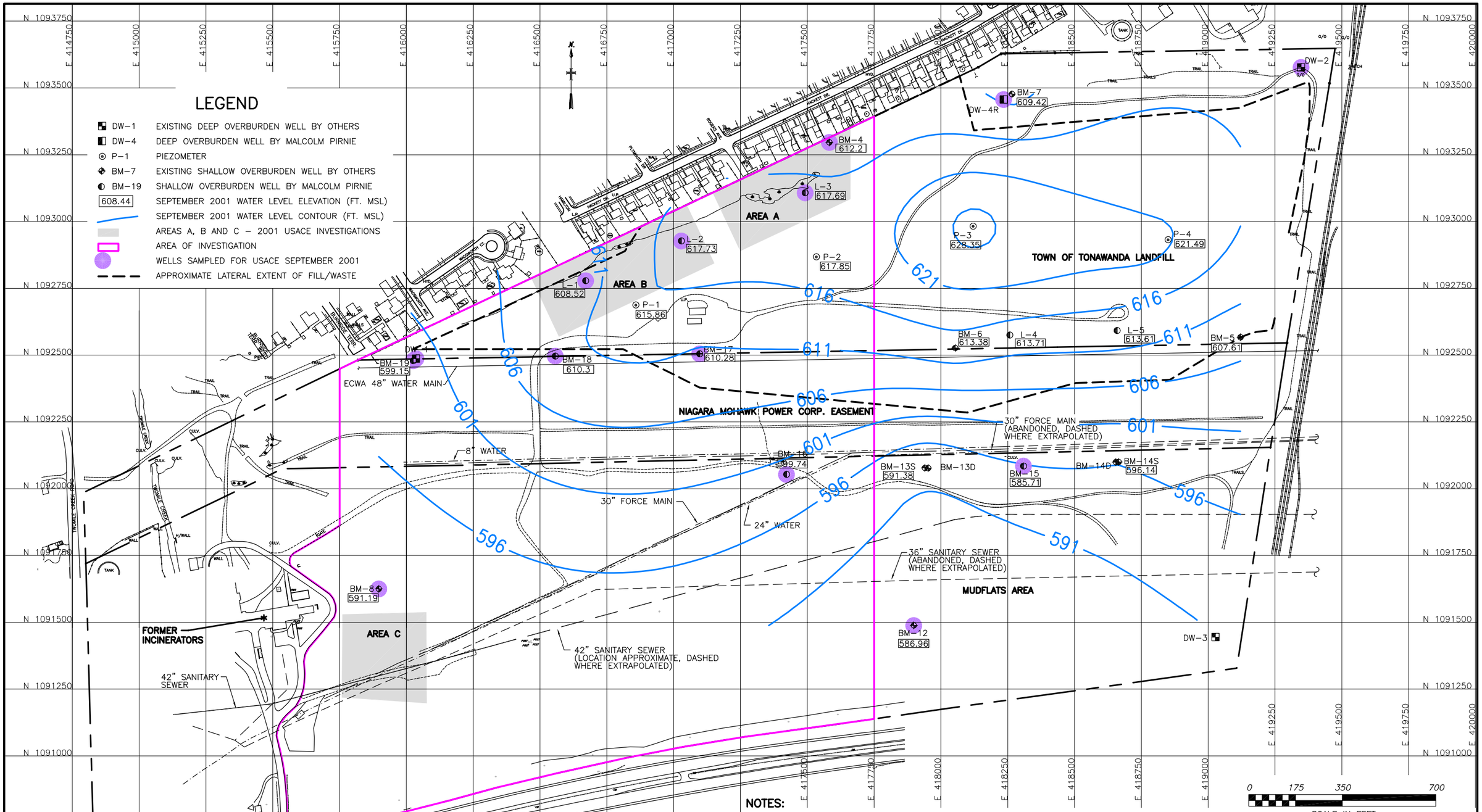
DRAWING TITLE: CROSS SECTION D – D'

PROJECT: FUSRAP
TONAWANDA LANDFILL VICINITY PROPERTY
TONAWANDA, NEW YORK

CLIENT: USACE – BUFFALO DISTRICT

SCALE: AS SHOWN
DATE: 7–9–03
DRAWN BY: VAL
FIGURE NO. 3–6
PROJECT NO. 01–1504–08–1165–280

TTLRIFSWECSA.DWG



NOTES:

1. THIS DRAWING IS BASED ON PLANS "TONAWANDA LANDFILL SITE PLAN" BY MALCOLM PIRNIE, INC. DATED JUNE 1999 AND "TOWN OF TONAWANDA LANDFILL TEST SITES", BY ENGINEER'S OFFICE, TOWN OF TONAWANDA, N.Y., REV. 1, DATED 9-19-83.
2. WELL BM-15 NOT USED TO DEVELOP CONTOURS DUE TO DEEPER SCREEN INTERVAL THAN ADJACENT WELLS.
3. WATER LEVEL CONTOURS REPRESENT A SINGLE POINT IN TIME AND MAY VARY DUE TO CLIMATIC CHANGES OR OTHER FACTORS. WATER LEVEL CONTOURS ARE INTERPOLATED BETWEEN DATA POINTS. WATER LEVEL CONTOURS ASSUME HOMOGENEOUS AND ISOTROPIC AQUIFER CONDITIONS AND HORIZONTAL FLOW. ACTUAL SUBSURFACE CONDITIONS MAY VARY FROM THOSE SHOWN OR INTERPOLATED.

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DRAWING TITLE
WATER LEVEL CONTOURS IN SHALLOW WELLS, SEPTEMBER 2001

PROJECT
FUSRAP
TONAWANDA LANDFILL VICINITY PROPERTY
TONAWANDA, NEW YORK

CLIENT
USACE – BUFFALO DISTRICT

SCALE	1"=350'
DATE	7-9-03
DRAWN BY	VAL
FIGURE NO.	3-7
PROJECT NO.	01-1504-08-1165-280

TTLRIFS3-7.DWG

TABLE 3-1
MONITORING WELL DATA AND GROUNDWATER ELEVATIONS
TONAWANDA LANDFILL VICINITY PROPERTY

WELL LOCATION	ELEVATION[1] TOP OF SCREEN	ELEVATION[1] BOTTOM OF SCREEN	LITHOLOGY MONITORED	K-VALUE[2] (cm/sec)	SEPTEMBER 2001	
					Depth to Water [3]	Water Elevation[1]
Screened Interval in Unconsolidated Glacial Deposits						
BM-4	608.10	597.10	clayey silt	1.1E-05	9.40	612.20
BM-5	604.91	587.91	clayey silt	6.9E-06	11.30	607.61
BM-7	617.24	595.24	silty sand	4.6E-06	15.82	609.42
BM-8	588.54	571.54	silty clay	6.7E-06	9.35	591.19
BM-12	589.24	572.24	silty clay	1.9E-06	16.28	586.96
BM-13S	596.78	585.28	silty clay	1.7E-06	14.40	591.38
BM-13D	571.69	559.19	silty clay	2.6E-08	18.65	587.04
BM-14S	601.90	590.90	clayey silt	4.1E-07	14.76	596.14
BM-14D	576.42	563.42	clayey silt	2.8E-07	obstruction	-
BM-15	588.70	576.20	clayey silt	2.1E-07	20.49	585.71
BM-16	587.86	575.36	silty sand	1.0E-06	14.12	599.74
BM-17	608.83	596.73	clayey silt	1.2E-07	11.45	610.28
BM-18	606.61	594.51	clayey silt	3.5E-06	9.21	610.30
BM-19	597.30	585.20	clayey silt	3.2E-07	11.05	599.15
DW-3	556.86	548.86	glacial till	2.4E-06	25.87	585.99
P-5	606.32	596.32	clayey silt	NC	dry	-
			Average:	2.7E-06		
Screened Interval in Contact Zone Aquifer						
DW-1	521.65	515.15	silty sand/gravel	2.9E-05	41.69	568.96
DW-2	559.81	552.31	sand/gravel	6.2E-03	39.63	569.18
DW-4R	560.33	547.83	sand/gravel	4.4E-05	52.72	570.11
			Average:	2.1E-03		
Screened Interval in Landfill Wastes/Fill						
BM-6	610.66	593.66	waste	8.8E-03	5.75	613.91
P-1	617.46	594.46	waste	7.5E-03	6.60	615.86
P-2	623.84	596.84	waste	8.5E-03	10.99	617.85
P-3	631.37	616.37	waste	1.1E-02	8.02	628.35
P-4	634.49	609.49	waste	1.0E-04	18.00	621.49
L-1	612.12	602.12	clay fill	NC	7.60	608.52
L-2	613.03	603.03	waste	NC	4.30	617.73
L-3	612.34	602.34	waste	NC	3.65	617.69
L-4	620.41	605.41	waste	NC	19.70	613.71
L-4	628.43	613.43	waste/silty clay	NC	24.82	613.61
			Average:	7.2E-03		

Notes:
(1) Measured in feet; elevation above mean sea level.
(2) Bouwer and Rice Method (slug test)- From Malcolm Pirnie 1999
(3) Measured in feet; elevation below top of riser.
Source of Groundwater Elevation Data: Malcolm Pirnie
NC = Not Calculated

4.0 NATURE AND EXTENT OF CONTAMINATION

The nature and extent of MED-like waste detected in surface and subsurface soils, sediment, surface water, and groundwater are described in this section. The discussion is separated into the Mudflats OU (Section 4.1) and the Landfill OU (Section 4.2). The field investigation conducted by USACE in 2001 to define the extent of radiological contamination in soil in the Mudflats OU and the Landfill OU included a gamma walkover survey to assess the extent of surficial contamination; downhole geophysics to evaluate the vertical extent of radiological contamination; and soil sampling and laboratory analyses for quantitative evaluation of the nature and extent of radiological contamination.

The 2001 field investigation conducted to evaluate the nature and extent of radiological contamination in groundwater and leachate included sampling of selected existing monitoring wells and laboratory analyses for quantitative evaluation of the nature and extent of radiological contamination. The investigation conducted to evaluate the nature and extent of radiological contamination in sediment and surface water samples in the Landfill OU included sediment and surface water sampling and laboratory analyses.

In addition, where field screening results indicated radiological contamination, soil samples were collected and analyzed to determine if any hazardous materials are collocated with MED-like material within the Mudflats OU and the Landfill OU.

4.1 Mudflats OU Investigation

4.1.1 Gamma Walkover Survey Results – Mudflats OU

As part of the 2001 USACE investigation, a GWS was conducted in the Mudflats OU. The purpose of the GWS was to confirm previous areas of elevated radiological activity and to assess areas of the Mudflats OU that had not been previously investigated. However, the area identified during prior investigations as having elevated radiological levels (Area C, Class 1) was covered with large piles of soil and soil fill, as indicated in Figure 2-1. These soils ranged in depth from 6 to 8 feet over most of the area to over 20 feet over a limited area (refer to Figure 3-1 for surface topography).

Therefore, confirmation of the previous survey results could not be made. A brief walkover survey of native soil around the piles was performed. A limited survey of the access path on the side of the large pile, as well as the soil fill over the original elevated sample location also was performed. The locations of these surveys in the immediate vicinity of the Area C, Class 1 area and other areas of the Mudflats are shown in Figure 4-1. During the GWS conducted in the Mudflats OU, no areas of elevated activity were detected. In order to determine sodium iodide (NaI) 2” x 2” local background, three reference areas were selected (Figure 4-11). Upon arrival at the site, Reference Area 2 was inaccessible due to standing water. In Reference Areas 1 and 3, ten integrated counts of one minute each were collected throughout each (10m x 10m) reference area grid. Background data were collected approximately 10cm above the surface of the soil. The mean count rate of Reference Areas 1 and 3 were 10,549 cpm and 9,365 cpm, respectively. Conservatively, the Reference Area 3 count rate of 9,365 cpm was used in the NaI 2” x 2” “background” count rate. An investigation level was set at the background count rate (9,365 cpm), summed with the minimum detectable count rate (MDCR), 1,600 cpm, which was 10,965 cpm. In the field, cpm was used as the investigation level.

4.1.2 Results of Radiological Analyses of Soils and Soils Screening Criteria – Mudflats OU

The results of radiological analyses of soils, a description of the screening criteria developed to assess radiological contaminants in soils and the results of the screening assessment are described in the following sections.

4.1.2.1 Results of Radiological Analyses of Soils – Mudflats OU

Soil samples were collected at 96 locations in the Mudflats OU. The locations of these sampling points are indicated in Figure 4-2 and the soil borings and associated soil sample IDs are listed in Table 2-2. From these 96 sampling locations, including Quality Control/Quality Assurance (QA/QC) samples, a total of 224 soil samples collected from the Mudflats OU. These samples were analyzed for the following:.

- Iso-Uranium 234, 235, and 238
- Iso-Thorium 228, 230, and 232
- Radium-226
- Radium-228
- Gamma Spectrometry (Isotope identification including Am-241)

Prior to conducting the 2001 investigation, a review of radiological data from previous investigations was conducted to classify impacted and non-impacted areas within the Mudflats OU. MARSSIM guidance was used to determine the study areas and to divide the Mudflats OU into the following three investigation areas: Class 1 (historically impacted); Class 2 (possibly impacted); and Class 3 (no expected impact) (USACE 2001a). As indicated in Figure 4-3, the Class 1 area encompasses the four borings (B3', B13, B14, and B15) where potentially MED-like (radiologically-impacted) material was previously detected (ORNL 1992).

The total number of samples, number of detects, minimum radionuclide concentration, maximum radionuclide concentration, mean radionuclide concentration, and 95th percentile of the upper confidence limit (UCL95) concentration for the soil samples collected in the three Mudflats OU investigation areas are summarized in Tables 4-1 through 4-6. Individual sample results are provided in Appendix A (which is bound separately). A report summarizing the data validation activities and results is included in Appendix B along with the results database.

4.1.2.2 Soils Radiological Screening Criteria and Assessment – Mudflats OU

To define the nature and extent of radiologically-impacted material (MED-like material) in the Mudflats OU, the 99 percent upper tolerance limit on the 99.9th percentile, with 99.9 percent coverage (UTL 99/99.9) was calculated for U-238, Th-230, and Ra-226 for the Mudflats OU background reference data set.[2] U-238, Th-230, and Ra-226 are considered primary constituents associated with MED-like material.

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[2] The UTL 99/99.9 is the upper 99 percent tolerance limit with 99.9 percent coverage. One can be 99 percent confident that 99.9 percent of the individual data points will fall below the UTL 99/99.9. The UTL 99/99.9 is a statistic about the upper-tail of the distribution. It can be thought of as a 99 percent confidence limit on the 99.9th percentile. The data distributions are tested and UCL95/UCL values calculated accordingly for risk calculations as presented in Section 6, however, for screening purposes normality was assumed here using the following parameters:

UTL 99/99.9 – mean + K(std), where:
Mean = arithmetic average of the original values,
K= appropriate table value from statistical tables (dependent on sample size),

The UTL 99/99.9 values for U-238, Th-230, and Ra-226 were used as a conservative screening tool to delineate the definitive areas of MED-like contamination. Background levels for these radiological isotopes were calculated based on concentrations in the Mudflats OU reference area, located to the east of the Mudflats OU Class 1 and 2 areas (Figure 4-2). The UTL 99/99.9 screening concentrations calculated for the three primary radionuclides of concern calculated for the Mudflats background reference area are as follows:

- Th-230 – 1.69 picocuries per gram (pCi/g)
- U-238 – 1.31 pCi/g
- Ra-226 – 2.22 pCi/g

The nature and extent of radiologically-impacted material within the Mudflats OU is defined by concentrations of Th-230, U-238, and/or Ra-226 that exceed the respective UTL 99/99.9 screening criteria. Of the 224 soil samples analyzed, concentrations of Th-230, U-238 and/or Ra-226 exceeded the UTL 99/99.9 screening criteria in only four soils samples from the two following borings:

- Soil samples TMF-0283 and TMF0285, collected from Area C, Class 1 boring TMFC1-005;
- Soil samples TMF-0222 and TMF-0223, collected from Area C, Class 2 boring TMFC2-012.

The locations of these two borings are shown in Figure 4-4. The results exceeding the screening criteria are shown in Table 4-7. Table 4-7 also lists historical soil sample results exceeding the screening criteria, as further discussed in this Section.

Note that soil sample TMF-0285 [which was collected from 3.5 to 4 feet below ground surface (bgs) in boring TMFC1-005] was collected from the fill material placed above the horizon at which MED-like material was detected in historical boring B13 (Figure 4-5). Soil exceeding the UTL 99/99.9 screening criteria also was encountered in the deeper sample that was collected from 9.75 to 10.25 feet bgs (TMF-0283), which was thought to correspond with the approximate interval that MED-like material was detected in historical boring B13.

The 2001 investigation also included soil borings in Area C, Class 1 at the locations of three borings where elevated concentrations of Th-230, U-238, and/or Ra-226 were detected during previous investigations. The 2001 borings and the corresponding historical borings are as follows:

- TMFC1-001 – ORNL designation B3';
- TMFC1-009 – ORNL designation B14; and
- TMFC1-013 – ORNL designation B15.

The locations of historic borings B3', B14, and B15 also are indicated in Figure 4-5 and the historical radiological data, including these three borings and boring B13, are summarized in Table 4-8. However, Th-230, U-238, and/or Ra-226 were not detected at concentrations above their respective UTL 99/99.9 screening criteria in the soil samples collected in 2001 from borings TMFC1-001, TMFC1-009, and TMFC1-013. Refer to Appendix A, Table A4-8, and Figure 4-5 of this report.

Based on these findings, it is believed that the MED-like material previously detected in historical borings B3', B13, B14 and B15 was moved during construction activities associated with the installation of the 42-inch sewer line. To assess whether the MED-like material was pushed to the north during site activities, soil borings TMFC1-002, TMFC1-003 and TMFC1-004 were installed to the north of boring TMFC1-005. However, in these three offset borings, Th-230, U-238, and/or Ra-226 were also not

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And std = standard deviation of the original values.

detected at concentrations above the UTL 99/99.9 screening criteria for the respective radionuclides (Appendix A, Table A4-8, and Figures 4-4 and 4-5 of this report).

In addition, to assess how the lateral extent of potentially MED-like soils for the 2001 data set compared with historical soils data, the historical Mudflats OU data was also compared to the UTL 99/99.9 screening criteria calculated for the 2001 Mudflats OU reference area (Table 4-8). Both the 2001 and the historical exceedances of the UTL 99/99.9 in soil were plotted in the vicinity of Area C in Figure 4-5. Except for historical borings S75, S77, S79, S81, and S83, all of the exceedances of the UTL 99/99.9 screening criteria were detected within the Class 1 and 2 areas of Area C. In historical borings S75, S77, S79, S81, and S83, U-238 was the only constituent of concern detected at concentrations just above the UTL 99/99.9 screening levels (Table 4-8). However, in the 2001 borings drilled near these borings, U-238, Th-230, and Ra-226 were not detected in soil at concentrations above their respective UTL 99/99.9 values. Historical and USACE 2001 soil samples from the Mudflats area showing U-238, Th-230[3] and Ra-226 exceeding the screening criteria are listed in Table 4-7.

4.1.3 Mudflats OU Downhole Geophysical Survey Results

During the Mudflats OU investigation, downhole gamma logging was conducted at each of the borings. The downhole gamma logging can be used to detect elevated levels of Ra-226 in the immediate vicinity of the subsurface borings, but does not detect the other two radionuclides of concern, at the Tonawanda Landfill Vicinity Property, Th-238, and U-238. The borings in which "peaks" in the downhole gamma readings were measured are presented on TableA4-14 of Appendix A. The downhole "peaks" were measured relative to background downhole gamma readings. Background downhole gamma readings were obtained from three boreholes located in the mudflats reference area. The soil samples that had concentrations of Th-230, U-238, and/or Ra-226 exceeding the UTL 99/99.9 screening criteria as determined by the Mudflats OU reference area are shown in Table A4-14 of Appendix A. The downhole gamma logs are included in Attachment E of Appendix A.

During the logging of the 96 borings drilled during the 2001 Mudflats OU investigation, elevated levels of gamma radiation (relative to background levels) were measured in only boring TMFC1-005 and boring TMFC2-012 (Table A4-14 of Appendix A). The peak measured in boring TMFC1-005 correlated well to the depth from which sample TMF-0285 was collected, which exceeded the UTL 99/99.9 screening criteria. In boring TMFC2-012, the interval at which a peak was measured (approximately 1 to 2.2 feet bgs) was not sampled for radiological analysis. However, samples were collected above (TMF-0222 at 0 to 0.5 ft bgs) and below (TMF-0223) in boring TMFC2-012 that did exceed the UTL 99/99.9 screening criteria (Table A4-14 of Appendix A).

In the Mudflats OU, the "peaks" detected during downhole gamma logging correlated fairly well to soil samples that had concentrations of Th-230, U-238, and/or Ra-226 that exceeded the UTL 99/99.9 screening criteria. The results of the analyses of all soil samples from the Mudflats and associated downhole gamma scans are provided in Appendix A, Tables A-4-14a through A4-14e.

4.1.4 Nature and Extent of Am-241 - Mudflats OU

As discussed earlier, Am-241, which represents another form of radiological contamination at the Tonawanda Landfill (Landfill parcel), also was detected in a limited number (11) of Mudflats OU soil samples (Table 4-9). The concentrations ranged from 0.079 pCi/g (sample TMF-0173 collected from soil

[3] Th-230 was historically analyzed using the gamma spec method, a method that produces relatively high detection limits for this weak gamma-emitting radionuclide. Alpha spec was used to analyze Th-230 in 2001 samples, producing typical detection limits less than 1 pCi/g.

boring TMF3B-057) to 0.5 pCi/g (sample TMF-0005 collected from soil boring TMFR1-003). The locations of the 2001 borings in which Am-241 was detected are shown in Figure 4-6.[4] Am-241 was not detected during the limited soil sampling activities conducted by ORNL in the vicinity of Area C of the Mudflats OU (ORNL 1992). Historically, Am-241 was primarily detected in only the eastern portion of the Tonawanda Landfill (Landfill parcel). For comparison, in the eastern portion of the Landfill parcel, Am-241 was detected in surface soil samples at concentrations ranging from 1 pCi/g to 157 pCi/g and in the subsurface soils at concentrations ranging from 1 pCi/g to 544 pCi/g (TMA/Eberline 1988).

In the soil samples in which Am-241 was detected, there were no exceedances of the UTL 99/99.9 screening criteria for U-238, Th-230, and/or Ra-226 indicating that at those locations potentially MED-like soil and soils containing concentrations of Am-241 are not commingled. The trace amounts of Am-241 detected are likely due to physical transfer (on vehicles, etc.) from the landfill.

4.1.5 Results of Chemical Analyses of Soils Samples – Mudflats OU

As outlined in the SAP (USACE 2001a), chemical samples were collected from a fraction of the locations which appeared to contain MED-like material, based on field screening. The purpose of the chemical sampling was to determine if chemical or non-MED-like wastes are commingled with the possible MED-related materials. This was for the purpose of establishing waste acceptance criteria, and for health and safety concerns relating to potential site contamination. Since field screening identified none of these areas in the Mudflats OU, three soil samples collected from the fill in Area C, Class 1 were analyzed for the presence of Target Analyte List (TAL)/Target Contaminant List (TCL) analytes as follows:

- TAL Metals and cyanide, various analytical methods
- TCL Volatiles, U.S. Environmental Protection Agency (EPA) Method 8260B
- TCL SemiVolatiles, EPA Method 8270C
- TCL Pesticides/Polychlorinated Biphenyl (PCB), Methods 8081A and 8082

For screening purposes, the chemical results were compared to 20 times the EPA Resource Conservation and Recovery Act of 1976 (RCRA) Toxicity limits (Code of Federal Regulations, Title 40, Section 261.24 [40 CFR 261.24]) as indicated in Table 4-10. Table 4-10 also summarizes exceedances of the chemical background levels from the 1993 RI report (BNI 1993a). In one sample collected from the Mudflats OU (TMF-0283), there was an exceedance of 20 times the lead standard (20 x 5 = 100 milligrams per kilogram (mg/kg)) and an exceedance of 20 times the mercury standard (20 x 0.2 = 4 mg/kg). This indicates that lead and mercury concentrations in soil in Area C of the Mudflats OU may exceed the EPA toxicity levels.

4.1.6 Groundwater Sampling Results – Mudflats OU

In the fall of 2001, groundwater samples were collected from four existing shallow groundwater monitoring wells (BM-8, BM-12, BM-15, and BM-16) located within the Mudflats. Monitoring wells BM-15 and BM-16 are located along the northern boundary of the Mudflats Area. BM-16 is within the OU, while BM-15 is east of the OU. BM-8 is located just north of Area C within the Mudflats OU, while BM-12 is located southwest of BM-15, outside the OU boundary. Refer to Figure 2-2 for monitoring well locations. The shallow groundwater flow at the Tonawanda Landfill (Landfill and Mudflats parcels) is generally in a radial pattern away from a groundwater mound that exists in the eastern portion of the Tonawanda Landfill (Landfill parcel) (Figure 3-7).

[4] The term "decision level" in Figure 4-6 refers to a 95 percent confidence level that the results of the respective radiological analysis will be distinguishable from laboratory background levels.

Each of the four monitoring wells were sampled for both total (unfiltered) and dissolved [filtered with a 0.45 micron (µm) filter] analytes. As noted by the USACE Field Representative at the site observing the sampling efforts, the "dissolved" samples were still visibly turbid, even after filtration, and may not be representative of dissolved conditions. The samples were analyzed for the following:

- Iso-Uranium 234, 235, and 238
- Iso-Thorium 228, 230, and 232
- Ra-226
- Ra-228
- Gross Alpha
- Gamma Spectrometry (Isotope identification including Am-241)
- Total Uranium

The groundwater samples collected from both the Landfill OU and the Mudflats OU were not analyzed for chemical parameters by USACE. As part of the Town of Tonawanda's semi-annual sampling activities conducted by Malcolm Pirnie, groundwater samples were collected and submitted by Malcolm Pirnie for chemical analysis. Since these chemical results are included by Malcolm Pirnie in their semi-annual reports, the results of those chemical analysis are not presented as part of this RI report.

The analytical results for the total (unfiltered) and dissolved (filtered) water samples are presented in Table 4-11. For screening purposes, these radiological groundwater results were compared to the groundwater standards of 40 CFR Part 192, Subpart A listed below:

- Combined Ra-226 and Ra-228 – 5 picocuries per liter (pCi/L),
- Gross Alpha (excluding radon and uranium) – 15 pCi/L,
- Combined U-234 and U-238 – 30 pCi/L, equivalent to a Total Uranium standard of 44 micrograms per liter (µg/L) where secular equilibrium is obtained between Uranium-234 and Uranium-238.

As indicated in Table 4-11, the groundwater screening levels for combined Ra-226 and Ra-228, Gross Alpha (excluding radon and uranium), combined U-234 and U-238, and total Uranium were not exceeded in either the total or dissolved groundwater samples collected from the Mudflats OU.

4.2 Landfill OU Investigation

4.2.1 Gamma Walkover Survey Results – Landfill OU

During the USACE 2001 investigation, a GWS was conducted in the Landfill OU to confirm previous areas of identified elevated radiological activity and assess areas of the Landfill OU that had not been previously investigated. A buffer area was placed around each Class 1 area. Buffer areas were designated as Class 2, and were surveyed in 10-meter transects (10 percent coverage). The balance of the OU was designated as Class 3, and was surveyed in 100-meter transects (1 percent coverage). The location of the Class 3 survey transect that was performed in the Landfill OU is shown in Figure 4-1, and the locations of the Class 1 and Class 2 Landfill OU transects are shown in Figure 4-7.

Within Area B, four localized areas of elevated activity were detected. Two of these localized areas (up to two m^2) were measured at 17,000 counts per minute (cpm), which was just above the investigation level of 11,000 counts per minute (cpm). Up to 27,000 cpm (approximately three times background) was detected in a 1 m^2 area near the site north fence. The highest activity detected at the Tonawanda Landfill Vicinity Property was (up to) 100,000 cpm (11 times background) in a three meter by six meter area. GWS results for Areas A and B are shown in Figure 4-7 and elevated activity results are summarized in Figure 4-8.

At each of the four localized areas of elevated activity, soil borings were drilled to assess the potential for MED-like material. Soil boring TLFB1A-001 was installed in the immediate vicinity where the highest activity (100,000 cpm) was detected by the 2001 GWS (Figure 4-9). At the two areas of elevated activities detected along the northern boundary of the Area B, soil borings TLFB1B-001 and TLFB1B-005 were installed. Soil boring TLFB1B-009 was installed southeast of soil boring TLFB1B-005 at the third area of elevated activity within Area B. The radiological analytical results for soil samples collected from soil borings TLFB1A-001, TLFB1B-001, TLFB1B-005, and TLFB1B-009 are discussed in the next section.

4.2.2 Results of Radiological Analyses of Soils and Soils Screening Criteria – Landfill OU

The results of radiological analyses of soils, a description of the screening criteria developed to assess radiological contaminants in soils and the results of the screening assessment are described in the following sections.

4.2.2.1 Results of Radiological Analyses of Soils – Landfill OU

Soil samples were collected at 114 locations in the Landfill OU. These sampling (boring) locations are shown in Figure 4-9. A total of 280 soil samples (including QA/QC samples) were collected at these 114 locations. The radiological analyses of these samples was the same as the analyses performed on the Mudflats OU soil samples as described in Section 4.1.2 and listed in Table 2-2.

Previous investigations had detected MED-like soils within the Class 1 portions of Areas A and B of the Landfill OU (BNI 1995 and ORNL 1992). The locations of the historical borings during previous investigations in the vicinity of Areas B and A are shown in Figure 4-10. MARSSIM guidance was used to classify the Landfill OU into Class 1, 2 and 3 areas. Summaries of the total number of samples, number of detects, minimum radionuclide concentrations, maximum radionuclide concentrations, mean radionuclide concentrations and UCL95 concentrations within the seven investigation areas of the Landfill OU are presented in Tables 4-12 through 4-19.

4.2.2.2 Soils Radiological Screening Criteria and Assessment – Landfill OU

The range of concentrations for Th-230, U-238, and Ra-226 detected in soil during the 2001 investigation within each of the seven areas (Tables 4-12 through 4-19) is discussed in Appendix A, and therefore, is not discussed in detail in this section. This section focuses on the areas within the Landfill OU where MED-like soil was determined to be present. To define the presence of potential MED-like soil, UTL 99/99.9 concentrations for U-238, Th-230, and Ra-226 for the Landfill OU background reference data set. The Landfill OU reference area is located along the southern boundary of the Landfill OU (Figure 4-9). The UTL 99/99.9 screening concentrations for the primary radionuclides of concern calculated for the Landfill OU background reference area are as follows:

- Th-230 – 1.58 pCi/g
- U-238 – 2.2 pCi/g
- Ra-226 – 2.8 pCi/g

These screening criteria were used to delineate definitive areas of MED-like contamination in the Landfill OU. For the 2001 data set, within the Landfill OU, the majority of the UTL 99/99.9 exceedances were detected in the Class 1 and 2 portions of Area A. The locations where samples exceeded the screening criteria are shown in Figure 4-11. Sample results exceeding the screening criteria are compiled in Table 4-20. Historical samples exceeding the criteria are also listed in Table 4-20. Exceedances of the UTL

99/99.9 screening criteria for Th-230, U-238 and Ra-226 also were detected in soil samples collected from the following four Landfill OU soil borings that are located outside of Area A (Figure 4-11 and Table 4-20):

- Class 3 soil boring TLF-063, which is located just east of Area A;
- Area B, Class 2 boring TLFB2-017;
- Area B, Class 1B boring TLFB1B-009; and
- Area B, Class 1A boring TLFB1A-001.

Details on these radionuclides, including individual sample results, are presented in Appendix A. These results are also included in the results database, which is available on CD-ROM in Appendix B.

Soil borings TLFB1B-009 and TLFB1A-001 (Figure 4-11) were installed at two of the locations where the 2001 GWS identified areas of elevated activity (Figure 4-8). However, at the two areas of elevated GWS activities detected along the northern boundary of Area B (Figure 4-8), exceedances of UTL 99/99.9 for Th-230, U-238, and Ra-226 were not observed in the soil samples collected from soil borings TLFB1B-001 and TLFB1B-005 (Figure 4-11).

Vertically, the depths at which the MED-like soils were detected during the 2001 investigation (within the Landfill OU) ranged from the surface (multiple detections) to 11.5 feet bgs in boring TLFA1-003 (Table 4-20).

To assess how the lateral extent of MED-like soils for the 2001 data set compared with historical data, the historical Landfill OU data also was compared to the UTL 99/99.9 screening criteria calculated for the 2001 Landfill OU reference area (Table 4-20). Both the 2001 and the historical exceedances of the UTL 99/99.9 screening levels in soil were plotted for Areas A and B on Figures 4-11 and 4-13, respectively. In general, the lateral extent of MED-like material as defined by the 2001 soil investigation is within the footprint of the MED-like material as defined by the historical investigations.

Within Area A, the majority of the potentially MED-like soil was detected south of the "wet area". The historical investigation (BNI 1995) detected potentially MED-like soil in borings B29RBH8 and B29RBH7 at sample depths of 22 to 24.5 feet bgs and 20 to 22 feet bgs, respectively (Table 4-21). The 1994 BNI sample from boring B29RBH8 showed U-238 at 3.1 pCi/g, which exceeds the screening level of 2.34 pCi/g, in a sample from a depth of 22 to 24.5 feet. The sample from this BNI boring from 19.5 to 22 feet showed U-238 at 18.6 pCi/g (Table 4-21). The closest boring in 2001 was TLAFA1-017 (at virtually the same boring location as BNI B29RBH8), which had a depth of 12 feet. This boring showed U-238 at 8.7 pCi/g at 2 feet and 9.3 pCi/g at 5.5 feet (Table 4-20). The boring log for this boring shows no recovery of samples from 8.5 to 12 feet. The 1994 BNI results indicating elevated U-238 (compared to screening criteria adopted for the 2001 investigation) to a depth of 24.5 feet at location B29RBH8 were not verified during the 2001 investigation since the depth of sampling, conducted in accordance with the SAP, in the adjacent 2001 boring did not exceed 12 feet. The results of the analyses of the soil samples from the 1994 BNI borings including B29RBH8 were, however, included in the risk assessment except for thorium results that were determined to be of questionable quality. A 1994 BNI sample from a boring identified as B29RBH7 showed U-238 at 3.4 pCi/g in a sample from 16 to 18 feet and 25.1 pCi/g in a sample from 14 to 16 feet (Table 4-21). These concentrations of U-238 exceed the screening criteria adopted for the 2001 investigation. The closest boring in 2001 was TLFA1-013 (located virtually at the same location as BNI boring B29RBH7). The 2001 sample results from boring TLFA1-013, which had a depth of 12 feet, show U-238 exceeding the screening level of 2.34 pCi/g in all except one of the samples, with the highest U-238 concentration detected at 15.5 pCi/g in the sample at 5.5 feet (Table 4-20). The 1994 BNI results indicating elevated U-238 (compared to screening criteria adopted for the 2001 investigation) to a depth of 22 feet at B29RBH7 were not verified during the 2001 investigation since the

depth of sampling conducted in accordance with the SAP in the adjacent 2001 boring did not exceed 12 feet. As described above, however, the results of the analyses of the soil samples from the 1994 BNI borings including B29RBH7 were included in the risk assessment except for thorium results that were determined to be of questionable quality. The deepest that potentially MED-impacted soil was detected during the 2001 investigation was from 11 to 11.5 feet bgs in boring TLFA1-013, which was installed at historical boring B29RBH7. This difference in the depth at which MED-like material was detected may be due to the heterogeneity of the MED-like material within Area A.

Within Area B, the historical and 2001 borings at which soil sample concentrations exceeded the UTL 99/99.9 values were all in the immediate vicinity of the drainage system that runs northeast-southwest along the northern boundary (Figure 4-13 and Table 4-20). However, unlike the Area A potentially MED-like soil, except for boring TLFB2-017 (where potentially MED-like soils were detected from 2.0 to 2.5 feet bgs), the soils detected in Area B were primarily confined to the surface soils (less than 0.5 feet bgs). As discussed above, the historical and USACE 2001 soil samples in which U-238, Th-230, and Ra-226 were detected above their respective UTL 99/99.9 in the Landfill are presented in Table 4-20.

The radiological soils in the investigation conducted in 2001 was designed to build upon the results of the investigations at the Landfill by ORNL in 1991 and by BNI in 1994. The ORNL investigation included more than 170 systematic and bias radiological soil samples to a maximum depth of 2.5 feet. The 1994 BNI investigation included samples from 10 boreholes, including samples from as deep as 24.5 feet and 22 feet. The 2001 investigation by USACE in the Landfill OU included 280 soil samples (including QA/QC) from 114 soil boring locations to depths up to 12 feet. Based on the findings of the 2001 investigation, it is concluded that the lateral extent of MED-like material in the Landfill OU is within the footprint of the MED-like material defined in the previous investigations. The depth of MED-like material is generally limited to shallow depths, but radionuclide concentrations were detected above screening levels at depths up to the maximum depths of the 2001 borings (12 feet).

At two historical locations, BNI samples showed U-238 at levels exceeding the 2001 screening criteria at depths up to 24.5. These earlier results exceed the 2001 screening criteria but did not exceed the DOE guideline criteria [5] used during the earlier studies by ORNL and BNI. Borings and soil sampling in 2001 at locations adjacent to these borings were limited to 12 feet and thus, elevated uranium was not verified, resulting in some uncertainty as to the depths of MED-like material at these locations. Based on all of the investigations, it is concluded that the lateral and vertical extent of MED-like material has been determined in accordance with SAP (USACE) project objectives.

4.2.3 Landfill OU Downhole Geophysical Survey Results

During the Landfill OU investigation, downhole gamma logging was conducted at each of the 114 borings, except for borings TLFA1-008 and TLF3-009. The downhole gamma logging can be used to detect elevated levels of radionuclides in the immediate vicinity of the subsurface borings. The soil samples that exceed the UTL 99/99.9, screening criteria for Th-230, U-238, and/or Ra-226 are presented on the same table as the borings in which "peaks" in downhole gamma readings were detected (Table A4-27 of Appendix A). A peak represents a zone of downhole gamma readings that exceed levels of concern that were established for the investigation. The levels of concern were based on background measurements taken at the reference area. These concern levels for borings with steel casing and without casing were 45 to 65 cps, respectively, for the shallow soil of the site and 75 to 110 cps, respectively, for deeper soils of the site. How the background gamma values for the 2001 investigation were established,

[5] Ra-226 at 5 pCi/g for surface soils, Ra-226 at 15 pCi/g for subsurface soils, and U-238 at 30 pCi/g as detailed earlier in Section 1.2.4.

and the levels of concern, are described in Attachment D of Appendix A. In general, the majority of the soil samples that exceeded the UTL 99/99.9 screening criteria did not have corresponding "peaks" in downhole gamma readings. The lack of corresponding peaks between the downhole gamma logs and soil samples is potentially due to the variability of soil concentrations at any given location. Because the majority of soil samples slightly exceeded background concentrations, it may be that insufficient energy was available to be distinguished from background. The downhole gamma logs are included in Attachment E of Appendix A.

However, in most of the borings where "peaks" in downhole gamma readings were detected, the soil samples collected from the same elevations were above the UTL 99/99.9 screening criteria (Table A4-27, Appendix A). Of most interest, in the borings where the highest concentrations of Th-230, U-238, and/or Ra-226 were detected in soils (TLFA1-003, TLFA1-006, and TLFA1-014), there was good depth correlation between the soils samples with elevated concentrations and the elevations at which the "peak" downhole gamma readings were measured. Even though the shallow "peak" of downhole gamma readings, which was encountered at approximately 5.6 feet bgs, was not sampled in boring TLFA1-014, elevated concentrations were detected in the soil sample collected from the 7.0 to 7.5 ft bgs interval. In addition, in boring TLFA1-014, a much higher peak was encountered at approximately 10.7 ft bgs. This depth could not be sampled due to poor recovery.

Therefore, in the Landfill OU, the downhole gamma logging was generally an effective tool for confirming the horizons within the subsurface where the majority of the highest concentrations of Th-230, U-238, and/or Ra-226, were detected. However, for a number of the Landfill OU soil samples that exceeded the UTL 99/99.9 screening criteria, there were not corresponding downhole gamma log peaks. The results of the analyses of all soil samples from the Landfill and associated downhole gamma scans are provided in Appendix A, Tables A-4-27a through A4-27g.

4.2.4 Nature and Extent of Am-241 Landfill OU

Similar to the Mudflats OU, Am-241 was detected in ten Landfill OU soil samples (Table 4-22). The locations of the Landfill OU borings in which Am-241 was detected during the 2001 investigation are shown in Figure 4-14. The concentrations ranged from 0.087 pCi/g (sample TLF-0400 collected from soil boring TMFR3-004) to 1.72 pCi/g (sample TLF-0476 collected from soil boring TLF3-006). Previous investigations also have detected Am-241 at limited locations along the Landfill access road that passes to the north of the Landfill OU reference area. (Figure 4-15). The historical analytical results are summarized on Table 4-21. The detections of Am-241 in soil during the 2001 investigation are consistent with the detections of Am-241 during previous investigations within the Landfill OU (ORNL 1992).

In the soil samples in which Am-241 was detected, there were no exceedances of the UTL 99/99.9 screening levels for U-238, Th-230, and/or Ra-226, indicating that at those locations the potentially MED-like soil and Am-241-impacted soil are not commingled.

4.2.5 Results of Chemical Analyses of Soil Samples – Landfill OU

Chemical analyses of soil samples was conducted to determine if any hazardous materials are collocated with MED-like material within the Landfill OU. Field screening of the soils collected from selected soil borings indicated elevated levels of radiation in Area A, therefore, soil samples collected from that area were submitted for chemical analysis. The chemical analytical results of soil samples collected from borings completed in the Landfill OU (Area A) are shown in Table 4-23.

A total of three samples and one duplicate were collected and analyzed for the presence of TAL metals and cyanide, TCL VOCs and SVOCs and TCL Pesticides/PCBs.

For screening purposes, the results were compared to 20 times the EPA RCRA Toxicity limits (40 CFR 261.24)Table 4-23 shows the results exceeding the RCRA screening levels. Table 4-23 also summarizes chemical exceedances of the background level from BNI 1993a. In the three samples, and one duplicate sample collected from the Landfill OU, there were exceedances of 20 times the lead standard (20 x 5 = 100 mg/kg). This indicates that the lead concentrations in Landfill OU soil may exceed the EPA toxicity levels.

4.2.6 Surface Water and Sediment Sampling Results – Landfill OU

During the 2001 investigation, surface water/sediment samples were collected from two locations within Area A, Class 1. In addition, one Area B, Class 2 surface water/sediment sampling location was selected to assess a seep outside of the areas where potential MED-like residuals were anticipated (Figure 4-16). Note that these sediment samples are not true sediment samples – rather they represent soil samples that were collected from below a wet area, and so are characterized as sediment samples.

The sediment sampling locations and associated surface water sample ID numbers are listed in the table below:

Sediment Sample Location	Surface Water ID	Investigation Area
TLFA1-S1	TLW-0100	Area A Class 1
TLFA1-S2	TLW-0101 Duplicate Sample TLW-9103	Area A Class 1
TLFA1-S3	Location not sampled	Area A Class 1
TLF3-S4	TLW-0102	Area B Class 2

Sediment sample TLF3-S4 actually was collected in the Class 2 portion of Area B, not in the Class 3 portion of the Landfill OU as labeled during sampling.

All of the sediment and surface water samples were analyzed for the following parameters:

- Iso-Uranium 234, 235, and 238
- Iso-Thorium 228, 230, and 232
- Ra-226
- Ra-228
- Gross Alpha
- Gamma Spectrometry (Isotope identification including Am-241)
- Total Uranium (surface water only)

4.2.6.1 Sediment Sample Results

The analytical results for the four sediment sampling locations, (TLFA1-S1, TLFA1-S2, TLFA1-S3, and TLF3-S4), collected from the Landfill OU are shown in Table 4-24. As with the soil samples collected from the Landfill OU, the UTL 99/99.9 screening levels for Ra-226, Th-230 and U-238 for the Landfill OU were used for a basis of comparison for the sediment sample analytical results. These screening levels are as follows:

- Th-230 – 1.58 pCi/g
- U-238 – 2.34 pCi/g
- Ra-226 – 2.27 pCi/g

In the sediment samples collected from Area A, Class 1 location TLFA1-S3, and Area B, Class 2 location TLF3-S4, concentrations of Ra-226, Th-230, and U-238 were not detected above the respective UTL 99/99.9 screening levels (Table 4-24). However, in the sediment samples collected from Area A, Class 1 sediment locations TLFA1-S1 and TLFA1-S2, all of the U-238 concentrations exceeded the UTL 99/99.9 value of U-238, which is 2.34 pCi/g. In the three sediment samples collected from sediment sampling location TLFA1-S2, Th-230 and Ra-226 were detected at concentrations above their respective UTL 99/99.9 screening levels of 1.58 pCi/g and 2.27 pCi/g, respectively (Table 4-24). The sediment sampling locations where the screening levels were exceeded are identified in Figure 4-16.

4.2.6.2 Surface Water Results

Surface water samples were collected from two leachate seeps/impoundment areas located within the Landfill OU area (Figure 4-16). Two samples and a duplicate (TLW-0100, TLW-0101, and duplicate TLW-9103) were collected from one seep located within Area A. A third leachate seep sample (TLW-0102) was collected from a seep in the Class 3 area near Area B (Table 4-24). These surface water samples were highly turbid and were not field filtered prior to analyses, which explains the elevated results described below. While these samples were surface water samples, for screening purposes the results were compared to the groundwater standards of 40 CFR Part 192, Subpart A listed below:

- Combined Ra-226 and Ra-228 – 5 pCi/L,
- Gross Alpha (excluding radon and uranium) - 15 pCi/L,
- Combined U-234 and U-238 - 30 pCi/L, equivalent to a Total Uranium standard of 44 µg/L where secular equilibrium is obtained between U-234 and U-238.

All of the surface water samples collected from the two leachate seeps had exceedances of the 40 CFR Part 192, Subpart A groundwater standards for either combined Ra-226 and Ra-228, gross Alpha (excluding radon and uranium), and/or Total Uranium (Table 4-24). These exceedances are briefly summarized below:

- The groundwater standard for Ra-226 + Ra-228 (5 pCi/L) was exceeded in one of the surface water samples from Area A (TLW-0101), the corresponding duplicate sample (TLW-9103), and the Area B surface water sample (TLW-0102), at concentrations of 5.23 pCi/L, 9.58 pCi/L, and 37.38 pCi/L, respectively (Table 4-24).
- The groundwater standard for total uranium (44 µg/L) was exceeded in the Class 1, Area A, surface samples (TLW-0100 and TLW-0101) and the corresponding duplicate sample (TLW-9103), at concentrations of 416 µg/L, 459 µg/L, and 294 µg/L, respectively (Table 4-24).
- The groundwater standard for U-234 + U-238 was exceeded in both of the surface water samples from Area A (TLW-0100 and TLW-0101), and the duplicate sample collected at the location where sample TLW-0101 was collected (TLW9103), at concentrations of 428 pCi/L, 342 pCi/L, and 325 pCi/L, respectively (Table 4-24).
- The groundwater standard for gross-alpha (excluding radon and uranium) (15 pCi/L) was exceeded for the Class 2, Area B surface water sample TLW-0102, at a concentration of 23.91 pCi/L (Table 4-24).

4.2.7 Groundwater[6] Sampling Results – Landfill OU

As part of the USACE RI, groundwater samples were collected from seven existing shallow monitoring wells (L-1, L-2, L-3, BM-4, BM-17, BM-18, and BM-19), and three deeper contact-zone aquifer monitoring wells (DW-1, DW-2 and DW-4R) located within the Landfill OU and the Landfill parcel (Figure 2-2). The following describes the rationale for sampling these shallow monitoring wells:

- Monitoring wells L-1 and L-2 are located within the Class 1 areas of Area B of the Landfill OU;
- Monitoring wells L-3 and BM-4 are located within the Class 1 and 2 areas, respectively, of Area A of the Landfill OU;
- Monitoring wells BM-17 and BM-18 are located downgradient (south) of Area B of the Landfill OU;
- Monitoring well BM-19 is located in what was assumed to be the cross-gradient direction (west, southwest) from Areas A and B of the Landfill OU;
- Monitoring well BM-7 is located in what was assumed to be the upgradient direction (northeast), from the Landfill OU.

In addition to the shallow monitoring wells, the following three deep monitoring wells were also sampled:

- DW-1, DW-2, and DW-4R.

Contact-zone aquifer monitoring wells DW-4R and DW-2 are located to the east, north-east of the Landfill OU (Figure 2-2), outside of the area of investigation within the Landfill parcel. Deep monitoring well DW-1 is located in the western portion of the Landfill parcel, outside of the Landfill OU (Figure 2-2). The regional direction of deep groundwater at and in the vicinity of the Tonawanda Landfill (Landfill and Mudflats parcels) is generally considered to be north towards the Niagara River (Wehran 1994).

As in the Mudflats OU investigation, groundwater samples from each monitoring well, both total (unfiltered) and dissolved (filtered with a 0.45 µm filter), were collected. As noted by the USACE Field Representative at the site observing the sampling efforts, the "dissolved" samples were still visibly turbid, even after filtration, and may not be representative of dissolved conditions. The samples were analyzed for the following:

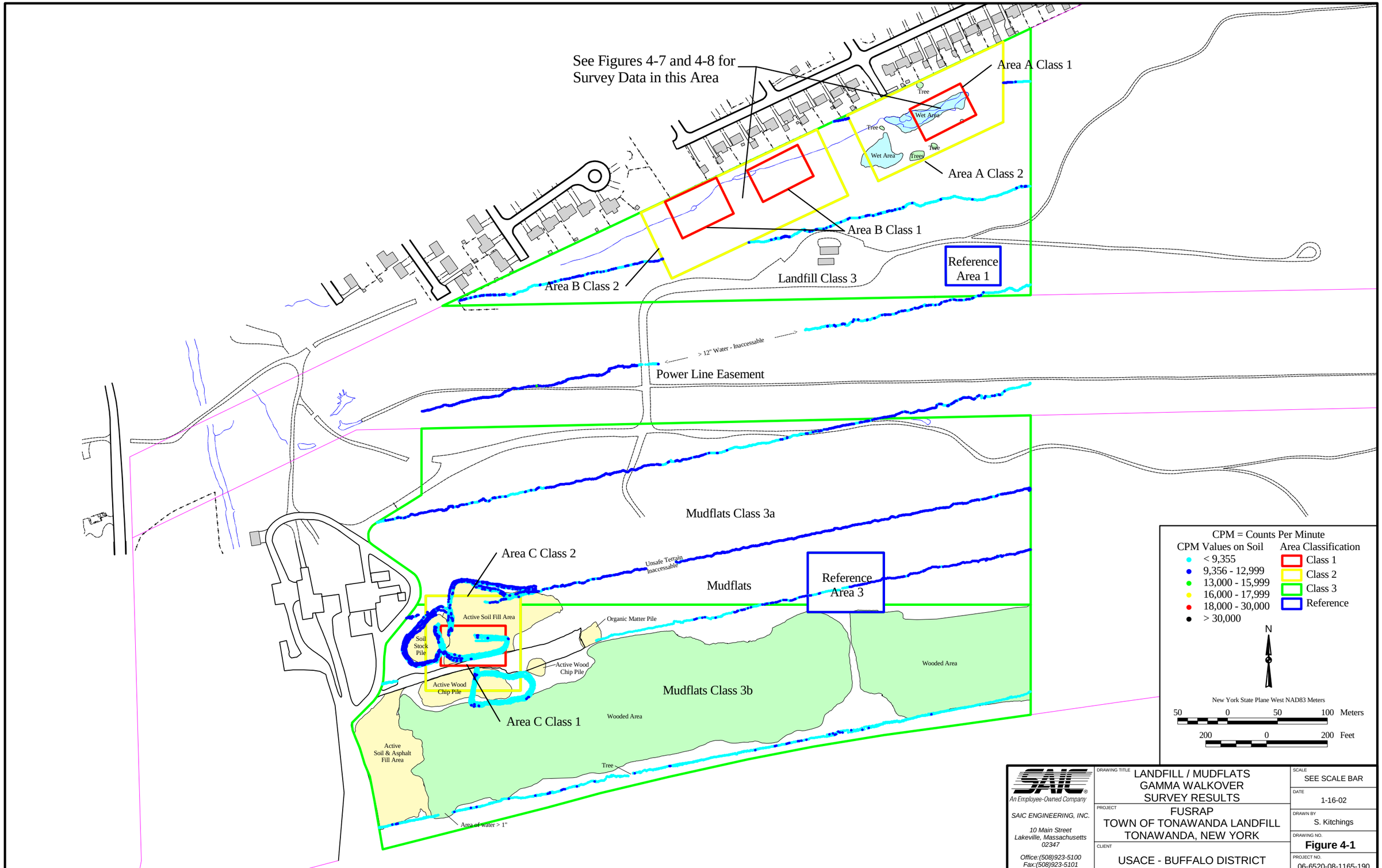
- Iso-Uranium 234, 235, and 238
- Iso-Thorium 228, 230, and 232
- Ra-226
- Ra-228
- Gross Apha
- Gamma Spectrometry (Isotope identification including Am-241)
- Total Uranium

Groundwater samples collected from the Landfill OU were not analyzed for chemical parameters by USACE. The radiological analytical results for the total and dissolved water samples are shown in Table 4-11. These water results were compared to the groundwater standards of 40 CFR Part 192, Subpart A.

[6] As described in Section 2.4, samples collected from monitoring wells are referred to as groundwater samples. Samples collected at wells within the Landfill, such as L-3, reflect water quality within the landfill material and the groundwater mound created in the Landfill area. Such samples have been referred to as leachate samples in Malcolm Pirnie reports.

As shown in Table 4-11, total Uranium and combined U-234 and U-238 were detected in water at the Landfill OU at concentrations above their respective 40 CFR Part 192, groundwater standards, which are 44 µg/L, and 30 pCi/L, respectively. In the unfiltered (total) samples collected from monitoring well L-3, (TLW-0150 and duplicate sample TLW-9178), Total Uranium was detected at concentrations of 175 µg/L and 164 µg/L, respectively. In the filtered (dissolved) samples collected from monitoring well L-3 (TLW-0177 and duplicate TLW-9180) Total Uranium was detected at concentrations of 133 µg/L and 134 µg/L, respectively (Table 4-11). In the unfiltered (total) samples collected from monitoring well L-3, (TLW-0150 and duplicate sample TLW-9178), combined U-234 and U-238 was detected at concentrations of 116.5 pCi/L and 116.7 pCi/L, respectively. In the filtered (dissolved) leachate samples collected from monitoring well L-3 (TLW-0177 and duplicate TLW-9180) combined U-234 and U-238 was detected at concentrations of 93.7 pCi/L and 107.8 pCi/L, respectively. Well L-3 is screened in the waste material itself, as further discussed in Section 5.

Monitoring well L-3 is located adjacent to the wet area in the Class 1 portion of Area A (Figure 2-2), where the majority of soil concentrations exceeding UTL 99/99.9 screening levels have been detected (Figure 4-12). In the total and dissolved water samples that were collected from the other nine monitoring wells, none of the sample results exceeded the 40 CFR Part 192 groundwater standards for either Total Uranium (44 µg/L), combined Ra-226 and Ra-228 (5 pCi/L), combined U-234 + U-238 (30 pCi/L), or gross Alpha (excluding radon and uranium) (15 pCi/L) (Table 4-11).



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DRAWING TITLE: LANDFILL / MUDFLATS GAMMA WALKOVER SURVEY RESULTS

PROJECT: FUSRAP TOWN OF TONAWANDA LANDFILL TONAWANDA, NEW YORK

CLIENT: USACE - BUFFALO DISTRICT

SCALE: SEE SCALE BAR

DATE: 1-16-02

DRAWN BY: S. Kitchings

DRAWING NO.: **Figure 4-1**

PROJECT NO.: 06-6520-08-1165-190

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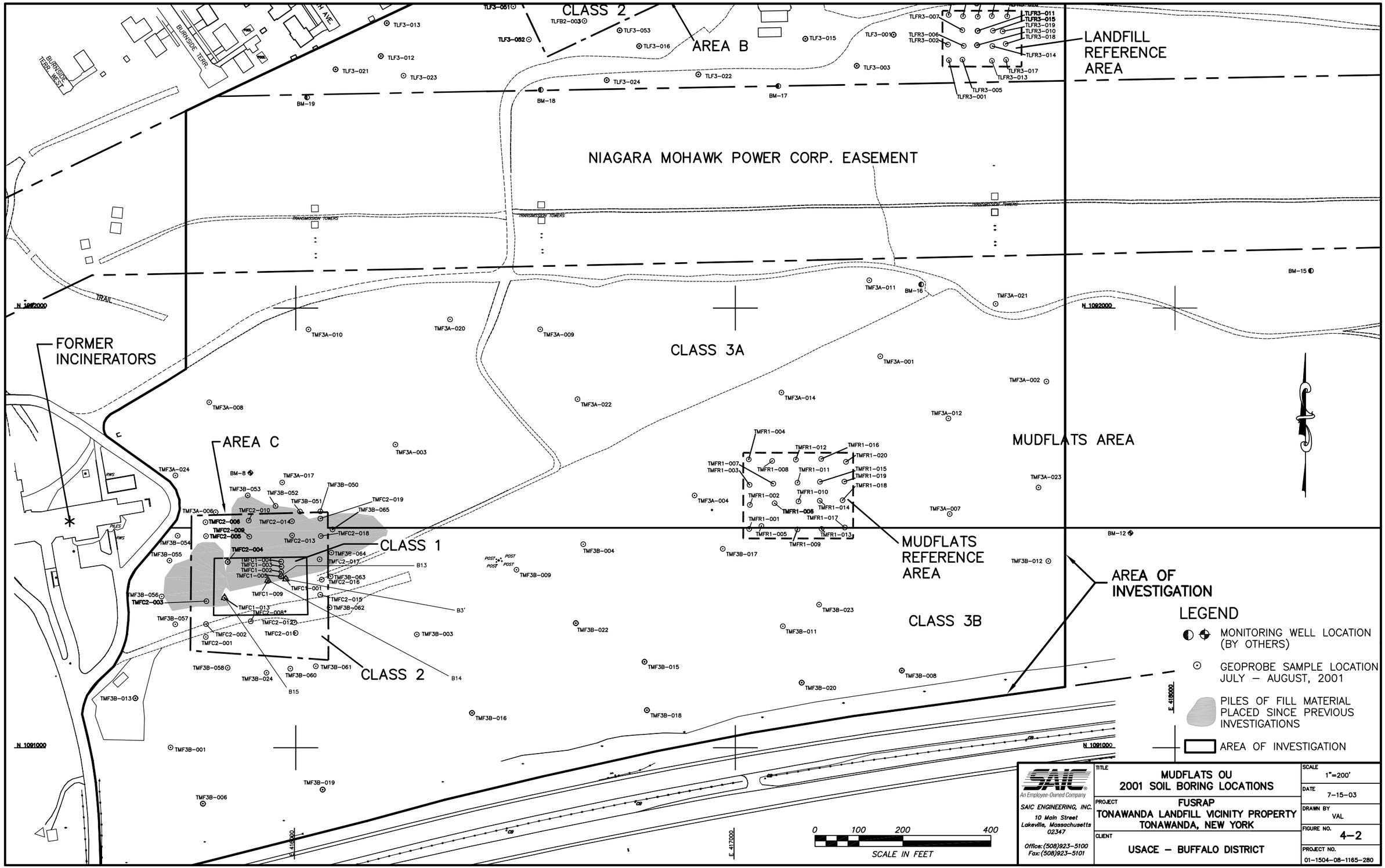
CLASS 2
AREA B
LANDFILL REFERENCE AREA
NIAGARA MOHAWK POWER CORP. EASEMENT
TRANSMISSION TOWERS
TRAIL
FORMER INCINERATORS
CLASS 3A
AREA C
MUDFLATS AREA
CLASS 1
MUDFLATS REFERENCE AREA
AREA OF INVESTIGATION
CLASS 3B
CLASS 2
BURNSIDE TERR.
BURNSIDE TERR. WEST
N 1092000
N 1091000
E 418000
E 417000
LEGEND
MONITORING WELL LOCATION (BY OTHERS)
GEOPROBE SAMPLE LOCATION JULY – AUGUST, 2001
PILES OF FILL MATERIAL PLACED SINCE PREVIOUS INVESTIGATIONS
AREA OF INVESTIGATION
0 100 200 400
SCALE IN FEET
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Fax: (508)923-5101
TITLE
MUDFLATS OU
2001 SOIL BORING LOCATIONS
PROJECT
FUSRAP
TONAWANDA LANDFILL VICINITY PROPERTY
TONAWANDA, NEW YORK
CLIENT
USACE – BUFFALO DISTRICT
SCALE
1"=200'
DATE
7-15-03
DRAWN BY
VAL
FIGURE NO.
4-2
PROJECT NO.
01-1504-08-1165-280
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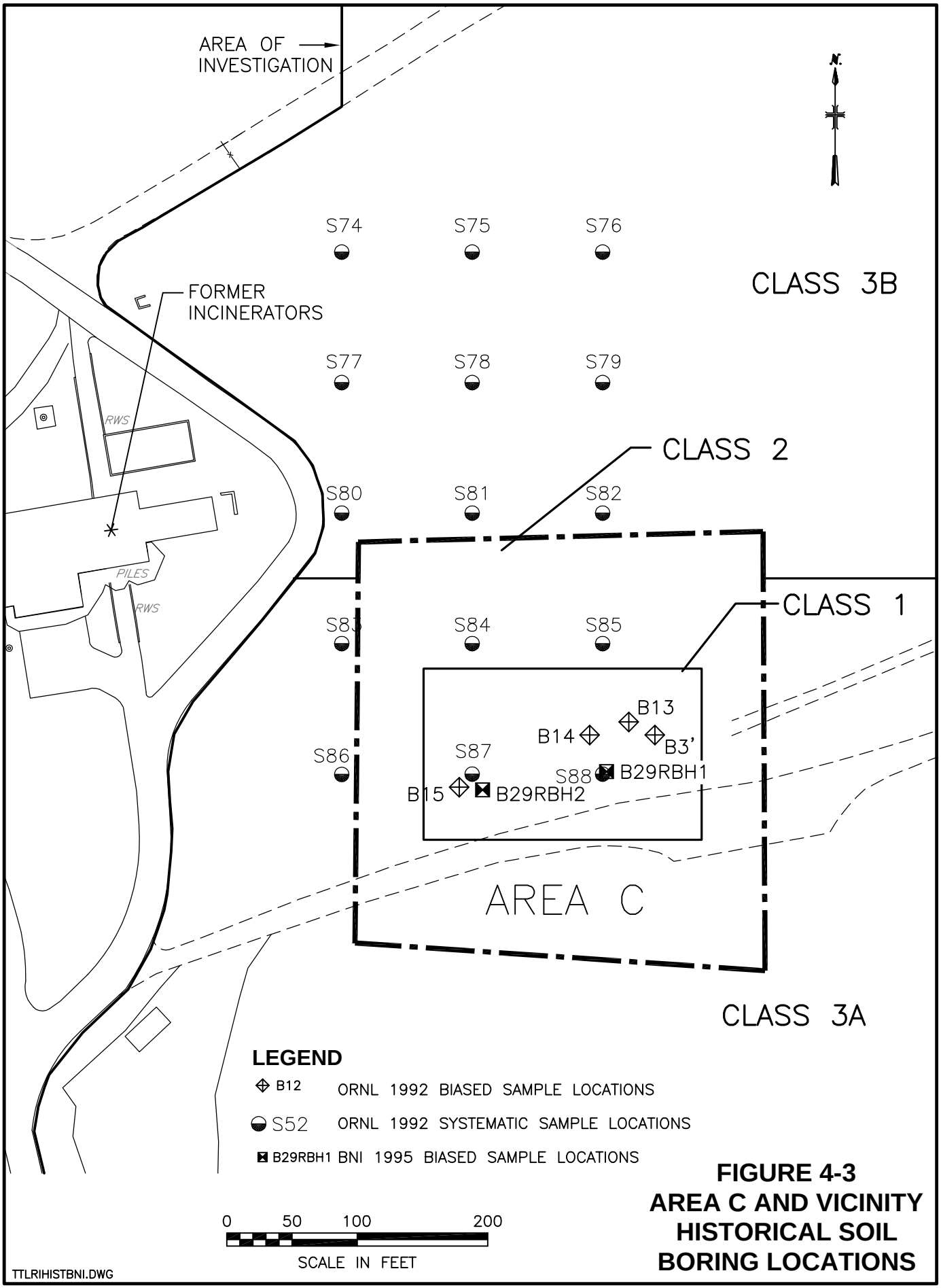
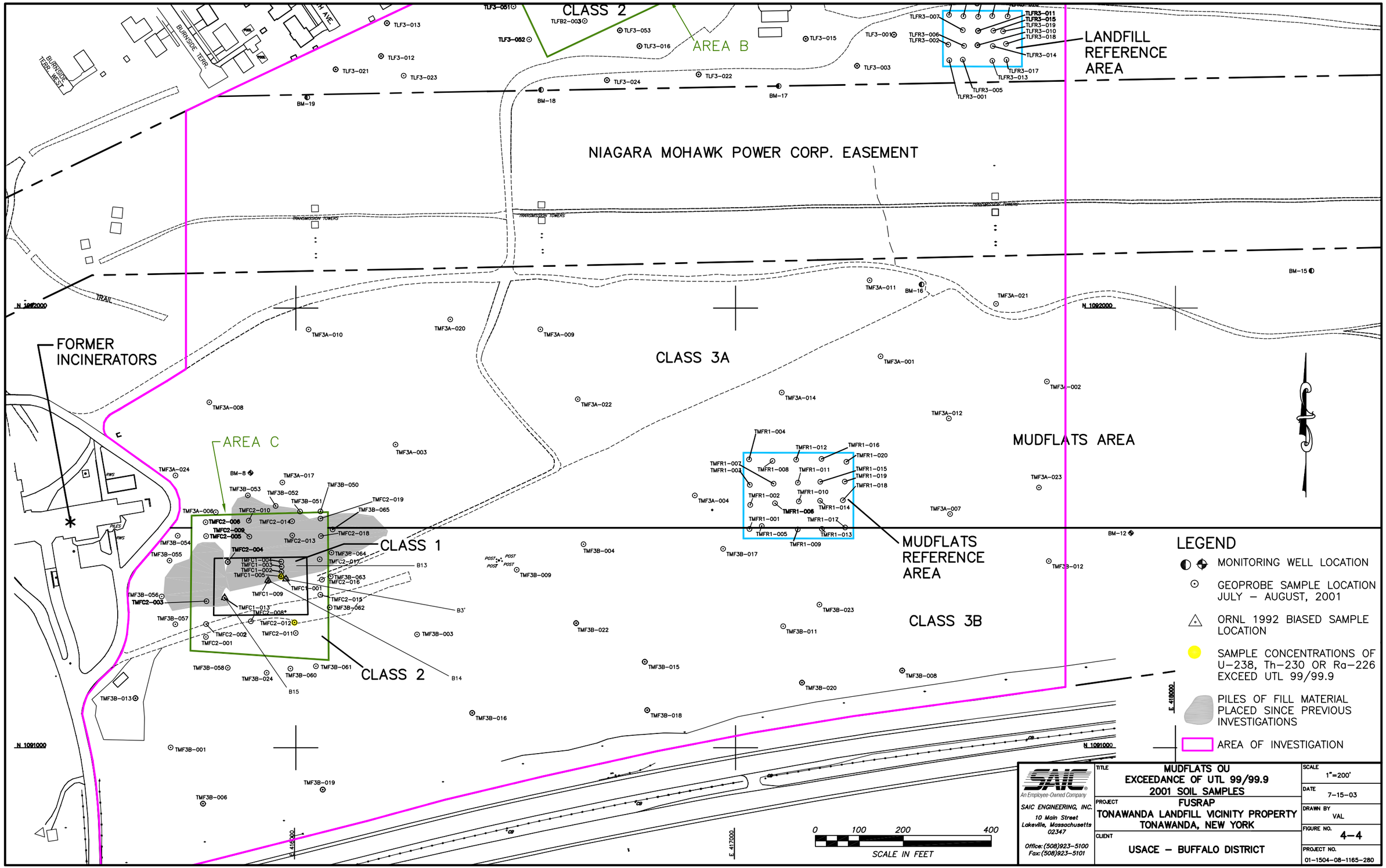


FIGURE 4-3
AREA C AND VICINITY
HISTORICAL SOIL
BORING LOCATIONS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AREA B
LANDFILL REFERENCE AREA
NIAGARA MOHAWK POWER CORP. EASEMENT
TRANSMISSION TOWERS
TRAIL
FORMER INCINERATORS
CLASS 3A
AREA C
MUDFLATS AREA
CLASS 1
MUDFLATS REFERENCE AREA
CLASS 3B
CLASS 2
BURNSIDE TERR.
BURNSIDE TERR. WEST
N 1092000
N 1091000
E 416000
E 417000
E 418000
LEGEND
MONITORING WELL LOCATION
GEOPROBE SAMPLE LOCATION JULY – AUGUST, 2001
ORNL 1992 BIASED SAMPLE LOCATION
SAMPLE CONCENTRATIONS OF U–238, Th–230 OR Ra–226 EXCEED UTL 99/99.9
PILES OF FILL MATERIAL PLACED SINCE PREVIOUS INVESTIGATIONS
AREA OF INVESTIGATION
0 100 200 400
SCALE IN FEET
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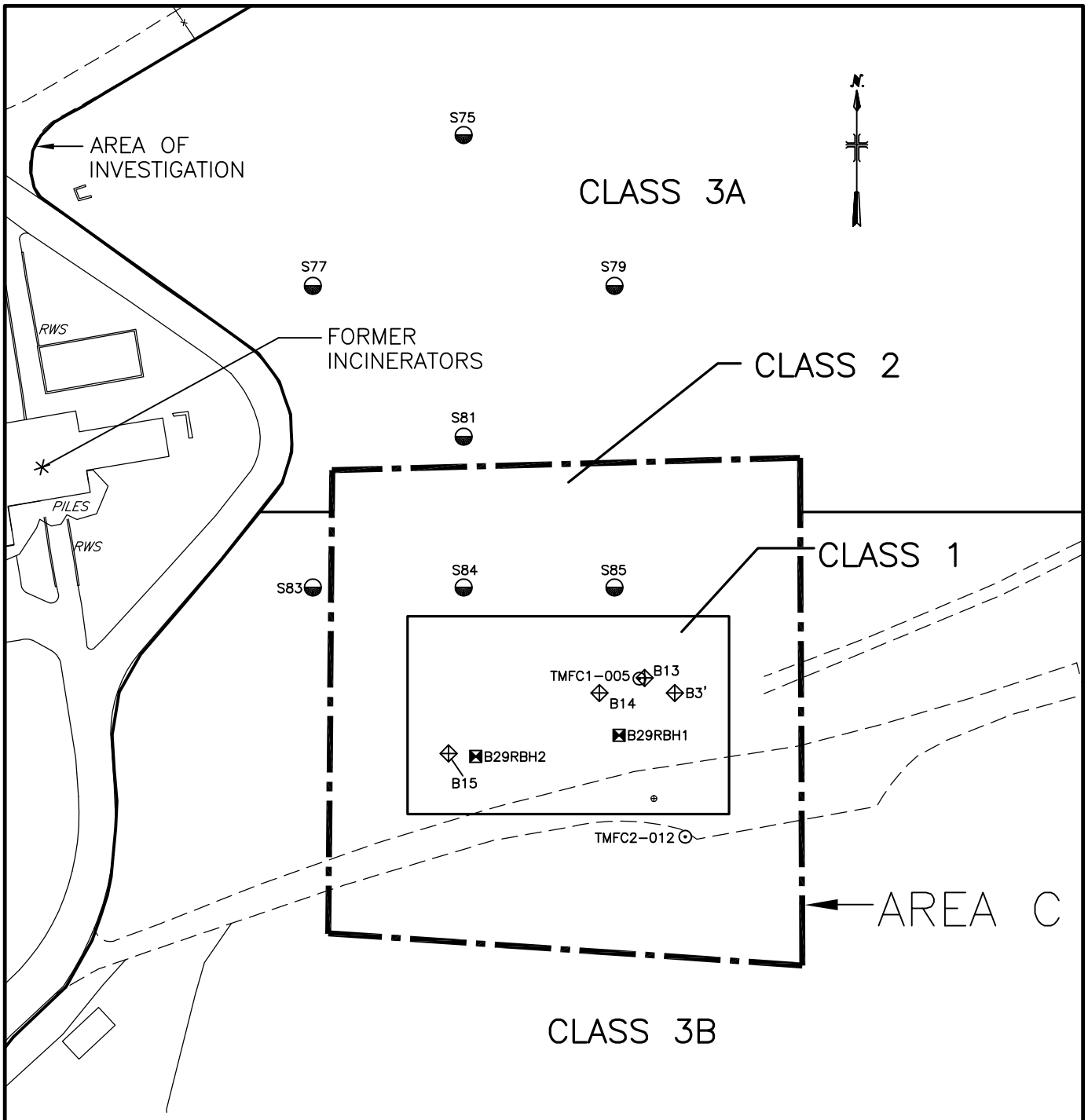
Fax: (508)923–5101
TITLE
MUDFLATS OU
EXCEEDANCE OF UTL 99/99.9
2001 SOIL SAMPLES
PROJECT
FUSRAP
TONAWANDA LANDFILL VICINITY PROPERTY
TONAWANDA, NEW YORK
CLIENT
USACE – BUFFALO DISTRICT
SCALE
1"=200'
DATE
7–15–03
DRAWN BY
VAL
FIGURE NO.
4–4
PROJECT NO.
01–1504–08–1165–280
TTLRI4–4.DWG



LEGEND

B13A	ORNL 1992 BIASED SAMPLE LOCATIONS
S74	ORNL 1992 SYSTEMATIC SAMPLE LOCATIONS
TMFC2-008	SAIC 2001 SAMPLE LOCATIONS
B29RBH4	BNI 1995 BIASED SAMPLE LOCATIONS

0 50 100 200

SCALE IN FEET

NOTE: ONLY HISTORICAL AND 2001 BORING LOCATIONS WHERE SOIL SAMPLE CONCENTRATIONS OF U-238, Th-230 OR Ra-226 EXCEED UTL 99/99.9 ARE PRESENTED.

FIGURE 4-5
AREA C (MUDFLATS OU)
EXCEEDANCE OF UTL 99/99.9
2001 AND HISTORICAL SOIL SAMPLES

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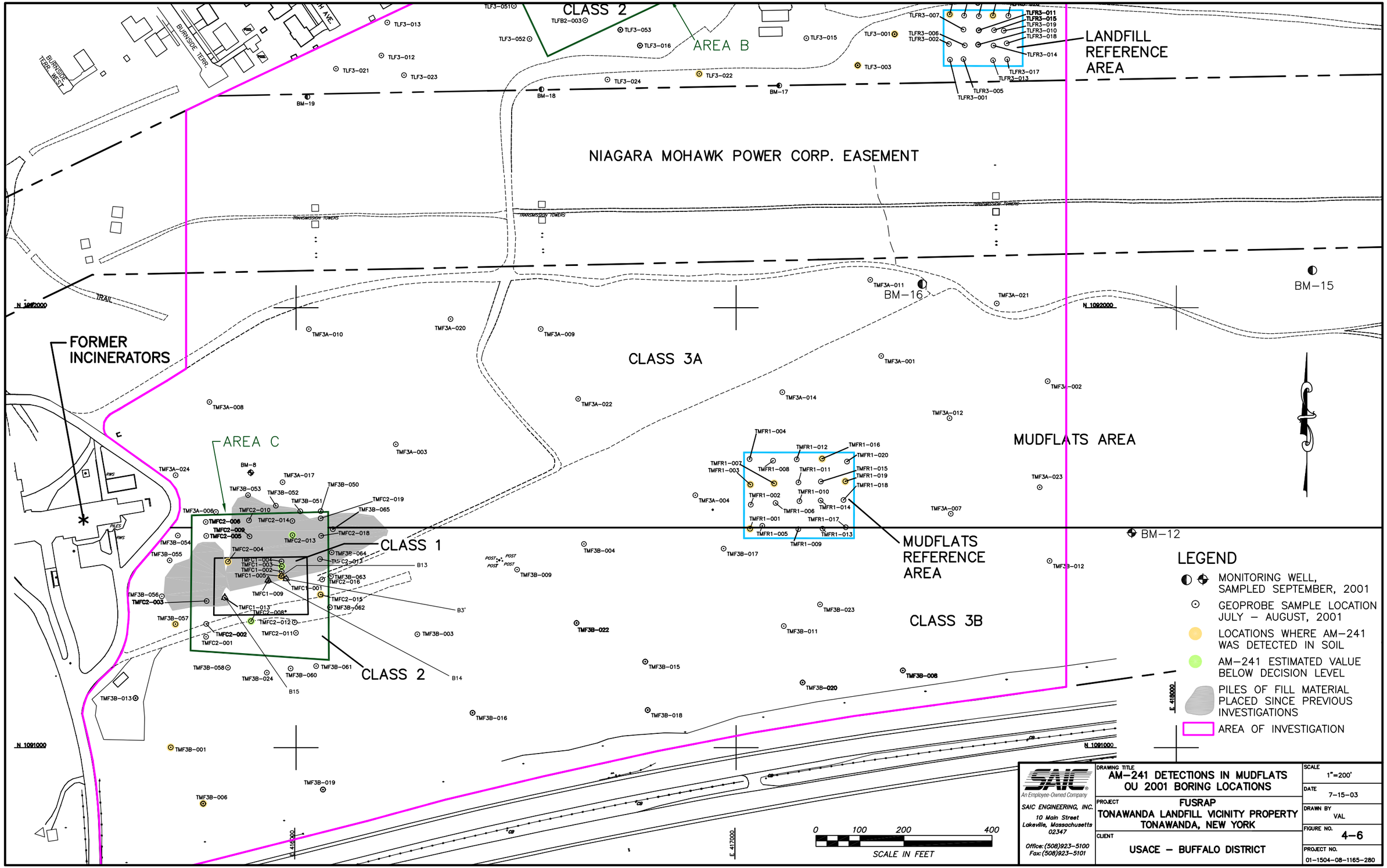

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DRAWING TITLE
AM-241 DETECTIONS IN MUDFLATS
OU 2001 BORING LOCATIONS

PROJECT
FUSRAP
TONAWANDA LANDFILL VICINITY PROPERTY
TONAWANDA, NEW YORK

CLIENT
USACE – BUFFALO DISTRICT

SCALE 1"=200'
DATE 7-15-03
DRAWN BY VAL
FIGURE NO. 4-6
PROJECT NO. 01-1504-08-1165-280

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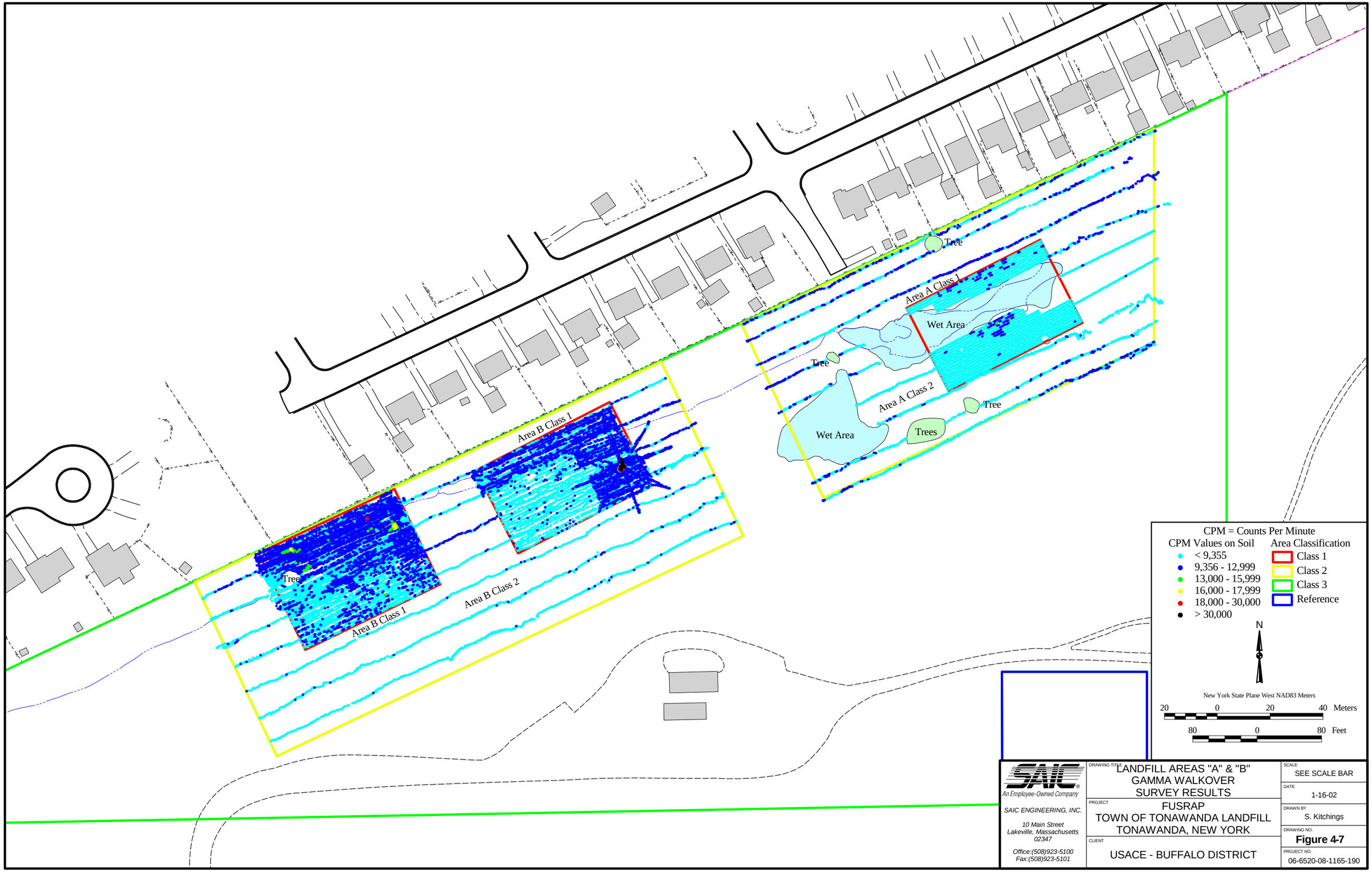
Tree
Area A Class 1
Wet Area
Tree
Area A Class 2
Tree
Wet Area
Trees
Area B Class 1
Tree
Area B Class 2
Area B Class 1
CPM = Counts Per Minute
CPM Values on Soil
< 9,355
9,356 - 12,999
13,000 - 15,999
16,000 - 17,999
18,000 - 30,000
> 30,000
Area Classification
Class 1
Class 2
Class 3
Reference
N
New York State Plane West NAD83 Meters
20 0 20 40 Meters
80 0 80 Feet
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GAMMA WALKOVER
SURVEY RESULTS
PROJECT
FUSRAP
TOWN OF TONAWANDA LANDFILL
TONAWANDA, NEW YORK
CLIENT
USACE - BUFFALO DISTRICT
SCALE
SEE SCALE BAR
DATE
1-16-02
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S. Kitchings
DRAWING NO.
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PROJECT NO.
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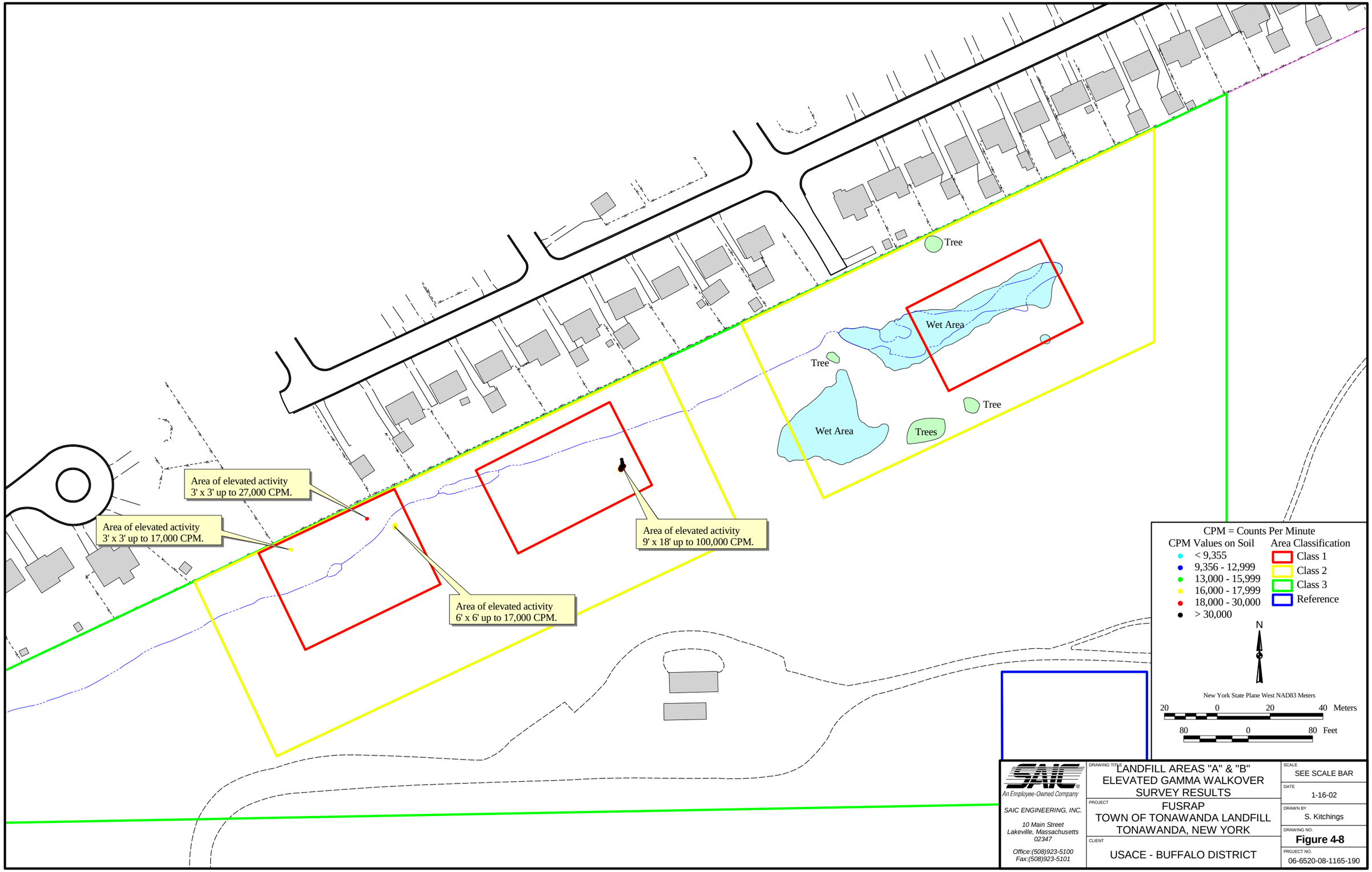

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ELEVATED GAMMA WALKOVER
SURVEY RESULTS

PROJECT
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TOWN OF TONAWANDA LANDFILL
TONAWANDA, NEW YORK

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USACE - BUFFALO DISTRICT

SCALE
SEE SCALE BAR

DATE
1-16-02

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Figure 4-8

PROJECT NO.
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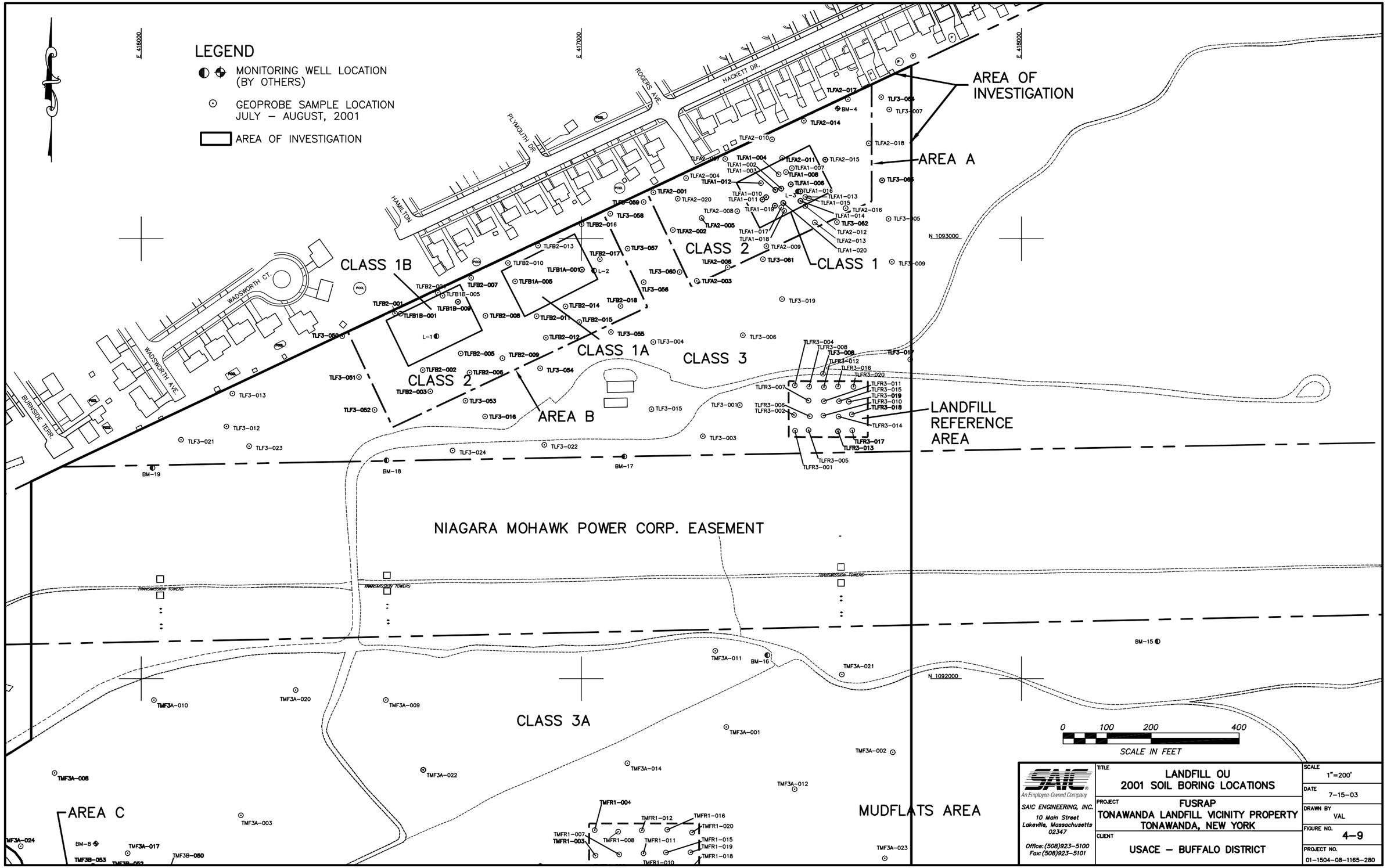
LEGEND
MONITORING WELL LOCATION (BY OTHERS)
GEOPROBE SAMPLE LOCATION JULY – AUGUST, 2001
AREA OF INVESTIGATION
E 416000
E 417000
E 418000
N 1093000
N 1092000
AREA OF INVESTIGATION
AREA A
CLASS 1
CLASS 2
CLASS 1B
CLASS 1A
CLASS 3
CLASS 2
AREA B
LANDFILL REFERENCE AREA
NIAGARA MOHAWK POWER CORP. EASEMENT
TRANSMISSION TOWERS
CLASS 3A
AREA C
MUDFLATS AREA
HACKETT DR.
ROGERS AVE.
PLYMOUTH DR.
HAMILTON
WADSWORTH CT.
WADSWORTH AVE.
BURNSIDE TERR.
POOL
0 100 200 400
SCALE IN FEET
SAIC
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SAIC ENGINEERING, INC.
10 Main Street
Lakeville, Massachusetts 02347
Office: (508)923-5100
Fax: (508)923-5101
TITLE
LANDFILL OU
2001 SOIL BORING LOCATIONS
PROJECT
FUSRAP
TONAWANDA LANDFILL VICINITY PROPERTY
TONAWANDA, NEW YORK
CLIENT
USACE – BUFFALO DISTRICT
SCALE 1"=200'
DATE 7-15-03
DRAWN BY VAL
FIGURE NO. 4-9
PROJECT NO. 01-1504-08-1165-280
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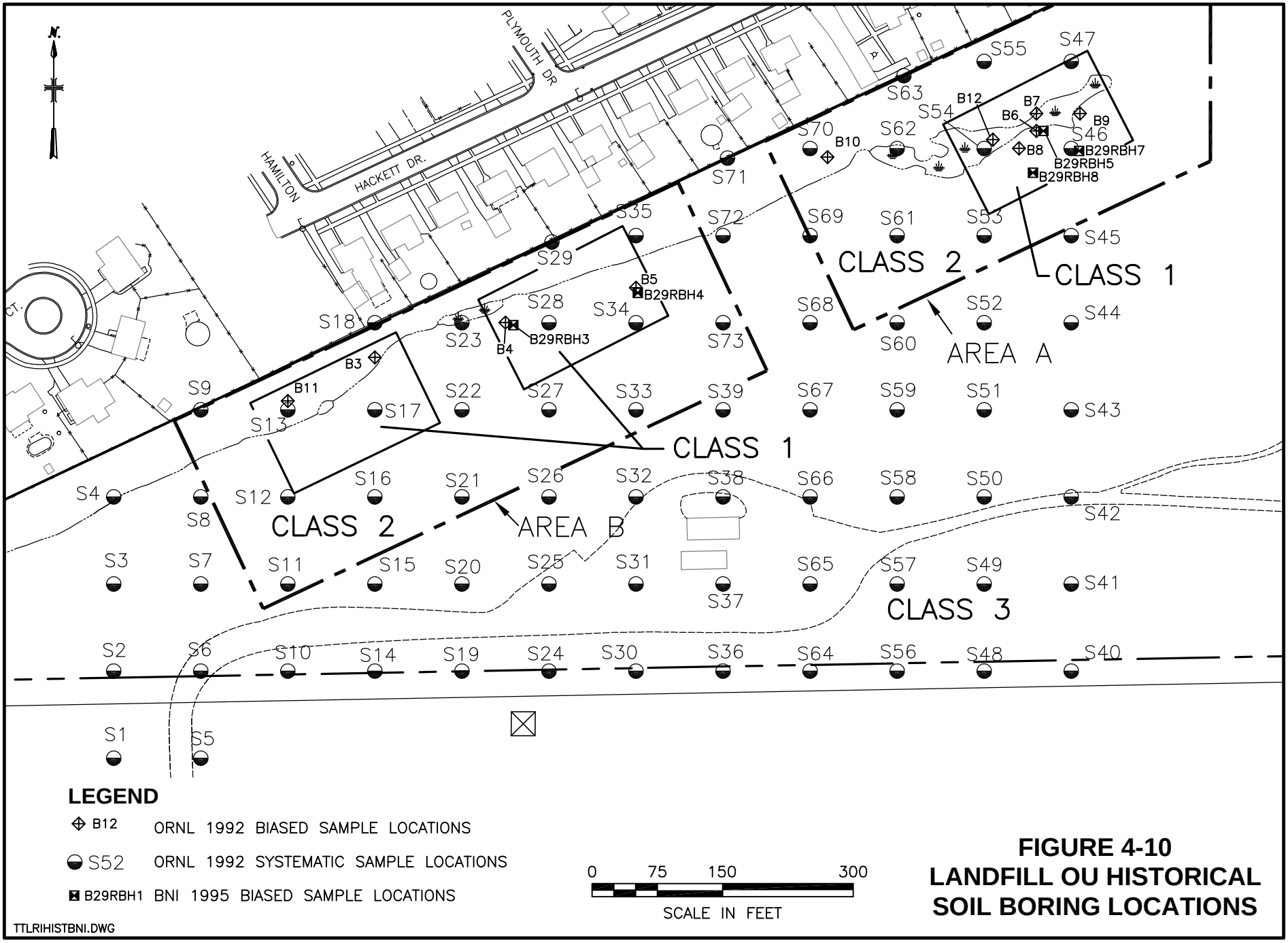
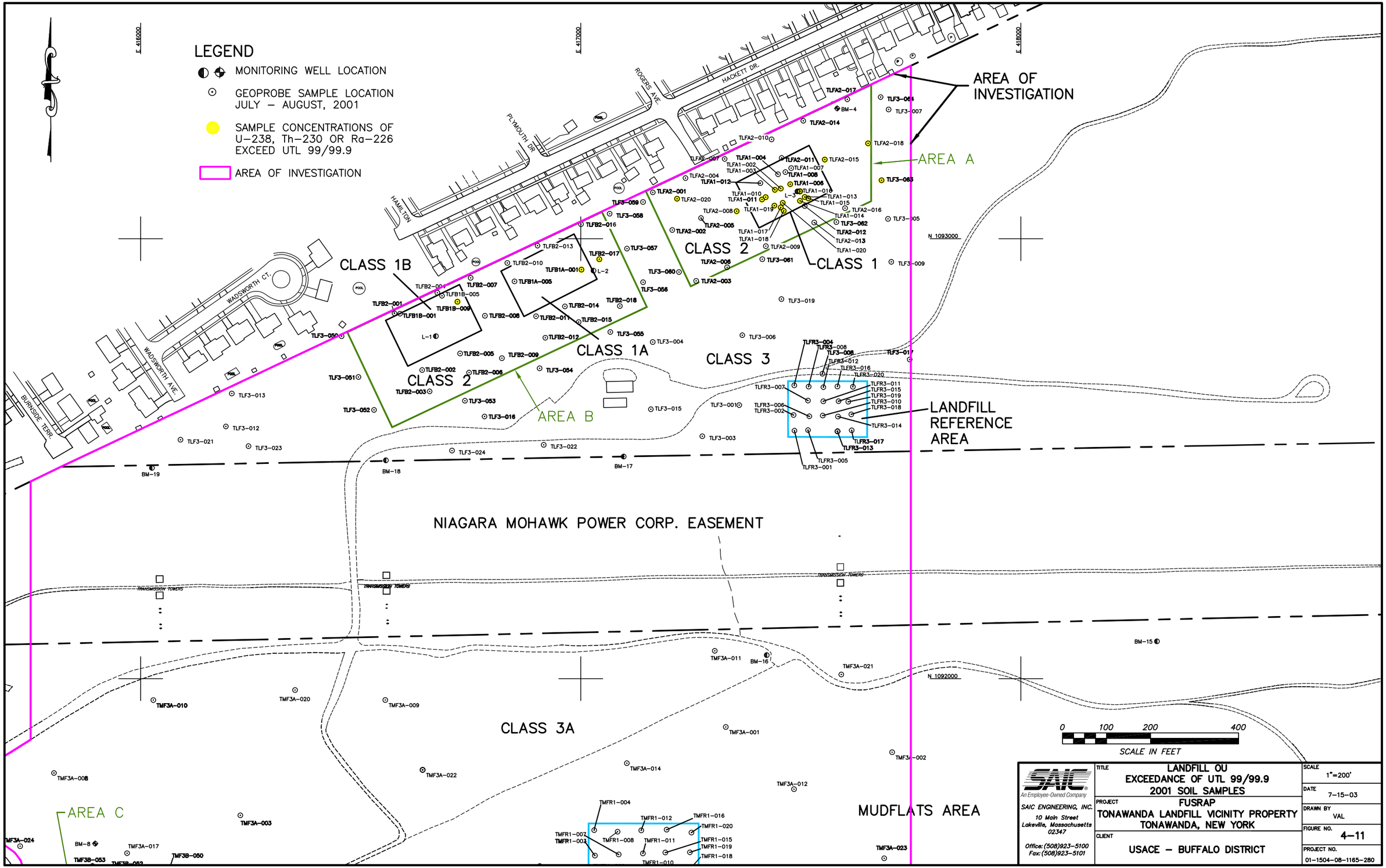


FIGURE 4-10
LANDFILL OU HISTORICAL SOIL BORING LOCATIONS


LEGEND
MONITORING WELL LOCATION
GEOPROBE SAMPLE LOCATION JULY – AUGUST, 2001
SAMPLE CONCENTRATIONS OF U–238, Th–230 OR Ra–226 EXCEED UTL 99/99.9
AREA OF INVESTIGATION
AREA OF INVESTIGATION
AREA A
AREA B
AREA C
CLASS 1
CLASS 1A
CLASS 1B
CLASS 2
CLASS 3
CLASS 3A
LANDFILL REFERENCE AREA
NIAGARA MOHAWK POWER CORP. EASEMENT
MUDFLATS AREA
TRANSMISSION TOWERS
HACKETT DR.
ROGERS AVE.
PLYMOUTH DR.
HAMILTON
WADSWORTH CT.
WADSWORTH AVE.
BURNSIDE TERR.
E 416000
E 417000
E 418000
N 1093000
N 1092000
0 100 200 400
SCALE IN FEET
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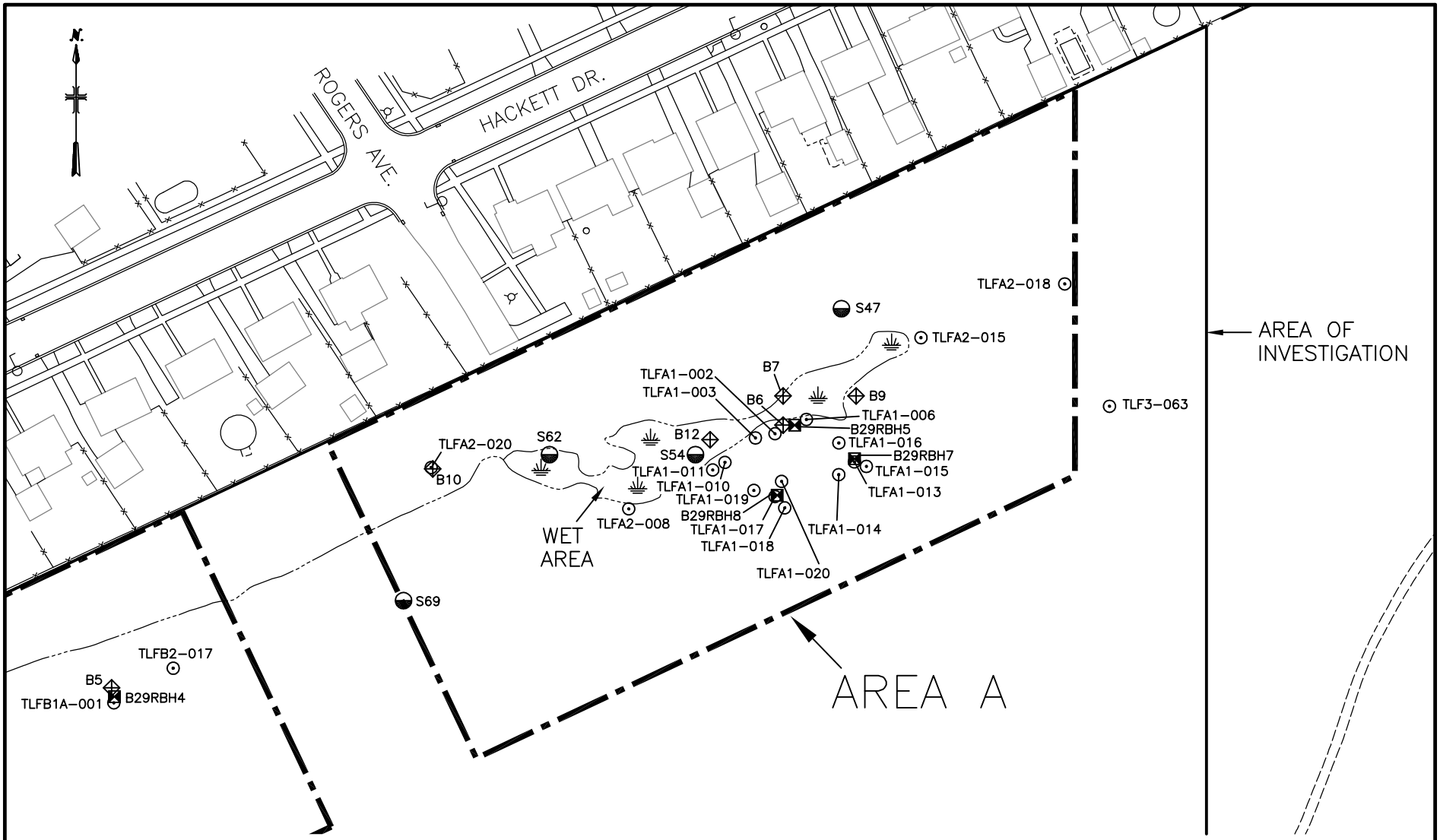
Lakeville, Massachusetts 02347
Office: (508)923–5100
Fax: (508)923–5101
TITLE
LANDFILL OU
EXCEEDANCE OF UTL 99/99.9
2001 SOIL SAMPLES
PROJECT
FUSRAP
TONAWANDA LANDFILL VICINITY PROPERTY
TONAWANDA, NEW YORK
CLIENT
USACE – BUFFALO DISTRICT
SCALE 1"=200'
DATE 7–15–03
DRAWN BY VAL
FIGURE NO. 4–11
PROJECT NO. 01–1504–08–1165–280
TTLRI4–4.DWG



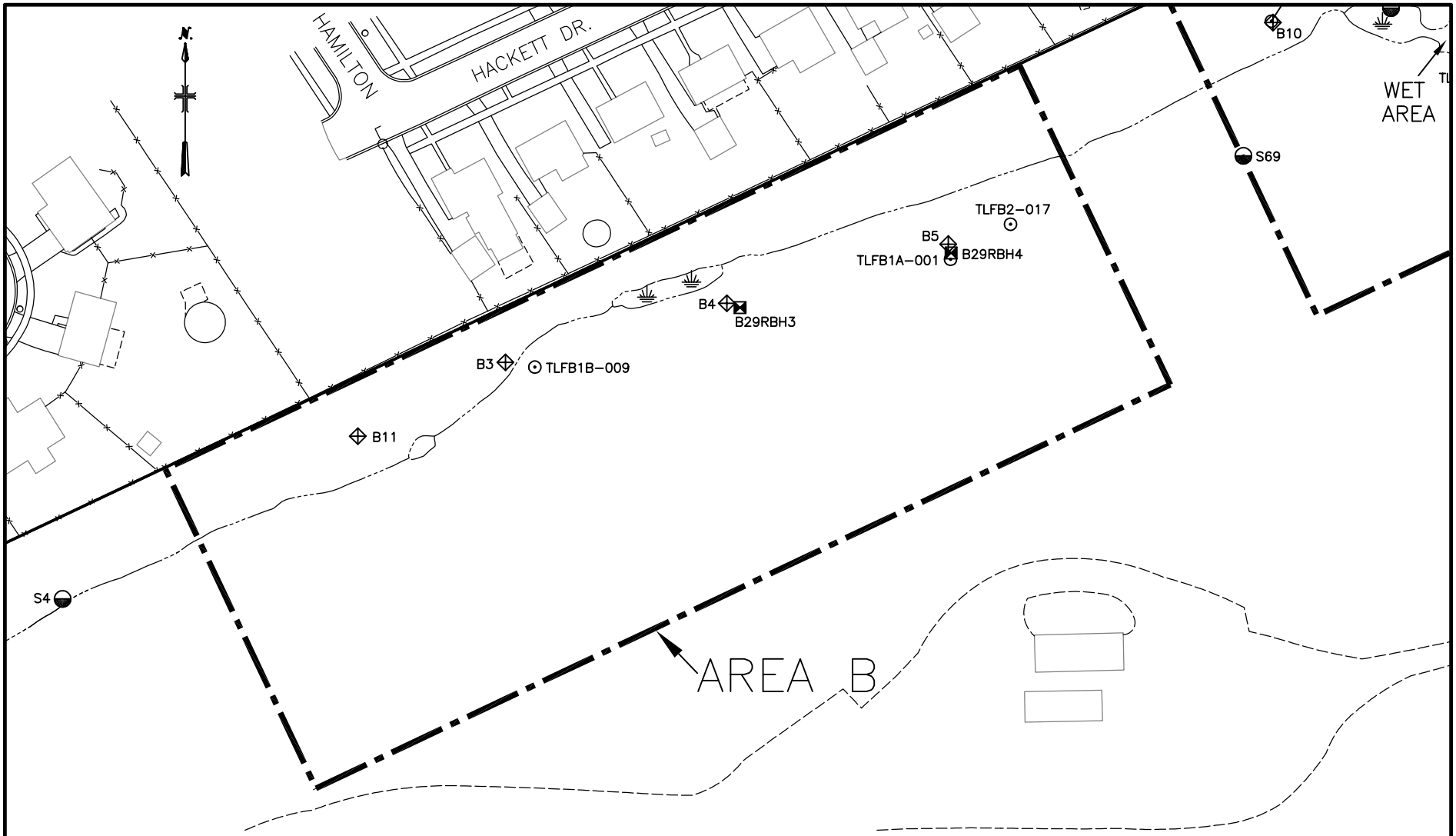
LEGEND

B12	ORNL 1992 BIASED SAMPLE LOCATIONS
S52	ORNL 1992 SYSTEMATIC SAMPLE LOCATIONS
TLF3–009	SAIC 2001 SAMPLE LOCATIONS
B29RBH4	BNI 1995 BIASED SAMPLE LOCATIONS

TTLRIEXCEED99.DWG

NOTE: ONLY HISTORICAL AND 2001 BORING LOCATIONS WHERE SOIL SAMPLE CONCENTRATIONS OF U–238, Th–230 OR Ra–226 EXCEED UTL 99/99.9 ARE PRESENTED.

FIGURE 4-12
AREA A (LANDFILL OU)
EXCEEDANCE OF UTL 99/99.9
2001 AND HISTORICAL SOIL SAMPLES



LEGEND

B4	ORNL 1992 BIASED SAMPLE LOCATIONS
S22	ORNL 1992 SYSTEMATIC SAMPLE LOCATIONS
TLF3–051	SAIC 2001 SAMPLE LOCATIONS
B29RBH4	BNI 1995 BIASED SAMPLE LOCATIONS

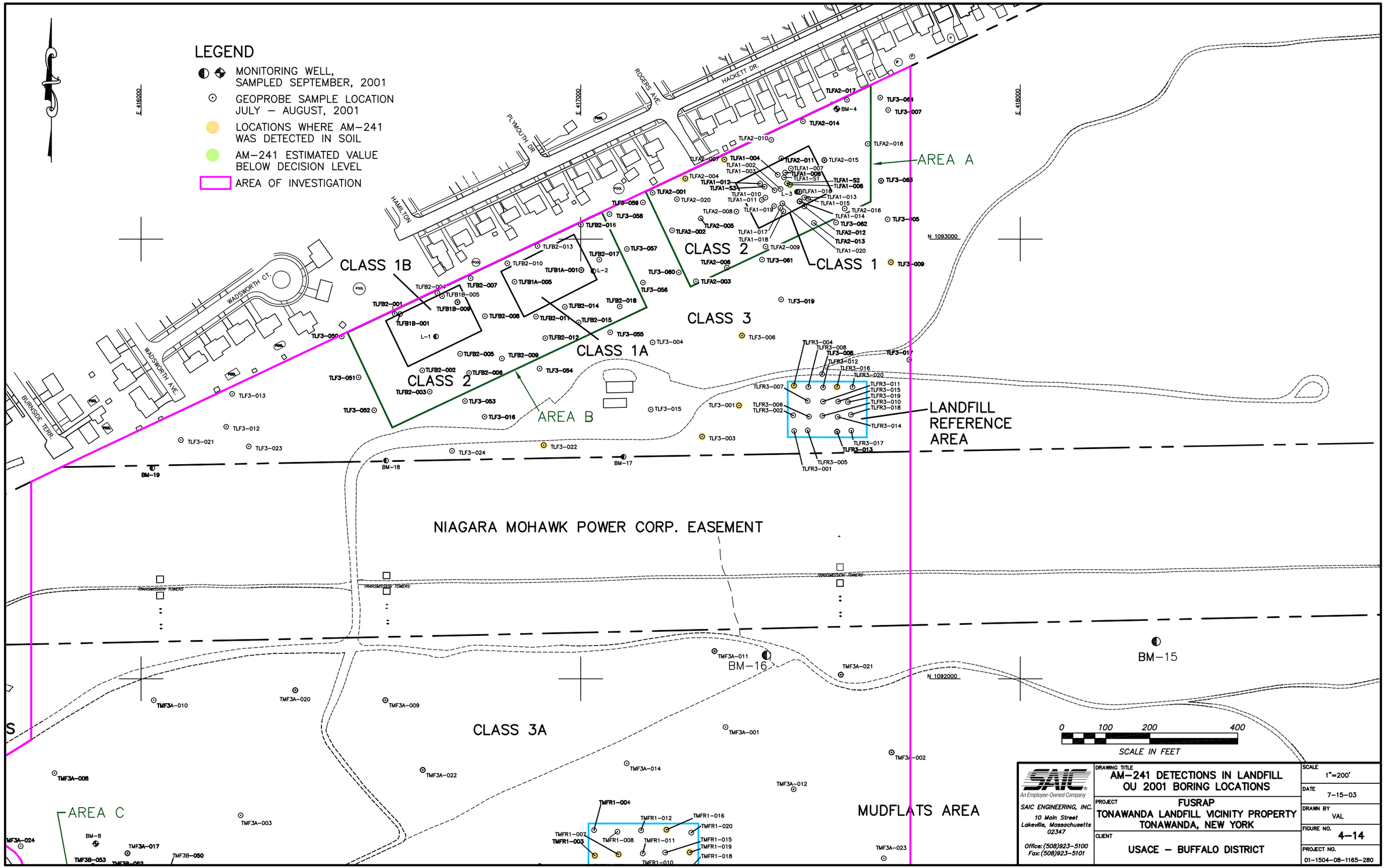
NOTE: ONLY HISTORICAL AND 2001 BORING LOCATIONS WHERE SOIL SAMPLE CONCENTRATIONS OF U–238, Th–230 OR Ra–226 EXCEED UTL 99/99.9 ARE PRESENTED.

0 50 100 200

SCALE IN FEET

FIGURE 4-13
AREA B (LANDFILL OU)
EXCEEDANCE OF UTL 99/99.9
2001 AND HISTORICAL SOIL SAMPLES

TTLRIEXCEED99.DWG


LEGEND
MONITORING WELL, SAMPLED SEPTEMBER, 2001
GEOPROBE SAMPLE LOCATION JULY – AUGUST, 2001
LOCATIONS WHERE AM–241 WAS DETECTED IN SOIL
AM–241 ESTIMATED VALUE BELOW DECISION LEVEL
AREA OF INVESTIGATION
E 416000
E 417000
E 418000
N 1093000
N 1092000
HACKETT DR.
ROGERS AVE.
PLYMOUTH DR.
HAMILTON
WADSWORTH CT.
WADSWORTH AVE.
BURNSIDE TERR.
CLASS 1B
CLASS 2
CLASS 1A
CLASS 3
CLASS 1
AREA A
AREA B
AREA C
LANDFILL REFERENCE AREA
NIAGARA MOHAWK POWER CORP. EASEMENT
TRANSMISSION TOWERS
CLASS 3A
MUDFLATS AREA
BM–15
BM–16
BM–17
BM–18
BM–19
0 100 200 400
SCALE IN FEET
SAIC
An Employee-Owned Company
SAIC ENGINEERING, INC.
10 Main Street
Lakeville, Massachusetts 02347
Office: (508)923–5100
Fax: (508)923–5101
DRAWING TITLE
AM–241 DETECTIONS IN LANDFILL OU 2001 BORING LOCATIONS
PROJECT
FUSRAP
TONAWANDA LANDFILL VICINITY PROPERTY
TONAWANDA, NEW YORK
CLIENT
USACE – BUFFALO DISTRICT
SCALE 1"=200'
DATE 7–15–03
DRAWN BY VAL
FIGURE NO. 4–14
PROJECT NO. 01–1504–08–1165–280
TTLRIAM–241.DWG

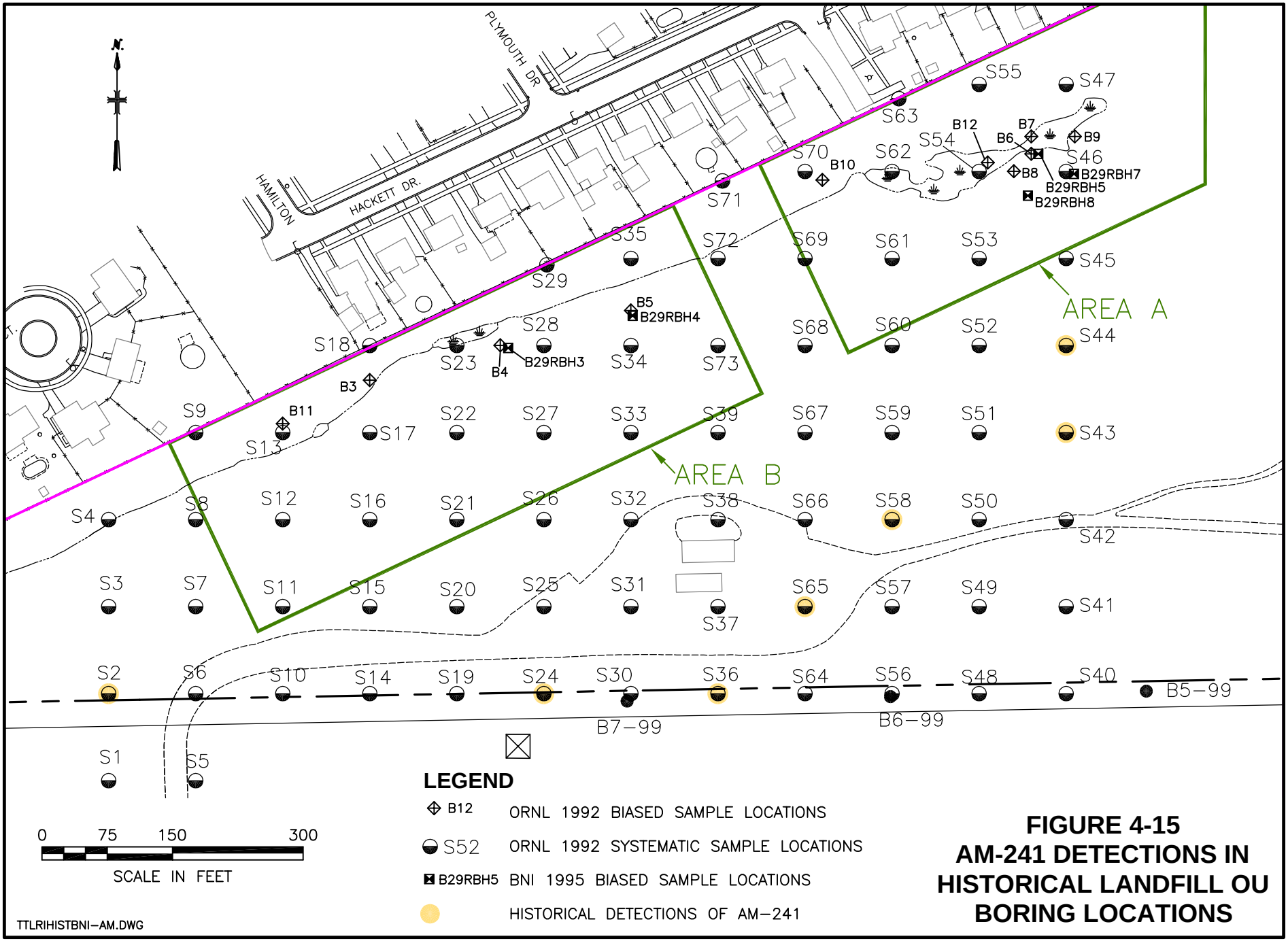


FIGURE 4-15
AM-241 DETECTIONS IN HISTORICAL LANDFILL OU BORING LOCATIONS

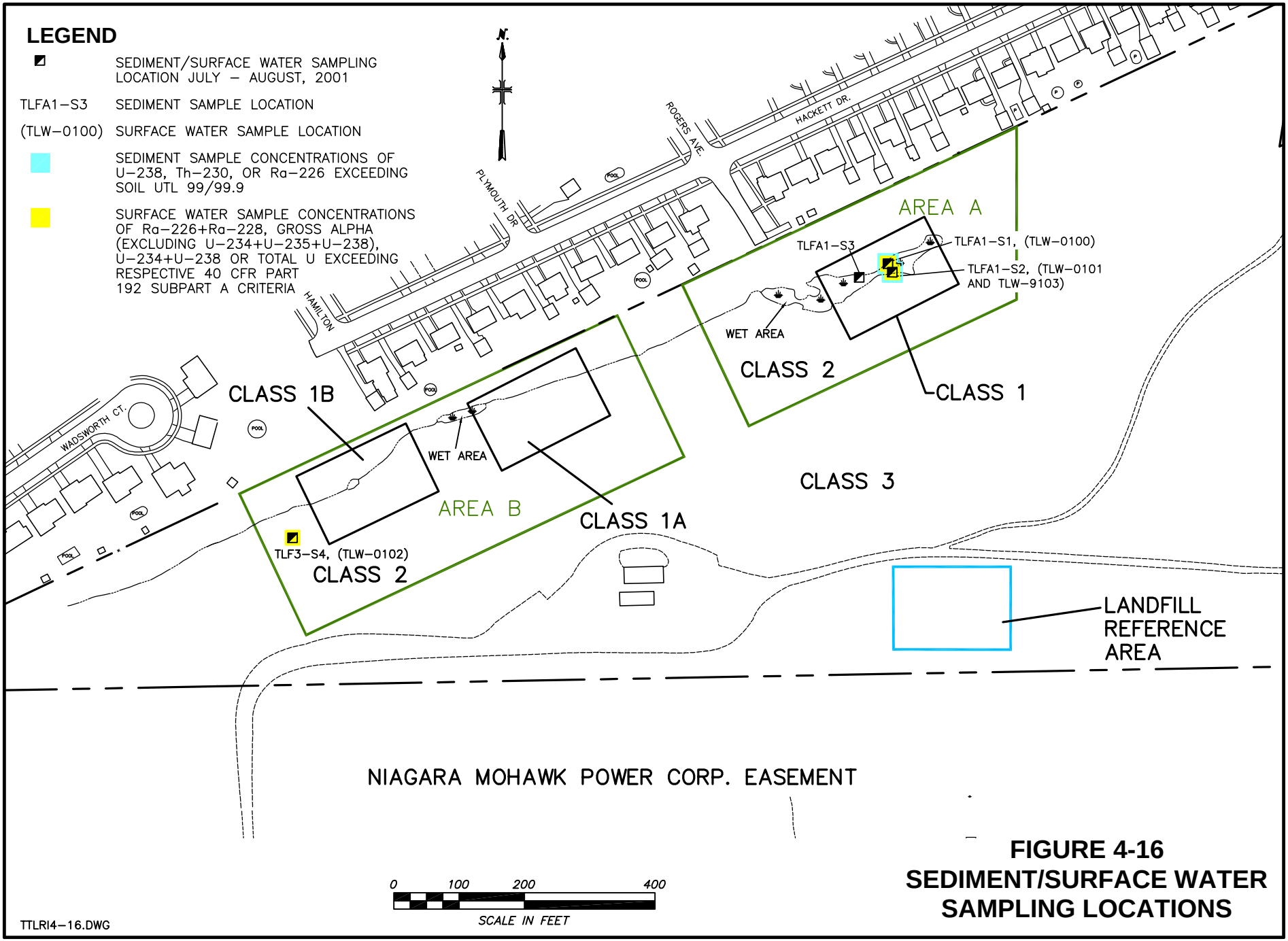


FIGURE 4-16
SEDIMENT/SURFACE WATER SAMPLING LOCATIONS

Table 4-1
Summary of Soil Results - Mudflats Reference Area

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	5	44	-0.29	0.5	0.02	0.05
Cs-137	4	4	0.09	0.38	0.19	0.33
K-40	44	44	15.7	25.1	18.83	19.41
Pa-231	2	44	-4.2	2.6	-0.62	-0.32
Ra-226	43	44	-0.03	1.74	0.83	0.91
Ra-228	44	44	0.54	1.1	0.76	0.79
Th-228	44	44	0.66	1.57	0.96	1.01
Th-230	44	44	0.49	1.49	0.88	0.93
Th-232	44	44	0.62	1.28	0.9	0.93
U-234	44	44	0.58	1.15	0.82	0.85
U-235	38	44	0.02	0.19	0.07	0.08
U-238	44	44	0.58	1.15	0.81	0.84

Refer to Appendix A, Table A4-3 for more detailed results.

Table 4-2
Summary of Soil Results - Mudflats Class 3A - Random Samples

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	0	40	-0.47	0.27	-0.01	0.03
Cs-137	4	4	0.04	0.26	0.11	0.22
K-40	40	40	11.2	22.9	18.29	18.96
Pa-231	1	40	-3.6	2.3	-0.62	-0.29
Ra-226	40	40	0.24	1.23	0.9	0.95
Ra-228	40	40	0.41	1.15	0.78	0.82
Th-228	40	40	0.57	1.29	0.9	0.94
Th-230	40	40	0.67	1.23	0.88	0.92
Th-232	40	40	0.54	1.24	0.84	0.88
U-234	40	40	0.63	1.21	0.84	0.88
U-235	37	40	0.03	0.2	0.08	0.09
U-238	40	40	0.58	1.06	0.85	0.89

Refer to Appendix A, Table A4-4 for more detailed results.

The data distributions were tested and UCL95/UCL values were calculated accordingly for the risk calculations as presented in Section 6. However, for screening purposes normality was assumed for the data presented in this table.

Note that for some radionuclides, a negative value is reported as the mean or UCL95.

When a large number of negative results are in the data set (common for nuclides that are largely undetected) a negative mean or UCL95 can result.

Table 4-3
Summary of Soil Results - Mudflats Class 3B - Random Samples

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	2	40	-0.23	0.46	0.01	0.04
Cs-137	5	5	0.12	0.37	0.23	0.32
K-40	40	40	4.1	22.6	17.32	18.24
Pa-231	0	40	-2.9	1	-0.91	-0.62
Ra-226	39	40	0.14	1.33	0.87	0.94
Ra-228	40	40	0.14	1.36	0.79	0.84
Th-228	40	40	0.18	1.27	0.91	0.97
Th-230	40	40	0.34	1.38	0.88	0.93
Th-232	40	40	0.25	1.2	0.9	0.95
U-234	40	40	0.36	1.08	0.84	0.88
U-235	39	40	0.01	0.27	0.11	0.13
U-238	40	40	0.39	1.06	0.85	0.88

Refer to Appendix A, Table A4-5 for more detailed results.

Table 4-4
Summary of Soil Results - Mudflats Class 3B - Biased Samples

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	1	34	-0.23	0.36	0	0.04
Cs-137	3	3	0.12	0.23	0.16	0.24
K-40	34	34	2.55	22.9	15.14	16.55
Pa-231	1	34	-3	1.3	-0.44	-0.13
Ra-226	34	34	0.18	1.64	0.84	0.93
Ra-228	33	34	0.14	1.08	0.65	0.71
Th-228	34	34	0.14	1.15	0.78	0.85
Th-230	34	34	0.5	1.36	0.86	0.91
Th-232	34	34	0.16	1.1	0.75	0.83
U-234	34	34	0.49	1.19	0.79	0.85
U-235	29	34	0.01	0.22	0.08	0.09
U-238	34	34	0.39	1.21	0.77	0.83

Refer to Appendix A, Table A4-6 for more detailed results.

The data distributions were tested and UCL95/UCL values were calculated accordingly for the risk calculations as presented in Section 6. However, for screening purposes normality was assumed for the data presented in this table.

Note that for some radionuclides, a negative value is reported as the mean or UCL95.
When a large number of negative results are in the data set (common for nuclides that are largely undetected) a negative mean or UCL95 can result.

Table 4-5
Summary of Soil Results - Mudflats Class 2, Area C

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	2	41	-0.27	0.28	0	0.03
Cs-137	4	4	0.11	0.32	0.2	0.3
K-40	41	41	5.8	22.9	15.89	16.9
Pa-231	2	41	-4.5	1.9	-0.48	-0.15
Ra-226	40	41	0.07	1.37	0.86	0.93
Ra-228	41	41	0.29	1.08	0.67	0.71
Th-228	40	41	0.15	1.42	0.85	0.91
Th-230	41	41	0.5	1.79	0.98	1.04
Th-232	41	41	0.31	1.29	0.84	0.9
U-234	41	41	0.51	2.92	0.98	1.11
U-235	37	41	0.01	0.5	0.13	0.16
U-238	41	41	0.48	3.04	0.94	1.07

Refer to Appendix A, Table A4-7 for more detailed results.

Table 4-6
Summary of Soil Results - Mudflats Class 1, Area C

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	1	25	-0.53	0.47	-0.05	0.02
Cs-137	4	4	0.09	0.21	0.15	0.2
K-40	25	25	6.8	19.3	15.44	16.48
Pa-231	0	25	-1.8	1.7	-0.24	0.06
Ra-226	25	25	0.39	22.6	1.68	3.17
Ra-228	25	25	0.47	0.79	0.67	0.7
Th-228	25	25	0.39	1.25	0.87	0.94
Th-230	25	25	0.62	31.5	2.19	4.27
Th-232	25	25	0.41	1.14	0.86	0.92
U-234	25	25	0.61	29	2.04	3.96
U-235	24	25	0.01	1.72	0.15	0.26
U-238	25	25	0.65	27.9	1.98	3.83

Refer to Appendix A, Table A4-8 for more detailed results.

The data distributions were tested and UCL95/UCL values were calculated accordingly for the risk calculations as presented in Section 6. However, for screening purposes normality was assumed for the data presented in this table.

Note that for some radionuclides, a negative value is reported as the mean or UCL95.

When a large number of negative results are in the data set (common for nuclides that are largely undetected) a negative mean or UCL95 can result.

Table 4-7
Summary of Elevated Soil Results - Mudflats
Th-230, U-238, and Ra-226 (Historical and USACE 2001) (1)

Boring Location	Depth (ft bgs)	Sample #	Th-230 Result (pCi/g)	U-238 Result (pCi/g)	Ra-226 Result (pCi/g)
MUDFLATS					
Screening Level UTL 99/99.9 (2)			**1.69**	**1.31**	**2.22**
Area C and Vicinity					
TMFC1 005	10.25	TMF-0283	1.06	1.37	0.98
TMFC1 005	4	TMF-0285	31.5	27.9	22.6
TMFC2 012	0.5	TMF-0222	1.79	2.73	1.32
TMFC2 012	3.5	TMF-0223	1.06	3.04	0.42
B3'	0.5	B3'A	(3)	18.00	11.00
B3'	1.0	B3'B	(3)	16.00	5.40
B13	0.5	B13A	27.00	30.00	16.00
B13	1.0	B13B	< 21.00	35.00	14.00
B13	1.5	B13C	31.00	35.00	19.00
B13	2.0	B13D	< 67.00	34.00	33.00
B13	2.5	B13E	< 20.00	20.00	22.00
B14	0.5	B14A	< 26.00	12.00	13.00
B14	1.0	B14B	< 22.00	18.00	22.00
B14	1.5	B14C	< 15.00	16.00	12.00
B14	2.0	B14D	< 28.00	13.00	20.00
B15	0.5	B15A	660.00	78.00	120.00
B15	1.0	B15B	< 9.90	2.63	3.50
B15	1.5	B15C	< 17.00	3.40	3.40
B15	2.0	B15D	< 17.00	3.00	2.80
B29RBH1	1.5	B01-001	7.90	6.40	4.20
B29RBH1	3.0	B01-002	3.00	20.80	2.40
B29RBH2	1.5	B02-005	4.00	4.10	4.30
S75	0.5	S75A	< 5.50	1.70	0.96
S75	1.5	S75C	< 5.00	1.40	0.86
S77	0.5	S77A	< 8.00	2.00	1.90
S77	1.0	S77B	< 11.00	1.70	1.30
S77	1.5	S77C	< 4.90	1.40	0.97
S79	0.5	S79	< 4.30	1.40	0.90
S81	1.0	S81B	< 7.90	1.50	0.98
S81	1.5	S81C	< 7.90	1.70	0.97
S83	0.5	S83	< 7.60	1.60	0.83
S84	0.5	S84	< 7.20	1.50	1.10
S85	0.5	S85A	< 9.50	1.50	0.89
S85	1.0	S85B	1.40	1.60	0.94

Notes:
1. Based on soil results from USACE 2001 investigations, ORNL 1992, and BNI 1995
2. UTL 99/99.9 - 99 percent confidence level that at least 99.9 percent of results will fall below the UTL 99/99.9
3. Not Measured

ft bgs - feet below ground surface
pCi/g - picocuries per gram
< denotes less than, i.e. isotope not detected at listed detection limit
Results from the USACE 2001 investigation exceeding the screening levels are shaded in this table.

Table 4-8
Mudflats OU Historical Radiological Data

		Depth (ft)		U-238			Ra-226			Th-230			Am-241			
Loc ID	Samp ID	Top	Bottom	Pr	Concentration (pCi/g)	± 2σ	Pr	Concentration (pCi/g)	± 2σ	Pr	Concentration (pCi/g)	± 2σ	Pr	Concentration (pCi/g)	± 2σ	Reference
Screening Level - UTL 99/99.9					**1.31**			**2.22**			**1.69**					
Area C, Class 1 and Class 2																
B3'	B3'A	0.0	0.5		**18.00**	3.00		**11.00**	0.10				<	0.1		ORNL 1992
B3'	B3'B	0.5	1.0		**16.00**	1.00		**5.40**	0.06				<	0.1		ORNL 1992
B13	B13A	0.0	0.5		**30.00**	4.00		**16.00**	0.20		**27.00**	40.00	<	0.1		ORNL 1992
B13	B13B	0.5	1.0		**35.00**	2.00		**14.00**	0.10	<	21.00		<	0.1		ORNL 1992
B13	B13C	1.0	1.5		**35.00**	4.00		**19.00**	0.20		**31.00**	40.00	<	0.1		ORNL 1992
B13	B13D	1.5	2.0		**34.00**	4.00		**33.00**	0.20	<	67.00		<	0.1		ORNL 1992
B13	B13E	2.0	2.5		**20.00**	2.00		**22.00**	0.10	<	20.00		<	0.1		ORNL 1992
B14	B14A	0.0	0.5		**12.00**	3.00		**13.00**	0.10	<	26.00		<	0.1		ORNL 1992
B14	B14B	0.5	1.0		**18.00**	2.00		**22.00**	0.10	<	22.00		<	0.1		ORNL 1992
B14	B14C	1.0	1.5		**16.00**	1.00		**12.00**	0.10	<	15.00		<	0.1		ORNL 1992
B14	B14D	1.5	2.0		**13.00**	3.00		**20.00**	0.20	<	28.00		<	0.1		ORNL 1992
B15	B15A	0.0	0.5		**78.00**	20.00		**120.00**	0.70		**660.00**	100.00	<	0.1		ORNL 1992
B15	B15B	0.5	1.0		**2.63**	1.00		**3.50**	0.04	<	9.90		<	0.1		ORNL 1992
B15	B15C	1.0	1.5		**3.40**	1.00		**3.40**	0.04	<	17.00		<	0.1		ORNL 1992
B15	B15D	1.5	2.0		**3.00**	1.00		**2.80**	0.04	<	17.00		<	0.1		ORNL 1992
B29RBH1	B01-001	0.0	1.5		**6.40**	2.20		**4.20**	0.27		**7.90**	**1.90**				BNI 1995
B29RBH1	B01-002	1.5	3.0		**20.80**	5.90		**2.40**	0.32		**3.00**	**0.69**				BNI 1995
B29RBH2	B02-005	0.0	1.5		**4.10**	2.60		**4.30**	0.39		**4.00**	**1.10**				BNI 1995
S83	S83	0.0	0.5		**1.60**	1.00		0.83	0.02	<	7.60		<	0.1		ORNL 1992
S84	S84	0.0	0.5		**1.50**	1.00		1.10	0.03	<	7.20		<	0.1		ORNL 1992
S85	S85A	0.0	0.5		**1.50**	0.80		0.89	0.02	<	9.50		<	0.1		ORNL 1992
S85	S85B	0.5	1.0		**1.60**	1.00		0.94	0.02		1.40	8.00	<	0.1		ORNL 1992
S85	S85C	1.0	1.5		1.20	0.80		0.91	0.02	<	11.00		<	0.1		ORNL 1992
S86	S86A	0.0	0.5		1.20	0.50		0.89	0.02	<	4.30		<	0.1		ORNL 1992
S86	S86B	0.5	1.0	<	2.50			1.00	0.02	<	11.00		<	0.1		ORNL 1992
S86	S86C	1.0	1.5		1.20	0.80		1.00	0.02	<	9.80		<	0.1		ORNL 1992
S87	S87	0.0	0.5		1.10	0.50		0.93	0.02	<	4.30		<	0.1		ORNL 1992
S88	S88	0.0	0.5		1.30	0.50		0.97	0.02	<	4.40		<	0.1		ORNL 1992

Table 4-8
Mudflats OU Historical Radiological Data

		Depth (ft)		U-238			Ra-226			Th-230			Am-241			
Loc ID	Samp ID	Top	Bottom	Pr	Concentration (pCi/g)	± 2σ	Pr	Concentration (pCi/g)	± 2σ	Pr	Concentration (pCi/g)	± 2σ	Pr	Concentration (pCi/g)	± 2σ	Reference
Screening Level - UTL 99/99.9					**1.31**			**2.22**			**1.69**					
Class 3																
S74	S74	0.0	0.5	<	2.00			1.10	0.02	<	11.00		<	0.1		ORNL 1992
S75	S75A	0.0	0.5		**1.70**	0.60		0.96	0.03	<	5.50		<	0.1		ORNL 1992
S75	S75B	0.5	1.0		1.00	1.00		0.86	0.02	<	8.00		<	0.1		ORNL 1992
S75	S75C	1.0	1.5		**1.40**	0.70		0.86	0.02	<	5.00		<	0.1		ORNL 1992
S76	S76	0.0	0.5		0.79	0.50		0.83	0.02	<	4.30		<	0.1		ORNL 1992
S77	S77A	0.0	0.5		**2.00**	0.80		1.90	0.03	<	8.00		<	0.1		ORNL 1992
S77	S77B	0.5	1.0		**1.70**	0.90		1.30	0.02	<	11.00		<	0.1		ORNL 1992
S77	S77C	1.0	1.5		**1.40**	0.60		0.97	0.02	<	4.90		<	0.1		ORNL 1992
S78	S78	0.0	0.5	<	2.40			0.99	0.02	<	13.00		<	0.1		ORNL 1992
S79	S79	0.0	0.5		**1.40**	0.50		0.90	0.02	<	4.30		<	0.1		ORNL 1992
S80	S80	0.0	0.5		0.81	0.40		0.81	0.02	<	4.10		<	0.1		ORNL 1992
S81	S81A	0.0	0.5	<	2.40			1.10	0.03	<	7.80		<	0.1		ORNL 1992
S81	S81B	0.5	1.0		**1.50**	1.00		0.98	0.02	<	7.90		<	0.1		ORNL 1992
S81	S81C	1.0	1.5		**1.70**	1.00		0.97	0.03	<	7.90		<	0.1		ORNL 1992
S82	S82	0.0	0.5		1.20	0.90		0.97	0.02	<	10.00		<	0.1		ORNL 1992

Average	**9.38**	**8.21**	**28.27**	**0.10**
# detected	39	43	7	0
# results	43	43	41	40
UCL95	13.19	13.10	54.97	0.10
Max	78.00	120.00	660.00	0.10
Min	0.79	0.81	1.40	0.10
stdev	14.85	19.11	101.78	0.00

Notes:
Pr - Preceding qualifier "<" denotes less than, i.e. isotope not detected at listed detection limit.
pCi/g - picocuries per gram
Bold denotes an exceedance of the UTL 99/99.9 screening level.
For comparison purposes only, the sample locations were classified based on areas identified during the 2001 field investigations.

Table 4-9
Summary of Mudflats OU
Am-241 Detections (USACE 2001)

Prefix	No.	Depth (ft bgs)	Sample #	Result (pCi/g)	Qual
TMFR1	001	2.5	TMF-0002	0.15	
TMFR1	003	0.5	TMF-0005	0.5	
TMFR1	007	4	TMF-0014	0.092	
TMFR1	016	4	TMF-0034	0.112	
TMFR1	019	4	TMF-0040	0.13	
TMFC1	005	10	TMF-0283	0.07	UJ
TMFC1	005	14	TMF-0284	0.47	
TMFC2	001	3.5	TMF-0219	-0.134	UJ
TMFC2	004	0.5	TMF-0214	0.102	
TMFC2	008	7	TMF-0231	-0.21	UJ
TMFC2	013	0.5	TMF-0236	-0.19	UJ
TMFC2	015	2	TMF-0224	0.28	
TMF3A	002	4	TMF-0060	-0.42	UJ
TMF3B	001	6.2	TMF-0102	0.12	
TMF3B	006	4	TMF-0128	0.46	
TMF3B	057	3.5	TMF-0173	0.079	

Notes:
UJ - Estimated, value below decision level
ft bgs - feet below ground surface
pCi/g - picocuries per gram

Table 4-10
Summary of Mudflats OU Chemical Results[1]

Compound	Standards (mg/kg)		Sample Result (mg/kg)		
	EPA RCRA (20x TCLP)	Background[2]	TMF-0282	TMF-0283	TMF-0284
Aluminum		13976	8000	19000	9400
Barium	2000	113	79	530	79
Calcium		32876	55000	63000	64000
Chromium	100	21.5	15	43	15
Copper		18.3	23	570	18
Iron		23700	20000	8800	25000
Lead	100	36	55	**300**	10
Magnesium		10421	8700	6800	18000
Mercury	4		0.13	**6.6**	0.0063
Potassium		162.56	1200	610	2000
Silver	100	2.91	0.11	24	0.024
Sodium		1023	1300	1200	260
Zinc		84.8	81	1100	69

Notes:
1. Only chemicals which exceed EPA RCRA screening or background levels are presented.
2. From BNI 1993.
mg/kg - milligrams per kilogram
TCLP - Toxicity Characteristic Leaching Procedure
Bold denotes an exceedance of EPA RCRA screening.
Refer to Appendix A, Table A4-12 for complete chemical results.

Table 4-11
Groundwater Sampling Results
Tonawanda Landfill Vicinity Property - September 2001

UNFILTERED SAMPLES (Total)

Analytes	Ra-226	Ra-228	Ra-226 + Ra-228	U-234	U-235	U-238	U-234 + U-238	U Total	Gross Alpha	Gross Alpha (2)	Th-230	Th-232
Standard (1)	NA	NA	**5**	NA	NA	NA	**30**	**44**	NA	**15**	NA	NA
Units	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	µg/L	pCi/L	pCi/L	pCi/L	pCi/L
WELL												
BM-4	1.5	3.2	4.7	14.4	0.4	12.3	26.7	30.1	26.8	-0.3	0.3	0.3
BM-4 (DUP)	1.7	1.2	2.9	13.6	0.5	11.6	25.2	35.6	26.0	0.3	0.3	0.3
BM-8	0.2	1.9	2.1	2.5	0.2	2.0	4.5	9.4	5.6	0.9	0.1	0.1
BM-12	1.2	0.7	1.9	4.3	0.3	3.1	7.4	5.7	10.3	2.6	0.1	0.2
BM-15	0.6	0.6	1.2	7.4	0.4	6.0	13.4	14.8	17.1	3.3	0.1	0.2
BM-16	0.4	1.0	1.5	13.2	0.6	9.9	23.1	27.0	25.4	1.7	0.0	0.0
BM-17	1.5	2.5	4.0	9.2	0.7	8.0	17.2	22.5	16.6	-1.3	0.3	0.1
BM-18	2.2	1.5	3.8	12.2	0.6	10.0	22.2	30.7	28.2	5.5	0.4	0.2
BM-19	0.7	1.3	2.0	12.1	0.7	10.6	22.7	34.8	21.1	-2.3	0.1	0.0
L-1	0.3	0.3	0.6	1.8	0.1	1.4	3.2	3.6	-0.5	-3.8	0.3	0.2
L-2	0.7	1.6	2.3	1.1	0.1	1.6	2.7	4.5	0.6	-2.2	1.1	1.1
L-3	0.9	0.7	1.6	58.2	2.5	58.3	116.5	175.0	114.0	-5.0	3.0	0.3
L-3 (DUP)	0.8	2.3	3.1	59.0	4.0	57.7	116.7	164.0	111.0	-9.7	4.3	0.7
DW-1	1.7	1.5	3.1	0.3	0.0	0.2	0.5	0.5	-3.3	-3.8	0.0	0.0
DW-2	0.6	2.1	2.7	0.2	0.0	0.1	0.3	0.3	0.9	0.5	0.2	0.1
DW-4R	0.5	0.9	1.4	0.2	0.0	0.1	0.3	1.1	9.1	8.7	0.4	0.3

FILTERED SAMPLES (Dissolved)

Analytes	Ra-226	Ra-228	Ra-226+ Ra-228	U-234	U-235	U-238	U-234 + U-238	U Total	Gross Alpha	Gross Alpha (2)	Th-230	Th-232
Standard (1)	NA	NA	**5**	NA	NA	NA	**30**	**44**	NA	**15**	NA	NA
Units	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	µg/L	pCi/L	pCi/L	pCi/L	pCi/L
WELL												
BM-4	0.7	1.4	2.0	12.2	0.8	11.6	23.8	32.1	23.9	-0.7	0.1	0.0
BM-4 (DUP)	0.9	1.8	2.7	12.5	0.5	10.8	23.3	37.7	29.7	5.9	0.0	0.0
BM-8	0.6	-0.7	-0.1	3.9	0.2	2.4	6.3	7.5	6.9	0.4	0.2	0.0
BM-12	0.7	1.5	2.3	4.2	0.1	2.6	6.8	5.4	4.9	-2.0	0.1	0.0
BM-15	0.6	2.1	2.7	6.3	0.4	5.1	11.4	15.4	11.1	-0.7	0.1	0.0
BM-16	0.4	-0.1	0.4	13.3	0.9	9.6	22.9	27.0	19.7	-4.1	0.1	0.0
BM-17	1.0	0.3	1.3	9.3	0.6	7.9	17.2	24.0	13.6	-4.2	0.1	0.0
BM-18	0.9	0.3	1.2	10.4	0.7	8.9	19.3	31.0	16.7	-3.3	0.0	0.0
BM-19	0.4	0.0	0.4	13.0	0.6	10.4	23.4	31.6	26.5	2.5	0.1	0.0
L-1	0.5	0.3	0.8	1.8	0.1	2.0	3.8	2.9	-0.7	-4.6	0.1	0.1
L-2	0.5	0.1	0.6	0.5	0.0	0.6	1.1	1.6	-0.7	-1.8	0.1	0.1
L-3	0.5	0.7	1.1	46.8	3.4	46.9	93.7	133.0	60.3	-36.8	0.5	0.1
L-3 (DUP)	1.0	0.5	1.5	54.1	2.5	53.7	107.8	134.0	83.3	-27.0	0.7	0.1
DW-1	0.7	1.9	2.6	0.2	0.1	0.0	0.2	0.4	-1.0	-1.3	0.2	-0.1
DW-2	0.7	1.2	1.9	0.1	0.0	0.0	0.1	0.2	-0.1	-0.1	0.1	0.0
DW-4R	0.7	1.0	1.7	0.2	0.0	0.1	0.2	0.4	-0.1	-0.4	0.1	0.0

Notes:
(1) The standard is the groundwater standard of 40 CFR Part 192 Subpart A.
(2) Excluding radon and uranium. (Radon purged from sample as part of analytical method)
(DUP) - Duplicate Sample
Where results are reported by the laboratory as undetected, the detection limit is reported as a result in this table.
Where results are reported by the laboratory as less than a specific concentration, that specific concentration is reported as a result in this table.
Results exceeding the 40 CFR Part 192 Subpart A standard are shaded in this table.
Refer to Appendix A, Tables A7-4 and A7-5 for complete results.

Table 4-12
Summary of Soil Results - Landfill Reference Area 3

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	2	40	-0.11	0.15	0	0.02
Pa-231	5	40	-1.1	4.9	0.07	0.34
Ra-226	39	40	0.03	1.91	1	1.08
Ra-228	38	40	0.17	1.8	0.72	0.79
Th-228	40	40	0.48	1.16	0.82	0.86
Th-230	40	40	0.62	1.28	0.92	0.96
Th-232	40	40	0.51	1.02	0.82	0.85
U-234	40	40	0.51	2.38	0.84	0.92
U-235	13	40	-0.01	0.22	0.06	0.07
U-238	40	40	0.44	2.49	0.85	0.94

Refer to Appendix A, Table A4-15 for more detailed results.

Table 4-13
Summary of Soil Results - Landfill Class 3 - Random Samples

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	6	40	-0.15	1.72	0.06	0.14
Pa-231	5	40	-0.9	2.9	0.15	0.35
Ra-226	40	40	0.52	1.49	0.95	1.01
Ra-228	3	40	0.62	0.22	0.58	0.69
Th-228	40	40	0.46	1.34	0.81	0.86
Th-230	40	40	0.87	0.62	0.87	0.91
Th-232	40	40	0.4	1.24	0.74	0.79
U-234	40	40	0.47	1.17	0.75	0.79
U-235	24	40	-0.02	0.14	0.06	0.07
U-238	40	40	0.43	1.07	0.79	0.82

Refer to Appendix A, Table A4-16 for more detailed results.

The data distributions were tested and UCL95/UCL values were calculated accordingly for the risk calculations as presented in Section 6. However, for screening purposes normality was assumed for the data presented in this table.

Note that for some radionuclides, a negative value is reported as the mean or UCL95.

When a large number of negative results are in the data set (common for nuclides that are largely undetected) a negative mean or UCL95 can result.

Table 4-14
Summary of Soil Results - Landfill Class 3 - Biased Samples

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	0	34	-0.1	0.1	-0.01	0.01
Pa-231	4	34	-0.9	3.1	0.15	0.41
Ra-226	34	34	0.4	2.73	0.96	1.09
Ra-228	34	34	0.31	2.52	0.75	0.87
Th-228	34	34	0.41	2.97	0.92	1.04
Th-230	34	34	0.53	3.08	0.92	1.05
Th-232	34	34	0.45	2.68	0.84	0.95
U-234	33	33	0.48	3.59	0.79	1.07
U-235	23	34	0.01	0.16	0.06	0.07
U-238	33	33	0.49	3.13	0.86	0.99

Refer to Appendix A, Table A4-17 for more detailed results.

Table 4-15
Summary of Soil Results - Landfill Class 2 - Area B

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	0	41	-5.7	0.05	-0.17	0.07
Pa-231	8	41	-0.7	5.4	0.29	0.58
Ra-226	41	41	0.43	1.54	1	1.06
Ra-228	41	41	0.34	1.68	0.76	0.82
Th-228	41	41	0.56	1.31	0.86	0.9
Th-230	41	41	0.65	7.5	1.08	1.36
Th-232	41	41	0.4	1.27	0.85	0.89
U-234	41	41	0.43	349	9.29	23.59
U-235	30	41	-0.01	19.3	0.54	1.33
U-238	41	41	0.42	357	9.48	24.11

Refer to Appendix A, Table A4-18 for more detailed results.

The data distributions were tested and UCL95/UCL values were calculated accordingly for the risk calculations as presented in Section 6. However, for screening purposes normality was assumed for the data presented in this table.

Note that for some radionuclides, a negative value is reported as the mean or UCL95.

When a large number of negative results are in the data set (common for nuclides that are largely undetected) a negative mean or UCL95 can result.

Table 4-16
Summary of Soil Results - Landfill Class 2 - Area A

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	2	42	-0.18	0.24	-0.03	-0.01
Pa-231	5	42	-1.9	5	0.18	0.49
Ra-226	42	42	0.26	4.45	1.14	1.36
Ra-228	39	42	0.23	4.12	0.87	1.05
Th-228	42	42	0.37	3.97	1.04	1.23
Th-230	42	42	0.49	6.3	1.09	1.35
Th-232	42	42	0.44	4.01	0.98	1.17
U-234	41	41	0.55	10.3	1.54	2.07
U-235	32	42	0.01	0.43	0.09	0.12
U-238	41	41	0.47	9.7	1.52	2.02

Refer to Appendix A, Table A4-19 for more detailed results.

Table 4-17
Summary of Soil Results - Landfill Class 1 - Area A

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	0	64	-2.99	0.05	-0.25	-0.14
Pa-231	4	64	-1.5	3	-0.1	0.09
Ra-226	64	64	0.49	20.1	3.34	4.19
Ra-228	61	64	0.25	4.3	1.6	1.83
Th-228	64	64	0.68	3.78	1.76	1.95
Th-230	64	64	0.58	76	5.42	8.16
Th-232	64	64	0.58	3.58	1.63	1.81
U-234	63	63	0.67	229	17.91	26.27
U-235	61	64	0.02	17.8	1.02	1.56
U-238	63	63	0.35	227	18.03	26.45

Refer to Appendix A, Table A4-20 for more detailed results.

The data distributions were tested and UCL95/UCL values were calculated accordingly for the risk calculations as presented in Section 6. However, for screening purposes normality was assumed for the data presented in this table.

Note that for some radionuclides, a negative value is reported as the mean or UCL95.

When a large number of negative results are in the data set (common for nuclides that are largely undetected) a negative mean or UCL95 can result.

Table 4-18
Summary of Soil Results - Landfill Class 1 - Area B Samples B1A

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	0	4	-0.15	-0.02	-0.06	0
Pa-231	1	4	-0.8	1.82	0.21	1.41
Ra-226	4	4	1.04	3.91	1.87	3.32
Ra-228	4	4	0.58	0.94	0.77	0.94
Th-228	4	4	0.83	0.88	0.87	0.89
Th-230	4	4	0.8	0.98	0.89	0.98
Th-232	4	4	0.85	0.92	0.88	0.91
U-234	4	4	0.7	1	0.82	0.96
U-235	3	4	0.05	0.08	0.06	0.08
U-238	4	4	0.81	1	0.9	0.99

Refer to Appendix A, Table A4-21 for more detailed results.

Table 4-19
Summary of Soil Results - Landfill Class 1 - Area B Samples B1B

Isotope	# detected	# samples	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Mean Concentration (pCi/g)	UCL95 Concentration (pCi/g)
Am-241	0	6	-0.09	0.03	-0.03	0.01
Pa-231	0	6	-0.5	1.2	0.05	0.52
Ra-226	6	6	0.75	2.86	1.32	1.94
Ra-228	6	6	0.68	1.5	0.99	1.28
Th-228	6	6	0.82	1.91	1.13	1.46
Th-230	6	6	0.8	1.8	1.15	1.47
Th-232	6	6	0.78	1.6	1.04	1.28
U-234	6	6	0.7	2.09	1.09	1.52
U-235	4	6	0.05	0.13	0.09	0.12
U-238	6	6	0.68	1.82	1.16	1.54

Refer to Appendix A, Table A4-21 for more detailed results.

The data distributions were tested and UCL95/UCL values were calculated accordingly for the risk calculations as presented in Section 6. However, for screening purposes normality was assumed for the data presented in this table.
Note that for some radionuclides, a negative value is reported as the mean or UCL95.

When a large number of negative results are in the data set (common for nuclides that are largely undetected) a negative mean or UCL95 can result.

Table 4-20
Summary of Elevated Soil Results - Landfill
Th-230, U-238, and Ra-226 (Historical and USACE 2001) (1)

Boring Location	Depth (ft bgs)	Sample #	Th-230 Result (pCi/g)	U-238 Result (pCi/g)	Ra-226 Result (pCi/g)
LANDFILL					
Screening Level UTL 99/99.9 (2)			**1.58**	**2.34**	**2.27**
Area A and Vicinity					
TLF3 063	2.5	TLF-0515	3.08	3.13	2.73
TLFA1 002	0.5	TLF-0694	1.44	3.61	2.81
TLFA1 002	2	TLF-0695	3.38	5.51	3.73
TLFA1 002	5	TLF-0696	2.28	8.1	3.68
TLFA1 002	11.5	TLF-0697	5.15		3.64
TLFA1 003	0.5	TLF-0690	1.29	3.66	1.58
TLFA1 003	1.5	TLF-0691	1.4	34.2	2.06
TLFA1 003	5.75	TLF-0692	71	227	18.6
TLFA1 003	11.5	TLF-0693	11.8	72	7.9
TLFA1 003	5.75	TLF-9717	76	205	16.9
TLFA1 006	0.5	TLF-0670	3.3	10.4	2.79
TLFA1 006	2	TLF-0671	13.8	40.5	14.9
TLFA1 006	4.5	TLF-0672	8.7	69	6
TLFA1 010	3	TLF-0645	2.85	34.9	3.68
TLFA1 010	6	TLF-0646	3.52	32.4	2.6
TLFA1 011	0.5	TLF-0686	1.54	5.57	1.42
TLFA1 011	1.5	TLF-0687	11.7	75	6
TLFA1 011	6.5	TLF-0688	3.53	23.3	4.26
TLFA1 011	12.5	TLF-0689	3.51	28.8	4.42
TLFA1 013	0.5	TLF-0640	1.6	3.41	1.39
TLFA1 013	1	TLF-0641	2.46	3.19	2.16
TLFA1 013	5.5	TLF-0642	2.79	15.5	2.45
TLFA1 013	11.5	TLF-0643	2.84	3.01	3.06
TLFA1 013	0.5	TLF-9712	1.9	2.04	1.6
TLFA1 013	1	TLF-9713	2.81	4.71	3.5
TLFA1 014	4.5	TLF-0652	1.97	2	2.1
TLFA1 014	7.5	TLF-0653	32.5	39.4	20.1
TLFA1 015	2	TLF-0648	3.55	4.04	2.97
TLFA1 015	8	TLF-0649	6.49	12.4	6.7
TLFA1 015	10.5	TLF-0650	4.36	8.6	5.8
TLFA1 015	2	TLF-9715	2.15	3.37	2.4
TLFA1 016	0.5	TLF-0661	1.24	2.41	0.83
TLFA1 016	5	TLF-0662	2.09	5.5	1.9
TLFA1 016	8.5	TLF-0663	1.36	5.9	1.61
TLFA1 017	2	TLF-0659	2.58	8.7	2.85
TLFA1 017	5.5	TLF-0660	3.13	9.3	3.43
TLFA1 018	7	TLF-0665	3.65	23	3.56
TLFA1 018	12	TLF-0666	5.13	14.5	1.89
TLFA1 019	0.5	TLF-0667	0.58	14.2	1.33
TLFA1 019	5.5	TLF-0668	4.08	12	4.04
TLFA1 019	6	TLF-0669	4.07	14.5	2.59
TLFA1 020	2.5	TLF-0655	1.82	7.2	1.99
TLFA1 020	8	TLF-0656	2.91	9.2	3.01
TLFA1 020	12	TLF-0657	2.75	5.7	3.31
TLFA2 008	0.5	TLF-0619	1.06	2.55	1.01

Table 4-20
Summary of Elevated Soil Results - Landfill
Th-230, U-238, and Ra-226 (Historical and USACE 2001) (1)

Boring Location	Depth (ft bgs)	Sample #	Th-230 Result (pCi/g)	U-238 Result (pCi/g)	Ra-226 Result (pCi/g)
LANDFILL					
Screening Level UTL 99/99.9 (2)			**1.58**	**2.34**	**2.27**
TLFA2 008	3	TLF-0620	6.3	9.7	3.91
TLFA2 015	0.5	TLF-0602	0.9	5.8	1.12
TLFA2 015	2.5	TLF-0603	3.35	7.2	4.45
TLFA2 018	3.5	TLF-0589	3.28	4.41	3.7
TLFA2 020	0.5	TLF-0598	0.65	2.35	1.29
B6	0.5	B6A	< 300.00	57.00	300.00
B6	1.0	B6B	< 47.00	18.00	75.00
B6	1.5	B6C	< 9.60	4.90	11.00
B7	0.5	B7A	< 58.00	120.00	170.00
B7	1.0	B7B	4300.00	150.00	2000.00
B7	1.5	B7C	< 820.00	310.00	1000.00
B7	2.0	B7D	< 150.00	290.00	46.00
B7	2.5	B7E	< 72.00	1800.00	21.00
B9	0.5	B9	< 9.70	1.60	3.70
B10	0.5	B10A	< 15.00	7.20	2.60
B10	1.0	B10B	< 12.00	5.20	2.60
B12	0.5	B12A	< 82.00	220.00	1.60
B12	1.0	B12B	< 46.00	170.00	1.50
B12	1.5	B12C	< 89.00	89.00	2.80
B29RBH5	1.5	B05-026	13.40	33.30	1.30
B29RBH5	3.0	B05-027	< 376.50	230.00	557.00
B29RBH5	5.0	B05-028	157.80	585.00	124.00
B29RBH5	7.0	B05-029	25.50	244.00	19.10
B29RBH5	9.0	B05-030	35.70	244.00	24.30
B29RBH5	11.0	B05-031	2.90	220.00	8.40
B29RBH5	11.5	B05-032	3.60	96.80	8.10
B29RBH5	12.5	B05-033	1.10	6.10	0.97
B29RBH7	16.0	B07-039	2.00	25.10	0.32
B29RBH7	18.0	B07-040	1.40	27.10	1.20
B29RBH7	22.0	B07-041	1.50	3.40	0.51
B29RBH8	22.0	B08-053	1.90	18.60	1.70
B29RBH8	24.5	B08-054	1.50	3.10	0.70
S47	0.5	S47A	< 11.00	2.50	1.30
S54	0.5	S54	< 26.00	56.00	1.50
S62	0.5	S62A	< 6.40	8.80	1.10
S62	1.0	S62B	< 9.50	9.60	1.10
S62	1.5	S62C	< 6.80	5.50	1.00
S69	1.5	S69C	< 16.00	2.60	1.20
Area B and Vicinity					
TLFB1A 001	0.5	TLF-0871	0.82	0.86	3.91
TLFB1B 009	0.5	TLF-0786	1.8	1.82	2.86
TLFB2 017	2.5	TLF-0739	7.5	357	1.06
B3	1.0	B3B	< 11.00	4.00	2.20
B4	0.5	B4A	820.00	< 15.00	240.00

Table 4-20
Summary of Elevated Soil Results - Landfill
Th-230, U-238, and Ra-226 (Historical and USACE 2001) (1)

Boring Location	Depth (ft bgs)	Sample #	Th-230 Result (pCi/g)	U-238 Result (pCi/g)	Ra-226 Result (pCi/g)
LANDFILL					
Screening Level UTL 99/99.9 (2)			**1.58**	**2.34**	**2.27**
B4	1.0	B4B	< 9.30	1.30	5.20
B5	0.5	B5A	1300.00	< 32.00	440.00
B5	1.0	B5B	660.00	78.00	120.00
B5	1.5	B5C	< 13.00	< 2.20	2.40
B11	0.5	B11A	< 8.40	4.20	2.60
B11	1.0	B11B	< 11.00	2.40	2.10
B29RBH3	1.5	B03-015	0.65	4.10	1.30
B29RBH4	1.5	B04-009	1.30	15.00	58.30
B29RBH4	3.0	B04-010	1.50	7.00	1.80
S4	0.5	S4	< 8.80	3.30	1.00

Notes:
1. Based on soil results from USACE 2001 investigations, ORNL 1992, and BNI 1995
2. UTL 99/99.9 - 99 percent confidence level that at least 99.9 percent of results will fall below the UTL 99/99.9

ft bgs - feet below ground surface
pCi/g - picocuries per gram
< denotes less than, i.e. isotope not detected at listed detection limit

Table 4-21
Landfill OU Historical Radiological Data

		Depth (ft)		U-238			Ra-226			Th-230			Am-241			
Loc ID	**Samp ID**	**Top**	**Bottom**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Reference**
Screening Level - UTL 99/99.9					**2.34**			**2.27**			**1.58**					
Area A, Class 1 and Class 2																
B29RBH5	B05-026	0.0	1.5		**33.30**	8.40		1.30	0.16		**13.40**	3.40				BNI 1995
B29RBH5	B05-027	1.5	3.0		**230.00**	60.70		**557.00**	14.70	<	376.50	92.30				BNI 1995
B29RBH5	B05-028	3.0	5.0		**585.00**	148.00		**124.00**	3.10		**157.80**	37.90				BNI 1995
B29RBH5	B05-029	5.0	7.0		**244.00**	60.20		**19.10**	0.73		**25.50**	6.40				BNI 1995
B29RBH5	B05-030	7.0	9.0		**244.00**	60.90		**24.30**	0.76		**35.70**	11.20				BNI 1995
B29RBH5	B05-031	9.0	11.0		**220.00**	55.50		**8.40**	0.35		**2.90**	0.84				BNI 1995
B29RBH5	B05-032	11.0	11.5		**96.80**	24.00		**8.10**	0.36		**3.60**	0.90				BNI 1995
B29RBH5	B05-033	11.5	12.5		**6.10**	1.90		0.97	0.16		1.10	0.39				BNI 1995
B29RBH7	B07-039	14.0	16.0		**25.10**	2.80		0.32	0.22		**2.00**	0.53				BNI 1995
B29RBH7	B07-040	16.0	18.0		**27.10**	6.90		1.20	0.15		1.40	0.37				BNI 1995
B29RBH7	B07-041	20.0	22.0		**3.40**	0.00		0.51	0.13		1.50	0.48				BNI 1995
B29RBH8	B08-053	19.5	22.0		**18.60**	4.90		1.70	0.18		**1.90**	0.49				BNI 1995
B29RBH8	B08-054	22.0	24.5		**3.10**	1.10		0.70	0.10		1.50	0.53				BNI 1995
B6	B6A	0.0	0.5		**57.00**	20.00		**300.00**	1.00	<	300.00		<	0.1		ORNL 1992
B6	B6B	0.5	1.0		**18.00**	4.00		**75.00**	0.30	<	47.00		<	0.1		ORNL 1992
B6	B6C	1.0	1.5		**4.90**	0.80		**11.00**	0.06	<	9.60		<	0.1		ORNL 1992
B7	B7A	0.0	0.5		**120.00**	7.00		**170.00**	0.50	<	58.00		<	0.1		ORNL 1992
B7	B7B	0.5	1.0		**150.00**	60.00		**2000.00**	6.00		**4300.00**	400.00	<	0.1		ORNL 1992
B7	B7C	1.0	1.5		**310.00**	50.00		**1000.00**	9.00	<	820.00		<	0.1		ORNL 1992
B7	B7D	1.5	2.0		**290.00**	20.00		**46.00**	0.70	<	150.00		<	0.1		ORNL 1992
B7	B7E	2.0	2.5		**1800.00**	200.00		**21.00**	0.50	<	72.00		<	0.1		ORNL 1992
B8	B8	0.0	0.5		1.30	0.80		1.20	0.02	<	9.90		<	0.1		ORNL 1992
B9	B9	0.0	0.5		1.60	1.00		**3.70**	0.04	<	9.70		<	0.1		ORNL 1992
B10	B10A	0.0	0.5		**7.20**	1.00		**2.60**	0.04	<	15.00		<	0.1		ORNL 1992
B10	B10B	0.5	1.0		**5.20**	2.00		**2.60**	0.04	<	12.00		<	0.1		ORNL 1992
B12	B12A	0.0	0.5		**220.00**	7.00		1.60	0.08	<	82.00		<	0.1		ORNL 1992
B12	B12B	0.5	1.0		**170.00**	7.00		1.50	0.10	<	46.00		<	0.1		ORNL 1992
B12	B12C	1.0	1.5		**89.00**	7.00		**2.80**	0.10	<	89.00		<	0.1		ORNL 1992
S46	S46	0.0	0.5		2.00	0.90		1.50	0.02	<	9.80		<	0.1		ORNL 1992
S47	S47A	0.0	0.5		**2.50**	1.00		1.30	0.02	<	11.00		<	0.1		ORNL 1992
S47	S47B	0.5	1.0		1.80	1.00		1.10	0.02	<	9.10		<	0.1		ORNL 1992
S47	S47C	1.0	1.5		2.00	1.00		1.40	0.03	<	17.00		<	0.1		ORNL 1992

Table 4-21
Landfill OU Historical Radiological Data

		Depth (ft)		U-238			Ra-226			Th-230			Am-241			
Loc ID	**Samp ID**	**Top**	**Bottom**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Reference**
Screening Level - UTL 99/99.9					**2.34**			**2.27**			**1.58**					
S53	S53	0.0	0.5		1.50	0.90		0.59	0.02	<	6.60		<	0.1		ORNL 1992
S54	S54	0.0	0.5		**56.00**	4.00		1.50	0.08	<	26.00		<	0.1		ORNL 1992
S55	S55	0.0	0.5		1.40	1.00		1.00	0.03	<	19.00		<	0.1		ORNL 1992
S61	S61	0.0	0.5		1.40	1.00		0.74	0.02	<	7.60		<	0.1		ORNL 1992
S62	S62A	0.0	0.5		**8.80**	0.90		1.10	0.03	<	6.40		<	0.1		ORNL 1992
S62	S62B	0.5	1.0		**9.60**	1.00		1.10	0.04	<	9.50		<	0.1		ORNL 1992
S62	S62C	1.0	1.5		**5.50**	1.00		1.00	0.03	<	6.80		<	0.1		ORNL 1992
S63	S63	0.0	0.5		1.30	0.50		0.84	0.02	<	4.20		<	0.1		ORNL 1992
S69	S69A	0.0	0.5		1.90	1.00		0.92	0.02	<	15.00		<	0.1		ORNL 1992
S69	S69B	0.5	1.0		1.40	0.80		1.00	0.02	<	10.00		<	0.1		ORNL 1992
S69	S69C	1.0	1.5		**2.60**	1.00		1.20	0.03	<	16.00		<	0.1		ORNL 1992
S70	S70	0.0	0.5		2.20	0.90		0.63	0.02	<	6.50		<	0.1		ORNL 1992
Area B, Class 1 and Class 2																
B29RBH3	B03-015	0.0	1.5		**4.10**	0.00		1.30	0.18		0.65	0.25				BNI 1995
B29RBH4	B04-009	0.0	1.5		**15.00**	0.00		**58.30**	1.70		1.30	0.46				BNI 1995
B29RBH4	B04-010	1.5	3.0		**7.00**			1.80	0.27		1.50	0.49				BNI 1995
B3	B3A	0.0	0.5		1.80	1.00		2.20	0.04	<	22.00		<	0.1		ORNL 1992
B3	B3B	0.5	1.0		**4.00**	2.00		2.20	0.04	<	11.00		<	0.1		ORNL 1992
B3	B3C	1.0	1.5		1.40	0.70		1.40	0.03	<	7.40		<	0.1		ORNL 1992
B4	B4A	0.0	0.5	<	15.00			**240.00**	0.90		**820.00**	200.00	<	0.1		ORNL 1992
B4	B4B	0.5	1.0		1.30	1.00		**5.20**	0.05	<	9.30		<	0.1		ORNL 1992
B5	B5A	0.0	0.5	<	32.00			**440.00**	2.00		**1300.00**	300.00	<	0.1		ORNL 1992
B5	B5B	0.5	1.0		**78.00**	20.00		**120.00**	0.70		**660.00**	100.00	<	0.1		ORNL 1992
B5	B5C	1.0	1.5	<	2.20			**2.40**	0.03	<	13.00		<	0.1		ORNL 1992
B11	B11A	0.0	0.5		**4.20**	1.00		**2.60**	0.04	<	8.40		<	0.1		ORNL 1992
B11	B11B	0.5	1.0		**2.40**	0.90		2.10	0.02	<	11.00		<	0.1		ORNL 1992
S9	S9	0.0	0.5		2.00	0.50		1.00	0.03	<	12.00		<	0.1		ORNL 1992
S11	S11	0.0	0.5		1.40	0.80		0.96	0.02	<	8.40		<	0.1		ORNL 1992
S12	S12	0.0	0.5	<	1.50			0.95	0.02	<	7.60		<	0.1		ORNL 1992
S13	S13	0.0	0.5		2.30	0.80		1.70	0.02	<	11.00		<	0.1		ORNL 1992
S16	S16	0.0	0.5		1.40	0.40		1.10	0.02	<	12.00		<	0.1		ORNL 1992
S17	S17A	0.0	0.5	<	1.40			0.79	0.02	<	8.40		<	0.1		ORNL 1992
S17	S17B	0.5	1.0		0.98	0.70		0.95	0.03	<	7.10		<	0.1		ORNL 1992
S17	S17C	1.0	1.5		1.00	1.00		0.76	0.02	<	7.40		<	0.1		ORNL 1992
S18	S18	0.0	0.5		1.40	0.90		0.89	0.02	<	8.00		<	0.1		ORNL 1992

Table 4-21
Landfill OU Historical Radiological Data

		Depth (ft)		U-238			Ra-226			Th-230			Am-241			
Loc ID	**Samp ID**	**Top**	**Bottom**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Reference**
Screening Level - UTL 99/99.9					**2.34**			**2.27**			**1.58**					
S21	S21	0.0	0.5		1.80	1.00		0.89	0.03	<	7.10		<	0.1		ORNL 1992
S22	S22	0.0	0.5		1.40	0.40		0.80	0.04	<	11.00		<	0.1		ORNL 1992
S23	S23	0.0	0.5		1.10	0.50		0.62	0.02	<	3.80		<	0.1		ORNL 1992
S27	S27	0.0	0.5		1.10	0.40		0.82	0.02	<	4.10		<	0.1		ORNL 1992
S28	S28A	0.0	0.5		0.74	0.50		0.81	0.02	<	4.30		<	0.1		ORNL 1992
S28	S28B	0.5	1.0		1.10	0.50		0.81	0.02	<	4.40		<	0.1		ORNL 1992
S28	S28C	1.0	1.5		1.10	0.90		0.86	0.03	<	8.60		<	0.1		ORNL 1992
S29	S29	0.0	0.5		1.40	0.90		0.99	0.02	<	11.00		<	0.1		ORNL 1992
S33	S33	0.0	0.5	<	1.20			0.79	0.02	<	8.10		<	0.1		ORNL 1992
S34	S34	0.0	0.5		0.88	0.50		0.82	0.02	<	4.30		<	0.1		ORNL 1992
S35	S35	0.0	0.5		2.90	1.00		1.10	0.03	<	8.10		<	0.1		ORNL 1992
S73	S73	0.0	0.5		1.60	0.60		0.95	0.02	<	4.90		<	0.1		ORNL 1992
Class 3																
S1	S1	0.0	0.5	<	2.50			0.80	0.02	<	7.70		<	0.1		ORNL 1992
S2	S2	0.0	0.5	<	2.00			0.92	0.02	<	6.30			0.22	0.18	ORNL 1992
S3	S3	0.0	0.5		1.50	0.60		0.93	0.02	<	4.50		<	0.1		ORNL 1992
S4	S4	0.0	0.5		**3.30**	1.00		1.00	0.03	<	8.80		<	0.1		ORNL 1992
S5	S5	0.0	0.5		1.20	0.50		0.90	0.02	<	4.60		<	0.1		ORNL 1992
S6	S6	0.0	0.5		1.00	0.80		0.77	0.02	<	6.10		<	0.1		ORNL 1992
S7	S7A	0.0	0.5		1.20	0.80		0.85	0.02	<	6.10		<	0.1		ORNL 1992
S7	S7B	0.5	1.0		1.60	0.50		0.99	0.02	<	4.00		<	0.1		ORNL 1992
S7	S7C	1.0	1.5		1.10	0.70		0.94	0.02	<	8.30		<	0.1		ORNL 1992
S8	S8	0.0	0.5		0.92	0.80		0.92	0.02	<	8.60		<	0.1		ORNL 1992
S10	S10	0.0	0.5		1.50	0.50		0.96	0.02	<	4.70		<	0.1		ORNL 1992
S14	S14A	0.0	0.5		1.10	0.80		0.96	0.02	<	9.50		<	0.1		ORNL 1992
S14	S14B	0.5	1.0		2.10	0.70		0.90	0.03	<	15.00		<	0.1		ORNL 1992
S14	S14C	1.0	1.5		1.20	0.90		0.79	0.03	<	7.80		<	0.1		ORNL 1992
S15	S15	0.0	0.5		0.52	0.30		0.75	0.02	<	3.20		<	0.1		ORNL 1992
S19	S19	0.0	0.5		1.40	0.60		0.85	0.02	<	4.70		<	0.1		ORNL 1992
S20	S20	0.0	0.5		0.92	0.60		0.60	0.02	<	5.20		<	0.1		ORNL 1992
S24	S24A	0.0	0.5		1.00	0.40		0.85	0.02	<	4.30			0.1	0.07	ORNL 1992
S24	S24B	0.5	1.0		1.00	0.60		0.87	0.02	<	4.90		<	0.1		ORNL 1992
S24	S24C	1.0	1.5		1.80	0.70		0.80	0.02	<	4.90		<	0.1		ORNL 1992
S25	S25	0.0	0.5		2.20	0.80		1.70	0.02	<	9.30		<	0.1		ORNL 1992
S26	S26A	0.0	0.5	<	2.40			1.00	0.02	<	8.40		<	0.1		ORNL 1992

Table 4-21
Landfill OU Historical Radiological Data

		Depth (ft)		U-238			Ra-226			Th-230			Am-241			
Loc ID	**Samp ID**	**Top**	**Bottom**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Reference**
Screening Level - UTL 99/99.9					**2.34**			**2.27**			**1.58**					
S26	S26B	0.5	1.0	<	1.10			0.85	0.02	<	9.00		<	0.1		ORNL 1992
S26	S26C	1.0	1.5		1.00	0.60		0.84	0.02	<	8.50		<	0.1		ORNL 1992
S30	S30	0.0	0.5	<	1.50			0.83	0.02	<	9.00		<	0.1		ORNL 1992
S31	S31	0.0	0.5		1.20	0.60		0.87	0.02	<	7.00		<	0.1		ORNL 1992
S32	S32	0.0	0.5		1.60	0.80		1.40	0.02	<	8.80		<	0.1		ORNL 1992
S36	S36A	0.0	0.5		0.98	0.30		0.85	0.02	<	4.30			0.38	0.07	ORNL 1992
S36	S36B	0.5	1.0		1.10	0.70		0.84	0.02	<	6.80		<	0.1		ORNL 1992
S36	S36C	1.0	1.5		0.98	0.50		0.85	0.02	<	4.30		<	0.1		ORNL 1992
S37	S37	0.0	0.5	<	1.20			0.77	0.02	<	5.10		<	0.1		ORNL 1992
S38	S38	0.0	0.5		0.83	0.30		0.84	0.02	<	3.20		<	0.1		ORNL 1992
S39	S39A	0.0	0.5		1.40	0.80		0.64	0.02	<	6.80		<	0.1		ORNL 1992
S39	S39B	0.5	1.0		1.20	0.60		0.36	0.02	<	6.20		<	0.1		ORNL 1992
S39	S39C	1.0	1.5	<	1.50			0.44	0.02	<	5.80		<	0.1		ORNL 1992
S40	S40	0.0	0.5		1.40	0.70		0.89	0.03	<	10.00		<	0.1		ORNL 1992
S41	S41A	0.0	0.5		1.50	1.00		1.00	0.03	<	15.00		<	0.1		ORNL 1992
S41	S41B	0.5	1.0		1.50	0.90		1.00	0.02	<	15.00		<	0.1		ORNL 1992
S41	S41C	1.0	1.5		1.70	1.00		1.00	0.02	<	11.00		<	0.1		ORNL 1992
S42	S42	0.0	0.5		0.58	0.30		0.70	0.01	<	2.90		<	0.1		ORNL 1992
S43	S43	0.0	0.5		0.81	0.30		0.80	0.02	<	4.00			0.63	0.06	ORNL 1992
S44	S44	0.0	0.5		1.10	0.70		0.82	0.02	<	10.00			0.67	0.2	ORNL 1992
S45	S45A	0.0	0.5		0.90	0.60		0.78	0.02	<	9.10		<	0.1		ORNL 1992
S45	S45B	0.5	1.0		1.10	0.80		0.82	0.02	<	8.00		<	0.1		ORNL 1992
S45	S45C	1.0	1.5		1.50	1.00		0.81	0.02	<	11.00		<	0.1		ORNL 1992
S48	S48A	0.0	0.5		1.60	0.80		0.91	0.02	<	9.40		<	0.1		ORNL 1992
S48	S48B	0.5	1.0		1.30	1.00		0.87	0.03	<	7.60		<	0.1		ORNL 1992
S48	S48C	1.0	1.5		1.40	0.80		0.90	0.02	<	11.00		<	0.1		ORNL 1992
S49	S49	0.0	0.5		1.90	1.00		0.98	0.02	<	7.60		<	0.1		ORNL 1992
S50	S50	0.0	0.5		0.87	0.40		0.68	0.02	<	3.60		<	0.1		ORNL 1992
S51	S51	0.0	0.5	<	1.50			0.82	0.02	<	6.90		<	0.1		ORNL 1992
S52	S52	0.0	0.5		0.89	0.50		0.76	0.02	<	4.20		<	0.1		ORNL 1992
S56	S56	0.0	0.5		1.50	1.00		0.84	0.02	<	7.80		<	0.1		ORNL 1992
S57	S57A	0.0	0.5	<	2.40			0.96	0.02	<	7.70		<	0.1		ORNL 1992
S57	S57B	0.5	1.0		1.00	0.90		0.84	0.02	<	7.40		<	0.1		ORNL 1992

Table 4-21
Landfill OU Historical Radiological Data

		Depth (ft)		U-238			Ra-226			Th-230			Am-241			
Loc ID	**Samp ID**	**Top**	**Bottom**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Pr**	**Concentration (pCi/g)**	**± 2σ**	**Reference**
Screening Level - UTL 99/99.9					**2.34**			**2.27**			**1.58**					
S57	S57C	1.0	1.5		1.90	1.00		0.84	0.02	<	8.50		<	0.1		ORNL 1992
S58	S58	0.0	0.5		0.82	0.70		0.81	0.02	<	6.90			0.38	0.2	ORNL 1992
S59	S59A	0.0	0.5		0.89	0.40		0.83	0.02	<	4.60		<	0.1		ORNL 1992
S59	S59B	0.5	1.0		1.80	1.00		0.88	0.03	<	7.20		<	0.1		ORNL 1992
S59	S59C	1.0	1.5		1.40	0.80		0.92	0.02	<	13.00		<	0.1		ORNL 1992
S60	S60	0.0	0.5		1.50	1.00		0.66	0.02	<	6.70		<	0.1		ORNL 1992
S64	S64	0.0	0.5		1.10	0.80		0.80	0.02	<	7.20		<	0.1		ORNL 1992
S65	S65	0.0	0.5		1.40	0.90		0.72	0.03	<	7.50			0.32	0.2	ORNL 1992
S66	S66A	0.0	0.5		1.90	1.00		0.89	0.02	<	9.10		<	0.1		ORNL 1992
S66	S66B	0.5	1.0		1.60	0.80		0.82	0.02	<	8.40		<	0.1		ORNL 1992
S66	S66C	1.0	1.5		0.33	1.00		0.78	0.02	<	6.70		<	0.1		ORNL 1992
S67	S67	0.0	0.5		2.10	1.00		0.80	0.02	<	7.10		<	0.1		ORNL 1992
S68	S68	0.0	0.5		0.62	0.40		0.94	0.02	<	3.80		<	0.1		ORNL 1992
S71	S71	0.0	0.5		1.20	0.50		0.99	0.02	<	4.70		<	0.1		ORNL 1992
S72	S72	0.0	0.5		1.20	1.00		0.95	0.03	<	8.30		<	0.1		ORNL 1992

Average	**36.32**	**36.23**	**70.02**	**0.12**
# detected	133	148	19	7
# results	148	148	148	132
UCL95	58.67	62.71	122.30	0.13
Max	1800.00	2000.00	4300.00	0.67
Min	0.33	0.32	0.65	0.10
stdev	163.65	193.94	382.91	0.08

Notes:
Pr - Preceding qualifier "<" denotes less than, i.e. isotope not detected at listed detection limit.
pCi/g - picocuries per gram
Bold denotes an exceedance of the UTL 99/99.9 screening level.
For comparison purposes only, the sample locations were classified based on areas identified during the 2001 field investigations.

Table 4-22
Summary of Landfill OU
Am-241 Detections (Historical and USACE 2001)

Prefix	No.	Depth (ft bgs)	Sample #	Result (pCi/g)	Qual
TLFR3	004	0.5	TLF-0400	0.087	
TLFR3	016	3.5	TLF-0427	0.15	
TLFA1	006	4.5	TLF-0672	-1.08	UJ
TLFA2	004	0.5	TLF-0572	0.24	
TLFA2	007	3.5	TLF-0575	0.14	
TLF3	001	0.5	TLF-0480	0.14	
TLF3	003	0.5	TLF-0474	0.26	
TLF3	006	0.5	TLF-0476	1.72	
TLF3	009	0.5	TLF-9488	0.15	
TLF3	022	0.5	TLF-9468	0.32	
TLF3	022	3	TLF-0471	0.12	
S2		0.5	S2	0.22	
S24		0.5	S24A	0.1	
S36		0.5	S36A	0.38	
S43		0.5	S43	0.63	
S44		0.5	S44	0.67	
S58		0.5	S58	0.38	
S65		0.5	S65	0.32	

Notes:
UJ - Estimated, value below decision level
ft bgs - feet below ground surface
pCi/g - picocuries per gram

Table 4-23
Summary of Landfill OU Chemical Results[1]

Compound	Standards (mg/kg)		Sample Result (mg/kg)			
	EPA RCRA (20x TCLP)	Background[2]	TLF-0661	TLF-0668	TLF-0677	TLF-9716
Aluminum		13976	6600	5900	14000	11000
Barium	2000	113	410	230	350	470
Beryllium		1	0.7	0.6	9.1	0.6
Cadmium	20	1	9.9	1.2	2.1	6.4
Calcium		32876	37000	5400	48000	58000
Chromium	100	21.5	87	31	29	49
Cobalt		10.5	16	8.3	9.5	12
Copper		18.3	360	300	150	280
Iron		23700	270000	58000	29000	120000
Lead	100	36	**1200**	**220**	**490**	**740**
Magnesium		10421	3900	560	13000	7800
Manganese		543	1800	300	510	1400
Nickel		22.5	72	51	29	48
Potassium		162.56	1500	850	3200	2000
Sodium		1023	1600	1100	1500	1500
Vanadium		24.5	18	30	24	14
Zinc		84.8	1600	240	490	960

Notes:
1. Only chemicals which exceed EPA RCRA screening or background levels are presented.
2. From BNI 1993.
mg/kg - milligrams per kilogram
TCLP - Toxicity Characteristic Leaching Procedure
Bold denotes an exceedance of EPA RCRA screening.
Refer to Appendix A, Table A4-25 for complete chemical results.

Table 4-24
Surface Water and Sediment Sampling Results
Landfill OU - September 2001

SURFACE WATER SAMPLES

Analytes		Ra-226	Ra-228	Ra-226 + Ra-228	U-234	U-235	U-238	U-234 + U-238	U Total	Gross Alpha	Gross Alpha (1)	Th-230	Th-232
Units		pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	µg/L	pCi/L	pCi/L	pCi/L	pCi/L
40 CFR 192, Subpart A				**5**				**30**	**44**		**15**		
Location	**Sample ID**												
TLFA1-S1	TLW-0100	3.06	1.89	4.95	217.00	20.70	211.00	428.00	416.00	266.00	-182.70	0.22	0.15
TLFA1-S2	TLW-0101	2.00	3.23	5.23	172.00	9.21	170.00	342.00	459.00	318.00	-33.21	0.53	0.08
TLF3-S4	TLW-0102	5.08	32.30	37.38	3.56	0.33	3.21	6.77	5.16	31.00	23.91	4.34	2.77
TLFA1-S2 (DUP)	TLW-9103	7.20	2.38	9.58	160.00	15.50	165.00	325.00	294.00	228.00	-112.50	0.47	0.08

(1) Excluding radon and uranium. (Radon purged from sample as part of analytical method)
(DUP) - Duplicate Sample

SEDIMENT SAMPLES

Analytes			Ra-226	U-238	Th-230
Units			pCi/g	pCi/g	pCi/g
Location	**Sample ID**	**Depth (1)**			
TLFA1-S1	TLF-0698	0.5	1.14	2.78	1.18
TLFA1-S1	TLF-0699	3	1.90	10.60	1.67
TLFA1-S2	TLF-0700	0.5	2.77	25.30	3.90
TLFA1-S2	TLF-0701	4	5.80	16.80	3.21
TLFA1-S2 (DUP)	TLF-9718	4	4.90	16.90	3.62
TLFA1-S3	TLF-0702	0.5	1.20	1.61	1.02
TLFA1-S3	TLF-0703	2	0.98	1.62	1.15
TLF3-S4	TLF-0490	0.5	0.87	0.77	1.07
TLF3-S4	TLF-0491	1	1.10	1.60	1.04

1. Measured from surface water/sediment interface.
Refer to Tables A5-1 and A5-2 for more complete results.
(DUP) - Duplicate Sample

5.0 CONTAMINANT FATE AND TRANSPORT

In the foregoing sections, the findings of investigations conducted at the Tonawanda Landfill Vicinity Property are described, including site characteristics and the nature and extent of site contamination. In this section, the means by which site contaminants may be released and transported are identified. The physical, chemical, and radiological characteristics of the MED-like materials identified in the Landfill and Mudflats are described. How site conditions and the characteristics of MED-like materials may result in contaminant releases and transport in site media is also described. The discussion of contaminant fate and transport in this section addresses current conditions. In accordance with landfill closure plans for the Landfill, the Landfill will be capped and maintained, significantly reducing any potential contaminant releases and subsequent transport of contaminants at and in the vicinity of the Landfill.

5.1 Contaminant Releases and Transport

Potential release and transport scenarios for the MED-like material at the Site include the following:

- displacement and transport by the action of humans or animals;
- displacement and transport by wind and air; and
- release and transport by water.

5.1.1 Actions by Humans and Animals

The physical displacement of contaminated material is possible when activities such as construction are inadvertently conducted in contaminated areas. The construction of a sewer line through an area of the Mudflats OU where elevated levels of radionuclides were detected in the past (Mudflats area) appears to have occurred. Burrowing animals may also displace contaminated soils. Where such burrowing breaches a cap, other releases may occur via wind or water.

5.1.2 Displacement and Transport by Wind and Air

The potential for displacement of contaminants by the wind (fugitive dust emissions), with subsequent transport in the air as particulate material, is always present where soils are directly exposed to the wind. The particulate size, moisture content, degree of vegetative cover, degree of soil disturbance, and other factors, as well as wind speed, direction and persistence determine the rate of dust emissions. Fugitive dust emissions potentials are highest in hot and dry conditions and may be persistent or short term during intrusive activities such as construction or other activities involving vehicles (trucks, dirt bikes, etc.).

In the case of the MED-like material, the presence of gamma emitting radionuclides presents a continuing means for the transport of electromagnetic energy to the space above and adjacent to the source area. And finally, as described above, the presence of Ra-226 results in the potential for the emission of the Ra-226 decay product, radon-222 (Rn-222) from the ground surface to the air if an adequate radon barrier is not in place.

While most of the landfill areas where MED-like material has been identified are vegetated, bare areas exist and access to these areas is not totally precluded. Thus, the potential for dust generation from off-road vehicles and other intrusive activities is not precluded.

5.2 Release and Transport by Water

To assess the potential for displacement and transport of the MED-like contaminants in the Landfill OU, via water, a conceptual understanding of water flow through the Landfill area and potential contaminant releases and contaminant transport is required. The following summarizes water flow pathways and potential contaminant release and transport scenarios. To illustrate these conditions, a conceptual drawing (schematic) of the location of the MED-like material in the Landfill OU and water flow pathways is provided as Figure 5-1. Figure 5-1 is not to scale, but is based in part on Figures 3-4 and 3-5, in Section 3.

5.2.1 Potential Release Scenarios from the Source Areas and Source Material Solubility

Figure 5-1 illustrates potential source areas for release of radionuclides at the Landfill OU. The principal radionuclides in these areas are U-238, Th-230 and Ra-226. The MED-like material appears to have been placed at various elevations within the Landfill OU and, currently, some of the MED-like material is still present at or near the existing surface and some of the material is buried under fill.

5.2.1.1 Releases Due to Erosion

As illustrated in Figure 5-1, one potential pathway for water transport of contamination at the landfill is by runoff. The degree of runoff depends upon the degree of infiltration and evapotranspiration that may occur, which is dependent on a number of factors, including antecedent moisture conditions, precipitation intensity, vegetative cover, soil characteristics, slope and other factors. Where runoff velocities are high, soil erosion occurs and where contaminated material is present at or near the surface, transport of contaminants would occur.

Significant erosion was not observed in the contaminated areas of the Landfill OU. Ponded areas of surface water are present, however, at some locations of elevated radionuclide concentrations. As described in Section 4.2.3, surface water and sediment samples were collected from the ponded area in Area A. At locations TLFA1-S1 and TLFA1-S2 (see Figure 4-16), elevated levels of radionuclides were detected in the sediment and in the overlying water samples, TLW-0100 and TLW-0101. These unfiltered and highly turbid surface water samples showed uranium concentrations up to 459 µg/L. The gamma walkover surveys of the topographically downgradient drainage areas did not detect elevated levels of radiation above background, indicating that significant transport of contaminants via surface water runoff is not occurring under existing conditions. This does not mean, however, that under conditions of more intensive surface water runoff, contaminants could not be transported from areas such as the ponded area in Area A, where elevated levels of radionuclides are already present in surface water and sediment.

Thus, the potential for transport of radionuclides via surface water exists at the Tonawanda Landfill Vicinity Property at locations such as the ponded area in Area A. At this location, the transport of the radionuclides is currently naturally controlled to the extent that vegetative cover is present in surrounding areas and to the extent that ponded and mildly sloping areas such as this tend to slow the velocity and the erosive/tractive force of surface water flow. These natural controls may lose effectiveness under more extreme rainfall and runoff conditions.

5.2.1.2 Source Area Releases to the Subsurface

In the technical background document on soil screening for radionuclides (EPA 2000c), EPA envisions the migration of radionuclides from soil to groundwater as a two-stage process: (1) a release of a

contaminant in soil leachate; and (2) transport of the contaminant through the underlying soil to groundwater. The principal means for facilitating any releases from the Landfill OU source areas is by dissolving the contaminants in the source area, with subsequent potential for transport of the contaminants in the liquid phase.

To estimate the potential for mobilizing the contaminants in the source areas the potential for liquid phase releases, information on the solubility of the radionuclides in water or other liquids that may be present in the landfill would be required. In one release scenario, water from precipitation or landfill leachate generated above the source area would move downward by gravity through the source material. As this liquid moves through the material, the U-238, Ra-226, or Th-230 would be transported in a dissolved phase in amounts which are dependent on the chemical nature of the constituents and the surrounding water chemistry. As shown in Figure 5-1, the source of water for transport is the precipitation that enters the landfill via infiltration. The infiltration is equal to the precipitation minus the runoff minus the evapotranspiration that would occur. As also shown in Figure 5-1, water infiltrating the landfill passes through the source material and provides the means for transport of dissolved contaminants.

5.2.1.3 Solubility of Radionuclides of Interest

The solubility of uranium compounds has been reported within a wide range. The residues of uranium processing at Linde resulted from a multi-stage process that utilized strong acid solutions (to a pH of 0.7 to 0.8). In assessing the potential for releases of radioactive contamination from the residues from Linde that were disposed at the Ashland properties, BNI noted that the residues disposed at the Ashland properties contain the insoluble residues from ore processing. BNI further notes that the residues were insoluble in the aggressive ore digestion process and reported that the most probable form of uranium present in the residues would be uranyl hydroxide which has a solubility in the range of about only 1×10^{-17} milligrams per liter (mg/L) (BNI 1993a). The uranium at the Tonawanda Landfill Vicinity Property may be more soluble. In the BNI estimates, a conservative value of the solubility of uranyl peroxide, 6 mg/L, was used (BNI 1998).

EPA (EPA 1999) reports that the maximum concentration of dissolved thorium that may occur in a low temperature aqueous system can be predicted with solubility of hydrous thorium oxide. In 0.1 molar $NaClO_4$ solution, the measured solubility of hydrous thorium oxide ranges from about 0.0007 mg/L to less than 0.0002 mg/L in the pH range from 5 to 10. The concentrations of dissolved thorium increases to approximately 600 mg/L as pH decreases from 5.0 to 3.2 (EPA 1999). BNI reported that the solubility of thorium, as thorium oxalate, is 17 mg/L, but also noted that the remedial investigation report (BNI 1993a) indicates that, as a result of ore processing, the thorium in the residues is primarily present as a hydroxide which is much less soluble (by many orders of magnitude) than thorium oxalate.

Limited data on the solubility of radium were found. BNI used the solubility of radium sulfate of 0.02 mg/L in evaluating the potential leaching from the residues transported to the Ashland properties from Linde (BNI 1993a).

5.2.2 Evaluation of Field Evidence of Contaminant Leaching from the Source Area

Results of water sampling in September 2001 include the results from monitoring well L-3 (see Table 4-11). Well L-3 is located in Area A, as shown in Figure 1-4, in close proximity to locations where elevated concentrations of radionuclides in soils were detected in 2001 and prior investigations. The highest levels of radionuclides detected in soils were from Boring B7 (ORNL 1992), which is located approximately 46 feet northwest of L-3, and shows U-238 at 1,800 pCi/g and Ra-226 at 21 pCi/g at a depth of 2.5 feet and Ra-226 at 2,000 pCi/g at a depth of one foot. Other soil boring locations near Well

L-3 with elevated radionuclide concentrations include TLFA1-003, located approximately 51 feet west; TLFA1-006, located approximately 23 feet west; and TLFA1-014, located approximately 22 feet south. (The analytical results for these soil samples are shown in Table 4-20.)

As shown in Table 2-1, Well L-3 is screened in the landfilled waste and it is in close proximity to or directly within the areas of elevated concentrations of MED-like radionuclides in the soils/soil-like material. As shown in Table 4-11, elevated levels of total uranium are seen in the filtered samples (and unfiltered samples) indicating the presence of dissolved uranium in landfill water at this location. The concentration of dissolved Ra-226 is consistent with dissolved Ra-226 at other locations and the levels of dissolved Th-230 appear higher than at other locations, but are at very low concentrations. These results indicate that uranium from the MED-like material in the Landfill OU is likely being dissolved in the landfill water at this location. Based on observed hydraulic gradients in the landfill, it would be expected that lateral and downward transport of the leached uranium is occurring. Given the relative insolubility of thorium, however, it would be difficult to attribute the elevated concentrations of thorium in soil at significant depths to leaching from overlying soils. How the material with elevated radionuclide concentrations came to be located in the landfill is unknown. With respect to a potential connection between surface water and groundwater in this area, there was no quantitative investigation conducted to address this issue, but qualitative observations can be made. A review of Malcolm Pirnie information indicates that in June 2001, the piezometric elevation in Well L-3 was 619.14 feet msl. Since the ground surface elevations at borings TLFA1-006 and TLFA1-003 are 618.71 feet msl and 618.91 feet msl, respectively, these boring locations may have been in the ponded area at that time. The ponded area has a muddy/silty bottom. If it is assumed that the material underlying the muddy silt is similar to the material encountered at boring location TLFA1-006, then this material would be classified as a dark silt with glass and debris to a depth of a little over 2 feet. The hydraulic conductivity of this material is not known. Since this material is not expected to be highly conductive (i.e., not a coarse sand) it could be envisioned that during precipitation events the ponded area receives runoff and direct precipitation and increases in surface elevation, then returns to a static condition at a lower elevation as seepage and evapotranspiration occurs. Depending on the hydraulic conductivity of this underlying material, it is possible that the elevation of the surface water is ultimately controlled by the elevation of the water in the landfill itself (i.e., during some periods, the ponded area elevation may be the same as the elevation of the water as measured in Well L-3).

To address the potential for vertical migration of radiological contamination in the Landfill and whether there is a potential surface water/groundwater connection in an area where elevated levels of contamination were detected, historic boring ORNL B-5, adjacent to BNI boring B29RBH4 and nearby 2001 investigation borings were reviewed. The total depth of boring B-5 conducted by ORNL in 1991 was 1.5 ft, and the highest contamination was detected in the sample from 0.5 to 1.0 ft at this location. The adjacent BNI boring (B29RBH4) showed contamination in the 0 to 1.5 ft sample, but only limited contamination in the 1.5 to 3 ft interval and adjacent USACE boring TLFB1A-001 showed only slightly elevated levels of Ra-226 at a depth of 0.5 ft. Well L-2 is about 30 ft southeast of B-5 and showed a piezometer elevation of 617.73 ft msl in September 2001. An earlier (June 14, 2001) measurement by Malcolm Pirnie showed the piezometric elevation in L-2 was 619.13 ft msl. Since the ground surface elevation at TLFB1A-001 (30 feet north) is 618.01 ft msl, the piezometric elevation surface in June at L-2 was about 1 ft above the grade at TLFB1A-001, indicating the potential upward hydraulic gradient at TLFB1A-001 at that time if these locations are hydraulically connected.

TLFB2-017 is located about 45 ft northeast of B-5 (and adjacent BNI and USACE borings) and about 30 ft north, northeast of well L-2. Its depth was 5 ft, but there was no recovery of the core from 3.5 to 5 ft. The highest radionuclide concentrations in this boring were at 2.5 ft, where U-238 was detected at 355 pCi/g and Th-230 was detected at 7.5 pCi/g. Samples above and below were not considered to be elevated. Again, the potential for vertical migration of contaminants at this location is not evidenced.

In summary, while the potential for vertical migration of radioactive contamination is not ruled out, the historical and 2001 USACE investigations do not appear to show evidence of such vertical migration.

With respect to the potential connection between surface water and groundwater, at one location in Area B (vicinity of TLFB2-017), relatively low hydraulic conductivity surface soils act to confine landfill water to some extent. Based on boring logs near the ponded area in Area B, this confining layer was not observed. The ponded water/subsurface water connection at this location was not investigated, but it is plausible that the ponded water elevation may reflect the elevation of the water in the landfill.

5.3 Potential Contaminant Transport After Releases from the Source Areas

In the Landfill, any liquid phase contaminants (i.e., contaminated leachate) released from the source areas could travel downward and laterally. As shown in Figure 5-1, under current conditions, this leachate has three potential pathways for migration. These are: infiltration into the silty clay formation which surrounds the waste in the landfill, either vertically or laterally; leachate breakouts at the ground surface; or potentially, infiltration into the bedding of the 48-inch water line that passes through the landfill. Transport of radionuclides with water in the subsurface is described in the following sections.

5.3.1 Transport of Radionuclides in the Subsurface

Transport of radionuclides and other contaminants through subsurface porous material is influenced by the physical and chemical nature of the transporting media (usually water) and the medium through which the flow occurs (soil, rock, landfilled material, etc.). The physical and chemical variables controlling transport of contaminants in the subsurface are described in the following sections.

5.3.1.1 Physical Characteristics of Subsurface Flow

Physically, the theoretical rate of porous flow is determined by two variables, hydraulic conductivity (also referred to as permeability) and the driving force (also referred to as hydraulic head). The hydraulic conductivity of porous or fractured subsurface material is controlled by the volumetric extent of voids or porosity within the material and the rate at which fluids can move from one void-space to another. The basis of porous media flow hydraulics is Darcy's Law, which states that the flow rate through a porous medium is proportional to the head loss and inversely proportional to the length of the flow path. In saturated conditions, and if flow is laminer and without turbulence, Darcy's Law is applicable and can be simply stated as: $V = Ki$ (where, V = velocity, K = hydraulic conductivity or permeability of the porous medium, i = hydraulic gradient).

The discharge velocity through a porous medium is determined as the volume of water that flows per unit time across a unit cross sectional area. In a porous medium, the flow is only through the void spaces. Therefore, the actual average interstitial velocity or seepage velocity is the discharge velocity divided by the porosity. The actual velocity is $V_{actual} = V/n$ (where, n = porosity).

Where the porous medium is made up of very fine particles, the porosity (n) is replaced by the effective porosity (n_e) which is the ratio of the volume of interconnected pores that are large enough to contain water molecules to the total volume of the media (Linsley and Franzini 1979) (USACE 1999b).

Typical values of K are widely available in the literature for different types of materials and typical values of n are also available. In landfill construction, bottom liners and caps are typically designed and constructed to have a layer of material with a maximum permeability, K, of 1×10^{-7} cm/s.

Horizontal hydraulic conductivity data for the waste material within the Landfill and for the native material around the landfill are available in the 1999 Malcolm Pirnie report (Malcolm Pirnie 1999). As shown in Table 3-1, the horizontal hydraulic conductivity of the waste material in the landfill is approximately 1×10^{-2} cm/s, while the horizontal hydraulic conductivity of the surrounding native material is approximately 1×10^{-6} cm/s. The horizontal hydraulic conductivity of the waste material (1×10^{-2} cm/s) indicates a conductivity roughly equivalent to clean sand and clean sand and gravel mixtures (Terzaghi and Peck 1948). Thus, the velocity of water through the waste would be expected to be rapid. The rate of water movement into the surrounding silty clay material would be expected to be four orders of magnitude slower (if equivalent hydraulic gradients and effective porosities are assumed).

The actual characteristics of flow of water through the subsurface is much more complex than described above. The simple principles of idealized porous media flow provide, however, a background for considering the transport of contaminants with water in the subsurface, as described below.

5.3.1.2 Chemical Transport in Subsurface Flow

As solutions move through the spaces within subsurface materials, solutes may either be added to or removed from that solution. Which solutes are removed or added, and the quantity and rate at which they are added or removed, is controlled by the geochemical nature of the solution and subsurface matrix. These geochemical processes may be very complex, and their understanding may require an extensive base of physical and chemical data which are rarely available. Most subsurface transport models lump the effects of all geochemical reactions into the concept of the distribution coefficient (K_d) or related retardation factors (R_f). K_ds and R_fs are described below.

5.3.1.2.1 Distribution Coefficients (K_d)

A partition (or distribution) coefficient or parameter, K_d, is a factor related to the partitioning of a contaminant between the solid and aqueous phases. A K_d value is inserted into computer models to quantify reduction in the rate of transport of the contaminant relative to the groundwater flow rate, either by advection or diffusion.

K_d is defined as the ratio of the quantity of the adsorbate adsorbed per mass of solid to the amount of the adsorbate remaining in solution in equilibrium. For the reaction

$$A + C_i = A_i,$$

The mass action expression for K_d, (typically in units of milliliters per gram [mL/g]) is

$$K_d = \frac{\textit{Mass of Adsorbate Sorbed}}{\textit{Mass of Adsorbate in Solution}} = \frac{A_i}{C_i}$$

where

A = free or unoccupied surface adsorption sites
C_i = total dissolved adsorbate remaining in solution at equilibrium (µg/mL), and
A_i = amount of adsorbate on the solid at equilibrium (µg/g)

Describing K_d in terms of this simple reaction assumes that A is in great excess with respect to C_i and that the activity of A_i is equal to 1 (EPA 1999).

5.3.1.2.2 Retardation Factors and Their Relationship to K_d Values

Retardation factors (R_f) are commonly used in modeling of transport of contaminants in groundwater. Mathematically, a chemical retardation factor, R_f, is defined as:

$$R_f = \frac{V_p}{V_c}$$

Where

V_p = velocity of water through a control volume
V_c = velocity of a contaminant through a control volume

In general, the retardation term is greater than 1, since the theoretical velocity of the water is greater than the transport velocity of the contaminant.

Knowledge of the K_d, the media bulk density, and porosity for porous flow allows calculation of the retardation factor. For porous flow with saturated conditions, the R_f is defined as:

$$R_f = 1 + \frac{r_b}{n_e} K_d$$

Where

ρ_b = porous media bulk density (mass/volume)
n_e = effective porosity of the media at saturation (EPA 1999)

As shown in these formulas, if K_d values are high, the R_f is high. Physically, this means that rate of transport of a contaminant V_c will be low in relationship to the theoretical rate of transport, V_p, of the water.

5.3.1.2.3 Reported K_d Values for Uranium

At the Landfill OU, the potential for the release and transport of uranium is of specific interest. The existing landfill conditions typically promote the reduction of uranium VI which is highly soluble, to uranium IV which is highly insoluble (Yu et. al. 2001). In the 1999 EPA report (EPA 1999), K_d values from more than 20 references are cited for the sorption of uranium onto soils, crushed rock, and single mineral phases. The uranium K_d values reported exhibit a large scatter. In general, the adsorption of uranium by soils and single-mineral phases in carbonate containing aqueous solutions is low at pH values less than 3, increases rapidly with increasing pH from pH 3 to 5, reaches a maximum in adsorption in the range of pH 5 to 8, and then decreases with increasing pH at a level of pH greater than 8.

The table below, taken from the 1999 report, summarizes the ranges of uranium K_d values reported within a range of pH values from 3 to 10.

Estimated Range of K_d Values for Uranium Based on pH

K_d (mL/g)	pH							
	3	4	5	6	7	8	9	10
Minimum	<1	0.4	25	100	63	0.4	<1	<1
Maximum	32	5,000	160,000	1,000,000	630,000	250,000	7,900	5

There are many factors that may ultimately determine the K_d and associated R_f for uranium at a given location, including the presence of organic species such as would be expected in a landfill environment. However, for radionuclides such as uranium, which is already soluble, the presence of organic species is not expected to have a significant effect for radionuclides in RCRA disposal facilities (Yu et al. 2001).

5.3.1.2.4 Minimum and Maximum R_f and K_d

The use of generic or default K_d values can result in significant error when used to predict the absolute impacts of contaminant migration or site-remediation options.

To address some of this concern when using generic or default K_d values for screening calculations, modelers often incorporate a degree of conservatism into their calculations by selecting limiting or bounding conservative K_d values. The most conservative estimate from an off-site risk perspective of contaminant migration through the subsurface natural soil is to assume that the soil has little or no ability to slow (retard) contaminant movement (i.e., a minimum bounding K_d value). Consequently, the contaminant would migrate in the direction of flow and, for a K_d value of approximately zero, would travel at the rate of the water. In the assessment of the transport of uranium at the Landfill OU, it was conservatively assumed that dissolved uranium would be transported at the velocity of the ground water (i.e., the R_f is assumed to be unity). This conservative assumption is warranted given the long life of the radionuclides of interest.

5.4 Malcolm Pirnie Assessment of Leachate Generation and Migration in the Landfill OU

In the early 1900's, a quarry was located in the western portion of the Landfill property. The quarry was reportedly abandoned at a depth of 60 feet when water was encountered. The exact location of the quarry is not known. Investigations using borings through the waste in the western portion of the Landfill indicate wastes to a depth of up to 31 feet below grade, and therefore, the reported quarry depth of 60 feet may not be accurate (Malcolm Pirnie 1999). Nonetheless, the filled area of the quarry creates a "bathtub" effect as precipitation moves downward into the excavated area, with the water transport rate in the waste (with a high hydraulic conductivity) potentially much faster than the rate at which water could be released to the surrounding low hydraulic conductivity material.

The Malcolm Pirnie report (Malcolm Pirnie 1999) notes that leachate from the Landfill exits the Landfill by two primary methods; seeps along the Landfill perimeter where the Landfill water table intersects the land surface; and downward or lateral flow into the surrounding native material. The Malcolm Pirnie report also notes that another potential leachate migration pathway is through the bedding of the 48-inch diameter ECWA pipeline that traverses parallel to the southern boundary of the Landfill. As shown conceptually in Figure 5-1, this water line may actually be constructed in the landfill area at some locations.

Malcolm Pirnie used the EPA Hydrologic Evaluation of Landfill Performance (HELP) model to estimate the water balance in the landfill using an average rate of precipitation to the landfilled wastes and an area of 57 acres. The five-year average precipitation over the landfill was calculated using the HELP model to be 113 gpm and infiltration into the waste was calculated to be 19 gpm. The Malcolm Pirnie report

concludes that a significant portion of the average leachate generation exits the landfill downward through the glacial deposits and the remainder is either stored or exits the landfill through seeps.

The report further indicates that under peak flow conditions, the leachate flows could be an order of magnitude higher. The Town of Tonawanda's current concept for closure includes a leachate collection system along the southern and northwestern (adjacent to the residential properties) boundaries of the Landfill. The collected leachate would be conveyed to the Town of Tonawanda WWTP. In the *Town of Tonawanda Landfill Leachate Treatability Study* (Malcolm Pirnie 2000), a peak leachate discharge rate of 190 gpm is considered in evaluating potential impacts to the WWTP. The Malcolm Pirnie report considers this a worst case situation under existing conditions.

The proposed conceptual closure plan includes a cap with 18 inches of low permeability (less than 1×10^{-7} cm/s) soil, an 18-inch soil barrier protection layer, and a 6-inch layer of soil capable of supporting vegetation. HELP modeling of the Landfill after capping, in accordance with the conceptual plan, indicates that after closure, the majority of the precipitation will take the form of runoff and the remainder will either drain laterally through the barrier protection layer or will be lost through evapotranspiration (Malcolm Pirnie 2000).

5.5 Assessment of Radionuclides in Groundwater

The results of the analyses of groundwater samples collected at the Tonawanda Landfill Vicinity Property are summarized in Table 4-11 in Section 4. The results of water samples from within the landfilled wastes (wells L-1, L-2 and L-3) are also shown in Table 4-11. (L-3 is located directly in an area of elevated soil radioactivity.)

A review of the sampling results shows that dissolved Ra-226 and Th-230 are at levels that may be expected at background locations.[7] As noted by the USACE Field Representative at the site observing the sampling efforts, the "dissolved" samples were still visibly turbid, even after filtration, and may not be representative of dissolved conditions. Dissolved uranium, however, appears to be somewhat elevated at most of the shallow well locations. Wells BM-4, BM-17, BM-18, and BM-19 are located at the edge of the Landfill or, in the case of well BM-17, in an area that has been landfilled at the surface. These four wells are all 25-29 feet deep, are screened in material described as clayey silt which has a hydraulic conductivity of 1.1×10^{-5} cm/s at BM-4 and 1.2×10^{-7} cm/s at BM-17. As shown in Table 4-11, concentrations of dissolved uranium in groundwater at these locations range from 24 µg/L to approximately 38 µg/L, or an average of about 30 µg/L. (Note that well BM-17 is within the footprint of the area that is considered a landfilled area, but it is screened in natural material below the filled area.) As described above, given the high hydraulic conductivity of the landfilled waste and the observed steep hydraulic gradient in the water table within the landfill waste, it is possible that uranium from the source area has been transported to the edge of the "bathtub" described in the Malcolm Pirnie report. Since wells BM-4, BM-17, BM-18, and BM-19 are located in the proximity of the landfill and the "bathtub", it is concluded that the groundwater at these locations may be impacted by dissolved uranium from the Landfill source areas.

Well BM-16 is located approximately 500 feet south of the landfill property and approximately 300 feet south of the southerly extent of landfilling that has occurred in the NMPC property. This well is about 42 feet deep and is screened in material described as silty, with a hydraulic conductivity of 1×10^{-6} cm/s.

[7] There are no background values available for groundwater at the Tonawanda Landfill Vicinity Property Site. Background values are reported in the 1993 RI report. These background values reflect groundwater sampling conducted on the Ashland properties and are: Total Uranium (A-234 + U-235 + U-238) = 3.4 pCi/L and Ra-226 = 0.3 pCi/L.

The concentration of dissolved uranium in groundwater at this location was 27 µg/L in September 2001, which is similar to the concentrations in groundwater nearer to the Landfill. That an elevated level of dissolved uranium is found at this distance from the landfill is difficult to explain based on a hydraulic conductivity of 1×10^{-6} cm/s. If a more conductive strata, (1×10^{-3} cm/s) were present in this area, then the dissolved uranium concentrations could be explained. However, the presence of a highly conductive strata has not been observed.

Well BM-15 is located approximately 900 feet east of well BM-16 in an area away from potential impact by the uranium in the Landfill OU source area. The dissolved uranium concentration in groundwater at this location is approximately 15 µg/L, which is about half of the concentration noted in the groundwater in the other wells. The reason why a slightly elevated concentration of uranium is present at this location is unknown. Wells BM-8 and B-12 are located in the Mudflats areas, and only low levels of uranium were detected in samples from these wells.

Based on the results of the 2001 groundwater sampling, it is concluded that groundwater in the vicinity of the Landfill may be impacted by releases of dissolved uranium from source areas in the Landfill OU. This potential is seen in wells BM-4, BM-17, BM-18, BM-19, with average dissolved uranium concentrations of 30 µg/L. Groundwater in the vicinity of well BM-16, located more distant from the Landfill, may be impacted, potentially facilitated by the presence of a strata of higher hydraulic conductivity than reported for this location. However, the presence of a highly conductive strata has not been observed.

5.6 Contaminant Transport – Mudflats OU

As described in Section 4, the investigations in 2001 did not find the areas of elevated radionuclides that were identified in earlier investigations in the Mudflats. This may be attributed to activities, conducted after the earlier investigations, such as the sewer line construction and other intrusive activities in these areas such as grading and filling which may have resulted in a reduction in average radionuclide concentrations at or near background levels. Thus, any transport of radionuclides in soils in the Mudflats area has been predominated by intrusive activities in the area and any soil contamination transport by natural means is considered minimal in comparison. Monitoring well BM-8 is located in the Mudflats just north of Mudflats Area C. Groundwater sample results from this monitoring well show near background levels for the radionuclides of interest, indicating any transport of radionuclides from more distant upgradient areas is not occurring at this location.

5.7 Summary

The principal mechanism for potential release of MED-like contaminants at the Tonawanda Landfill Vicinity Property is by leaching of uranium from source areas in the vicinity of well L-3. Uranium leached into the saturated landfill waste may be easily transported in dissolved form to the edges of the landfill. The dissolved uranium may be transported, at a much slower rate, to groundwater in the Landfill vicinity. The presence of elevated levels of uranium in groundwater in close proximity to the Landfill suggests that some uranium is being transported. The potential presence of higher permeability strata at some locations could explain how groundwater may be impacted at more distant locations. However, the presence of a highly conductive strata has not been observed.

Closure of the Landfill in accordance with current conceptual plans would significantly reduce precipitation into the landfilled waste and mounding in the water table in the Landfill would be decreased, resulting in a potential reduction in uranium leaching.

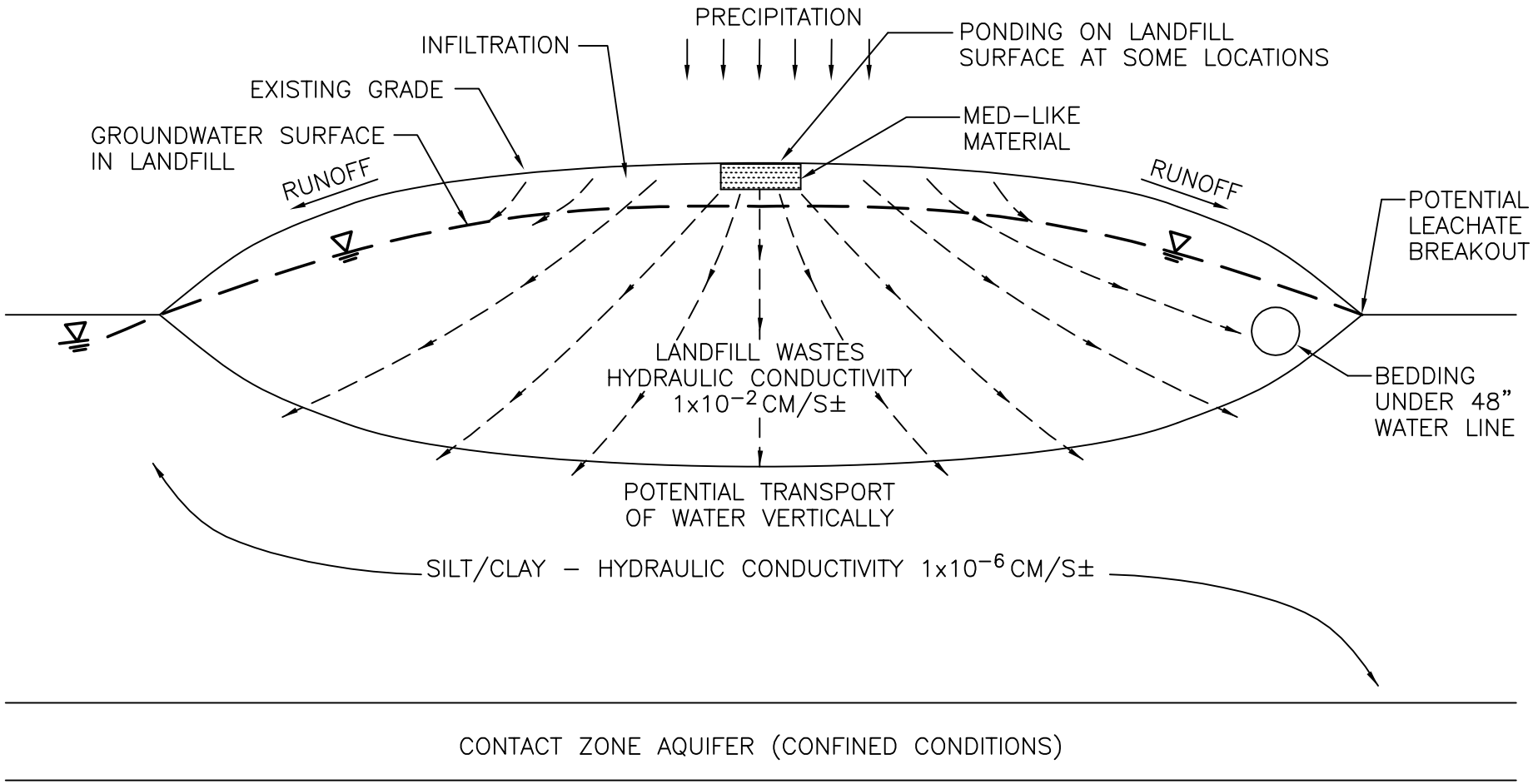


FIGURE 5-1

POTENTIAL WATER MIGRATION PATHWAYS FROM THE MED-LIKE MATERIAL AREAS - CURRENT CONDITIONS
TONAWANDA LANDFILL OU

TTLRI5–1.DWG

6.0 RADIOLOGICAL BASELINE RISK ASSESSMENT

6.1 Introduction

The objective of this radiological BRA is to provide an analysis of baseline human health risks that would result from exposure to possible MED-related contaminants at the Tonawanda Landfill Vicinity Property. In addition, the BRA contains a screening level ecological risk assessment for exposure to the possible MED-related contaminants. The approach used for the Tonawanda BRA is based on EPA *Risk Assessment Guidance for Superfund* (RAGS – EPA 1989) and prior USACE reports (USACE 2002). The risk to human health is determined using the RESidual RADioactivity (RESRAD) code, Version 6.21 (ANL 2001). This code was developed by Argonne National Laboratory (ANL) and is a widely accepted methodology for determining the radiological dose and carcinogenic risk to human health due to radioactive contaminants. The radiological doses associated with the exposure scenarios evaluated in the BRA are reported in the following sections, along with the risks, for reference in the event that dose-based applicable or relevant and appropriate requirements (ARARs) are considered for the Site.

USACE completed a screening-level Radiological Human Health Assessment (HHA) for the Landfill and Mudflats site in February, 1999 (USACE 1999a). The radiological BRA differs from the 1999 HHA in that it is a full baseline risk assessment performed in accordance with CERCLA guidance. The BRA incorporates new data and considers additional potential receptors. For example, the BRA considers exposure durations up to 30 year while the maximum duration in the HHA is 9 years. Additionally, the RI data results in a generally lower source term than presented in the 1999 HHA. As a result, the yearly doses calculated in the 1999 HHA are higher than in the BRA, but the lifetime risks are higher in the BRA.

This BRA identifies the primary sources/release mechanisms, environmental transport media, principal exposure points and principal exposure routes for the contaminants at the Tonawanda Landfill Vicinity Property. Potential human and environmental receptors are characterized. The potential health risks and ecological impacts due to radiological contamination at the Tonawanda Landfill Vicinity Property are documented for the current and future land uses in the absence of remedial action. This BRA, therefore, satisfies CERCLA requirements for a detailed analysis of the no-action alternative. This analysis, together with the remainder of the RI report, will serve as the primary means of documenting the no-action alternative.

6.1.1 Scope of the BRA

This BRA includes the evaluation of potential radiological carcinogenic risk for the areas of the Tonawanda Landfill Vicinity Property which may have been impacted by MED-related contaminants. The BRA is limited to possible MED-related materials. It is an evaluation of radiological dose and carcinogenic risks from exposure to radionuclides. It does, however, also include the non-carcinogenic risk estimates for uranium.

Chemical contamination at the Tonawanda Landfill Vicinity Property is not considered in this BRA. Based upon the sampling performed in 2001, chemical and radiological contamination do not appear to be commingled. The reasoning for not including chemical contamination in the BRA is as follows:

- Chemical contamination has not typically been identified with potential MED-related residues.
- The 1993 DOE BRA (DOE 1993) examined chemical contamination at the Linde, Ashland 1, Ashland 2 and Seaway Sites. It considered transient and employee receptors. All mean and

reasonable maximum exposure (RME) risks for carcinogenic chemicals were below 10^{-4}. Hazard Indices (HI) were calculated for chemical non-carcinogenic health effects. All HIs were below the threshold level of 1. (DOE 1993). As demonstrated in the Tonawanda Site BRA, the chemical risk is much lower than the radiological risk. The relationship between chemical and radiological risk holds across various scenarios.

- Any chemicals present in the Tonawanda Landfill may not be MED-related due to the nature of it being a landfill.

In the BRA, human exposures are evaluated under current and future central tendency (CT-mean or average) and reasonable maximum exposure (RME) conditions for various site-specific exposure scenarios and receptors. Exposure scenarios were developed based on existing conditions and potential future uses. Exposure scenarios examined for the Landfill OU include: baseline conditions (recreational use - current), a worker who constructs the landfill cap for closure (construction worker), and a recreational user who utilizes the Landfill following closure (recreational user - future). The post-closure exposure scenarios assume that the Landfill is closed in accordance with the closure plans submitted by Malcolm Pirnie, the Town of Tonawanda's contractor, without removal of radioactive material. Exposure scenarios for the Mudflats OU include a recreational user, a construction worker, and an industrial worker. Residential future use is believed to be unlikely; however, residential scenarios (adult and child) were developed for the Mudflats.

There are three identified "impacted areas". On Figure 6-1 these are identified as Areas A, B and C. Exposure Units (EUs) were developed based on these areas. The EUs for the Tonawanda Landfill Vicinity Property are as follows:

Exposure Unit	Description
1	Landfill Areas A and B and Vicinity
2	Remainder of Landfill Area of Investigation
3	Mudflats Area A
4	Mudflats Area B
5	Mudflats Area C and Vicinity
6	All site groundwater

These EUs are depicted in Figure 6-2.

Sampling locations for the 2001 RI investigations are depicted in Figure 6-2 (groundwater), Figures 4-2 and 4-9 (soil) and Figure 4-16 (surface water and sediment). Sampling locations from the historical investigations (ORNL 1992, BNI 1995) are depicted in Figure 6-3. The RI investigations were designed to supplement the earlier investigations, although some historical data are not of sufficient quality to include in this BRA. For example, Th-230 samples collected by ORNL were analyzed by gamma spectrometry. The methods resulted in high detection limits and unrealistically high reported values. These data are not used to estimate risk in this BRA which relies instead on the Th-230 data collected during the 2001 effort. Additionally, previous investigations identified elevated levels of radionuclides in the mudflats. Between the previous and the 2001 investigations significant re-contouring and general disturbance of soils has taken place that either buried or blended the soils with elevated results. Because the systematic/comprehensive investigation in 2001 could not locate previously elevated concentrations, only the 2001 data are used in risk/dose calculations.

6.1.2 Organization of the BRA

This BRA is organized according to the suggested EPA RAGS outline (EPA 1989) with minor modifications. Section 6.2, Identification of constituents of potential concern (COPCs), reviews existing

radiological data collected from the site, and identifies the data and COPCs used in this risk assessment. Section 6.3, Exposure Assessment, provides a brief description of those physical features of the Tonawanda Landfill Vicinity Property that affect the risk assessment, especially in terms of material fate and transport. Section 6.3 also summarizes site characteristics pertinent to the exposure assessment, develops exposure point concentrations, identifies potentially exposed populations, and defines primary exposure pathways. Exposure point concentrations are estimated for each selected exposure pathway and exposure unit. Section 6.4, Toxicity Assessment, discusses human health effects for the chemical toxicity of uranium, and presents quantitative toxicity values. Section 6.5, Risk Characterization, presents estimates for each exposure unit of incremental risk and annual dose from each selected COPC and exposure pathway to each receptor identified in Section 6.3. Section 6.5 also develops the constituents of concern (COCs) for the Tonawanda Landfill Vicinity Property. Section 6.6, Screening Ecological Risk Assessment, evaluates potential effects on biota from the contamination at the Tonawanda Landfill Vicinity Property. Section 6.7 presents the summary and conclusions of the radiological BRA.

6.2 Identification Of Contaminants Of Potential Concern

The purpose of this section is to describe the process of identifying COPCs and to present a summary of those selected for modeling exposure and risk. An important part of the process is evaluating not only the types and sources of contamination, but sampling, analysis, and modeling procedures used to estimate contaminant concentrations and distribution relative to the properties, media, and receptors that comprise the Tonawanda Landfill Vicinity Property.

Portions of the Tonawanda Landfill Vicinity Property are contaminated with radionuclides from the U-238, uranium-235 (U-235), and Th-232 decay chains, including Ra-226 and Th-230 that may have originated from uranium ore processing . Other constituents such as americium-241 (Am-241) and cesium-137 (Cs-137) have also been identified in site soils, although these radionuclides are not linked to MED-related activities and are not carried forward in risk/dose calculations whether or not they are identified as COPCs.

6.2.1 Data Collection and Evaluation

In accordance with the Town of Tonawanda Landfill RI Work Plan (USACE 2001b) the SAP (USACE 2001a) and the Quality Assurance Project Plan (QAPP, USACE 2001c), samples were collected from the following media: soil, sediment, surface water, and groundwater. Samples were analyzed for isotopic radium, thorium, and uranium and gross alpha (water samples), depending on the media. Gross gamma scans (i.e., walkover surveys) were also performed. Results of this sampling are used in the analytical data set evaluated in this BRA. A limited number of samples were analyzed for chemical parameters to determine if chemicals were commingled with possible MED-related material and for waste characterization. Results of the chemical sampling are not addressed in this BRA.

Historical data (ORNL 1992, BNI 1995) of sufficient quality are also used in the analytical data set evaluated in this BRA. This data reported results for Ra-226, Th-230, Th-232, U-238 and Am-241. Analyses were performed using gamma or alpha spectrometry, depending on the study.

SAIC conducted internal data validation on all data associated with samples obtained during the RI, in accordance with the approved QAPP (USACE 2001c). Results flagged “J” (estimated) during the validation have been used as reported. Results flagged “U” (not detected) have been included in the database for statistical summaries at the estimated result below the reporting limit (RL). Results flagged “R” (rejected) during data validation were excluded from the risk assessment summaries. The full report on data validation of the RI sampling is provided in Appendix B of this RI report.

6.2.2 Initial Data Reduction

Potential radiological constituents at the Tonawanda Landfill Vicinity Property are members of the naturally occurring U-238, U-235 and Th-232 decay series, as shown in Figures 6-4, 6-5 and 6-6. Because cancer slope factors (CSFs) are limited to radionuclides with half-lives of six months or longer, the primary list of potential radiological constituents includes only the long-lived radionuclides in these series (short-lived decay products are included in slope factors for long-lived radionuclides so that they need not be included separately.) The list of long-lived radionuclides includes U-238, U-234, Th-230, Ra-226 and lead-210 (Pb-210) from the U-238 series; Th-232, Ra-228 and Th-228 from the Th-232 series; and U-235, protactinium-231 (Pa-231) and actinium-227 (Ac-227) from the U-235 series. Other long-lived radionuclides detected at the site, including potassium-40 (K-40), Am-241, Th-229, and Cs-137 are also evaluated as potential COPCs although are not considered MED-related.

The site database includes results obtained through different analytical methods, sometimes producing multiple entries for a single sample and radionuclide (e.g., U-235 concentrations were measured using both alpha and gamma spectrometry). Because of the multiple analytical methods and the established relationships between radionuclides in decay series, not all data should be used at face value in risk calculations. Instead, a series of tests was performed to refine the data set used in the risk calculations so that each sample contained a single result for each radionuclide. Site data were refined using the criteria described below:

- Many samples were analyzed by both alpha spectrometry and gamma spectrometry. Because the detection limits and analytical errors are lower for alpha spectrometry, this method was used preferentially to estimate the source term.
- In a limited number of cases, the alpha spectrometry value was rejected in data validation. In these cases, the gamma spectrometry value was used.
- The ORNL 1992 report utilized gamma spectrometry to determine the Th-230 activities. The reporting limits listed for these analyses are much higher than those seen using alpha spectrometry. These values are not used given there are sufficient Th-230 results from the 2001 characterization effort.
- Because no results were available, Pb-210 was assumed to be in equilibrium with Ra-226, its closest long-lived parent.
- Because no results were available, Ac-227 was assumed to be in equilibrium with Pa-231, its closest long-lived parent.
- Ac-228 is assumed to be in equilibrium with Ra-228.

Additionally, some radionuclides are not identified in the landfill reference dataset. In these cases the values from the mudflats reference dataset are assigned.

This approach simplified the source term calculation process by eliminating extraneous information and improved the overall quality of the data set used in risk calculations. In general, alpha spectrometry is preferred over gamma spectrometry, short-lived decay products are assumed to be in equilibrium with their closest long-lived parent, and missing long-lived radionuclides are assigned concentrations equivalent to the nearest parent nuclide.

6.2.2.1 Background Sampling

Background samples for each medium are used to identify naturally occurring levels of radionuclides not affected by onsite sources.

For soil samples, two areas on the Site were identified as background areas – one in the Mudflats, one in the Landfill. Eighteen to twenty borings were performed at each location. Two samples, surface and subsurface, plus Quality Assurance/Quality Control (QA/QC) samples, were collected from each boring. The background areas selected were similar to areas being investigated, but were far enough removed from the suspected impacted areas so that no contamination was expected. Background values for other media were taken from the 1993 RI report (BNI 1993) and the 1993 BRA (DOE 1993). A summary of the background concentrations is presented in Table 6-1. The background concentrations determined in the Landfill and Mudflats Reference Areas compare favorably with background concentrations reported in the ORNL 1992 report. The ORNL report listed average soil background concentrations (based on four off-site samples) of 1.0 pCi/g U-238, 0.9 pCi/g Ra-226 and 0.8 pCi/g Th-232 (ORNL 1992).

Table 6-1 lists the mean and 95th percentile upper tolerance limit (95% UTL) background levels. The 95% UTL represents that background level below which ninety-five percent of all background sample results would be expected to fall.

For EUs 1 and 2, the background data for the landfill area are used. For EUs 3, 4, and 5, the background data for the mudflats area are used.

6.2.2.2 Sampling Locations and Media

Samples were collected for the following media: surface soil, subsurface soil, groundwater, surface water, and sediment. Groundwater sample locations are depicted in Figure 6-2. Soil sample locations are depicted in Figures 4-2, 4-9 and 6-3. Sediment and surface water sample locations are depicted in Figure 4-16. Further details are discussed below in the EU specific sections.

6.2.2.3 Sampling Methods

Sampling methods are discussed in section 2. Samples were collected in accordance with the SAP (USACE 2001a) and the QAPP (USACE 2001c). All samples were collected with dedicated or decontaminated sampling equipment.

6.2.2.4 QA/QC Methods

Radiological sample analyses for the RI were performed by various laboratories in accordance with approved protocols. The detailed analytical results are contained in appendices to this RI report. Data quality objectives and QA/QC procedures are discussed in the SAP (USACE 2001a) and QAPP (USACE 2001c). Historical data was collected with varying degrees of QA/QC. This leads to some uncertainty when using the historical data.

Note that for some radionuclides, a negative value is reported as the mean or UCL95. Negative results are due to the detector background correction performed as part of the analysis. Both the detector background counts and the sample counts are statistical functions. Sometimes the background counts exceed the sample counts, resulting in a negative value. When a large number of negative results are in the data set (common for nuclides that are largely undetected) a negative mean or UCL95 can result.

6.2.3 Exposure Unit 1 – Landfill Areas A and B and Vicinity

6.2.3.1 Area- and Media-specific Sample Collection Strategy

The EU 1 dataset consists of results from the following samples: All biased and most systematic samples from the Landfill portion of the ORNL 1992 investigation, samples from Bechtel National, Inc. (BNI 1995) which fall within the footprint of the study area, and the Class 3 biased, Area A Class 1 and 2, and Area B Class 1A, 1B, and 2 samples from this investigation. Refer to Figures 4-9, 4-16 and 6-3 for samples included in this Exposure Unit.

Surface water and sediment samples were also collected in this exposure unit. The material in EU 1 classified as sediment during the USACE 2001 investigations is not sediment in the strict sense. The material was primarily organic, and it rests below the above-mentioned surface water (three locations) and a leachate seep (one location). Any remedial actions on soil would also address this material. Therefore, the sediment data is considered with the soil for EU 1. COPCs were not evaluated for surface water because there is no viable exposure pathway. Surface water is a minor pathway that is not evaluated quantitatively in this BRA.

6.2.3.2 Data from Site Investigations

Sample results from EU 1 were classified by depth: surface samples (from 0 to 2 feet below ground surface) and subsurface samples (from 2 feet to the depth of investigation). All MED-related radionuclides except Ac-227 and Pb-210 are included in the surface and subsurface datasets. Concentrations for these radionuclides are assigned from the nearest parent radionuclide. Cs-137 and K-40 results are not present in the EU 1 dataset and, because they are not MED-related and may not be estimated based on relationships with other radionuclides, these radionuclides are assumed to be present in negligible concentrations. The statistical summary and results of the COPC screening are shown in Tables 6-2 (surface) and Table 6-3 (subsurface).

6.2.3.3 Comparison of Radionuclide Concentrations to Background

Although risk-based screening levels for Tonawanda Landfill Vicinity Property radionuclides are not available from EPA Region 9[8], default radiological preliminary remediation goals (PRGs) are typically below background, and background concentrations of these radionuclides typically produce risks on the order of 10^{-4}. Therefore, radionuclides are subject to a background screen but not a risk screen to identify COPCs. This background screen consists of comparing the maximum detected radionuclide concentration against background criteria (95% UTL). If the maximum detected concentration is below background criteria, the radionuclide is not considered a COPC. However, if the radionuclide is present at concentrations above background criteria, that radionuclide is retained as a COPC, depending on the results of the weight-of-evidence screen.

The COPC screening is documented in Table 6-2 (surface soil) and Table 6-3 (subsurface soil). Based on this background screening all long-lived radionuclides in the uranium, thorium, and actinium decay series are retained as COPCs for surface and subsurface soil. Additionally, Am-241 is retained for surface and subsurface soils. All these radiological constituents retained by the background screen are subjected to a weight-of-evidence screen before assigning the final set of COPCs for EU 1.

[8] EPA Region 9 maintains listings of risk-based screening levels for constituents being addressed at contaminated sites. These listings are widely used as risk assessments are prepared.

The available dataset does not include soil/sediment results for U-total. That is, only radioisotophic uranium results are presented in units pCi/g. Therefore, U-total concentrations are estimated assuming the following relationship:

$$C_{U\text{-}238}\,(\text{pCi/g}) = \text{U-total (mg/kg)} \times 1.24\times10^{-8} \times 10^{12} \times 10^{-6} \times 27.027 \qquad \text{Eq. 1}$$

$$C_{U\text{-}238}\,(\text{pCi/g}) = 0.335 \times \text{U-total (mg/kg)} \qquad \text{Eq. 2}$$

where

$C_{U\text{-}238}$ is the concentration of U-238 in soil/sediment (pCi/g);
U-total is the total uranium concentration in soil/sediment (mg/kg);
1.24×10^{-8} is the specific activity of U-238 (TBq/g) (Shleien 1992);
10^{-6} is a mass conversion factor (kg/mg);
10^{12} is an activity conversion factor (Bq/TBq); and
27.027 is an activity conversion factor (pCi/Bq).

Using this relationship U-total is estimated to exist above the background UTL in EU 1 and is retained as a COPC pending results of the weight-of-evidence screen.

6.2.3.4 Weight of Evidence Screening

Because of problems inherent in applying a single statistical tool to data sets that have different characteristics, an additional screening step was applied to the data after they were screened against background concentrations. This screening step is referred to as a weight-of-evidence screening; that is, multiple types of evidence are considered to determine whether a radionuclide is site-related or naturally occurring. This screening is applied to constituents that are not screened out during the background screen. The following weight-of-evidence screening technique is used to further evaluate the data.

Radionuclides infrequently detected are eliminated as COPCs if they were detected in less than five percent of the samples from a given medium, unless their presence is expected based on historical site information or is likely to identify the existence of a hot spot. Because the UTL represents the 95th percentile of the data (not the full range), it is possible to observe occasional detects above the UTL that are still within the range of background. If few detections are greater than the UTL or a radionuclide is detected at levels only slightly above the background screening value, the constituent is evaluated from the list of COPCs. This screen would eliminate Am-241 as a COPC given it is detected in only 1 of 102 surface and 2 of 198 subsurface EU 1 samples for a frequency less than 5 percent. The result of 0.24 pCi/g does not represent a hot spot (i.e., a large deviation from background), thus Am-241 is not a COPC. An additional screen is applied to U-total given a non-carcinogenic risk-based PRG is calculated for this special case constituent. Receptor-specific and site-specific PRGs are calculated using the same (or as similar as possible) parameters as used in RESRAD calculations as described in Section 6.3. These PRGs are presented in Table 6-4 and are applied according to the EU. For the mudflats, the most conservative anticipated future land uses is resident child, thus the corresponding 47 mg/kg is used to screen data from EUs 3, 4, and 5. Residents are not future users of the landfill EUs, thus the construction worker PRG of 128 mg/kg is used to screen data from EUs 1 and 2.

For EU1 (in the landfill), the maximum estimated U-total concentrations in surface and subsurface soils are above the construction worker PRG and, thus, U-total is retained as a COPC.

The final screen for EU 1 data is the background subtraction screen. This screen consists of subtracting average background concentrations from the exposure point concentration (smaller of maximum detected

and UCL95 concentrations) to determine if a net (above background) exposure is likely for the EU. The final set of COPCs for EU 1 is listed in Table 6-5.

6.2.4 Exposure Unit 2 – Remainder of Landfill

6.2.4.1 Area- and Media-specific Sample Collection Strategy

The EU 2 dataset consists of results from the following samples: Several systematic samples from the ORNL 1992 investigation, and the Class 3 random Landfill from this investigation. Refer to Figures 4-9 and 6-3 for samples included in this EU. No sediment samples were collected in this EU.

6.2.4.2 Data from Site Investigations

Sample results from EU 2 are classified by depth: surface samples (0 to 2 feet below ground surface) and subsurface samples (from 2 feet to the depth of investigation). All MED-related radionuclides except Ac-227 and Pb-210 are included in the surface and subsurface datasets. Concentrations for these radionuclides are assigned from the nearest parent radionuclide. Cs-137 and K-40 results are not present in the EU 2 dataset and, because they are not MED-related and may not be estimated based on relationships with other radionuclides, these radionuclides are assumed to be present in negligible concentrations. The statistical summary and results of the COPC screening are shown in Tables 6-2 (surface) and Table 6-3 (subsurface).

6.2.4.3 Comparison of Radionuclide Concentrations to Background

Radiological data for EU 2 were compared to the 95% UTL background levels in the same manner as EU 1 data as is documented in Table 6-2 (surface soil) and Table 6-3 (subsurface soil). Based on this background screening, Am-241, Pb-210, Ra-226, U-238, and U-total are retained as COPCs for surface soil; and Am-241, Ac-227, Pa-231, Pb-210, Ra-226, Ra-228, Th-228, Th-230, Th-232. U-238, and U-total are retained as COPCs for subsurface soil.

6.2.4.4 Weight of Evidence Screening

The background subtraction screen eliminates Pb-210 and Ra-226 in surface soil and Pb-210, Ra-226, Ra-228, and Th-232 in subsurface soil. U-total is eliminated from both surface and subsurface soils due to the background screen. COPC screening for EU 2 is documented in Tables 6-2 and 6-3 and the final list of COPCs for EU 2 is presented in Table 6-5.

6.2.5 Exposure Unit 3 – Mudflats Random Sampling Area A

6.2.5.1 Area- and Media-specific Sample Collection Strategy

The EU 3 dataset consists of results from the following samples: Several systematic samples from the ORNL 1992 investigation, and the Class 3A random Mudflats samples from this investigation. Refer to Figures 4-2 and 6-3.

No surface water or sediment samples were collected in this exposure unit.

6.2.5.2 Data from Site Investigations

Sample results from EU 3 were classified by depth: surface samples (from 0 to 2 feet below ground surface) and subsurface samples (from 2 feet to the depth of investigation). All MED-related radionuclides except Ac-227 and Pb-210 are included in the surface and subsurface datasets. Concentrations for these radionuclides are assigned from the nearest parent radionuclide.

6.2.5.3 Comparison of Radionuclide Concentrations to Background

Radiological data for EU 3 were compared to the 95% UTL background levels in the same manner as EU 1 data as is documented in Table 6-2 (surface soil) and Table 6-3 (subsurface soil). Based on this background screening Ac-227, Pa-231, Th-229, and U-234 are retained as COPCs for surface soil; and Ac-227, Pa-231, Th-228, Th-229, Th-232, and U-235 were retained as COPCs for subsurface soil.

6.2.5.4 Weight of Evidence Screening

All radionuclides except Th-229 are eliminated as surface soil COPCs primarily because the maximum detected results is less than the background UTL. Am-241 may also be eliminated because it wasn't detected in any sample. The maximum U-total result is less than the PRG. The subsurface screens eliminate all radionuclides except Th-228, Th-229, Th-232, and U-235. As with surface soil Am-241 is not detected in any sample and the maximum U-total result is less than the PRG. COPC screening for EU 3 is documented in Tables 6-2 and 6-3 and the final list of COPCs for EU 3 is presented in Table 6-5.

6.2.6 Exposure Unit 4 – Mudflats Random Sampling Area B

6.2.6.1 Area- and Media-specific Sample Collection Strategy

The EU 4 dataset consists of results from the following samples: The Class 3B random Mudflats samples from this investigation. Refer to Figure 4-2.

No surface water or sediment samples were collected in this exposure unit.

6.2.6.2 Data from Site Investigations

Sample results from Exposure Unit 4 were classified by depth: surface samples (from 0 to 2 feet below ground surface) and subsurface samples (from 2 feet to the depth of investigation). All MED-related radionuclides except Ac-227 and Pb-210 are included in the surface and subsurface datasets. Concentrations for these radionuclides are assigned from the nearest parent radionuclide.

6.2.6.3 Comparison of Radionuclide Concentrations to Background

Radiological data for EU 4 were compared to the 95% UTL background levels in the same manner as EU 1 data as is documented in Table 6-2 (surface soil) and Table 6-3 (subsurface soil). Based on this background screening only Ra-228, Th-229, and U-235 are retained as COPCs for surface soil; and Am-241, Ra-228, Th-228, Th-229, Th-230, Th-232, and U-235 are retained as COPCs for subsurface soil.

6.2.6.4 Weight of Evidence Screening

All radionuclides retained from background screen are also retained by the weight-of-evidence screen for both surface and subsurface soil. COPC screening for EU 4 is documented in Tables 6-2 and 6-3 and the final list of COPCs for EU 4 is presented in Table 6-5.

6.2.7 Exposure Unit 5 – Mudflats Area C And Vicinity

6.2.7.1 Area- and Media-specific Sample Collection Strategy

The EU 5 dataset consists of results from the Class 3 biased, and Area C Class 1 and 2 samples from the 2001 investigation. Refer to Figures 4-2 and 6-3.

No surface water or sediment samples were collected in this exposure unit.

6.2.7.2 Data from Site Investigations

Sample results from Exposure Unit 5 were classified by depth: surface samples (from 0 to 2 feet below ground surface) and subsurface samples (from 2 feet to the depth of investigation). All MED-related radionuclides except Ac-227 and Pb-210 are included in the surface and subsurface datasets. Concentrations for these radionuclides are assigned from the nearest parent radionuclide.

6.2.7.3 Comparison of Radionuclide Concentrations to Background

Radiological data for EU 5 were compared to the 95% UTL background levels in the same manner as EU 1 data as is documented in Table 6-2 (surface soil) and Table 6-3 (subsurface soil). Based on this background screening Pb-210, Ra-226, Th-229, Th-230, U-234, U-235, U-238, and U-total are retained as COPCs for surface soil; and Am-241, cadmium-109 (Cd-109), Pb-210, Ra-226, Th-228, Th-229, Th-230, Th-232, U-234, U-235, U-238, and U-total are retained as COPCs for subsurface soil.

6.2.7.4 Weight of Evidence Screening

Only U-total is eliminated from the list of COPCs is surface soil and only Am-241 is eliminated in subsurface soil. U-total does not pass the PRG screen and Am-241 is detected in less than 5 percent of subsurface samples. COPC screening for EU 5 is documented in Tables 6-2 and 6-3 and the final list of COPCs for EU 5 is presented in Table 6-5.

6.2.8 Exposure Unit 6 – Site Groundwater

6.2.8.1 Area- and Media-specific Sample Collection Strategy

Exposure Unit 6 consists of the following samples: All groundwater samples from across the site, collected as part of this investigation.

6.2.8.2 Data from Site Investigations

Fourteen monitoring wells were sampled and analyzed for radiological constituents as part of the 2001 RI investigations. Ra-226 and U-total are detected in all samples. Ra-228, Th-228, Th-230, Th-232, U-234, U-235, U-238 and K-40 were detected in from 2-15 samples. Am-241 and Pa-231 were not detected in

any groundwater samples. Given that groundwater is not potable these data were not screened to identify COPCs. With no complete exposure pathway risk and dose calculations are not required.

6.2.9 COPC Summary

The final set of EU-specific COPCs for the Tonawanda Landfill Vicinity Property are presented in Table 6-5. This list excludes constituents that are either short-lived decay products, are less than the respective background UTLs, are infrequently detected, are below the average background concentrations, or are below PRG concentrations. The list includes Am-241, Th-229, and Cd-109 that are not MED-related and are not carried forward in risk/dose calculations. All long-lived members of the uranium, thorium, and actinium decay series are represented in some combination of EU COPCs but most EUs retain only a few, if any COPCs.

6.3 Exposure Assessment

This section addresses the environmental fate and transport of the COPCs identified in Section 6.2 and the potential pathways by which human populations (e.g., transient visitors and workers) could be exposed to radiological contaminants at the Tonawanda Landfill Vicinity Property. Chemical exposure is determined for uranium only. As explained below (Section 6.3.2), there are no current residential exposure pathways. Future residential use is not considered to be plausible for the landfill, but it is considered plausible for the Mudflats. Exposure estimates are provided each of the EUs defined in Section 6.1.1. The site dataset is summarized in this section and Appendix B and presented as the exposure point concentration [EPC - defined as the lesser of the 95th percentile upper confidence limit on the mean (UCL95) or the maximum concentration, with mean background subtracted] for each of the operable units. In identifying primary pathways of exposure at each location, current and plausible future land uses of the properties and surrounding areas are considered. This section describes exposure scenarios, develops information on exposure pathways, estimates the concentration of the contaminants of potential concern at points of human exposure, and determines receptor intakes. The uncertainties of the exposure assessment are discussed in Section 6.5.

6.3.1 Characterization of Exposure Setting

The exposure setting for the Tonawanda Landfill Vicinity Property is described briefly in terms of both the natural environment and local land use and demography. The setting is described in more detail in section 3. The purpose of the following discussion is to provide information pertinent to the identification of exposure pathways and estimation of exposure rates for receptors that could be exposed to contaminants.

6.3.1.1 Environmental Setting

The Tonawanda Landfill is approximately 170 acres in size and is divided into two parcels – the former Town of Tonawanda Landfill, which is approximately 55 acres in area, and the Mudflats portion that is approximately 115 acres in area (Figure 1-3). The 1999 Radiological Human Health Assessment (USACE 1999a) characterized the Landfill and Mudflats Areas, identified in the 1992 and 1995 study areas, as the two areas of exposure. Both parcels are owned, and located, within the Town of Tonawanda. The Landfill OU is located at the western end of the landfill, as depicted in Figure 6-1. Likewise, the Mudflats OU is located at the western end of the Mudflats. Exposure Units 1 and 2 comprise the Landfill OU, while Exposure Units 3, 4, and 5 comprise the Mudflats OU.

Site conditions that may affect fate and transport of contaminants and resultant potential for human exposure include physical surficial features, climate, ecological resources, geology, surface water and groundwater, and soil type, including erosion potential. These site conditions are discussed in the following sections.

6.3.1.1.1 Topography

Surface Topography

The Tonawanda Landfill is located in the Eastern Lake Section of the Central Lowland physiographic province. The characteristic landscape of this section consists of dissected and glaciated lowlands and escarpments (Fenneman 1946; from BNI 1993). The Tonawanda Landfill is located on a broad lowland east of Twomile Creek, which flows into the Niagara River to the North (Figure 1-2).

The Landfill OU is located north of the Mudflats OU on the opposite side of the NMPC power line easement and bordered by a residential subdivision to the north and northwest, a railroad easement to the east, the NMPC easement to the south. The western portion of the landfill parcel has some hills and mounds but is primarily sloping towards the west/northwest. Vegetative cover in the western portion of the landfill is limited to grass, scrub trees, and bushes. The eastern portion of the landfill parcel is more heavily vegetated than the western portion. Several large willow trees and brush consistent with wetlands overgrowth are present over a majority of the eastern half of the site. Portions of the western half of the landfill adjacent to the residential abutters have been maintained as lawn with a substantial grass base. The eastern portion of the landfill is gently sloping to the north/northeast with plateaued regions along the southern border of the parcel adjacent to the NMPC easement. Maximum change in elevation over the landfill parcel is estimated to be to be about 30 feet from a high elevation of approximately 638 feet relative to mean sea level (msl) at the eastern end to a low elevation of approximately 606 feet msl at the eastern end (Malcolm Pirnie 1999).

The Mudflats OU of the Tonawanda Landfill is located south of the Landfill OU on the opposite side of the NMPC easement. The parcel is bordered to the east by a railroad easement, the former Town of Tonawanda incinerator facility to the west, and the New York Thruway to the south. The Mudflats cover approximately 115 acres with very little topographic relief. Soil mounding was observed along the northern boundary the Mudflats parcel near the NMPC easement. Vegetative cover over the area mainly consists of overgrown grass, brush, and small scrub trees. A bank of large trees was noted along the southern border of the property. Ephemeral streams and ponding were noted at several locations at the site. The area of possible MED-related material disposal (Area C on Figure 6-1) has been covered by approximately eight to ten feet of fill material (street sweepings, etc.) deposited there by the town. This "fill" material is material that the Town placed there that can be used as fill for other activities. Based on available information, the Mudflats were not used as a landfill.

6.3.1.1.2 Climate

The climate in the portion of New York State in which the Tonawanda Landfill is located in can generally be described as moderate. Based on the 30-year monthly average (from 1951 to 1980) for the nearby City of Buffalo, the mean daily air temperature ranges from a low of 23.5 degrees Fahrenheit in the month of January, to a high of 70.7 degrees Fahrenheit in the month of July. Precipitation is fairly uniform in distribution throughout the year, with an average annual precipitation value of approximately 37.5 inches (Wehran 1994).

6.3.1.1.3 Ecological Resources

Section 6.6.2 contains a detailed description of ecological resources at the site; therefore, only a brief discussion is presented here. The Tonawanda Landfill Vicinity Property lies within the Beech-Maple Forest section of the Eastern Broadleaf Forest division (Bailey 1995). Eyre (1980) shows the predominant forest cover type in the Tonawanda area as elm-ash-cottonwood (locally exhibited as ash-elm-maple), surrounded by maple-beech-birch forest cover type. Black and green ash; red and silver maple; and American, rock, and slippery elm are typical forest trees in this area. Common associate species include eastern cottonwood, aspen, hawthorn, pin cherry, and American beech. Eastern hemlock and eastern white pine were once abundant in the region but have been eliminated from the area by logging, forest fires, farming, and urban development.

Today, very little actual forest habitat remains in the Tonawanda area. Urban development for residential and industrial use has eliminated any undisturbed habitat. Most natural habitat types remain only as small pockets of woodlands on or in poorly drained areas (Galvin 1979). The Town of Tonawanda Landfill provides only minimal habitat for urban wildlife, supporting only cosmopolitan species of birds and small mammals (Ford, Bacon, and Davis Utah, Inc. 1981). Typical wildlife species include birds such as rock dove, American crow, unidentified seagulls, mourning dove, killdeer, European starling, common grackle, red-winged blackbird, northern (Baltimore) oriole, American goldfinch, and American robin, and mammals such as whitetail deer, house mouse, Norway rat, eastern cottontail rabbit, eastern gray squirrel, raccoon, opossum, striped skunk, and fox.

6.3.1.1.4 Geology

The Tonawanda Landfill is located near the Niagara River within the Erie-Ontario Lowland Physiographic Unit of New York (Muller 1965; from BNI 1993a). The Eire-Ontario Lowland has significant relief characterized by the following two major escarpments: the Niagara and the Onondaga. The Onondaga escarpment is a north-facing, east-northeast trending topographic rise that extends parallel to and immediately north of the Allegheny plateau, which is part of the Appalachian Upland. The Niagara escarpment exists approximately two-thirds of the distance between the Onondaga escarpment and Lake Ontario. The Niagara escarpment separates the Erie-Ontario Lowland into the following two segments: a northern, topographically lower segment and a southern, topographically higher segment (BNI 1993). The Tonawanda Landfill is located between the Niagara and Onondaga escarpments.

6.3.1.1.5 Surface Water and Groundwater

<u>Surface-Water Hydrology</u>

The surface water hydrology at the Tonawanda Landfill is controlled by the manmade features that characterize both the Landfill and the Mudflats. In the Landfill, even though the topography is somewhat irregular, the ground surface generally slopes radially away from the highest point of the Landfill, which is in the eastern portion of this site area. Runoff flows radially from the top of the Landfill and is collected in intermittent swales along the northwestern, northeastern, and eastern edges of the Landfill OU. The northeastern swale discharges to the marshy area northeast of the site, and the eastern swale discharges to a drainage ditch along the railroad tracks (Malcolm Pirnie 1999).

The northwestern swale that runs along the northwestern border of the Landfill collects runoff from Areas A and B of the Landfill trends northeast to southwest. During storm events the surface water collected in this northeast to southwest trending swale eventually flows east and southeast towards the former incinerator building, where it is collected in a storm water piping system. This storm water collection system eventually drains into the Twomile Creek, which is located along the western border of the

Tonawanda Landfill. The north-south trending Twomile Creek flows to the north and empties into the Niagara River, which is located approximately 1 mile north of the Tonawanda Landfill (Malcolm Pirnie 1999).

Runoff along the southern border of the Landfill occurs as sheet flow into the wet area in the NMPC property. Surface water is held in the NMPC property by a berm along the southern boundary until it discharges from the wet area of the NMPC property into a culvert beneath the Landfill access road. This culvert discharges into a east-west trending drainage ditch that also flows to the west and to the storm water that flows through this ditch is collected by the same storm water collection system that pipes the surface water to the Twomile Creek to the west.

This east-west trending drainage ditch also collects the surface water from the western and central portions of the Mudflats, which, like the Landfill, also gently slopes, to the west towards Twomile Creek. However, within the Mudflats OU is poorly drained and therefore much of the surface water ponds on top of the relatively impermeable silts and clays of the underlying sediments, hence the name "Mudflats".

Within the Tonawanda Landfill, no perennial streams have been identified. However, seeps have been observed on the perimeter of the Landfill OU that have been formed in the following two ways: 1) at the base of the landfill slopes, where the shallow water table intersects the land surface and 2) at the edge of the Landfill waste material where permeable waste meets less permeable silts and clays. It does not appear that surface water flows from these seeps (Wehran 1994 and Malcolm Pirnie 1999).

Hydrogeology

The objective of the 2001 USACE investigation, was not to characterize the water-bearing zones at the Tonawanda Landfill. During the 2001 USACE investigation, monitoring wells were not installed nor were any of the soil borings drilled deep enough to encounter any of the water-bearing zones within the unconsolidated glacial deposits. Therefore, the hydrogeology of the Tonawanda Landfill is based on the investigations conducted at the Tonawanda Landfill (Wehran 1994 and Malcolm Pirnie 1999) and the Tonawanda Site (BNI 1993) by previous investigators.

At the Tonawanda Landfill groundwater occurs in the following three distinct hydrogeologic systems:

- Saturated, permeable landfill waste;
- The semi-confined sand and silty sand lenses that are present within the fine-grained glacial till and glacio-lacustrine deposits (silts and clays);
- the coarser-grained sand and gravel Basal unit overlying the bedrock and the shallow portion of the bedrock aquifer that contains fractures, joints, and solution cavities. At the Tonawanda Landfill Vicinity Property, this unit was referred to as the Contact-Zone Aquifer.

Detailed descriptions of each hydrogeologic unit are presented in the reports summarizing investigation of the Tonawanda Landfill and the adjacent Mudflats and are summarized briefly below (Wehran 1994 and Malcolm Pirnie 1999).

Saturated Landfill Wastes Groundwater exists in the saturated wastes within the Landfill OU. These landfill wastes have hydraulic conductivities (k) that are approximately four orders of magnitude higher than the underlying fine-grained glacial deposits ($k=10^{-2}$ cm/s for the landfill wastes vs. $k=10^{-6}$ cm/s for the glacial deposits) (Malcolm Pirnie 1999). According to previous investigations, within the Landfill portion of the Site, the groundwater flow for the shallow groundwater is primarily through the permeable landfill wastes.

Unconsolidated Glacial Deposits. The majority of the glacial deposits encountered at the Tonawanda Landfill are fine-grained silts and clays inter-bedded with thin (less than 4 feet thick) sand and silty sand lenses that are not considered laterally extensive. Groundwater flow occurs through these sand lenses. These sand units are considered limited in aerial extent and previous studies did not consider these deposits as providing extensive migration pathways for leachate migration (Malcolm Pirnie 1999).

The groundwater flow through landfill wastes and the glacial sediments the Tonawanda Landfill Vicinity Property is generally in a radial pattern away from a groundwater mound that exists in the eastern portion of the Tonawanda Landfill. This groundwater mound is located to the east of the Landfill portion of the area of investigation, in the vicinity of shallow piezometers P-3 and P-4 (Refer to Figure 6-2 for locations of wells). Horizontal groundwater gradients were measured at 0.003 feet/feet and 0.02 feet/feet in the Landfill and Mudflats, respectively. Average linear velocity of groundwater flow was 3.5 feet/year and 1.4 feet/year in the Landfill and Mudflats, respectively (Wehran 1994).[9]

Contact-Zone Aquifer The contact-zone aquifer is a confined water-bearing zone that has been extensively investigated at the neighboring FUSRAP Sites (Linde, Ashland 1, Ashland 2, and Seaway) (BNI 1993a). At the Tonawanda Landfill Vicinity Property, the contact-zone aquifer is defined as the coarse-grained sand and gravel Basal unit overlying the bedrock and the shallow portion of the bedrock aquifer that contains fractures, joints, and solution cavities. However, at the Tonawanda Landfill, the three deep monitoring wells (DW-1, DW-2, and DW-4) were only completed within the overlying coarse-grained glacial deposits.

The regional direction of deep groundwater flow in both the sand and gravel layers and bedrock were found to be in a generally northward direction toward the Niagara River (Wehran 1994). A field permeability test on monitoring well DW-1, which is installed in this sand and gravel unit, indicated that the hydraulic conductivity of this unit was approximately 3×10^{-5} cm/s, which is within the range of aquifer hydraulic conductivity values calculated for the contact-zone aquifer at the Tonawanda Landfill Vicinity Property.

6.3.1.1.6 Soils

The undisturbed (non-fill and waste) soils encountered at the Tonawanda Landfill are composed of unconsolidated glacial deposits composed primarily of silt and clay with some trace of fine-grained sand and also a trace of fine-grained gravel. During the 2001 USACE investigation, the maximum depths that soil samples were collected from in the Mudflats OU and Landfill OU were to depths of 13.5 and 18.0

[9] For the Landfill, the Wehran estimates were based on a hydraulic conductivity of 1.0×10^{-5} cm/s, a hydraulic gradient of 0.02 ft/ft and an effective porosity of 0.06, resulting in an estimated linear velocity of 3.5 ft/yr. For the Mudflats, the Wehran estimates were based on a hydraulic conductivity of 4×10^{-6} cm/s, a hydraulic gradient of 0.02 and an effective porosity of 0.06, resulting in an estimated linear velocity of 1.4 ft/yr. No hydraulic conductivity testing was conducted as part of the 2001 USACE investigation. As indicated in Table 3-1, hydraulic conductivity estimated from slug tests in the unconsolidated glacial deposits also report hydraulic conductivity values much lower than those used in the Wehran estimates. Use of these values would result in estimated linear velocities much slower than these estimates.

feet below ground surface (bgs), respectively. Therefore, the descriptions of the soils at the Tonawanda Landfill are primarily based on the classifications by previous investigations (Wehran 1994).

Grain size analysis were performed on soil samples collected from previous and based on the results the soils were classified as either Lean Clay (CL) or Silt (ML) based on the United Soil Classification System (USCS). These classifications are consistent with the USCS classifications based on field classifications and grain size analysis conducted on undisturbed soils collected during the 2001 USACE investigation.

The investigations conducted at the Tonawanda Landfill Vicinity Property classified the following four distinct surficial deposits: glacial till, varved clay, glacio-lacustrine deposits, and glacio-fluvial deposits (BNI 1993a). However, at the Tonawanda Landfill, the soil descriptions were too generalized to distinguish between the fine-grained glacial till and the underlying varved clay and glacio-lacustrine deposits (Malcolm Pirnie 1999).

6.3.1.2 Demography and Land Use

The Tonawanda Landfill is located in the Town of Tonawanda in northern Erie County near the Niagara County border. Section 3.7 of the *Tonawanda Site RI Report* (BNI 1993) has an extensive section on Demography and Land Use, and the majority of the subsections apply to both of the Tonawanda Landfill and the Tonawanda Landfill Vicinity Property except for the following sections:

- Access to the Property and Adjacent Areas
- Land Use

Therefore, these are briefly discussed in this section.

6.3.1.2.1 Access to the Property and Adjacent Areas

The border of the Tonawanda Landfill is fenced along the northern, eastern and southern property boundaries. Along the northern boundary, which is adjacent to a residential neighborhood, there are breaks in the fence where some of the property owners have pushed back the fence to gain access to the site. In addition, even though most of the western boundary, which is bounded by a walking path next to Twomile Creek, is fenced, there are also some breaks that allow access to trespassers on foot and on motorcycles. Vehicular traffic off East Park Drive is controlled by a gate that is locked after operating hours.

6.3.1.2.2 Land Use

The Tonawanda Landfill is located in a Performance Standards (PS) Use District as defined by the Town of Tonawanda Town zoning law. The Tonawanda Town Code defines the purpose of the Performance Standards Use as follows: "The purpose of this district is to encourage and allow the most appropriate use of the land available now as well as approaching future commercial and industrial uses unhampered by restrictive categorizing, thus extending the desirability of flexible zoning, subject to change with changing condition" (Town of Tonawanda 1990).

The eastern portion of the Landfill is currently being capped by the Town of Tonawanda, which is bringing in material to cover the Am-241 contamination in the eastern portion of the Landfill. However, in the western portion of the Landfill, no site activities are being conducted, except for occasional mowing of the grasses within the landfill area as part of site maintenance.

Currently the only site activities conducted at the Mudflats consist of use of the western portion of the property near the entrance gate for disposal of street sweeping debris, compost material, and staging of road maintenance materials. This work is performed by Town of Tonawanda personnel.

There is evidence of recreational use (walking, riding dirt bikes, etc.) in both the Landfill and the Mudflats.

Anticipated future uses of the Landfill include a Site construction worker (landfill closure) and post-closure recreational use. No residential scenarios are considered within the Landfill. In accordance with USEPA guidance, *Presumptive Remedy for CERCLA Municipal Landfill Sites* (EPA 1993a), institutional controls may be assumed to preclude residential use of municipal landfills.

Anticipated future uses of the Mudflats include a construction worker (industrial facility), an industrial worker, and a recreational user. Material from portions of the Mudflats may also be used as cover material for landfill closure.

An additional residential scenario is also evaluated for the Mudflats. This use is not anticipated and is unlikely. However, it is a possible future use of the area and establishes an upper bound of risk for the Mudflats.

6.3.2 Identification of Exposure Pathways

A complete exposure pathway consists of at least the following four elements: (1) a source and mechanism of contaminant release to the environment (with receiving media); (2) environmental transport medium (fate and transport) for the released contaminants; (3) a point of human contact with the contaminated medium (exposure point); and (4) a route of human receptor exposure (exposure route) at the exposure point. An integration of sources, releases, fate and transport mechanisms, exposure points, and exposure routes are evaluated for complete exposure pathways. If any of these elements is missing, the pathway is incomplete and will not be considered further in the risk evaluation.

Conceptual site models were developed for the Tonawanda Landfill and Mudflats to illustrate the potential exposure pathways. Figures 6-7 and 6-8 are schematic diagrams depicting the pathways for each of the Exposure Units. In the conceptual site model diagrams, completed exposure pathways are indicated by shaded blocks. A completed pathway exists when a receptor potentially could be exposed to a contaminated source by one of the exposure routes. Incomplete pathways occur when any of the pathway components are missing or when features such as engineering controls or access restrictions are in place to prevent release and migration of, or contact with, contaminants. Blocks with no shading indicate incomplete pathways. For instance, in EUs 1 and 2, since the landfill will be capped in the near future, exposure to subsurface soil is not considered to be a complete pathway.

6.3.2.1 Contaminant Sources and Release Mechanisms

The principal contaminant source is contaminated soils. A smaller amount of contamination is present in surface water, sediment, and groundwater. Exposure to surface water (present in EU 1 only) is not considered to be a viable pathway because the surface water body is a shallow, seasonal, highly turbid collection point for surface water and landfill leachate. It has no recreational value and is unlikely to be used for recreational or other purposes. Incidental exposure to groundwater could occur during construction activities. This pathway, however, would be incidental, and is considered to be insignificant compared to other exposure pathways

The material in EU 1 classified as sediment during the USACE 2001 investigations is not sediment in the strict sense. As discussed in Section 6.2.2.1, this material is considered with the soil EPCs.

Groundwater is not considered a contaminant source of concern in this BRA, because due to high dissolved solids, sulfates, and chloride levels, it is not of drinking water quality. Additionally, all nearby residents are connected to the municipal water system.

Contamination may be released from contaminant sources in a number of ways, including:

- human activity such as excavation of soils, repair or demolition of structures, and management of stored waste;
- emission of radon;
- fugitive dust resulting from resuspension of particulate material from soil surfaces, where it is inhaled by humans or deposited on the soil surface, plants, or structures;
- erosion and surface runoff, which may carry contaminants to sedimentation points or to surface water or groundwater;
- leaching of material from subsurface and surface soil, which may transfer contaminants to the groundwater; and
- contaminant uptake from soil by plants growing in contaminated soil, with subsequent ingestion.

The Landfill was designated as a FUSRAP vicinity property in 1992 (DOE 1992) based on field sampling and gamma survey results that indicate the presence of MED-like material at several locations in the now non-operational landfill (ORNL 1992).

6.3.2.2 Fate and Transport Mechanisms

Following release from sources, contaminants may migrate in environmental media through several mechanisms. However, because of the site-specific factors, certain potential release mechanisms and receiving media do not play a significant role in contaminant fate and transport and resulting human exposure at the Tonawanda Landfill Vicinity Property. For example, because the groundwater aquifer is not of drinking water quality, migration of contaminants through groundwater is not considered an important release mechanism. Similarly, due to the urban industrial nature of the site, uptake of contaminants by biota is not currently an important release mechanism, although this is included in the residential scenario.

The environmental pathways considered most important for potential human exposures to site contaminants under current conditions include:

- external gamma radiation from radioactively contaminated soils and materials,
- incidental soil ingestion, and
- resuspension and airborne dispersal of particulates.

6.3.2.3 Exposure Routes and Pathways

In the assessment of human health risk, exposure points are locations where human receptors can come into contact with contaminants. Exposure route refers to the process by which the human receptor comes into contact with the contaminant at the exposure point. The exposure routes that exist at the Tonawanda Landfill Vicinity Property are:

- inhalation of resuspended particulates containing COPCs;
- direct ingestion of soils;
- direct gamma radiation from soils; and
- ingestion of contaminated plants.

A conceptual site model of potential radiological exposure pathways was developed for the Tonawanda Landfill Vicinity Property and is shown in Figures 6-7 and 6-8. Inhalation of contaminated particulates, incidental soil ingestion and direct radiation are complete pathways for all receptors and scenarios. Ingestion of contaminated homegrown produce is also considered in the residential scenario.

Complete groundwater pathways do not occur in current or future scenarios because groundwater is not potable (BNI 1993a). As discussed in Section 6.3.2.1, there are no complete pathways for surface water, and sediment is considered with soil.

Radon is a radioactive noble gas that tends to accumulate in enclosed structures. This BRA qualitatively addresses the potential for exposure to indoor radon. Radon limits are based on concentration and not risk or dose. The difference is partly because background radon concentrations are highly variable, typically producing risk estimates well above the CERCLA target risk range. In fact, EPA has stated in *Model Standards and Techniques for Control in New Residential Buildings* that "indoor radon levels for any given building cannot (accurately) be predicted due to different site and environmental conditions, building design, construction practices, and variations in the operation of buildings." USACE does not attempt to calculate indoor radon levels that may grossly overestimate or underestimate current or future conditions, but rather presumes that radon will be controlled per the selected Applicable Relevant and Appropriate Requirements [ARAR(s)] and remedial alternative by controlling the concentration of Ra-226 in soil.

Finally, dermal slope factors are not available for the radiological constituents. Thus, the dermal contact pathway is not evaluated.

6.3.3 Quantification of Exposure

6.3.3.1 Exposure Assessment

For radiological contaminants, exposures were estimated using RESRAD Version 6.21 and standard parameter values identified for various exposure conditions (EPA 1997, EPA 1989 and ANL 2001). For uranium toxicity, exposures were estimated using standard exposure equations and, to the extent possible, the same parameter values are used in RESRAD modeling. Site-specific exposure parameter values were used in selected scenarios, as discussed below. For this CERCLA exposure assessment, intake variables for given pathways were selected to estimate the reasonable maximum exposure (RME) conditions. The RME is the maximum exposure that is reasonably expected to occur at the site and represents a conservative estimate of exposure. RME exposure parameters used in RESRAD are summarized in Appendix C1, Table C1-1. Additionally, the central tendency (CT) exposure that is expected to occur at the Site is assessed for consideration if the RME risks exceed target risk criteria. The CT assumptions are presented in Appendix C1, Table C1-2.

Brief descriptions of the exposure scenarios, by exposure unit, are described in the following sections. A summary of the exposure scenarios evaluated for each EU is presented in Figures 6-7 and 6-8. A detailed list of input parameters is provided in Appendix C1.

6.3.3.1.1 Exposure Unit 1

Exposure Unit 1 consists of the portion of the Landfill which encompasses the vicinity of Areas A and B (refer to Figure 6-2). The approximate area of this EU is 37,000 m^2.

Exposure scenarios developed for EU 1 are: Recreational (current use and future use) and Construction Worker (future use - Landfill closure). Exposure to surface soil only is considered, since the Landfill closure will preclude excavation in this area. Refer to Section 6.3.3.2 for EPC development.

Recreational - Current Use

The recreational scenario is used to represent likely current and near-term future uses. There is some evidence that the area has been used for recreational purposes and many closed landfills have been subsequently developed as parks in the region. To model the recreational exposure, the fraction of time (percent of time) spent outdoors onsite was set to 0.012 (1.2 percent) representing 17 minutes/day (Exposure Factors Handbook (EFH) - EPA 1997) for the RME case. The actual occupancy factor would likely be lower considering that the areas with elevated radioactivity are localized and isolated, so continuous exposures during recreational activity are unlikely. For the CT case, an occupancy factor of 0.006, representing 50 hrs/year on site was assumed (ANL 2001).

Duration for the recreational user was set to 30 years (representing the 95th percentile of time spent at a single residence (EPA 1997)) for the RME case and at 9 years (representing the average time at a single residence (EPA 1997) for the CT case. Moderate activity was used for the inhalation rate (1.6 m^3/hr) (ANL 2001 from EPA 1997). For the RME case, 100 mg/day incidental soil ingestion was assumed (ANL 2001) while for the CT case, it was set at 50 mg/day (EPA 1997). A 0.001 g/m^3 mass loading (USNRC 1992) with a 30 percent respirable fraction (Paustenbach 1989) was assumed. (Refer to Appendix C1).

Recreational – Future Use

The recreational future use scenario parallels the current use scenario, above, with the exception that 3 ft (0.9 m) of cover is assumed to be in place, thus precluding future exposures assuming the cover is maintained. Assuming the cover is allowed to degrade over time and COPCs are again exposed, the future recreational user, under a worst-case scenario, is subject to the same risks as the current user.

It is assumed that the Landfill will be closed in accordance with the Landfill Closure Plan (Wehran 1994), without removal of the possible MED-related material.

Construction Worker – Future Use

The construction worker scenario was chosen to estimate dose if the landfill is closed without removal of the radioactive materials. To model the construction worker scenario, the Town of Tonawanda Landfill closure proposal was used to establish the exposure conditions during landfill closure. Landfill closure plans call for placement of a geotextile membrane over the waste, covering the membrane with an 18 inch clay barrier layer (Component 1), placing a 12 inch gravel barrier protection layer over that (Component 2), then covering with 6 inches of topsoil to support vegetation (Component 3). Each layer acts as a shield to reduce the workers' exposure during the construction of subsequent layers. However, no cover depth is assumed during the construction activities for conservatism, to address a potential broad range of construction-related activities in the landfill EUs, and to be consistent with the mudflats construction receptor.

Duration for the construction scenario was conservatively assumed to be one year. Moderate activity was used for the inhalation rate (1.6 m^3/hr) (ANL 2001 from EPA 1997). For the RME case, 480 mg/day incidental soil ingestion was assumed (Yu 1993) while for the CT case, it was set at 240 mg/day. A 0.001 g/m^3 mass loading (USNRC 1992) with a 30 percent respirable fraction (Paustenbach 1989) was assumed. (Refer to Appendix C-2).

6.3.3.1.2 Exposure Unit 2

Exposure Unit 2 consists of the western portion of the Landfill outside of EU 1 (refer to Figure 6-2). The approximate area of this EU is 42,000 m^2.

Exposure scenarios and parameters developed for EU 2 are the same as for EU 1. Refer to Section 6.3.3.1.1.

Exposure to surface soil only is considered, since the landfill closure will preclude excavation in this area. Refer to Section 6.3.3.2 for EPC development.

6.3.3.1.3 Exposure Unit 3

Exposure Unit 3 consists of the northern portion of the Mudflats which encompasses the Class 3 Area A (refer to Figures 6-1 and 6-2). The approximate area of this EU is 113,000 m^2.

Exposure scenarios developed for EU 3 are: Recreational (current use); Recreational (future use); Construction Worker (future use); and Residential (additional scenario – not considered to be plausible).

Exposure to surface soil only is considered for this EU, as no COPCs were retained for subsurface soil (refer to Section 6.2).

Recreational - Current Use and Future Use

The recreational scenarios for EU 3 are the same as the current use recreational scenario described for EU 1. Refer to Section 6.3.3.1.3.

Construction Worker – Future Use

The construction scenario in the Mudflats was assumed to consist of a one-year construction cycle, 40 hrs/wk, for a total of 2,000 hrs. The fraction of time for this (assumed all outdoors) is: 2,000 hrs/8,760 hrs = 0.23. Other parameters (inhalation rate, dust loading, etc.) are established in Section 6.3.3.1.1 for EU 1. (Refer to Appendix C-2).

Industrial Worker Scenario

The industrial worker is a likely future use for the Mudflats. If the land is developed for commercial or industrial use, it will likely be paved, thus greatly reducing the potential for exposure to radioactive materials. The industrial worker is assumed to be onsite 8 hours per day, spending 1 hour outdoors and 7 hours indoors, for 250 days each year giving an onsite time fraction of 0.20 indoors and 0.029 outdoors. The exposure duration was set to 6.6 years based on EPA's 1997 Exposure Factors Handbook (EPA 1997). (Refer to Appendix C-2).

The inhalation rate assumes an hourly average worker inhalation rate of 1.3 m^3/hr (EPA 1997). Dust loading uses the same ambient conditions as the recreational user (refer to Section 6.3.3.1.1). Incidental soil ingestion was assumed to be 36.5 g/yr for the RME case (ANL 2001) and 18.25 g/yr for the CT case (EPA 1997).

Resident – Additional Scenario

Residential use of the Mudflats is not considered to be likely; however, it is considered to provide an upper bound on risk estimates. Both an adult and a child receptor are considered.

The residential scenario assumes a "backyard gardener" with consumption of fruit, vegetables, and grains grown at the residence (assumed to be 5%), but with no on-site production of milk, meat, poultry, or seafood. Additionally, as has been discussed, groundwater at the Site is not considered to be potable. See Appendix C-2 for a complete description of the residential parameters.

Resident – Adult

For the adult, dust loading of 0.006 g/m^3 (30 percent respirable) was assumed. Fraction of time indoors was assumed to be 0.66, based on 350 days/yr present at home and 16.4 hrs/day spent indoors (EPA 1997). Fraction of time outdoors was assumed to be 0.08, based on 350 days/yr at home, and 2 hrs/day spent outdoors (EPA 1997).

For the adult RME case, duration of exposure was set to 30 years, representing the 96th percentile of time spent at a single residence (EPA 1997). An inhalation rate of 8,400 m^3/yr was assumed (ANL 2001). Soil ingestion was assumed to be 100 g/day (ANL 2001), homegrown fruit and vegetable intake was assumed to be 452 kg/yr, representing the 95th percentile of intake (EPA 1997), and leafy vegetable intake was assumed to be 14 kg/year (ANL 2001). Body weight was assumed to be 70 kg.

For the adult CT case, duration of exposure was set to 9 years, representing the 50th percentile of time spent at a single residence (EPA 1997). An inhalation rate of 5,550 m^3/yr was assumed (EPA 1997). Soil ingestion was assumed to be 50 g/day (EPA 1997), homegrown fruit and vegetable intake was assumed to be 115 kg/yr, representing the mean intake (EPA 1997). Leafy vegetable intake was assumed to be 8 kg/yr, representing the mean intake (EPA 1997). Body weight was assumed to be 70 kg.

Resident – Child

For the child, dust loading of 0.006 g/m^3 (30 percent respirable) was assumed. Duration was set to six years. Fraction of time indoors was assumed to be 0.74, based on 350 days/yr present at home and 19 hrs/day (weekdays) and 17 hours/day (weekends) spent indoors (EPA 1997). Fraction of time outdoors was assumed to be 0.22, based on 350 days/yr at home, and 5 hours/day (weekdays) and 7 hours/day (weekends) spent outdoors (EPA 1997).

For the child RME case, an inhalation rate of 4,800 m^3/yr was assumed (based on ANL 2001 and EPA 1997). Soil ingestion was assumed to be 200 g/day (ANL 2001), homegrown fruit and vegetable intake was assumed to be 99 kg/day, representing the 95th percentile of intake (EPA 1997), and leafy vegetable intake was assumed to be 3 kg/year (ANL 2001). Body weight was assumed to be 15 kg.

For the child CT case, an inhalation rate of 3180 m^3/yr was assumed (EPA 1997). Soil ingestion was assumed to be 50 g/day (EPA 1997), homegrown fruit and vegetable intake was assumed to be 24.8 kg/day, representing the mean intake (EPA 1997). Leafy vegetable intake was assumed to be 1.7 kg/yr, representing the mean intake (EPA 1997). Body weight was assumed to be 15 kg.

6.3.3.1.4 Exposure Unit 4

Exposure Unit 4 consists of the southern portion of the Mudflats which encompasses the Class 3 Area B (refer to Figures 6-1 and 6-2). The approximate area of this EU is 100,000 m^2.

Exposure scenarios developed for EU 4 are the same as for EU 3.

Exposure to surface and subsurface soil is considered in this EU for future activities, as these activities may bring soil that is correctly considered subsurface, to the surface.

6.3.3.1.5 Exposure Unit 5

Exposure Unit 5 consists of the portion of the Mudflats which encompasses the vicinity of Area C (refer to Figure 6-2). The approximate area of this EU is 15,000 m^2.

Exposure scenarios and parameters developed for EU 5 are the same as for EU 3.

Exposure to surface and subsurface soil is considered in this EU for future activities, as these activities may bring soil that is currently considered subsurface, to the surface.

6.3.3.1.6 Exposure Unit 6

Exposure Unit 6 consists of the Site groundwater. No exposure pathways were identified for this source, since site groundwater is not potable. No scenarios are considered for exposure to Site groundwater.

6.3.3.2 Exposure Point Concentrations

Statistical analysis was performed on the radiological data sets by sub-areas to determine the normality of the data set. If the analyte passed the Shapiro-Wilk statistical test for normalcy (SAS 1990), the untransformed data were used to calculate the mean and UCL95 concentrations. Otherwise, the measured results were assumed to be log normally distributed and were transformed before use.

Exposure point concentrations of contaminants must be determined for quantitative health risk assessment. This may be accomplished by analyzing samples collected from locations where human receptors may come into contact with the contaminants or by onsite measurements with radiation detection instruments. When laboratory analysis or onsite measurement data are not available, exposure point concentrations may be estimated using a variety of modeling techniques.

In order to quantify exposure to each receptor, an EPC, or the estimate of the constituent concentration a receptor is likely to come in contact with over the duration of exposure, was calculated. For both the CT and the RME scenarios, the UCL95 of the arithmetic mean was calculated according to the guidance provided in the *Supplemental Guidance to RAGS: Calculating the Concentration Term* (EPA 1992) and used as the EPC. However, when the UCL95 for a COPC was greater than the maximum detected value for that COPC the maximum detected value was used as the EPC, not the UCL95. The distribution for each data set was tested for normality using the Shapiro-Wilk normality test. The equations used to calculate the UCL95 for normal and log normal data sets are presented below.

The UCL95 of the arithmetic mean for normal distribution was calculated as follows:

$$UCL95 = \mu + t\,(s/n^{1/2})$$

where:

UCL95	=	upper confidence limit
t	=	Student t statistic
s	=	standard deviation
n	=	number of data
μ	=	mean of data results

The UCL95 of the arithmetic mean for a log normal distribution was calculated using the following equation:

$$UCL = e^{\mu + 0.5s^2 + sH/((n-1)^{1/2})}$$

where:

UCL	=	upper confidence limit
H	=	H statistic
s	=	standard deviation
n	=	number of data
e	=	exponential constant
μ	=	mean of data results

The exposure concentrations defined above were used to estimate the intake of each COPC to individual receptors via all pathways and medium proposed in the conceptual model.

For the Tonawanda Landfill Vicinity Property, only soil has been identified as a source for which complete exposure pathways exist. Surface soil EPCs for each of the EUs and subsurface soil EPCs for EUs 4 and 5 are developed in Tables 6-6 and 6-7.

6.3.3.3 Uranium Chemical Toxicity

Exposure to uranium for the purposes of determining the chemical health effects (kidney toxicity) assumes soil ingestion is the primary pathway.

Incidental ingestion of soils and sediments was estimated using the following equation:

$$\textit{Constituent Intake (mg / kg – d)} = \frac{C_s \times IR_s \times CF \times EF \times ED}{BW \times AT}$$

where:

C_s	=	constituent concentration in soils or sediments (mg/kg)
IR_s	=	ingestion rate (mg soil/day)
CF	=	conversion factor (10^{-6} kg/mg)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days) (365 days x ED)

Parameter values for use in this equation are described in the preceding sections and are provided in Appendix C1.

6.4 Toxicity Assessment

This section briefly details the radiological and chemical toxicity of the COPCs at the Tonawanda Landfill Vicinity Property. These COPCs consist of several radionuclides, which are all considered to be carcinogens. The only COPC that also has a chemical toxicity is uranium, which is believed to affect the kidneys (EPA 1993b).

Toxicity assessment for contaminants found at Superfund sites is generally accomplished in two steps: hazard identification and dose-response assessment. These two steps are discussed in the EPA Risk Assessment Guidance for Superfund (EPA 1989). The first step, hazard identification, is the process of determining whether exposure to an agent can cause an increase in the incidence of a particular adverse health effect (e.g., cancer, birth defect) and whether the adverse health effect is likely to occur in humans. Hazard identification involves characterizing the nature and strength of the evidence of causation. The second step, dose-response evaluation, is the process of quantitatively evaluating the toxicity information and characterizing the relationship between the dose of the contaminant administered or received and the incidence of adverse health effects in the exposed population. From this quantitative dose-response relationship, toxicity values (e.g., reference doses and slope factors) are derived that can be used to estimate the incidence or potential for adverse effects as a function of human exposure to the agent. These toxicity values are used in the risk characterization step to estimate the likelihood of adverse effects occurring in humans at different exposure levels.

6.4.1 Radiation Toxicity

All radioactive constituents are considered to be carcinogens. Radium is considered to be a Group A human carcinogen (Agency for Toxic Substances and Disease Registry - ATSDR 1990). To estimate radiological risk, the RESRAD code utilizes Health Effects Assessment Summary Tables (HEAST) CSF values. These slope factors are presented in units of risk per pCi (internal pathways) or risk per year per pCi/g (external pathway).

The RESRAD code utilizes conversion factors from EPA Federal Guidance Reports 11 and 12 (Eckerman 1988, Eckerman 1993) to estimate radiological dose. These factors are presented in units of millirem (mrem) per pCi (internal pathways) or mrem per year per pCi/g (external pathway). Cancer risk is calculated using FGR 13 cancer risk coefficients (Eckerman 1999).

6.4.2 Uranium Chemical Toxicity

Uranium is has been shown to be chemically toxic, primarily affecting the kidneys. Animal studies reported effects on the kidney from chronic inhalation and oral exposure to uranium (ATSDR 1989). The reference dose (RfD) for uranium (soluble salts) is 0.003 mg/kg/d[EPA Integrated Risk Information System (IRIS)]. This is a non-cancer effect, so no cancer slope factor is associated with uranium toxicity.

6.5 Risk Characterization

This section presents the current and future risk projections for human receptors at the Tonawanda Landfill Vicinity Property.

For the radiological assessment, carcinogenic risk is defined as the incremental lifetime probability of cancer morbidity and does not include genetic or noncarcinogenic effects. Cancer risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of pathway-specific exposure to carcinogenic contaminants. The non-carcinogenic risk due to uranium is expressed with the Hazard Index, which compares uranium intake to the reference dose.

6.5.1 Risk Characterization Methodology And Assumptions

Assumptions describing risk characterization methodology are described in the following sections. The assumptions are more completely described in Appendix B.

6.5.1.1 Radiological Risks

Exposures to low levels of ionizing radiation could result in cancer induction, serious genetic effects, and other detrimental health effects. The predominant health concern associated with the radioactive contaminants at the Tonawanda Landfill Vicinity Property is the induction of cancer. The radiological health risks presented in the BRA are limited to this concern. This approach is consistent with EPA guidance (EPA 1989).

The methodology used in the RESRAD code for estimating cancer risks follows the EPA risk assessment guidance (EPA 1989) and is presented in detail in Appendix N of the RESRAD User's Manual (ANL 2001). Risk characterization integrates the findings of the exposure assessment and toxicity assessment to estimate the likelihood that a receptor will experience cancer as a result of exposure to radiological COPCs. Risks were calculated from toxicity information and the results of the exposure assessment. Total risk refers to risk associated with all radiological COPCs in an exposure unit. Site-related risk refers to the risk associated with the COPCs as a result of site-related activity. Contributions from background are not included in these evaluations.

Specifically, when the gross EPC was larger than the background UTL, average background was subtracted producing a net EPC. Otherwise, the net EPC was assumed to be zero. The incremental lifetime cancer risk (ILCR) was calculated using RESRAD and compared to the range specified in the EPA RAGS (EPA 1989) of 10^{-6} to 10^{-4} , or 1 in 1,000,000 to 1 in 10,000 persons developing a fatal cancer. The RESRAD code provides estimates of ILCR by radionuclide and pathway. Radiological dose estimates in mrem/yr also are provided for comparison against dose-based goals.

Risk was estimated using the parameter values listed in Appendix B, values listed in Appendix B, and the RESRAD code Version 6.21. Risk estimates were calculated covering a 1,000-year period because certain regulations specifically limit doses to within 1,000 years, and 40 CFR 192.02 calls for control of residual radioactive materials to be effective for up to 1,000 years. The maximum risk over this period was then selected for comparison to risk criteria.

Appendix C presents the summary of the risk calculation for each receptor and pathway. The following sections summarize the total radionuclide risk results for exposure to surface and subsurface soil. Risk is summarized in Tables 6-6.

6.5.2 Risk Estimates

For clarity of presentation, the risk estimates resulting from potential radiological and chemical exposure to uranium are presented separately in the following sections. Exposure estimates are presented for each exposure scenario for the mean receptor and the RME receptor. All exposure scenarios are described in Section 6.3. Detailed parameters for each scenario are provided in Appendix B. EPCs used in these scenarios are listed in Tables 6-2 and 6-3.

Tables 6-6 and 6-7 present the doses and risks for the EU-specific exposure scenarios. Risks are presented for various times, up to 1000 years in the future. Due to the decay of Th-230 to Ra-226, the maximum risk often occurs at 1000 years where Th-230 is a dominant constituent. The timing of the maximum risk depends on the radionuclide mix being considered.

If the total risk exceeds the 10^{-4} upper risk range, then COCs are defined as all radionuclides with a risk in excess of 10^{-6}.

6.5.2.1 Exposure Unit 1

6.5.2.1.1 Recreational User

The total excess cancer risks for exposure to surface soil are 1.3×10^{-4} (RME) and 1.9×10^{-5} (CT) as presented in Table 6-6. The corresponding calculated radiological dose rates for the current recreational user are 6.0 mrem/yr (RME) and 2.8 mrem/yr (CT) as presented in Table 6-7. Non-carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium are less than 1.0 as presented in Table 6-8, thus uranium metal is not identified as a COC in EU-1 for the recreational user.

Since the RME risk is greater than 1×10^{-4}, COCs are defined for those COPCs with producing a risk greater than 1×10^{-6}. Risk-based COC defined for EU-1 and the recreational scenario are Pb-210 and Ra-226. Since a recreational user is not expected to be exposed to subsurface soil no risks were calculated for subsurface soils within EU-1.

The BRA includes new data and considers additional potential receptors not considered in the 1999 HHA. The BRA considers the RME exposure duration to be 30 years, whereas the 1999 HHA assumed a nine-year exposure duration. Additionally, the RI data results in a generally lower source term than the 1999 HHA. As a result, the doses calculated in the 1999 HHA are higher than in the BRA, but the risks are higher in the BRA.

6.5.2.1.2 Construction Worker

The total excess cancer risks for a construction worker exposed to surface soil in EU-1 are 9.1×10^{-5} (RME) and 8.8×10^{-5} (CT) as presented in Table 6-6. The corresponding calculated maximum dose rates exposure to surface soil user are 130 mrem/yr (RME) and 120 mrem/yr (CT) as presented in Table 6-7. HI estimates for exposure to uranium metal are less than 1.0 as presented in Table 6-8, thus uranium metal is not identified as a COC in EU-1 for the construction worker.

Since the RME risk is less than 1×10^{-4} and the HI is less than 1.0, no risk-based COCs are defined for the construction worker in EU-1. However, the RME and CT doses for surface and subsurface soils are greater than 25 mrem/yr due to exposures to Pb-210 and Ra-226 (no other radionuclide produces a dose greater than 1 mrem/yr). Therefore, Pb-210 and Ra-226 are identified as COCs for the construction worker in EU-1.

6.5.2.2 Exposure Unit 2

6.5.2.2.1 Recreational User

No COPCs are identified for surface soil in EU-2, therefore, all risks and doses are acceptable as presented in Tables 6-6 and Table 6-7, respectively. Uranium was not retained as a surface or subsurface soil COPC so the non-carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium metal are zero as presented in Table 6-8, thus uranium metal is not identified as a COC in EU-2 for the recreational user. The recreational user is not expected to be exposed to subsurface soil so no risks were calculated for subsurface soils within EU-2.

Since no COPCs we identified for EU-2 surface soil no COCs were identified. Since a recreational user is not expected to be exposed to subsurface soil no risks were calculated for subsurface soils within EU-2.

6.5.2.2.2 Construction Worker

This scenario considers a future construction worker working for one year in EU-2. Exposure to both surface and subsurface soils was considered. No COPCs are identified for surface soil in EU-2, therefore, all risks and doses are acceptable as presented in Tables 6-6 and Table 6-7, respectively. The total excess cancer risk is for a construction worker exposed to subsurface soil in EU-2 is 1.7×10^{-7} (RME) and 1.6×10^{-7}(CT). The difference between the RME and CT scenarios was only in the value of the incidental soil ingestion rate, which is not a significant pathway. Calculated risks are below the EPA risk threshold of 10^{-6}. This scenario considers the construction worker placing the cap on the landfill. The corresponding calculated maximum dose rates for the future construction worker exposed to subsurface soil are 0.64 mrem/yr (RME) and 0.52 mrem/yr (CT) and are presented in Table 6-7.

No COCs were identified within EU-2 for this land use scenario.

6.5.2.3 Exposure Unit 3

6.5.2.3.1 Recreational User

No MED-like COPCs are identified for surface soil in EU-3, therefore, all risks and doses are acceptable as presented in Tables 6-6 and Table 6-7, respectively. Uranium was not retained as a surface soil and subsurface COPC so the non-carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium metal are zero as presented in Table 6-8, thus uranium metal is not identified as a COC in EU-3 for the recreational user. Since a recreational user is not expected to be exposed to subsurface soil no risks were calculated for subsurface soils within EU-3.

No COCs were identified in surficial soil within EU-3 for this land use scenario.

6.5.2.3.2 Construction Worker

This scenario considers a future construction worker working for one year in EU-3. No COPCs are identified for surface soil in EU-3 therefore, all risks and doses are acceptable as presented in Tables 6-6 and Table 6-7, respectively. The total excess cancer risk is for a construction worker exposed to subsurface soil in EU-3 is 1.8×10^{-7} for both the RME and CT scenario. The corresponding radiological dose rates for the construction worker exposed to subsurface soil in EU-3 was 0.26 mrem/yr (RME) and 0.25 mrem/yr (CT). Total uranium was not retained as a surface soil and subsurface COPC so the non-

carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium metal are zero as presented in Table 6-8, thus uranium metal is not identified as a COC in EU-3 for the recreational user.

No COCs were identified for surface soils within EU-3 for this land use scenario.

6.5.2.3.3 Industrial Worker

This scenario considers a future industrial worker working at a future facility in EU-3. No COPCs are identified for surface soil in EU-3, therefore, all risks and doses are acceptable as presented in Tables 6-6 and Table 6-7, respectively. The total excess cancer risk is for exposure to subsurface soil was 3.7×10^{-7} for both the RME and CT scenarios. Calculated risks are below the EPA risk range of 10^{-6} to 10^{-4}. The corresponding radiological dose rates for the future industrial worker exposed to subsurface soil was 0.11 mrem/yr for both the RME and CT scenarios. Uranium was not retained as a surface soil and subsurface COPC so the non-carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium metal are zero as presented in Table 6-8. Thus uranium metal is not identified as a COC in EU-3 for the industrial worker.

No COCs were identified for surface or subsurface soils within EU-3 for this land use scenario.

6.5.2.3.4 Resident – Adult

This scenario considers a resident adult living in EU-3. This is not considered to be a plausible scenario. No MED-like COPCs are identified for surface soil in EU-3, therefore, all risks and doses are acceptable as presented in Tables 6-6 and Table 6-7, respectively. The total excess cancer risks for a resident adult exposed to subsurface soil are 8.2×10^{-6} (RME) and 1.6×10^{-6} (CT). The calculated RME risk for the resident adult falls within the EPA risk range of 10^{-6} to 10^{-4}. The corresponding radiological dose rates for the resident adult exposed to subsurface soil are 0.37 mrem/yr (RME) and 0.36 mrem/yr (CT). Corresponding radiological dose rates are presented in Table 6-7. Uranium (U-total) was not retained as a surface soil and subsurface COPC so the non-carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium metal are zero as presented in Table 6-8. Thus uranium metal is not identified as a COC in EU-3 for the resident adult.

No COCs were identified for surface or subsurface soil within EU-3 for this land use scenario. The dominant pathway was plant ingestion.

6.5.2.3.5 Resident – Child

This scenario considers a resident child living in EU-3. This is not considered to be a plausible scenario. No COPCs are identified for surface soil in EU-3, therefore, all risks and doses are acceptable as presented in Tables 6-6 and Table 6-7, respectively. The total excess cancer risks for a resident child exposed to subsurface soil in EU-3 are 1.7×10^{-6} for both the RME and CT scenario. The calculated RME risk for the resident child falls within the EPA risk range of 10^{-6} to 10^{-4}. The corresponding radiological dose rates for the resident child exposed to subsurface soil in EU-3 are 0.55 mrem/yr (RME) and 0.54 mrem/yr (CT). Corresponding maximum dose rates are presented in Table 6-7. Uranium (U-total) was not retained as a surface soil and subsurface COPC so the non-carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium metal are zero as presented in Table 6-8. Thus uranium metal is not identified as a COC in EU-3 for the resident child.

No COCs were identified for surface or subsurface soil within EU-3 for the RME and CT scenarios for this land use scenario. The dominant pathway was plant ingestion.

6.5.2.4 Exposure Unit 4

6.5.2.4.1 Recreational User

The scenario considers a recreational user in EU-4. The recreational user is expected to only be exposed to surface soil. The total excess cancer risks for a recreational user exposed to surface soil within EU-4 are 1.1×10^{-7} (RME) and 2.8×10^{-8} (CT). Calculated risks are below the EPA risk threshold of 10^{-6}. The corresponding radiological dose rates for the recreational user exposed to surface soil are 0.0074 mrem/yr (RME) and 0.0035 mrem/yr (CT). Corresponding radiological dose rates are presented in Table 6-7. Total uranium was not retained as a surface soil and subsurface COPC so the non-carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium metal are zero as presented in Table 6-8.

No COCs were identified for surface and subsurface soils within EU-4 for this land use scenario.

6.5.2.4.2 Construction Worker

This scenario considers a future construction worker working for one year in EU-4. Exposure to both surface and subsurface soils was considered. The total excess cancer risks for a construction worker exposed to surface soil within EU-4 are 1.1×10^{-7} for both the RME and CT scenarios. The total excess cancer risks for a construction worker exposed to subsurface soil within EU-4 are 3.7×10^{-7} for both the RME and CT scenarios. Calculated risks are below the EPA risk threshold of 10^{-6}. The corresponding radiological dose rates for the construction worker exposed to surface soil are 0.15 mrem/yr (RME) and 0.014 mrem/yr (CT). The corresponding calculated maximum dose rates for the construction worker exposed to subsurface soil are 0.52 mrem/yr (RME) and 0.051 mrem/yr (CT). Corresponding radiological dose rates are presented in Table 6-7. Total uranium was not retained as a surface soil and subsurface COPC so the non-carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium metal are zero as presented in Table 6-8.

No COCs were identified for surface and subsurface soils within EU-4 for this land use scenario.

6.5.2.4.3 Industrial Worker

This scenario considers a future industrial worker working at a future facility in EU-4. The total excess cancer risks for an industrial worker exposed to surface soil are 4.1×10^{-7} (RME) and 4.0×10^{-7} (CT). The total excess cancer risks for an industrial worker exposed to subsurface soil are 1.1×10^{-6} for both the RME and CT scenarios. Refer to Table 6-6 for RME and CT results. Calculated risks are within the EPA risk range of 10^{-6} to 10^{-4}. The corresponding radiological dose rates for the industrial worker exposed to surface soil are 0.068 mrem/yr (RME) and 0.067 mrem/yr (CT). Corresponding maximum dose rates are presented in Table 6-7. Total uranium was not retained as a surface soil and subsurface COPC so the non-carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium metal are zero as presented in Table 6-8.

No COCs were identified for surface or subsurface soils within EU-4 for this land use scenario.

6.5.2.4.4 Resident – Adult

This scenario considers a resident adult living in EU-4. This is not considered to be a plausible scenario. Exposure to both surface and subsurface soils (e.g., to account for the ground being turned over during excavation) is considered. The total excess cancer risks for a resident adult exposed to surface soil are 4.0 x 10^{-6} (RME) and 1.8 x 10^{-6} (CT). The total excess cancer risks for a resident adult exposed to subsurface soil are 2.1 x 10^{-5} (RME) and 5.1 x 10^{-6} (CT). Refer to Table 6-6 for RME and CT results. Calculated risks are within or below the EPA risk range of 10^{-6} to 10^{-4}. The corresponding radiological dose rates for the resident adult exposed to surface soil are 0.32 mrem/yr (RME) and 0.24 mrem/yr (CT). The corresponding radiological dose rates for the resident adult exposed to subsurface soil are 0.89 mrem/yr (RME) and 0.76 mrem/yr (CT). Corresponding radiological dose rates are presented in Table 6-7. Total uranium was not retained as a surface soil and subsurface COPC so the non-carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium metal are zero as presented in Table 6-8.

No COCs were identified for surface or subsurface soils within EU 4 for this land use scenario.

6.5.2.4.5 Resident – Child

This scenario considers a resident child living in EU-4. This is not considered to be a plausible scenario. Exposure to both surface and subsurface soils (e.g., to account for the ground being turned over during excavation) is considered. The total excess cancer risks for a resident child exposed to surface soil in EU-4 are 1.9 x 10^{-6} (RME) and 1.8 x 10^{-6} (CT). The total excess cancer risks for a resident child exposed to subsurface soil in EU-4 are 5.0 x 10^{-6} (RME) and 4.8 x 10^{-6} (CT). Refer to Table 6-6 for RME and CT results. Calculated risks are within the EPA risk range of 10^{-6} to 10^{-4}. The corresponding radiological dose rates for the resident child are 0.35 mrem/yr (RME) and 0.33 mrem/yr (CT). The corresponding radiological dose rates for the resident child exposed to subsurface soil are 1.1 mrem/yr for both the RME and CT scenarios. Corresponding maximum dose rates are presented in Table 6-7. Total uranium was not retained as a surface soil and subsurface COPC so the non-carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium metal are zero as presented in Table 6-8.

No COCs were identified in surface or subsurface soils at EU 4 for this land use scenario.

6.5.2.5 Exposure Unit 5

6.5.2.5.1 Recreational

The scenario considers a recreational user in EU-5. The recreational user is expected to only be exposed to surface soil. The total excess cancer risks for a recreational user exposed to surface soil within EU-5 are 3.0 x 10^{-7} (RME) and 4.8 x 10^{-8} (CT). Calculated risks are below the EPA risk threshold of 10^{-6}. The corresponding radiological dose rates for the recreational user exposed to surface soil in EU-5 are 0.013 mrem/yr (RME) and 0.0062 mrem/yr (CT). Corresponding radiological dose rates are presented in Table 6-7. Total uranium was not retained as a surface soil COPC so the non-carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium metal are zero as presented in Table 6-8.

No COCs were identified for surface soils within EU-5 for this land use scenario

6.5.2.5.2 Construction Worker

This scenario considers a future construction worker working for one year in EU-5. Exposure to both surface and subsurface soils was considered. The total excess cancer risks for a construction worker

exposed to surface soil in EU-5 are 2.0 x 10^{-7} (RME) and 1.9 x 10^{-7} (CT). The total excess cancer risks for a construction worker exposed to subsurface soil in EU-5 are 9.9 x 10^{-7} (RME) and 9.5 x 10^{-7} (CT). Refer to Table 6-6 for RME and CT results. Calculated risks are below the EPA risk range of 10^{-6} to 10^{-4}. The corresponding radiological dose rates for the construction worker exposed to surface soil are 0.29 mrem/yr (RME) and 0.27 mrem/yr (CT). The corresponding radiological dose rates for the construction worker exposed to subsurface soil are 0.1.4 mrem/yr (RME) and 1.3 mrem/yr (CT). Corresponding maximum dose rates are presented in Table 6-7.

No COCs were identified in surface or subsurface soils at EU 5 for this land use scenario.

6.5.2.5.3 Industrial Worker

This scenario considers a future industrial worker working at a future facility in EU-5. The total excess cancer risks for an industrial worker exposed to surface soil are 6.0 x 10^{-7} (RME) and 5.9 x 10^{-7} (CT). The difference between the RME and CT scenarios was only in the value of the incidental soil ingestion rate, which is not a significant pathway. Refer to Table 6-6 for RME and CT results. Calculated risks are below the EPA risk range of 10^{-6} to 10^{-4}. The corresponding radiological dose rates for the industrial worker exposed to surface soil are 0.12 mrem/yr for both the RME and CT scenarios. Corresponding maximum dose rates are presented in Table 6-7. Total uranium was not retained as a surface soil COPC so the non-carcinogenic risk [i.e., hazard index (HI)] estimates for exposure to uranium metal is zero as presented in Table 6-8. The non-carcinogenic risk estimate for uranium in subsurface soil is less than one.

No COCs were identified for surface or subsurface soils at EU 5 for this land use scenario.

6.5.2.5.4 Resident – Adult

This scenario considers a resident adult living in EU-5. This is not considered to be a plausible scenario. Exposure to both surface and subsurface soils (e.g., to account for the ground being turned over during excavation) is considered. The total excess cancer risks for a resident adult exposed to surface soil are 1.2 x 10^{-5} (RME) and 2.8 x 10^{-6} (CT). The total excess cancer risks for a resident adult exposed to subsurface soil are 6.1 x 10^{-5} (RME) and 1.4 x 10^{-5} (CT). Calculated risks are within the EPA risk range of 10^{-6} to 10^{-4}. Refer to Table 6.6 for RME and CT results. The corresponding radiological dose rates for the resident adult exposed to surface soil are 0.68 mrem/yr (RME) and 0.46 mrem/yr (CT). The corresponding radiological dose rates for the resident adult exposed to subsurface soil are 3.3 mrem/yr (RME) and 2.2 mrem/yr (CT). Corresponding radiological dose rates are presented in Table 6-7.

No COCs were identified for surface soils within EU-5 for this land use scenario.

6.5.2.5.5 Resident – Child

This scenario considers a resident child living in EU-5. This is not considered to be a plausible scenario. Exposure to both surface and subsurface soils (e.g., to account for the ground being turned over during excavation) is considered. The total excess cancer risks for a resident child exposed to surface soil are 2.9 x 10^{-6} (RME) and 2.6 x 10^{-6} (CT). The total excess cancer risks for a resident child exposed to subsurface soil are 1.4 x 10^{-5} (RME) and 1.3 x 10^{-5} (CT). Refer to Table 6-6 for RME and CT results. The calculated RME and CT risk are within the EPA risk range of 10^{-6} to 10^{-4} for the resident child (exposure to subsurface soil) exceeds the upper limit of the EPA risk range of 10^{-6} to 10^{-4}. The corresponding radiological dose rates for the resident child exposed to surface soil are 0.69 mrem/yr (RME) and 0.61 mrem/yr (CT). The corresponding radiological dose rates for the resident child exposed

to subsurface soil are 0.3.3 mrem/yr (RME) and 0.2.9 mrem/yr (CT). Corresponding maximum dose rates are presented in Table 6-7.

No COCs were identified for surface soils within EU 5 for this land use scenario. External gamma was the dominant pathway.

6.5.3 Uranium Chemical Toxicity Assessment

As developed in Section 6.2, total uranium concentrations in Exposure Unit 1 (surface soils) and Exposure Unit 5 (subsurface soils) exceeded the EPA Region 9 PRGs (EPA 2000). Each of the exposure scenarios in Section 6.3 were assessed to determine total intake of uranium, which was compared to the uranium reference dose of 0.003 mg/kg-d (EPA 1993b) to determine the Hazard Index for uranium chemical toxicity. Only EU 1 (surface soil) and EU 5 (subsurface soil) identified U-total as a COPC for which a complete pathway exists. The uranium chemical toxicity calculations for EUs 1 and 5 are summarized in Table 6-8. The Hazard Index does not exceed one for any scenario.

6.5.4 Uncertainty Related to the Risk Estimate

The evaluation of radiological and chemical risks (uranium) to human health presented in this BRA is, by necessity, based on a number of assumptions. In addition, many uncertainties are inherent to the risk assessment process. This section provides additional discussion of the rationale for the major assumptions used in this assessment and associated uncertainties, in order to address their potential impact on the results contained herein. Uncertainties for ecological risk assessment are discussed in Section 6.6.5.

6.5.4.1 Identification of Contaminants of Concern

The identification of COCs for a human health evaluation relies on both information from site characterization activities and the application of a selection process. Considerable data have been collected for the site under the site characterization effort. The COC selection process was designed using EPA guidance to identify those contaminants that contribute most to the estimates of excess risks.

The contaminant selection screening may also introduce uncertainty. The estimated health effects could be higher if all compounds were included in the baseline assessment. To address this uncertainty, the selection process for radionuclides is designed to include all components of the measured radioactive decay series by assuming secular equilibrium. Hence, the uncertainty associated with the screening step for radiological COCs is considered to be biased toward overestimation of risk.

Soil, which is the primary focus of this assessment relative to forthcoming cleanup decisions, is considered to be fairly well characterized for identification of radiological contaminants. The radiological risks for soil were based on reported radionuclide concentrations, as provided in the RI report. Historic samples were analyzed only for selected radionuclides of the U-238 and Th-232 decay series; no other naturally occurring, accelerator-produced, or fission product radionuclides were considered. The RI data (see Section 4) includes full isotopic information for Ra, Th and U, as well as gamma scan information. However, in order to merge the historic and 2001 data sets, the conservative assumption of secular equilibrium between the radionuclides in each decay series was made. Concentrations of the associated decay products were estimated based on this assumption and included in the risk characterization. This assumption may lead to overestimation of dose and risk. The approach used in this BRA is consistent with prior BRAs conducted for the Linde Site (DOE 1993).

Chemical risks (with the exception of total uranium) were not evaluated. Even if chemical risks had been evaluated, however, cancer risks from exposures to chemicals and cancer risks from exposures to radionuclides are not additive. Therefore, the resulting radiological risk estimates would not be affected by whether or not chemical cancer risks are also evaluated.

6.5.4.2 Exposure Assessment

An exposure assessment is constructed from a number of site-specific considerations, including exposure point concentrations, scenario assumptions and intake parameters, and primary exposure pathways.

Factors that can contribute to uncertainty in exposure point concentrations include data availability and data heterogeneity. Extensive data are available for radionuclide concentrations in soil, but heterogeneity in the spatial distribution of contaminants could contribute to uncertainties when estimating appropriate exposure point concentrations. The UCL95 confidence of the mean, minus the mean background concentration, was used for the exposure point concentrations. This spatial averaging may overestimate or underestimate exposures for a receptor who may preferentially spend time at a particular location. The uncertainties related to data heterogeneity in soil remain significant and may be the most important component of total uncertainty in exposure assessment.

An additional uncertainty in the sample data relates to the volumetric distribution of the residual radioactive materials. Each data point is given equal weight in calculating the concentration statistics, although each data point does not necessarily represent a fixed volume of soil nor are sampling locations uniformly distributed throughout the site. Since many sample locations are biased toward locations of increased direct gamma activity, the sample statistics are likely to over-estimate the actual radionuclide concentrations in site soils.

The residual radioactivity is assumed (modeled) to be uniformly distributed throughout a 0.61-m (2 ft) thick layer of soil across the impacted areas. Actual site conditions are expected to be much more irregular, such that the thickness of this residual soil layer may range from several feet to a few inches. Similarly, the radionuclide concentrations are not homogeneous throughout the site. The 0.61-meter homogeneous layer assumed for this analysis represents an idealized model of actual conditions, but still provides a conservative dose estimate

In the absence of measurements needed to assess the inhalation pathway at the Site, air particulate concentrations have been modeled to estimated exposure point concentrations. Although greater uncertainty is associated with the exposures calculated for this pathway, inhalation is generally a minor contributor to radiological risks associated with the Site. Therefore, the effect of this uncertainty on the exposure assessment is considered to be small.

The method for addressing non-detects (less than values) also affects the exposure point concentrations. The inclusion of the detection limit for non-detects tends to increase the reported concentrations and resultant uncertainty. The detection limits for most analyses were low relative to background or the appropriate soil concentration guidelines. The uncertainty associated with the incorporation of non-detects is considered to be small, with the exception of Th-230. The majority of the historical Th-230 data are MDAs taken directly from the 1992 ORNL report. No data qualifiers are listed for this data, and the reported MDA values are in most cases many times the associated Ra-226 and U-238 concentrations (when equilibrium conditions are expected). As a result this data was not considered when calculating the EPCs. There are sufficient data for Th-230 from the 2001 investigation that this does not affect the representativeness of the data.

Another source of uncertainty is associated with the assumptions used to identify scenarios and intake parameters for the exposure estimates. Site-specific factors were used to select the scenario assumptions such as the extent of exposure (i.e., the exposure time, frequency, and duration) and to identify potential receptors (e.g. employees and transients).[10] These assumptions use information on current land use and reasonable projections of future land use that consider the time frame of the assessment. The uncertainty in the scenarios developed for the current conditions is low because the time period is relatively short; current land uses are expected to continue during this period.

The selection of scenarios for evaluation was based on the most reasonable future land use given the present uses and local trends. The Town of Tonawanda Landfill and the Mudflats area are currently zoned industrial by the Town of Tonawanda. Residential development in the landfill appears highly unlikely due to aesthetics and the physical health problems that may arise from residing on a closed landfill. Deed restrictions could further reduce the possibility that the land may be used for different, possibly unacceptable, land uses, such as residential or industrial. Similarly, the mudflats would be poorly suited for residential development because it is located between a major interstate highway and the landfill. Although the stated intended land uses used for this assessment are the most likely for the future, there is always an uncertainty about the potential for other land uses to occur well into the future. Should the use of the land change to where an individual is in contact with the residual radiological materials for extended periods, the risk to the individual could be unacceptable. Therefore, land use restrictions should be maintained for the longest possible period. The uncertainty in the selected scenarios is low.

Best professional judgment was used to define the variables used to estimate CT exposures and RMEs for the identified receptors. Intake parameters used in the exposure assessment were derived from data in the literature, including EPA guidelines. Since considerable information is available with respect to reasonable assumptions for intake parameters (e.g., inhalation rates), the related uncertainty is expected to be low. Furthermore, uncertainties associated with selecting values from the typical ranges identified for these parameters are not expected to significantly affect potential exposure estimates.

The exposure pathways quantified in this BRA were determined on the basis of the site conceptual model and related characterization data. The uncertainty associated with selected pathways for this assessment is low because site characterization data support the conceptual model.

6.5.4.3 Toxicity Assessment

Standard dose conversion factors and risk estimates were used to estimate the carcinogenic hazards associated with radioactive contaminants. The health effects associated with radiation exposure have been studied for decades and have been well characterized. HEAST 2001 dose conversion factors were used in RESRAD for the calculation of radiological doses. The risk estimators used in this assessment are generally accepted by the scientific community as representing reasonable projections of the hazards associated with radiation exposure.

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[10] One example is the consideration of a juvenile recreational scenario. A recreational juvenile scenario with an exposure time of 2 hrs/day for 6 months/year for an exposure duration of 6 years was initially considered but not included in the evaluation.

The juvenile scenario would result in a fraction outdoors of 0.041 (vs. the 0.012 used for the recreational scenario evaluated in the BRA), but the total exposure duration would decrease from 30 to 6 years. Evaluating this juvenile receptor would result in slightly lower overall risks (~8.9 E-05 vs. 1.3 E-04), but higher yearly doses (~19.8 mrem/year vs. 5.8 mrem/year. (Risks and doses are approximately proportional to the fraction outdoor and exposure duration, since the dominant pathway for Ra-226, the dominant radionuclide, is external gamma). Since the BRA focuses on cancer risks, the recreational scenario that was evaluated is actually more conservative than the juvenile receptor initially considered.

Human epidemiological data on carcinogenesis from exposure to ionizing radiation is more extensive than that for most chemical carcinogens. However, these data are based primarily on studies of populations exposed to radiation doses and dose rates that are orders of magnitude higher than the levels of concern at the Tonawanda Landfill Vicinity Property (e.g., atomic bomb survivors, uranium mine workers, radium dial painters). Use of these data to predict excess cancer risk from low-level radiation exposure requires extrapolation based upon very uncertain dose-response assumptions. This uncertainty is evidenced by the revision in cancer risk estimates presented in the BEIR V report (NRC 1990) by a factor of 3 to 4 over those presented only 10 years earlier in the BEIR III report (NRC 1980) due primarily to additional study of the atomic bomb survivors and reassessment of the atomic bomb dosimetry. Whereas this revision would indicate higher radiological risks than previously predicted, the BEIR V report also states that "epidemiological data cannot rigorously exclude the existence of a threshold in the millirem dose range. Thus, the possibility that there may be no risks from exposures comparable to the external natural background radiation cannot be ruled out. At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero" (NRC 1990).

6.5.4.4 Risk Characterization

Most of the assumptions built into this BRA tend to overestimate potential risks, including conservative assumptions for the exposure scenarios. Therefore, actual risks are likely to be lower than those presented in this assessment. However, some of the procedures used and uncertainties inherent in the human health assessment process may tend to underestimate potential risks, including the use of standard dose conversion factors based on adult exposures for estimating radiation doses.

The radiological dose conversion factors used in this assessment are based on the International Council on Radiation Protection (ICRP) reference man. The reference man is an adult male weighing 70 kg. The ICRP selected such a standardized individual for their dosimetry models because their main concern is associated with worker protection; the majority of radiation workers are adult males. Children are more susceptible to radiation exposure, and such effects are significant only for young children (ages 0 – 6 years). Young children are not expected to be the primary receptors of the Tonawanda Landfill Vicinity Property because they are not expected to wander out on the landfill/mudflats on their own. Therefore, while use of dose conversion factors derived for adult males may introduce some uncertainty into the risk assessment, this uncertainty is considered to be small.

The estimation of health effects associated with radiation doses was based on lifetime-average risk estimators for all routes of exposure. These lifetime-average risk estimators are appropriate because they reflect the likely conditions of exposure, i.e., any given age group could be exposed to the radioactive contaminants. For EU 1 the reported risk is 1.3×10^{-4} which is slightly above the threshold risk. However RAGS indicates that one significant figure is all that need be reported. This then would put the risk at the risk threshold. The risk associated with EU 1 is driven by a number of analyses from historical investigations located in a few spots (See Table 4-20 and Figure 6-3). The comprehensive investigation completed in 2001 evaluated these areas with both a gamma walkover and a sampling program. The levels of radionuclides found in the most recent sampling did not confirm the levels reported in earlier investigations. It is plausible that the areas involved were small or that natural and anthropogenic processes have diluted or covered these areas. Thus it is likely that no areas exceed the CERCLA risk threshold. The uncertainty associated with the risk estimates used to assess radiation toxicity in this BRA is low.

For the assessments on chemical toxicity, EPA has medium confidence on the study on which the RfD was based, since it was well designed, but used a small number of experimental animals; medium confidence in the database because there are adequate studies on the effects of uranium in various species; and consequently, medium confidence in the RfD (EPA 1993b).

6.6 Screening Ecological Risk Assessment

6.6.1 Rationale

It was assumed that terrestrial and some aquatic biota live and forage in the OUs at the Tonawanda Landfill. These biota receive both external and internal exposure to radionuclide constituents of potential concern (i.e., COPCs) in soil, sediment, and surface water. Biota of various types are assumed to receive external radiation when they are in contact with soil and other media. In addition, radionuclides in soil are bioaccumulated in soil invertebrates, which serve as food for small mammals and birds that eat the soil invertebrates. These predators bioaccumulate COPCs from their food, and thus receive internal radiation from the soil COPCs. In aquatic habitats, aquatic and sediment biota also bioaccumulate COPCs.

The approach taken in this assessment was to use screening levels developed and applied for the Painesville Ohio location (USACE 2002) for exposure of biota to radionuclides in soil, sediment, and surface water. The radionuclide-specific thresholds are for a set of radionuclides at Tonawanda similar to those at the Painesville location. The method uses screening level radiation doses that are one-tenth of the generally accepted safe daily doses for populations of soil invertebrates, mammals, and birds and sediment and surface water biota (NCRP 1991).

The scope of the Tonawanda Landfill evaluation is a screening-level risk assessment. The purpose of the screening-level risk assessment is to evaluate whether existing data justify a decision that site contaminants do not pose a risk to ecological receptors, or whether additional evaluation is necessary. The screening-level risk assessment is intentionally conservative. If no potential for risk is identified in a conservative screening-level risk assessment, then risk managers can confidently conclude that no further action (continued investigation, remediation) is required at the site.

6.6.2 Habitat

6.6.2.1 Tonawanda Habitat Overview

The Tonawanda site lies within the Beech-Maple Forest section of the Eastern Broadleaf Forest division (Bailey 1995). Eyre (1980) shows the predominant forest cover type in the Tonawanda area as elm-ash-cottonwood (locally exhibited as ash-elm-maple), surrounded by maple-beech-birch forest cover type. Black and green ash (*Fraxinus nigra* and *F. pennsylvanica* respectively); red and silver maple (*Acer rubrum* and *A saccharinum*); and American, rock, and slippery elm (*Ulmus americana*, *U. thomasii*, and *U. rubra* respectively) are typical forest trees in this area. Common associate species include eastern cottonwood (*Populus deltoides*), aspen (*Populus tremuloides* and *P. grandidentata* respectively), hawthorn (*Crataegus* sp.), pin cherry (*Prunus pennsylvanica*), and American beech (*Fagus grandifolia*). Eastern hemlock (*Tsuga canadensis*) and eastern white pine (*Pinus strobus*) were once abundant in the region but have been eliminated from the area by logging, forest fires, farming, and urban development.

Today very little actual forest habitat remains in the Tonawanda area. Urban development for residential and industrial use has eliminated any undisturbed habitat. Most natural habitat types remain only as small pockets of woodlands on or in poorly drained areas (Galvin 1979). The Town of Tonawanda Landfill

provides only minimal habitat for urban wildlife, supporting only cosmopolitan species of birds and small mammals (Ford, Bacon, and Davis Utah, Inc. 1981). Typical wildlife species include birds such as rock dove (*Columba livia*), American crow (*Corvus brachyrhynchos*), unidentified seagulls, mourning dove (*Zenaida macroura*), killdeer (*Charadrius vociferus*), European starling (*Sturnus vulgaris*), common grackle (*Quiscalus quiscula*), red-winged blackbird (*Agelaius phoeniceus*), northern (Baltimore) oriole (*Icterus galbula*), American goldfinch (*Carduelis tristis*), and American robin (*Turdus vulgaris*), and mammals such as whitetail deer (*Odocoileus virginianus*), house mouse (*Mus musculus*), Norway rat (*Rattus norvegicus*), eastern cottontail rabbit (*Sylvilagus floridanus*), eastern gray squirrel (*Sciurus niger*), raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*), and foxes (*Vulpes* sp.).

6.6.2.2 Habitat at Town of Tonawanda Landfill

Habitat at the Town of Tonawanda Landfill consists of highly disturbed area that has recently stabilized. Habitat at the landfill consists of managed grassland and open woodlands in upland areas and persistent emergent wetland vegetation in the wet areas along the drainage ditch that traverses Areas A and B. Area A includes about 2.8 acres, Area B includes about 3.5 acres, and the drainage ditch drains for 1500 feet to the southwest and eventually off of the landfill site.

The managed grassland habitat type consists largely of a mix of grasses intermingled with various herbaceous plants. Typical species include Kentucky bluegrass (*Poa pratensis*), fescue grass (*Festuca* spp.), strawberry (*Fragaria virginiana*), common yarrow (*Achillea millefolium*), old field cinquefoil (*Potentilla simplex*), flat-top fragrant-golden-rod, Canada golden-rod, wrinkled golden-rod, tall golden-rod (*Solidago altissima*), horseweed (*Conzya canadensis*), small white aster (*Aster vimineus*), hawkweed (*Hieracium* spp.), teasel (*Dipsacus sylvestris*), purple loosestrife (*Lythrum salicaria*), soft rush (*Juncus effusus*), and path rush (*Juncus tenuis*). These areas are maintained in an early successional state by periodic mowing to control invasion by woody shrubs and trees. Most of Area A and Area B consists of the managed grassland habitat type.

Open woodland habitat type includes numerous open-grown deciduous trees interspersed with grasses and herbaceous species. The canopy is open so plenty of sunlight reaches the ground between trees. Trees are large and multi-branched; canopies are full and branches typically reach the ground because shading is limited. Trees include large willows, maples, hawthorns, and black locust (*Robinia pseudoacacia*). Most of Area A and Area B consists of the open woodland habitat type.

Persistent emergent wetland vegetation grows in the drainage ditch that traverses the main part of Areas A and B, and poorly drained depressions at the site. The drainage ditch runs parallel to the fence on the north boundary and cuts right through the middle of Areas A and B. Dominant vegetation in the drainage ditch consists primarily of exotic, invasive plants that are typical of highly disturbed conditions in wet areas of the northeastern U.S. The most common plants in the drainage ditch are broad-leaved cattail (*Typha latifolia*), common reed (*Phragmites australis*), and purple loosestrife.

6.6.2.3 Habitat at Mudflats Area

The Mudflats Area is located south-southeast of Areas A and B and east of Area C. The Mudflats Area encompasses a total area of about 115 acres. Habitat at the Mudflats Area consists of large areas with a mix of grasses and herbaceous plants interspersed with areas of bare soil.

The Mudflats Area has an extensive disturbance history. The area was originally used as a borrow area for the construction of Interstate 290. This excavation left large expanses of bare soil. Most of these bare areas have since revegetated with a community composed of several grasses and herbaceous plants as

plant succession progressed. Subsequent investigations at the Mudflats Area revealed buried wastes that were eventually capped with fresh soil. These recently disturbed areas remain largely devoid of vegetation. As the area stabilizes, plants from the surrounding habitat should eventually colonize the bare areas.

Habitat at the vegetated parts of the Mudflats Area is similar to the managed grassland habitat in Areas A and B. Typical plants include Kentucky bluegrass, fescue grass, wild strawberry, common yarrow, old field cinquefoil, flat-top fragrant-golden-rod, Canada golden-rod, wrinkled golden-rod, tall golden-rod, horseweed, small white aster, hawkweed, teasel, purple loosestrife, common rush, soft rush, path rush. Trees grow in less disturbed areas on the fringe around the Mudflats Area. Tree species include large willows, maples, hawthorns, and black locust. Animal species at the Mudflats Area include of the same species, including whitetail deer, observed elsewhere at the Town of Tonawanda Landfill site.

6.6.3 Inputs and Methods

The screening level for radionuclides is a threshold "no effect" dose. The screening levels are calculated for organisms exposed to radionuclides by direct contact with the medium and by ingestion of contaminated food.

The receptors evaluated for screening were sediment invertebrates immersed in sediment, aquatic invertebrates immersed in surface water, and small fish exposed to radionuclides in sediment and surface water. The acceptable daily dose for invertebrates and fish of 1.0 rad/day (rad/d) (NCRP 1991), where 1 rad is defined as the unit of absorbed dose equal to 1 Joule/kg, is thought not to cause harm to populations of invertebrates and fish. This value was multiplied by a safety factor of 0.1 to give the target daily doses of 0.1 rad/d (USACE 2002). The radionuclide screening levels were derived for parent isotopes using the radionuclide exposure model of Sample et al. (Sample et al. 1997), and thus include internal and external exposures from absorbed energies of alpha, beta, and gamma emissions for each isotope.

Screening levels for sediment and aquatic invertebrates were calculated by methods presented by Sample et al. (Sample et al. 1997). External radiation to sediment invertebrates immersed in sediment and to aquatic invertebrates immersed in water was evaluated for beta and gamma radiation and absorption only, since alpha radiations do not penetrate media sufficiently to cause an external exposure. The calculation of screening levels for sediment and aquatic invertebrates is presented in Table 6-9. Screening levels for small fish include external radiation from sediment and surface water and internal radiation from ingested and bioconcentrated COPCs. Screening levels for sediment invertebrates, aquatic invertebrates and small fish are presented in Table 6-10. The smaller screening level for sediment was used in the evaluation of sediment, and the smaller screening level for surface water was used in the evaluation of surface water.

The acceptable daily dose for mammals of 0.1 rad/d (NCRP 1991) is thought not to cause harm to populations of mammals and birds. This value was multiplied by a safety factor of 0.1 to give the target daily doses of 0.01 rad/d. The radionuclide screening levels were derived using the radionuclide exposure model of Sample et al. (Sample et al. 1997), and thus include internal and external exposures from alpha, beta, and gamma emissions for each isotope.

For soil exposure, the organisms evaluated were terrestrial small mammals, terrestrial birds, and soil invertebrates. Small mammals and other small organisms have small living areas or home ranges; thus, exposure would be maximal compared to large mammals, such as deer, and other large organisms, such as raptors, which have large home ranges. Therefore, exposure would be minimal. For exposure of terrestrial biota at the Tonawanda Landfill, screening level concentrations were calculated by methods used at Painesville (USACE 2002). The calculation of screening levels for small mammals is presented

in Table 6-11. Screening levels for small birds were calculated by similar methods. Screening levels for soil invertebrates were used. A comparison of screening levels for small mammals, small birds, and soil invertebrates is presented in Table 6-12. Screening levels for small mammals were used in the evaluation of soil because they are smaller than screening levels for small birds and soil invertebrates. Therefore, the screen is more conservative than if birds or soil invertebrates were evaluated.

For small mammals, the screening level is the soil concentration at which the receptor receives the screening radiation dose. It is calculated by adding external and internal doses for parent and daughter radionuclides and solving the resulting dose equation for soil concentration when the dose is the screening level. This is done by dividing the screening level dose, 0.01 rad/d, by all of the factors except radionuclide concentration in the dose equation. For example, the screening level for small mammals is calculated as:

Dose = Surface external dose + Subsurface external dose + Internal dose

$= (C_s \times f_{aboveground} \times 0.7 \times 5.12\times10^{11} \times DCF \times 2) + (C_s \times 1.05 \times f_{belowground} \times 5.11\times10^{-5} \times (\text{Beta energy} + \text{Gamma energy} \times \text{Gamma absorption})) + (C_i \times BAF_{mamm} \times 5.11\times10^{-5} \times (20 \times \text{Alpha energy} + \text{Beta energy} + \text{Gamma energy} \times \text{Gamma absorption}))$ (Sample et al. 1997)

Surface —

Surface dose (rad/d) = $C_s \times f_{aboveground} \times 0.7 \times 5.12\times10^{11} \times DCF \times 2$

where:

C_s = concentration of COPC (pCi/g soil)
$f_{aboveground}$ = fraction of time animal is assumed to spend on ground surface
0.7 = roughness factor for ground surface
5.12×10^{11} = conversion factor
DCF = dose conversion factor (Eckerman and Ryman 1993)
2 = height factor to adjust for exposure close to ground surface

Subsurface —

Subsurface dose (rad/d) = $C_s \times 1.05 \times f_{belowground} \times 5.11\times10^{-5} \times (\text{Beta energy} + \text{Gamma energy} \times \text{Gamma absorption})$

where:

C_s = concentration of COPC (pCi/g soil)
1.05 = conversion factor to account for immersion in soil rather than water (Sample et al. 1997)
$f_{belowground}$ = fraction of time animal is assumed to spend on ground surface
0.0000511 = conversion factor (rad/d per pCi/g×MeV/disintegration)
Beta energy = energy of beta decay (Eckerman and Ryman 1993)
Gamma energy = energy released by change of energy level (Eckerman and Ryman 1993)
Gamma absorption = fraction of gamma energy absorbed by tissue (Blaylock et al. 1993)

Internal —

Internal dose (rad/d) = $C_i \times 5.11\times10^{-5} \times (20 \times \text{Alpha energy} + \text{Beta energy} + \text{Gamma energy} \times \text{Gamma absorption})$

where:

C_i = internal concentration of COPC
0.0000511 = conversion factor (rad/d per pCi/g×MeV/disintegration)
20 = quality factor to account for greater damage done by alpha radiation
Alpha energy = energy of alpha decay (Eckerman and Ryman 1993)
Beta energy = energy of beta decay (Eckerman and Ryman 1993)
Gamma energy = energy released by change of energy level (Eckerman and Ryman 1993)
Gamma absorption = fraction of gamma energy absorbed by tissue (Blaylock et al. 1993)

$$0.01 \text{ rad/d} = C_s \times [(f_{aboveground} \times 0.7 \times 5.12\times10^{11} \times DCF \times 2) + (1.05 \times f_{belowground} \times 5.11\times10^{-5} \times (\text{Beta energy} + \text{Gamma energy} \times \text{Gamma absorption})) + (BAFi\ BAFmamm \times 5.11\times10^{-5} \times (20 \times \text{Alpha energy} + \text{Beta energy} + \text{Gamma energy} \times \text{Gamma absorption}))]$$

and

$$C_s = 0.01 / [(f_{aboveground} \times 0.7 \times 5.12\times10^{11} \times DCF \times 2) + (1.05 \times f_{belowground} \times 5.11\times10^{-5} \times (\text{Beta energy} + \text{Gamma energy} \times \text{Gamma absorption})) + (BAFi \times BAFmamm\ 5.11\times10^{-5} \times (20 \times \text{Alpha energy} + \text{Beta energy} + \text{Gamma energy} \times \text{Gamma absorption}))]$$

Internal concentrations were calculated for soil invertebrates by multiplying the soil concentration by the bioaccumulation factor (BAFi) for each radionuclide (Table 6-11). Small mammal tissue concentrations are found by multiplying the concentration in earthworms by a bioaccumulation factor (BAFmamm) that was calculated from the ingestion-to-beef transfer factors published by Baes et al. 1984. The BAFmamm is calculated by multiplying the transfer factor (mg/kg tissue per mg ingested/d) by an estimated food consumption rate of 50 kg/d for cattle (Baes et al. 1984) to arrive at the bioaccumulation factor BAFmamm, in units of mg/kg tissue per mg/kg food. BAFmamm values are also found in Table 6-12.

6.6.3.1 Results

This section presents results of the analysis of sediment, surface water, and soil screening at the Tonawanda Landfill.

6.6.3.1.1 Sediment

Table 6-13 presents a summary of COPC concentrations in sediment from 2001 USACE Investigations along with the screening level concentrations for sediment exposure. Maximum concentrations for all COPCs were below the screening levels. Therefore, it was concluded that exposure of sediment biota to COPCs in Tonawanda Landfill sediment is unlikely to cause harm from radiation doses.

6.6.3.1.2 Surface water

Table 6-14 presents a summary of COPC concentrations in surface water from 2001 USACE Investigations along with the screening levels for surface water exposure. Maximum concentrations all COPCs were below the screening levels. Therefore, it was concluded that exposure of aquatic biota to COPCs in Tonawanda Landfill surface water is unlikely to cause harm from radiation doses.

6.6.3.1.3 Screening of Terrestrial Small Mammals

Table 6-15 presents summaries of COPC concentrations from the radiological human health assessment and the lowest of the screening levels for soil exposure (Table 6-12). Maximum concentrations of Ra-226, Th-230, and U-238 were above the screening levels. However, all maximum concentrations in the USACE samples were below the screening levels. Therefore, it was concluded that the 1999 samples required further analysis, whereas exposure of terrestrial biota to concentrations included in the 2001 USACE data is unlikely to cause harm from radiation doses.

To analyze the previous investigation samples (ORNL 1992, BNI 1995) further, each individual sample with a concentration above a screening threshold was identified. The samples identified were at locations B4, B5, B6, B7, and B12. There were one to four samples at each location, each having a different sampling depth between 0 cm and 61 cm (24 in). To ensure a conservative evaluation, the maximum concentration at each location was used in the analysis, which is shown in Table 6-16. For each COPC

and each sample location, a hazard quotient (HQ) was calculated by dividing the reported soil concentration by the concentration that would result in the maximum allowable dose. For each sample location, HQs were summed to calculate the hazard index (HI).

A summary of the HIs is presented in Table 6-17. Two samples, B5 and B7, had HIs above 1; that is, for those samples the total radiation dose was above the allowable level of 0.1 rad/d. One sample, B5, is in the area designated Area B, and the other, B7, is in the area designated Area A. Therefore, of many locations that were sampled in Area B and Area A, one sample in each sub-area, i.e., geographic sample aggregates in the landfill, had COPC concentrations that might harm populations of terrestrial receptors. Ra-226 and Th-230 were the major contributors to ecological risk, with HQs of 0.30 and 0.87, respectively, in sample B5 (HI = 1.28) and 1.34 and 2.89, respectively, in sample B7 (HI = 4.72) (see Tables 6-16 and 6-17). However, the exposure of ecological receptors moving around the landfill is much lower: the HQs for the EPCs of Ra-226 and Th-230 calculated for all samples (Table 6-15) are 0.044 and 0.087, respectively. Therefore, despite the presence of two identifiable hot spots at the landfill, because of the large number of samples in each sub-area that were below concentrations that would lead to harmful doses, it is unlikely that free-ranging terrestrial populations would be harmed by COPC exposures.

6.6.3.2 Uncertainties

A number of factors may introduce uncertainty into the risk evaluation. This section will discuss some of the major uncertainties in exposure assessment and effects assessment.

6.6.3.2.1 Exposure Assessment

The exposure assessment assumes that populations of terrestrial receptors are exposed to COPCs in soil. COPC concentrations in samples reported in the radiological human health assessment (USACE 1999a) were higher than those in samples taken at nearly the same locations in the 2001 USACE sampling. The USACE technical memorandum (USACE 1999a) indicates that some samples analyzed by Oak Ridge National Laboratories were analyzed by different methods from the methods used by USACE. The memorandum states that the Oak Ridge National Laboratories analyses may have overestimated concentrations of Ra-226 and Th-230.

External exposure is calculated by using formulas that assume that half of the receptor's time is spent below ground, with the remainder of time spent above ground. Different terrestrial receptors spend different amounts of time below ground, so there is uncertainty that external exposure of any particular species is accurately calculated. External exposures may be higher or lower than the calculated exposures. However, internal exposure is much higher than external exposure, so the uncertainty of external exposure levels has little effect on the overall exposure assessment.

Internal exposures are calculated by using bioconcentration factors from soil into food. It was assumed that soil invertebrates were more highly exposed, but bioaccumulation factors for soil invertebrates were not available. The higher of plant bioaccumulation factors and mammal bioaccumulation factors was used for each COPC; bioaccumulation into food may be higher or lower than calculated in this assessment.

6.6.3.2.2 Effects Assessment

The screening levels used in this assessment, 0.1 rad/d for sediment and aquatic biota and 0.01 rad/d for small mammals, are one-tenth of allowable concentrations that are expected not to be harmful to populations of ecological receptors, and the dose of 0.1 rad/d used to calculate HQs and HIs for small

mammals is the allowable concentration. Data on the effects of low-level exposure to radionuclides are insufficient to determine a more certain effects threshold, but it is likely that higher doses than the allowable concentrations are not harmful to populations of ecological receptors. Therefore, it is likely that the severity of effects of exposure to COPCs at the Tonawanda Landfill is overestimated.

Internal exposure to alpha radiation has a greater biological effect per pCi than exposure to beta and gamma radiation. The biological effect is adjusted by multiplying alpha radiation exposures by a "quality factor", which is 20 in the method used. There are indications that a quality factor of 5 may be more appropriate for ecological receptors (Kocher and Trabalka 2000). Therefore, internal exposure to alpha radiation, which is the predominant exposure for the COPCs at Tonawanda Landfill, may be overestimated by a factor of 4 in this assessment.

6.6.3.3 Summary

A screening risk assessment was performed for ecological receptors exposed to COPCs in sediment, surface water, and soil at Tonawanda Landfill. It followed the pattern of work in the Painesville, Ohio, RI (USACE 2002). Concentrations and exposure equations were chosen to make exposures conservative. Screening level doses were set at 0.1 rad/d for aquatic biota and 0.01 rad/d for small mammals. Each screening level was the safe daily dose published by NCRP (1991) multiplied by a safety factor of 0.1. Sediment, surface water, and soil screening levels were calculated by modeling the sum of external and internal exposures for each receptor. Maximum concentrations of COPCs were compared to the screening levels. No COPC concentration in sediment or surface water exceeded its screening level. Maximum concentrations of Ra-226, Th-230, and U-238 exceeded the screening levels in samples used for the radiological human health assessment (USACE 1999a), but no sample from the 2001 USACE data exceeded screening levels. HQs were calculated for each of the 1999 samples (5 samples) that had at least one concentration above the screening level. Each HQ was the soil concentration divided by the allowable concentration. HQs were summed to compute the HI, a measure of the total dose. Of the five samples, locations B4, B6, and B12 had HIs below 1. Locations B5 and B7 had HIs above 1 but below 5, and Location B7 had two HQs above 1. Ra-226 and Th-230 contributed the most to daily dose. It was concluded that Area B and Area A have soil concentrations that might cause harm to terrestrial receptors from radiation doses. However, average doses within those units are likely to be below doses that would harm free-ranging populations of terrestrial receptors.

Also, note that the terrestrial and wetland areas at the site are of poor quality and are not currently managed for ecological purposes, nor are there any plans to manage these areas for ecological purposes in the future. These current and future land uses will allow for minimal habitat for ecological receptors and thus minimal exposure to ecological receptors.

6.7 Summary and Conclusions

The BRA for the Tonawanda Landfill Vicinity Property utilized soil contamination data from prior and 2001 investigations by USACE to identify COPCs. These COPCs were determined using screening techniques detailed in Section 6.2, and include U-238, U-235, Th-232 and their long-lived daughter products (including Th-230 and Ra-226).

The property was divided into six exposure units to facilitate the calculation of exposure point concentrations and risks. Current and plausible future use scenarios were considered and evaluated, as detailed in Section 6.3. Completed pathways for exposure were also assessed in Section 6.3. Pathways identified as complete included exposure to external gamma radiation; exposure via inhalation of airborne particles; ingestion of soil; and ingestion of homegrown produce (for residential scenarios). EU 6, site

groundwater, was eliminated because no complete pathway existed, since the site groundwater is non-potable. The remaining exposure units were assessed for exposure to radioactive contaminants in surface and subsurface soils. Both RME and CT exposure scenarios were considered. The risk based on the RME parameters was calculated for every scenario. If the RME risk exceeded 10^{-6}, then the CT risk was also developed for that scenario. The radiological risks are summarized in Section 6.7.1, below. Risks were calculated using the RESRAD computer code.

In addition to the radiological risk, the hazard posed by the chemical toxicity of uranium was assessed. The results of this assessment are summarized in Section 6.7.4.

Finally, an ecological risk screening was performed, to assess the impact of contamination on terrestrial and aquatic biota. This assessment is detailed in Section 6.6, and summarized in Section 6.7.5.

6.7.1 Radiological Risk

Radiological risks are summarized by exposure unit and scenario in Table 6-18 (RME) and Table 6-19 (CT). These results indicate that for current and plausible future scenarios, all excess cancer risks except one are less than the 10^{-4} risk threshold. The risk for the recreational user, in EU 1, is at the CERCLA risk threshold. As discussed in the Uncertainty section this risk is driven by a few hot spots derived from historical data which were not confirmed in the 2001 investigation and sampling. It is likely therefore that the risk level is well below the CERCLA risk threshold for all plausible scenarios.

Additional resident adult and child scenarios for EU's 3 ,4 and 5 were also considered. Risks for these scenarios all were below the 10^{-4} CERCLA risk threshold.

6.7.2 Contaminants of Concern

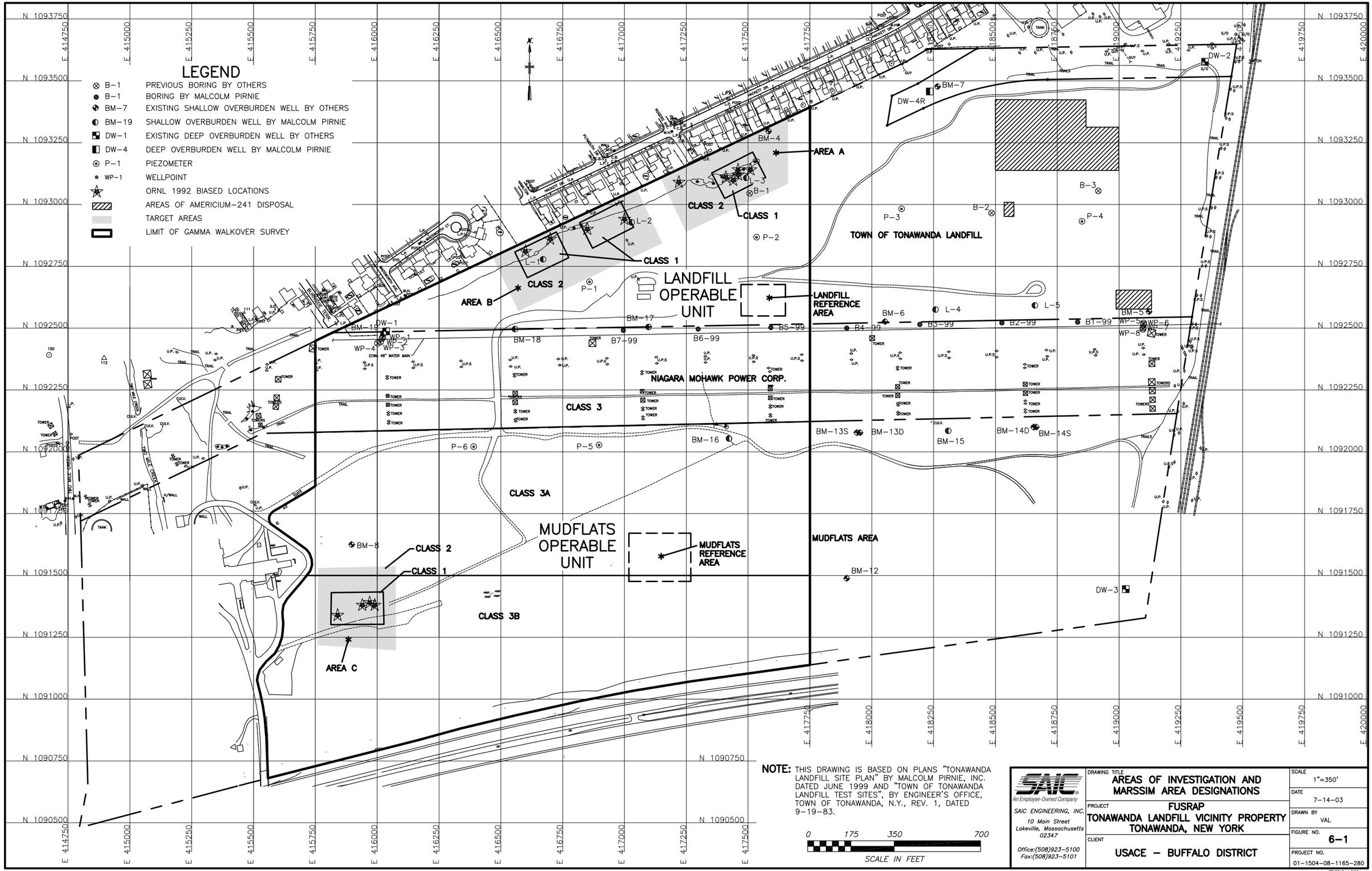
COCs were determined based on risk. If the total risk exceeded 1×10^{-4} for a given scenario, then COPCs that contributed greater than 10^{-6} were considered to be COCs. These are summarized in Table 6-20. Pb-210 and Ra-226 are the dominant radionuclides, and are COCs for surface soils for only the Recreational scenario in EU 1. No other COCs were identified for the other considered scenarios in EU 1 or for any scenarios in EU 2, 3, 4 or 5.

6.7.3 Chemical Toxicity

Uranium is a kidney toxin at concentrations slightly above background levels, and is the only radionuclide for which the chemical toxicity has been identified to be comparable to or greater than the radiotoxicity. Only uranium is considered as both a carcinogenic and non-carcinogenic hazard. For this reason, the radiological risk of uranium were estimated using the RESRAD code which utilizes HEAST CSF values while chemical toxicity was estimated using the RfD. Uranium toxicity did not exceed a Hazard Index of one for any scenarios.

6.7.4 Ecological Risk

The ecological risk screening identified limited areas that pose a threat to terrestrial receptors. These areas are located within Exposure Unit 1. Ecological risk will be addressed when this portion of the landfill is capped, or it will be addressed if the material is removed. Also, note that the terrestrial and wetland areas at the site are of poor quality and are not currently managed for ecological purposes, nor are there any plans to manage these areas for ecological purposes in the future. These current and future land uses will allow for minimal habitat for ecological receptors and thus minimal exposure to ecological receptors.



NOTE: THIS DRAWING IS BASED ON PLANS "TONAWANDA LANDFILL SITE PLAN" BY MALCOLM PIRNIE, INC. DATED JUNE 1999 AND "TOWN OF TONAWANDA LANDFILL TEST SITES", BY ENGINEER'S OFFICE, TOWN OF TONAWANDA, N.Y., REV. 1, DATED 9-19-83.

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DRAWING TITLE
AREAS OF INVESTIGATION AND MARSSIM AREA DESIGNATIONS

PROJECT
FUSRAP
TONAWANDA LANDFILL VICINITY PROPERTY
TONAWANDA, NEW YORK

CLIENT
USACE – BUFFALO DISTRICT

SCALE	1"=350'
DATE	7-14-03
DRAWN BY	VAL
FIGURE NO.	6-1
PROJECT NO.	01-1504-08-1165-280

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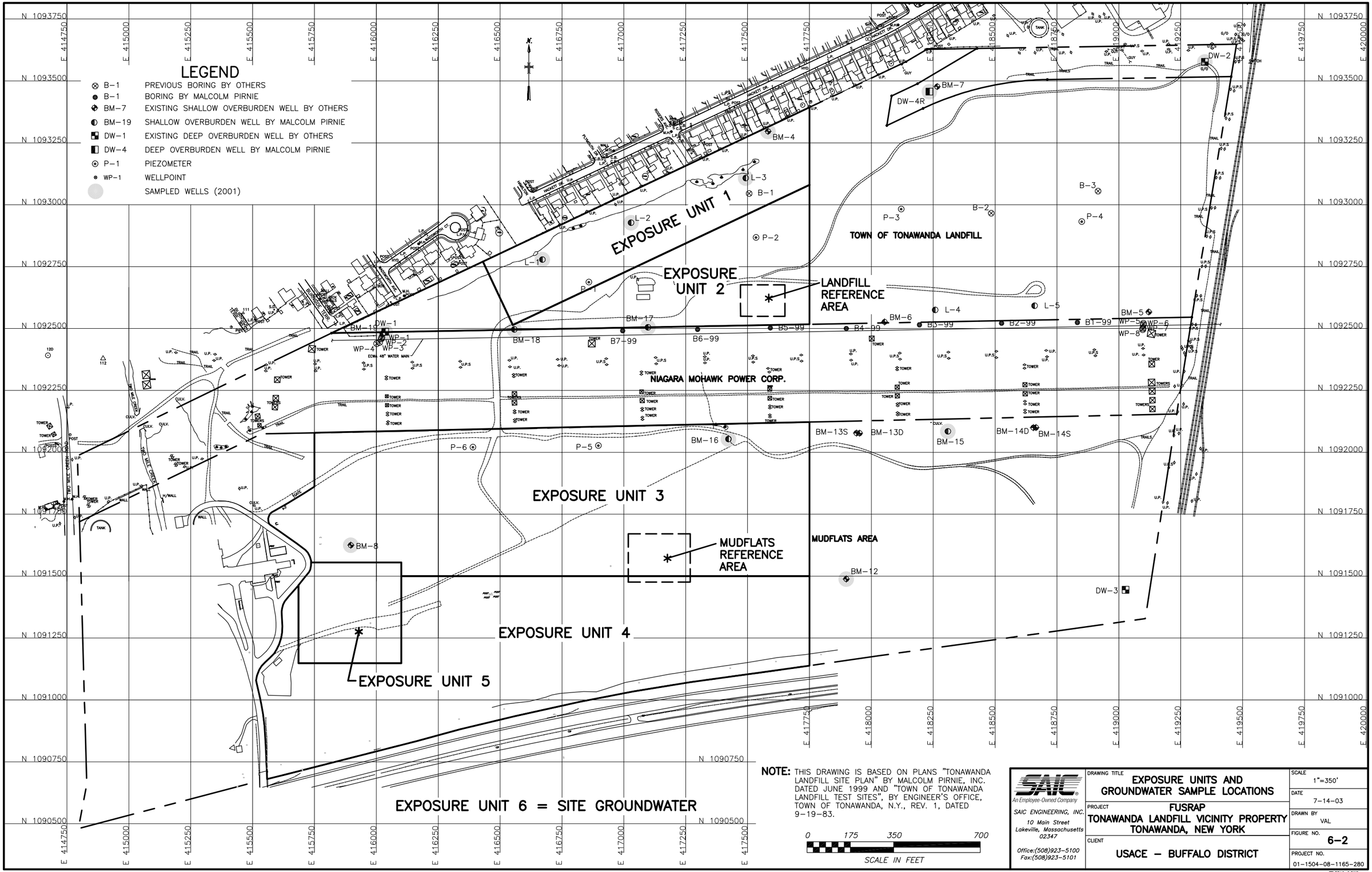

NOTE: THIS DRAWING IS BASED ON PLANS "TONAWANDA LANDFILL SITE PLAN" BY MALCOLM PIRNIE, INC. DATED JUNE 1999 AND "TOWN OF TONAWANDA LANDFILL TEST SITES", BY ENGINEER'S OFFICE, TOWN OF TONAWANDA, N.Y., REV. 1, DATED 9-19-83.

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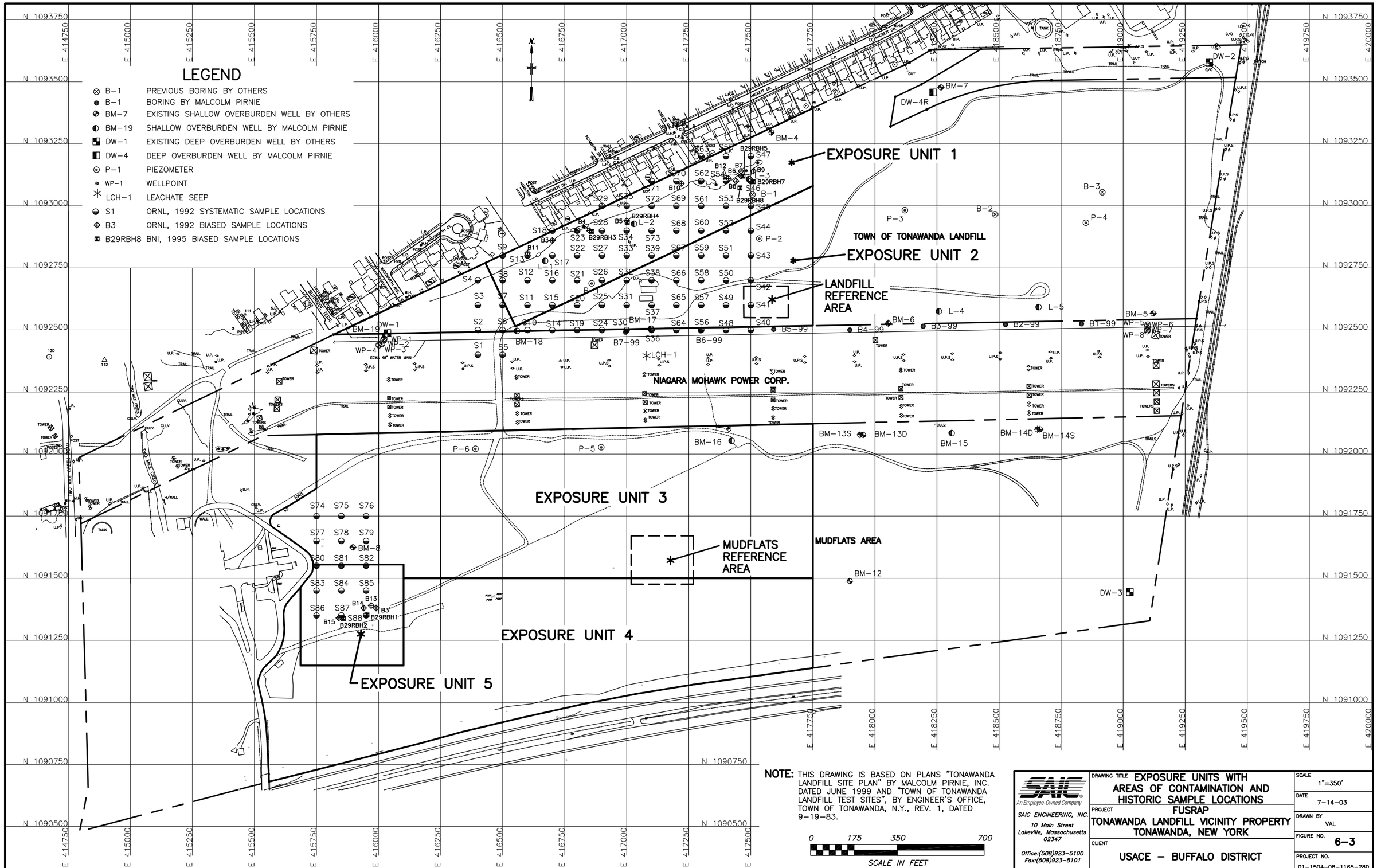
DRAWING TITLE	EXPOSURE UNITS AND GROUNDWATER SAMPLE LOCATIONS
PROJECT	FUSRAP TONAWANDA LANDFILL VICINITY PROPERTY TONAWANDA, NEW YORK
CLIENT	USACE – BUFFALO DISTRICT
SCALE	1"=350'
DATE	7-14-03
DRAWN BY	VAL
FIGURE NO.	6-2
PROJECT NO.	01-1504-08-1165-280

TTLBRA6-2.DWG



NOTE: THIS DRAWING IS BASED ON PLANS "TONAWANDA LANDFILL SITE PLAN" BY MALCOLM PIRNIE, INC. DATED JUNE 1999 AND "TOWN OF TONAWANDA LANDFILL TEST SITES", BY ENGINEER'S OFFICE, TOWN OF TONAWANDA, N.Y., REV. 1, DATED 9-19-83.

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DRAWING TITLE	EXPOSURE UNITS WITH AREAS OF CONTAMINATION AND HISTORIC SAMPLE LOCATIONS
PROJECT	FUSRAP TONAWANDA LANDFILL VICINITY PROPERTY TONAWANDA, NEW YORK
CLIENT	USACE – BUFFALO DISTRICT
SCALE	1"=350'
DATE	7-14-03
DRAWN BY	VAL
FIGURE NO.	6-3
PROJECT NO.	01-1504-08-1165-280

TTLBRA6-3.DWG

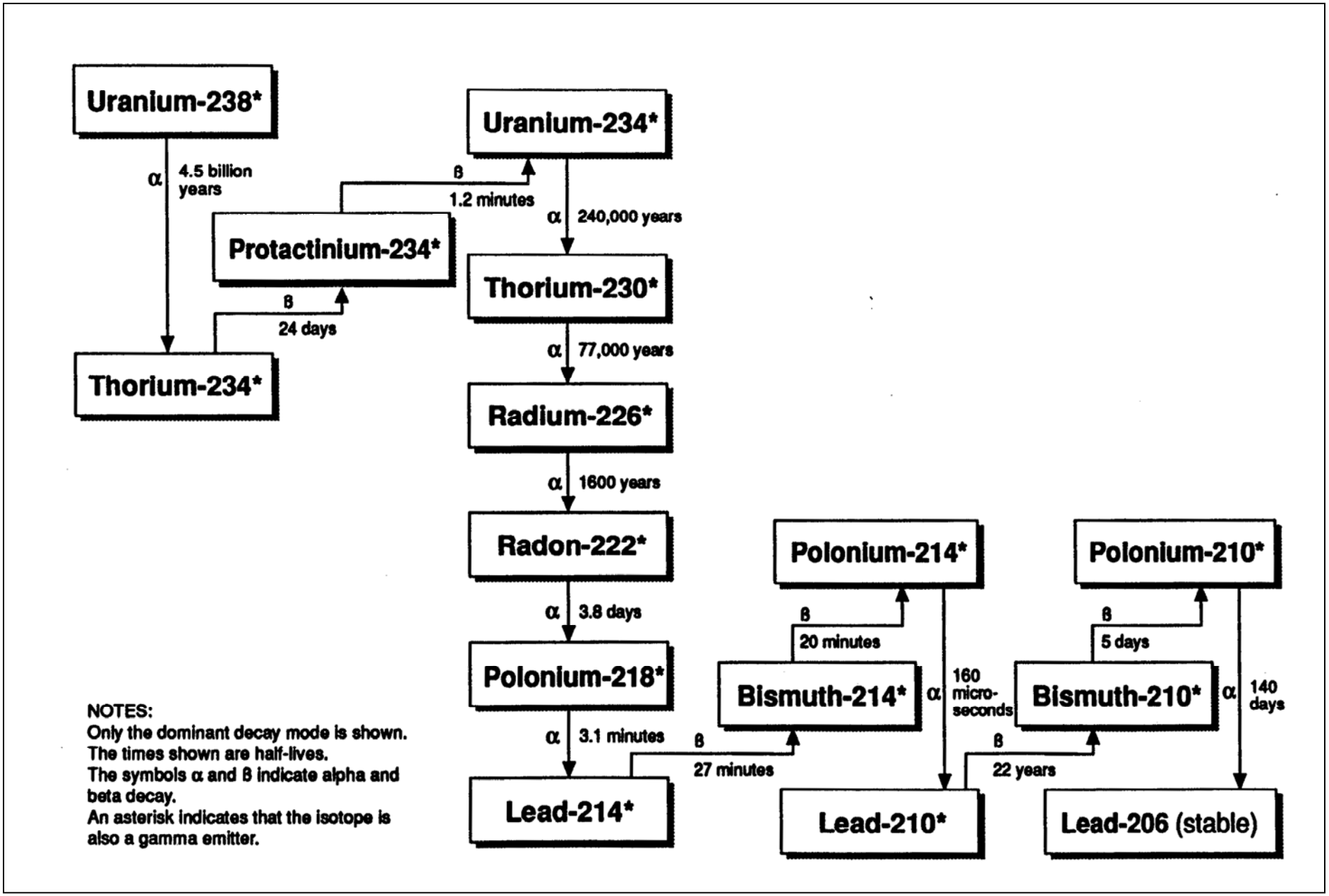

Figure 6-4. Uranium-238 Radioactive Decay Series

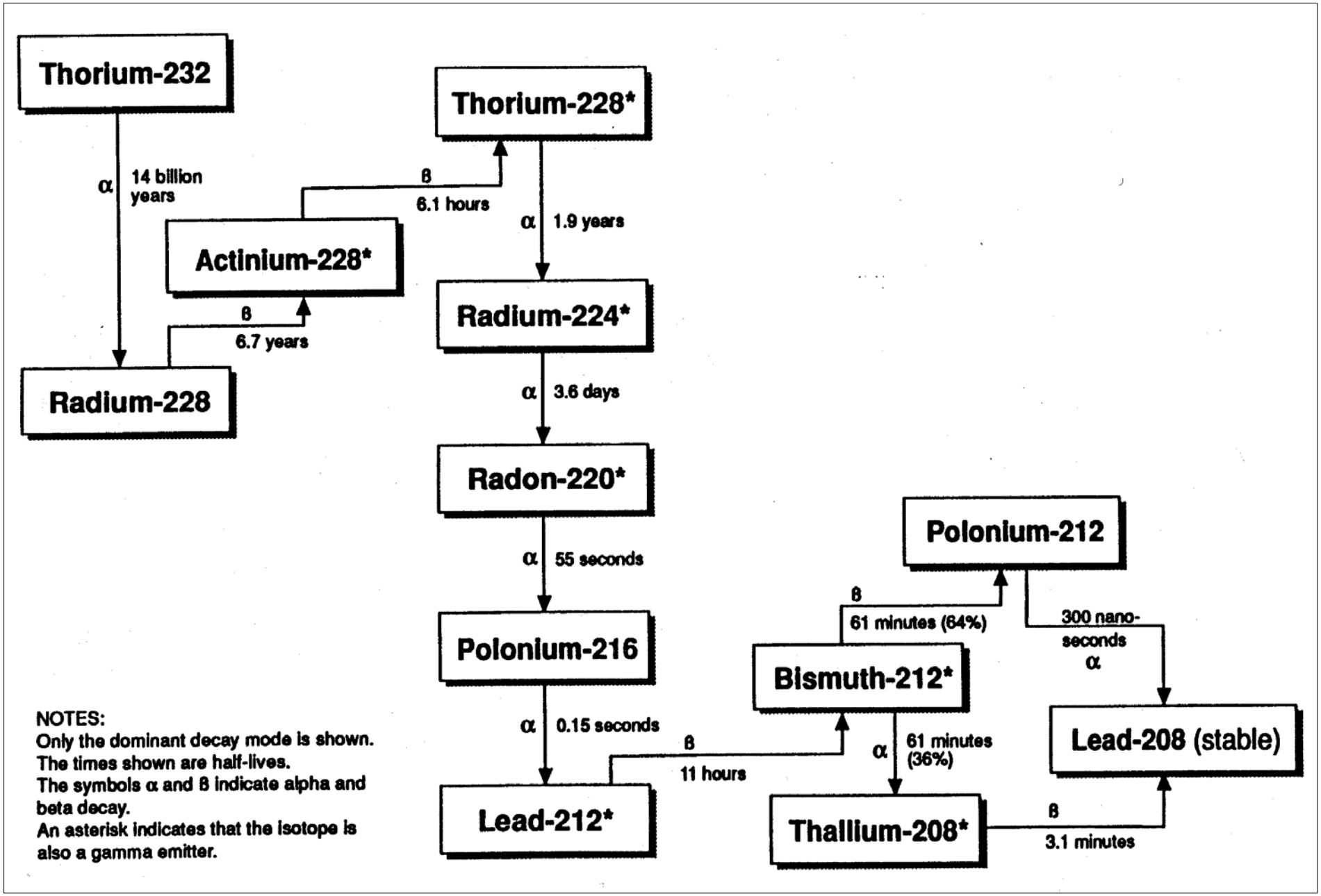

Figure 6-5. Thorium-232 Radioactive Decay Series

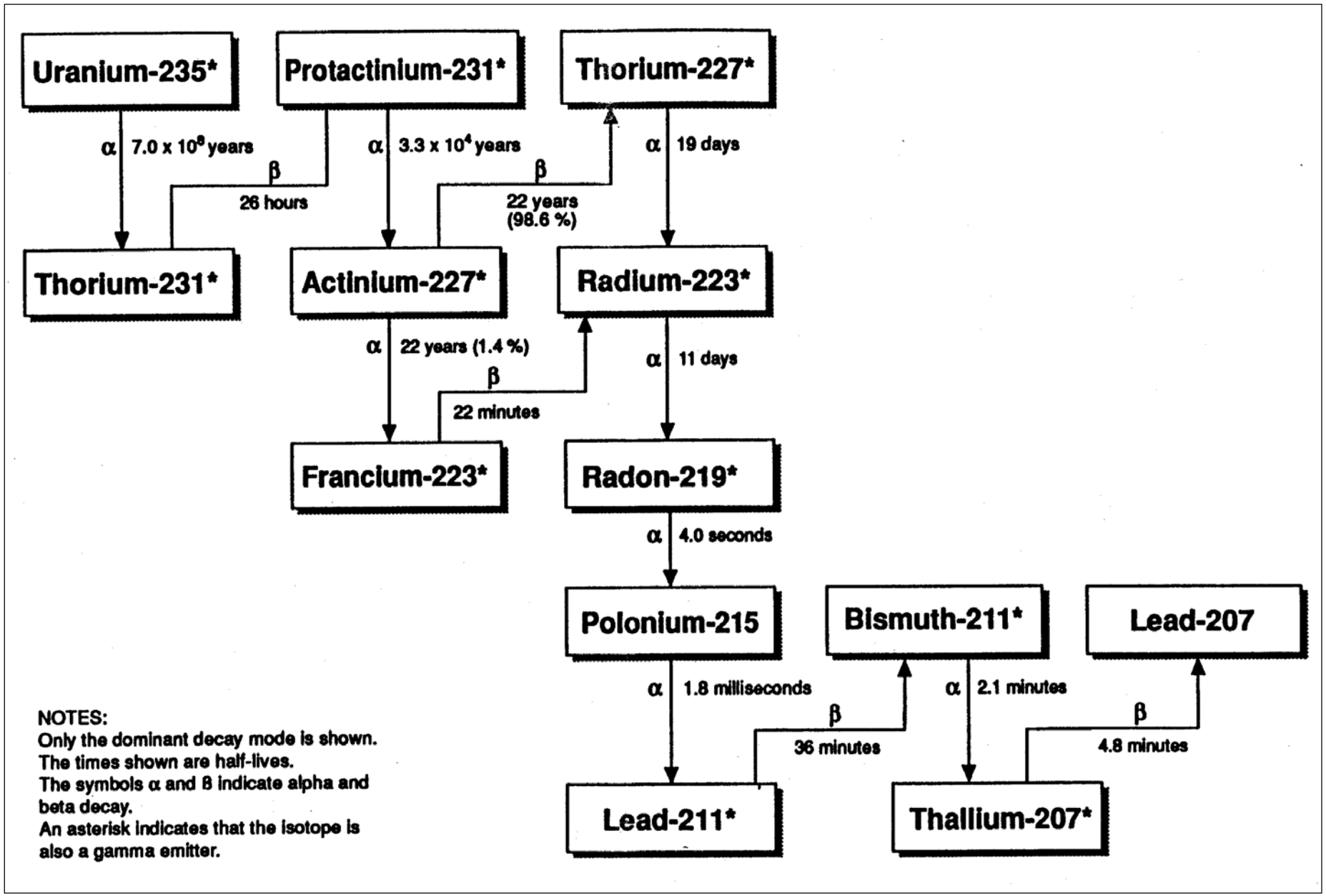

Figure 6-6. Uranium-235 Radioactive Decay Series

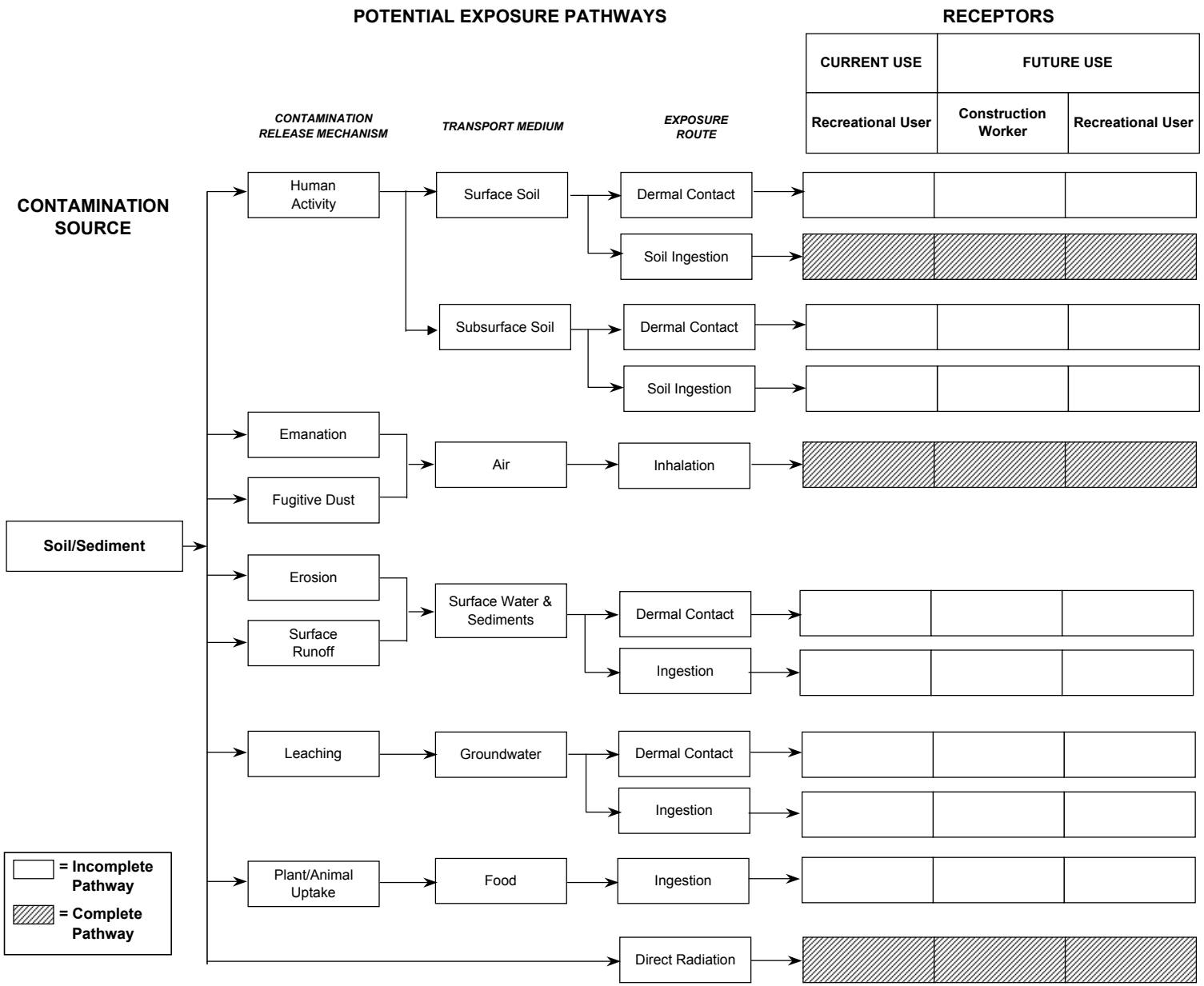

Figure 6-7. Conceptual Site Model for Exposure Pathways for Radiologically Contaminated Soil and Sediment

Exposure Units 1 and 2

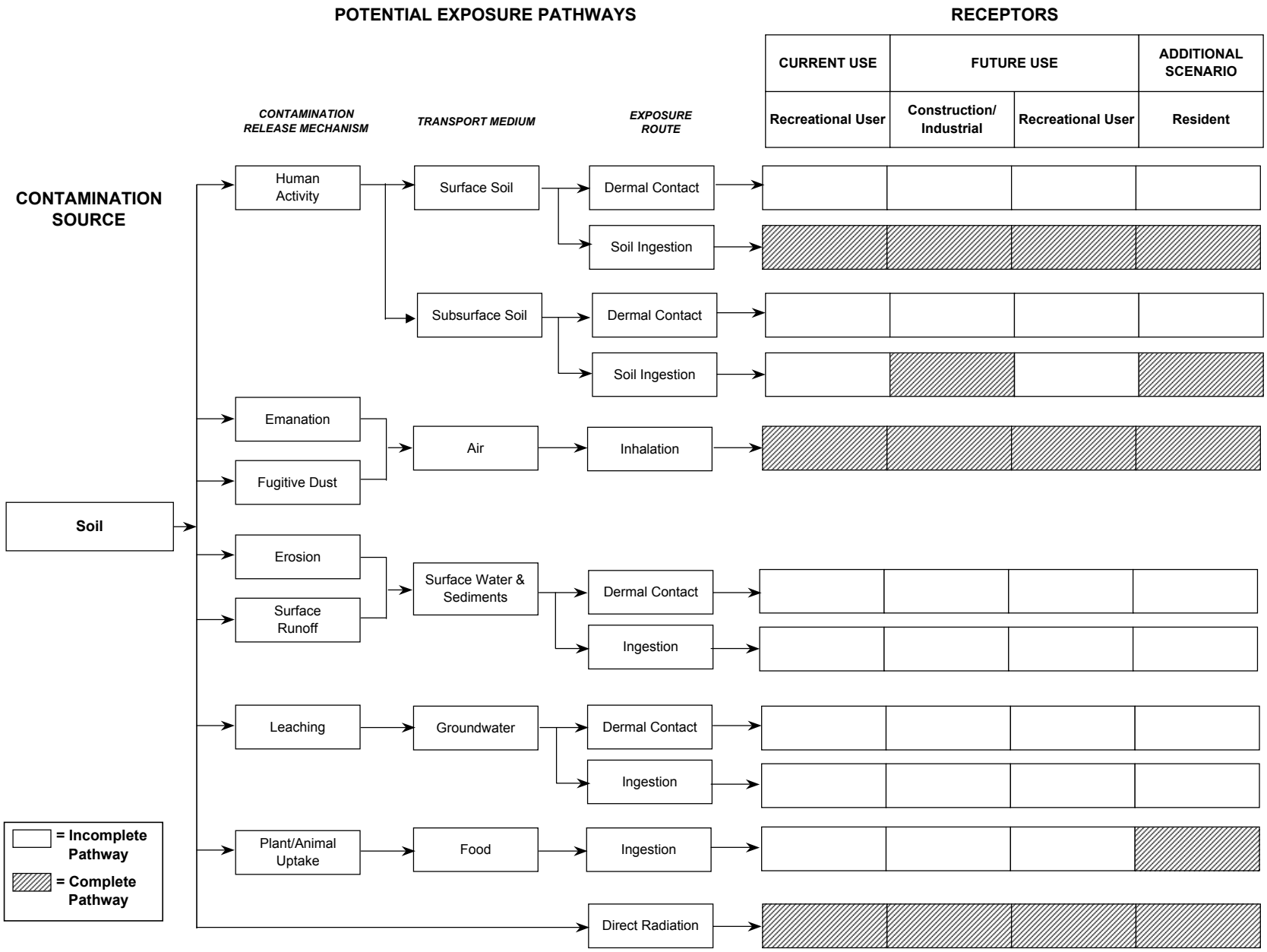

Figure 6-8. Conceptual Site Model for Exposure Pathways for Radiologically Contaminated Soil

Exposure Units 3, 4 and 5

Table 6-1
Background Radionuclide Concentrations

Analyte	Units	Results > Det. Limit	Minimum Detect	Maximum Detect	Average Result	Dist.	95% UCL of Mean	Gross EPC	Net EPC	Reference UTL
Landfill Background Area - Surface Soil										
Am-241	pCi/g	1/ 19	8.7E-02	8.70E-02	6.1E-03	D	1.8E-02	1.83E-02	NA	8.00E-02
Ac-227	pCi/g				2.33E-01				NA	3.17E+00
Pa-231	pCi/g	3/ 19	6.3E-01	4.90E+00	2.3E-01	D	7.2E-01	7.15E-01	NA	3.17E+00
Pb-210	pCi/g				9.50E-01				NA	1.70E+00
Ra-226	pCi/g	18/ 19	7.1E-01	1.40E+00	9.5E-01	X	1.1E+00	1.07E+00	NA	1.70E+00
Ra-228	pCi/g	19/ 19	5.3E-01	1.80E+00	8.0E-01	X	9.2E-01	9.23E-01	NA	1.53E+00
Th-228	pCi/g	19/ 19	4.8E-01	1.06E+00	8.7E-01	N	9.2E-01	9.25E-01	NA	1.22E+00
Th-230	pCi/g	19/ 19	7.0E-01	1.12E+00	9.3E-01	N	9.8E-01	9.77E-01	NA	1.22E+00
Th-232	pCi/g	19/ 19	5.9E-01	1.02E+00	8.6E-01	N	9.1E-01	9.08E-01	NA	1.13E+00
U-234	pCi/g	19/ 19	5.2E-01	1.33E+00	8.4E-01	L	9.2E-01	9.19E-01	NA	1.37E+00
U-235	pCi/g	8/ 19	4.7E-02	2.20E-01	4.9E-02	D	7.2E-02	7.19E-02	NA	1.89E-01
U-238	pCi/g	19/ 19	6.1E-01	1.86E+00	8.6E-01	X	9.6E-01	9.64E-01	NA	1.50E+00
Uranium	mg/kg				2.56E+00				NA	4.48E+00
Mudflats Background Area - Surface Soil										
Analyte	Units	Results > Det. Limit	Minimum Detect	Maximum Detect	Average Result	Dist.	95% UCL of Mean	Gross EPC	Net EPC	Reference UTL
Am-241	pCi/g	1/ 22	5.0E-01	5.00E-01	1.80E-02	D	6.2E-02	6.20E-02	NA	3.00E-01
Bi-212	pCi/g	11/ 11	8.8E-01	2.19E+00	1.38E+00	L	1.6E+00	1.60E+00	NA	2.59E+00
Bi-214	pCi/g	22/ 22	4.5E-01	8.90E-01	6.97E-01	N	7.4E-01	7.39E-01	NA	9.66E-01
Ac-227	pCi/g				0.00E+00				NA	1.44E+00
Pa-231	pCi/g	1/ 22	2.2E+00	2.20E+00	0.00E+00	D	-1.2E-01	-1.19E-01	NA	1.44E+00
Pb-212	pCi/g	22/ 22	6.8E-01	1.38E+00	9.75E-01	L	1.1E+00	1.05E+00	NA	1.53E+00
Pb-214	pCi/g	22/ 22	4.5E-01	9.70E-01	7.32E-01	N	7.8E-01	7.78E-01	NA	1.03E+00
Pb-210	pCi/g				8.66E-01				NA	1.54E+00
Ra-226	pCi/g	22/ 22	3.0E-01	1.40E+00	8.66E-01	N	9.7E-01	9.71E-01	NA	1.54E+00
Ra-228	pCi/g	22/ 22	5.6E-01	1.10E+00	7.92E-01	L	8.5E-01	8.45E-01	NA	1.16E+00
Th-228	pCi/g	22/ 22	6.7E-01	1.57E+00	1.05E+00	N	1.1E+00	1.14E+00	NA	1.62E+00
Th-229	pCi/g	14/ 22	5.2E-01	2.25E+00	6.34E-01	X	8.1E-01	8.05E-01	NA	1.73E+00
Th-230	pCi/g	22/ 22	4.9E-01	1.49E+00	9.51E-01	N	1.0E+00	1.04E+00	NA	1.51E+00
Th-232	pCi/g	22/ 22	6.2E-01	1.17E+00	9.16E-01	N	9.8E-01	9.81E-01	NA	1.33E+00
Tl-208	pCi/g	21/ 21	1.8E-01	3.66E-01	2.74E-01	N	2.9E-01	2.94E-01	NA	4.01E-01
U-234	pCi/g	22/ 22	7.1E-01	1.15E+00	8.41E-01	X	8.8E-01	8.82E-01	NA	1.11E+00
U-235	pCi/g	17/ 22	4.6E-02	1.90E-01	6.23E-02	X	7.7E-02	7.75E-02	NA	1.60E-01
U-238	pCi/g	22/ 22	5.8E-01	1.15E+00	8.38E-01	N	8.9E-01	8.87E-01	NA	1.15E+00
Uranium	mg/kg				2.50E+00				NA	3.44E+00
Landfill Background Area - Subsurface Soil										
Analyte	Units	Results > Det. Limit	Minimum Detect	Maximum Detect	Average Result	Dist.	95% UCL of Mean	Gross EPC	Net EPC	Reference UTL
Am-241	pCi/g	2/ 39	8.7E-02	1.50E-01	2.99E-03	D	1.3E-02	1.27E-02	NA	8.12E-02
Ac-227	pCi/g				1.62E-01				NA	2.15E+00
Pa-231	pCi/g	5/ 39	6.3E-01	4.90E+00	1.62E-01	D	4.1E-01	4.10E-01	NA	2.15E+00
Pb-210	pCi/g				1.00E+00				NA	1.66E+00
Ra-226	pCi/g	38/ 39	5.8E-01	1.91E+00	1.00E+00	X	1.1E+00	1.08E+00	NA	1.66E+00
Ra-228	pCi/g	37/ 39	3.6E-01	1.80E+00	7.22E-01	X	8.0E-01	7.96E-01	NA	1.32E+00
Th-228	pCi/g	39/ 39	4.8E-01	1.16E+00	8.26E-01	N	8.6E-01	8.65E-01	NA	1.14E+00
Th-230	pCi/g	39/ 39	6.2E-01	1.28E+00	9.20E-01	N	9.6E-01	9.62E-01	NA	1.26E+00
Th-232	pCi/g	39/ 39	5.1E-01	1.02E+00	8.17E-01	N	8.5E-01	8.51E-01	NA	1.09E+00
U-234	pCi/g	39/ 39	5.1E-01	2.38E+00	8.47E-01	X	9.3E-01	9.28E-01	NA	1.50E+00
U-235	pCi/g	13/ 39	4.7E-02	2.20E-01	4.59E-02	D	6.1E-02	6.13E-02	NA	1.69E-01
U-238	pCi/g	39/ 39	4.4E-01	2.49E+00	8.55E-01	X	9.5E-01	9.51E-01	NA	1.62E+00
Uranium	mg/kg				2.55E+00				NA	4.84E+00

Table 6-1
Background Radionuclide Concentrations

Mudflats Background Area - Subsurface Soil										
Analyte	**Units**	**Results > Det. Limit**	**Minimum Detect**	**Maximum Detect**	**Average Result**	**Dist.**	**95% UCL of Mean**	**Gross EPC**	**Net EPC**	**Reference UTL**
Am-241	pCi/g	5/ 44	9.2E-02	5.00E-01	2.05E-02	D	4.6E-02	4.58E-02	NA	2.32E-01
Bi-212	pCi/g	24/ 24	4.4E-01	2.19E+00	1.21E+00	N	1.3E+00	1.34E+00	NA	2.07E+00
Bi-214	pCi/g	44/ 44	4.5E-01	8.90E-01	6.53E-01	L	6.8E-01	6.81E-01	NA	9.02E-01
Ac-227	pCi/g				0.00E+00				NA	1.37E+00
Pa-231	pCi/g	2/ 44	2.2E+00	2.60E+00	0.00E+00	D	-6.1E-02	-6.06E-02	NA	1.37E+00
Pb-212	pCi/g	44/ 44	6.0E-01	1.38E+00	9.21E-01	L	9.7E-01	9.67E-01	NA	1.34E+00
Pb-214	pCi/g	44/ 44	4.5E-01	9.70E-01	7.09E-01	N	7.4E-01	7.35E-01	NA	9.25E-01
Pb-210	pCi/g				8.32E-01				NA	1.52E+00
Ra-226	pCi/g	43/ 44	3.0E-01	1.74E+00	8.32E-01	N	9.1E-01	9.15E-01	NA	1.52E+00
Ra-228	pCi/g	44/ 44	5.4E-01	1.10E+00	7.65E-01	L	8.0E-01	7.96E-01	NA	1.04E+00
Th-228	pCi/g	44/ 44	6.6E-01	1.57E+00	9.57E-01	L	1.0E+00	1.01E+00	NA	1.44E+00
Th-229	pCi/g	33/ 44	5.1E-01	2.25E+00	6.94E-01	X	8.1E-01	8.06E-01	NA	1.64E+00
Th-230	pCi/g	44/ 44	4.9E-01	1.49E+00	8.84E-01	L	9.3E-01	9.34E-01	NA	1.33E+00
Th-232	pCi/g	44/ 44	6.2E-01	1.28E+00	8.96E-01	L	9.4E-01	9.36E-01	NA	1.25E+00
Tl-208	pCi/g	43/ 43	1.8E-01	3.66E-01	2.71E-01	N	2.8E-01	2.84E-01	NA	3.76E-01
U-234	pCi/g	44/ 44	5.8E-01	1.15E+00	8.18E-01	L	8.5E-01	8.47E-01	NA	1.08E+00
U-235	pCi/g	38/ 44	3.1E-02	1.90E-01	6.85E-02	X	7.9E-02	7.89E-02	NA	1.56E-01
U-238	pCi/g	44/ 44	5.8E-01	1.15E+00	8.11E-01	L	8.4E-01	8.43E-01	NA	1.09E+00
Uranium	mg/kg				2.42E+00				NA	3.26E+00

Distribution Codes:
D = fewer than 50% detected - distribution not determined (treated as Normal for UCL/UTL calculations)
L = lognormal distribution
N = normal distribution
X = neither normal nor lognormal (treated as Normal for UCL/UTL calculations)

Acronyms and Notes:
Dist. = distribution of dataset
EPC = exposure point cpncentration; lesser of UCL and maximum detect; net value calculated by subtracting average background
NA = not applicable
UTL = upper tolerance limit
boxed radionuclides assumed to be in equilibrium
shaded rows are computed values
Mudflats reference average Pa-231 value set to 0.0 pCi/g to avoid calculational errors associated with subtracting negative values
Uranium = U-238 (pCi/g) / 0.335 (mg/kg per pCi/g); conversion factor derived assuming natural uranium abundance and a U-238 specific activity of 1.24E-8 pCi/g

Table 6-2
COPC Screening for Tonawanda Landfill Vicinity Property - Surface Soil (0-2 feet bgs)

Analyte	$t_{1/2}$ (yrs)	Units	Results > Det. Limit	Minimum Detect	Maximum Detect	Average Result	Dist.	95% UCL of Mean	Gross EPC	Net EPC	Reference UTL	Max >UTL	$t_{1/2}$ >6mo	Freq >5%	Max >PRG	COPC	Reason Code
Exposure Unit 1																	
Am-241	4.32E+02	pCi/g	1/ 102	2.4E-01	2.40E-01	-2.3E-02	D	-1.0E-02	-1.03E-02	0.00E+00	8.00E-02	Y	Y	N	NA	N	F
Ac-227	2.18E+01	pCi/g			5.40E+00			2.2E-01	2.23E-01	0.00E+00	3.17E+00	Y	Y	Y	NA	N	B
Pa-231	3.28E+04	pCi/g	10/ 102	5.4E-01	5.40E+00	9.8E-02	D	2.2E-01	2.23E-01	0.00E+00	3.17E+00	Y	Y	Y	NA	N	B
Pb-210	2.23E+01	pCi/g			2.00E+03			4.6E+01	4.64E+01	4.55E+01	1.70E+00	Y	Y	Y	NA	Y	
Ra-226	1.60E+03	pCi/g	183/ 183	2.6E-01	2.00E+03	2.6E+01	X	4.6E+01	4.64E+01	4.55E+01	1.70E+00	Y	Y	Y	NA	Y	
Ra-228	5.75E+00	pCi/g	100/ 102	4.1E-01	3.43E+00	8.5E-01	X	9.3E-01	9.30E-01	1.26E-01	1.53E+00	Y	Y	Y	NA	Y	
Th-228	1.91E+00	pCi/g	102/ 102	3.7E-01	3.34E+00	1.0E+00	X	1.1E+00	1.10E+00	2.36E-01	1.22E+00	Y	Y	Y	NA	Y	
Th-230	7.70E+04	pCi/g	102/ 102	4.9E-01	1.38E+01	1.4E+00	X	1.6E+00	1.64E+00	7.10E-01	1.22E+00	Y	Y	Y	NA	Y	
Th-232	1.41E+10	pCi/g	102/ 102	4.4E-01	3.24E+00	9.5E-01	X	1.0E+00	1.02E+00	1.58E-01	1.13E+00	Y	Y	Y	NA	Y	
Th-234	6.60E-02	pCi/g	2/ 2	4.4E-01	5.40E-01	4.9E-01	N	8.1E-01	5.40E-01			Y	N	Y	NA	N	T
U-234	2.45E+05	pCi/g	100/ 100	4.8E-01	7.20E+01	3.3E+00	X	4.9E+00	4.88E+00	4.04E+00	1.37E+00	Y	Y	Y	NA	Y	
U-235	7.04E+08	pCi/g	81/ 102	3.0E-02	2.71E+00	1.7E-01	X	2.3E-01	2.35E-01	1.86E-01	1.89E-01	Y	Y	Y	NA	Y	
U-238	4.47E+09	pCi/g	172/ 181	4.2E-01	3.10E+02	1.2E+01	X	1.7E+01	1.66E+01	1.58E+01	1.50E+00	Y	Y	Y	NA	Y	
Uranium		mg/kg			9.25E+02				4.96E+01	4.71E+01	4.48E+00	Y	NA	Y	Y	Y	
Exposure Unit 2																	
Am-241	4.32E+02	pCi/g	3/ 19	1.4E-01	1.72E+00	1.1E-01	D	2.7E-01	2.70E-01	2.64E-01	8.00E-02	Y	Y	Y	NA	Y	
Ac-227	2.18E+01	pCi/g			1.94E+00			3.7E-01	3.73E-01	1.40E-01	3.17E+00	N	Y	Y	NA	N	M
Pa-231	3.28E+04	pCi/g	2/ 19	1.2E+00	1.94E+00	1.6E-01	D	3.7E-01	3.73E-01	1.40E-01	3.17E+00	N	Y	Y	NA	N	M
Pb-210	2.23E+01	pCi/g			1.70E+00			9.4E-01	9.42E-01	0.00E+00	1.70E+00	Y	Y	Y	NA	N	B
Ra-226	1.60E+03	pCi/g	70/ 70	5.2E-01	1.70E+00	9.0E-01	X	9.4E-01	9.42E-01	0.00E+00	1.70E+00	Y	Y	Y	NA	N	B
Ra-228	5.75E+00	pCi/g	17/ 19	2.5E-01	8.60E-01	5.3E-01	N	6.2E-01	6.17E-01	0.00E+00	1.53E+00	N	Y	Y	NA	N	M
Th-228	1.91E+00	pCi/g	19/ 19	4.6E-01	1.01E+00	7.4E-01	L	8.1E-01	8.15E-01	0.00E+00	1.22E+00	N	Y	Y	NA	N	M
Th-230	7.70E+04	pCi/g	19/ 19	6.3E-01	1.20E+00	8.7E-01	L	9.4E-01	9.36E-01	6.80E-03	1.22E+00	N	Y	Y	NA	N	M
Th-232	1.41E+10	pCi/g	19/ 19	4.0E-01	9.70E-01	6.9E-01	L	7.6E-01	7.61E-01	0.00E+00	1.13E+00	N	Y	Y	NA	N	M
U-234	2.45E+05	pCi/g	19/ 19	4.7E-01	1.11E+00	7.4E-01	L	8.1E-01	8.11E-01	0.00E+00	1.37E+00	N	Y	Y	NA	N	M
U-235	7.04E+08	pCi/g	12/ 19	3.9E-02	1.28E-01	5.5E-02	N	7.1E-02	7.12E-02	2.24E-02	1.89E-01	N	Y	Y	NA	N	M
U-238	4.47E+09	pCi/g	65/ 70	3.3E-01	3.30E+00	1.2E+00	L	1.3E+00	1.27E+00	4.15E-01	1.50E+00	Y	Y	Y	NA	N	M
Uranium		mg/kg			9.85E+00				3.80E+00	1.24E+00	4.48E+00	Y	NA	Y	N	N	P
Exposure Unit 3																	
Am-241	4.32E+02	pCi/g	0/ 20			1.2E-02	D	3.0E-02	3.00E-02	2.39E-02	3.00E-01	N	Y	N	NA	N	M, F
Bi-212	1.15E-04	pCi/g	7/ 7	1.0E+00	2.80E+00	1.5E+00	L	2.1E+00	2.07E+00			Y	N	Y	NA	N	T
Bi-214	3.79E-05	pCi/g	19/ 19	4.5E-01	9.40E-01	7.0E-01	N	7.5E-01	7.47E-01	5.00E-02		Y	N	Y	NA	N	T
Ac-227	2.18E+01	pCi/g			2.30E+00			1.5E-01	1.49E-01	1.49E-01	1.44E+00	Y	Y	Y	NA	N	M
Pa-231	3.28E+04	pCi/g	1/ 20	2.3E+00	2.30E+00	-1.9E-01	D	1.5E-01	1.49E-01	1.49E-01	1.44E+00	Y	Y	Y	NA	N	M
Pb-212	1.21E-03	pCi/g	20/ 20	6.2E-01	1.35E+00	8.7E-01	L	9.5E-01	9.55E-01	0.00E+00		Y	N	Y	NA	N	T
Pb-214	5.10E-05	pCi/g	20/ 20	4.6E-01	1.02E+00	7.3E-01	L	7.9E-01	7.93E-01	6.12E-02		Y	N	Y	NA	N	T
Pb-210	2.23E+01	pCi/g			1.23E+00			9.7E-01	9.71E-01	1.05E-01	1.54E+00	N	Y	Y	NA	N	M
Ra-226	1.60E+03	pCi/g	20/ 20	4.8E-01	1.23E+00	9.0E-01	N	9.7E-01	9.71E-01	1.05E-01	1.54E+00	N	Y	Y	NA	N	M
Ra-228	5.75E+00	pCi/g	20/ 20	4.8E-01	1.03E+00	7.6E-01	N	8.1E-01	8.09E-01	1.75E-02	1.16E+00	N	Y	Y	NA	N	M
Th-228	1.91E+00	pCi/g	20/ 20	6.7E-01	1.29E+00	9.2E-01	L	1.0E+00	1.00E+00	0.00E+00	1.62E+00	N	Y	Y	NA	N	M
Th-229	7.34E+03	pCi/g	20/ 20	6.7E-01	2.31E+00	1.6E+00	X	1.8E+00	1.85E+00	1.22E+00		Y	Y	Y	NA	Y	
Th-230	7.70E+04	pCi/g	20/ 20	7.3E-01	1.23E+00	9.2E-01	L	9.9E-01	9.89E-01	3.89E-02	1.51E+00	N	Y	Y	NA	N	M
Th-232	1.41E+10	pCi/g	20/ 20	6.3E-01	1.24E+00	8.4E-01	L	9.0E-01	9.03E-01	0.00E+00	1.33E+00	N	Y	Y	NA	N	M
Tl-208	5.84E-06	pCi/g	19/ 19	1.5E-01	3.50E-01	2.5E-01	N	2.7E-01	2.74E-01	0.00E+00		Y	N	Y	NA	N	T
U-234	2.45E+05	pCi/g	20/ 20	6.7E-01	1.21E+00	8.5E-01	L	9.1E-01	9.06E-01	6.53E-02	1.11E+00	Y	Y	Y	NA	N	M
U-235	7.04E+08	pCi/g	17/ 20	3.8E-02	1.51E-01	8.0E-02	N	9.6E-02	9.60E-02	3.37E-02	1.60E-01	N	Y	Y	NA	N	M
U-238	4.47E+09	pCi/g	20/ 20	5.8E-01	1.03E+00	8.6E-01	N	9.1E-01	9.10E-01	7.27E-02	1.15E+00	N	Y	Y	NA	N	M
Uranium		mg/kg			3.07E+00				2.72E+00	2.17E-01	4.48E+00	N	NA	Y	N	N	M, P

Table 6-2
COPC Screening for Tonawanda Landfill Vicinity Property - Surface Soil (0-2 feet bgs)

Analyte	$t_{1/2}$ (yrs)	Units	Results > Det. Limit	Minimum Detect	Maximum Detect	Average Result	Dist.	95% UCL of Mean	Gross EPC	Net EPC	Reference UTL	Max >UTL	$t_{1/2}$ >6mo	Freq >5%	Max >PRG	COPC	Reason Code
Exposure Unit 4																	
Am-241	4.32E+02	pCi/g	0/ 20			-1.7E-02	D	1.6E-03	1.56E-03	0.00E+00	3.00E-01	N	Y	N	NA	N	M, F
Bi-212	1.15E-04	pCi/g	6/ 6	1.1E+00	1.90E+00	1.4E+00	L	1.7E+00	1.68E+00	2.95E-01	2.59E+00	N	N	Y	NA	N	M, T
Bi-214	3.79E-05	pCi/g	18/ 18	3.1E-01	9.30E-01	6.3E-01	N	7.0E-01	6.96E-01	0.00E+00	9.66E-01	N	N	Y	NA	N	M
Ac-227	2.18E+01	pCi/g			0.00E+00			-2.9E-01	-2.90E-01	0.00E+00	3.17E+00	N	Y	N	NA	N	M, F
Pa-231	3.28E+04	pCi/g	0/ 20			-5.0E-01	D	-2.9E-01	-2.90E-01	0.00E+00	1.44E+00	N	Y	N	NA	N	M, F
Pb-212	1.21E-03	pCi/g	20/ 20	2.0E-01	1.20E+00	8.8E-01	N	9.8E-01	9.76E-01	1.20E-03	1.53E+00	N	N	Y	NA	N	M, T
Pb-214	5.10E-05	pCi/g	20/ 20	2.9E-01	9.00E-01	7.0E-01	X	7.6E-01	7.62E-01	3.01E-02	1.03E+00	N	N	Y	NA	N	M, T
Pb-210	2.23E+01	pCi/g			1.28E+00			9.2E-01	9.19E-01	5.29E-02	1.70E+00	N	Y	Y	NA	N	M
Ra-226	1.60E+03	pCi/g	19/ 20	1.4E-01	1.28E+00	7.9E-01	X	9.2E-01	9.19E-01	5.29E-02	1.54E+00	N	Y	Y	NA	N	M
Ra-228	5.75E+00	pCi/g	20/ 20	1.4E-01	1.36E+00	7.9E-01	X	8.7E-01	8.74E-01	8.21E-02	1.16E+00	Y	Y	Y	NA	Y	
Th-228	1.91E+00	pCi/g	20/ 20	1.8E-01	1.27E+00	9.2E-01	X	1.0E+00	1.02E+00	0.00E+00	1.62E+00	N	Y	Y	NA	N	M
Th-229	7.34E+03	pCi/g	20/ 20	5.9E-01	2.25E+00	1.4E+00	X	1.7E+00	1.71E+00	1.07E+00	1.73E+00	Y	Y	Y	NA	Y	
Th-230	7.70E+04	pCi/g	20/ 20	3.4E-01	1.14E+00	9.0E-01	X	9.7E-01	9.74E-01	2.35E-02	1.51E+00	N	Y	Y	NA	N	M
Th-232	1.41E+10	pCi/g	20/ 20	2.5E-01	1.20E+00	8.9E-01	X	9.9E-01	9.93E-01	7.62E-02	1.33E+00	N	Y	Y	NA	N	M
Tl-208	5.84E-06	pCi/g	18/ 18	2.1E-01	4.10E-01	2.9E-01	L	3.2E-01	3.20E-01	4.61E-02	4.01E-01	Y	N	Y	NA	N	T
U-234	2.45E+05	pCi/g	20/ 20	3.6E-01	1.08E+00	8.7E-01	X	9.4E-01	9.42E-01	1.01E-01	1.11E+00	N	Y	Y	NA	N	M
U-235	7.04E+08	pCi/g	19/ 20	2.9E-02	2.70E-01	1.1E-01	N	1.4E-01	1.38E-01	7.59E-02	1.60E-01	Y	Y	Y	NA	Y	
U-238	4.47E+09	pCi/g	20/ 20	3.9E-01	1.06E+00	8.5E-01	X	9.2E-01	9.21E-01	8.34E-02	1.15E+00	N	Y	Y	NA	N	M
Uranium		mg/kg			3.16E+00				2.75E+00	2.49E-01	4.48E+00	N	NA	Y	N	N	M, P
Exposure Unit 5																	
Am-241	4.32E+02	pCi/g	2/ 42	1.0E-01	2.80E-01	-9.6E-03	D	1.2E-02	1.19E-02	0.00E+00	3.00E-01	N	Y	N	NA	N	M, F
Bi-212	1.15E-04	pCi/g	9/ 9	4.5E-01	2.10E+00	9.8E-01	L	1.4E+00	1.42E+00	4.20E-02	2.59E+00	N	N	Y	NA	N	M, T
Bi-214	3.79E-05	pCi/g	40/ 40	2.7E-01	1.04E+00	5.8E-01	L	6.3E-01	6.27E-01	0.00E+00	9.66E-01	Y	N	Y	NA	N	T
Ac-227	2.18E+01	pCi/g			1.30E+00			-7.5E-03	-7.52E-03	0.00E+00	1.44E+00	N	Y	N	NA	N	M, F
Pa-231	3.28E+04	pCi/g	2/ 42	1.3E+00	1.30E+00	-1.7E-01	D	-7.5E-03	-7.52E-03	0.00E+00	1.44E+00	N	Y	N	NA	N	M, F
Pb-212	1.21E-03	pCi/g	42/ 42	1.7E-01	1.02E+00	6.8E-01	X	7.4E-01	7.42E-01	0.00E+00	1.53E+00	N	N	Y	NA	N	M, T, F
Pb-214	5.10E-05	pCi/g	42/ 42	3.3E-01	9.50E-01	6.5E-01	N	6.9E-01	6.85E-01	0.00E+00	1.03E+00	N	N	Y	NA	N	M, T
Pb-210	2.23E+01	pCi/g			1.64E+00			9.6E-01	9.62E-01	9.56E-02	1.54E+00	Y	Y	Y	NA	Y	
Ra-226	1.60E+03	pCi/g	42/ 42	3.7E-01	1.64E+00	8.7E-01	L	9.6E-01	9.62E-01	9.56E-02	1.54E+00	Y	Y	Y	NA	Y	
Ra-228	5.75E+00	pCi/g	41/ 42	2.3E-01	1.08E+00	5.9E-01	N	6.4E-01	6.35E-01	0.00E+00	1.16E+00	N	Y	Y	NA	N	M
Th-228	1.91E+00	pCi/g	41/ 42	2.5E-01	1.17E+00	7.3E-01	N	8.0E-01	7.97E-01	0.00E+00	1.62E+00	N	Y	Y	NA	N	M
Th-229	7.34E+03	pCi/g	38/ 42	3.9E-01	6.04E+00	3.2E+00	X	3.7E+00	3.67E+00	3.03E+00	1.73E+00	Y	Y	Y	NA	Y	
Th-230	7.70E+04	pCi/g	42/ 42	5.0E-01	1.79E+00	9.5E-01	L	1.0E+00	1.03E+00	7.65E-02	1.51E+00	Y	Y	Y	NA	Y	
Th-232	1.41E+10	pCi/g	42/ 42	2.3E-01	1.22E+00	7.4E-01	N	8.1E-01	8.06E-01	0.00E+00	1.33E+00	N	Y	Y	NA	N	M
Tl-208	5.84E-06	pCi/g	36/ 36	8.3E-02	3.70E-01	2.3E-01	N	2.5E-01	2.47E-01	0.00E+00	4.01E-01	N	N	Y	NA	N	M, T
U-234	2.45E+05	pCi/g	42/ 42	4.9E-01	2.67E+00	9.3E-01	X	1.0E+00	1.03E+00	1.87E-01	1.11E+00	Y	Y	Y	NA	Y	
U-235	7.04E+08	pCi/g	38/ 42	3.7E-02	4.80E-01	1.0E-01	X	1.2E-01	1.22E-01	5.94E-02	1.60E-01	Y	Y	Y	NA	Y	
U-238	4.47E+09	pCi/g	42/ 42	3.9E-01	2.73E+00	8.9E-01	X	9.8E-01	9.83E-01	1.45E-01	1.15E+00	Y	Y	Y	NA	Y	
Uranium		mg/kg			8.15E+00				2.93E+00	4.34E-01	4.48E+00	Y	NA	Y	N	N	P

Distribution Codes:
D = fewer than 50% detected - distribution not determined (treated as Normal for UCL/UTL calculations)
L = lognormal distribution
N = normal distribution
X = neither normal nor lognormal (treated as Normal for UCL/UTL calculations)

Table 6-2
COPC Screening for Tonawanda Landfill Vicinity Property - Surface Soil (0-2 feet bgs)

Acronyms and Notes:
COPC = constituent of potential concern
Dist. = distribution of dataset
EPC = exposure point cpncentration; lesser of UCL and maximum detect; net value calculated by subtracting average background
NA = not applicable
UCL = upper confidence limit
UTL = upper tolerance limit
$t_{1/2}$ = radiological half-life
boxed radionuclides assumed to be in equilibrium
shaded rows are computed values
Mudflats reference average Pa-231 value set to 0.0 pCi/g to avoid calculational errors associated with subtracting negative values
Uranium = U-238 (pCi/g) / 0.335 (mg/kg per pCi/g); conversion factor derived assuming natural uranium abundance and a U-238 specific activity of 1.24E-8 pCi/g

COPC Reason Codes:
B = Net EPC less than average background concentration
F = frequency of detects less than 5% and not a "hot spot"
M = maximum detected result less than background UTL
O = other; non-site-related; could be qualitative COPC
P = maxumim result less than worst-case PRG for EU (resdient child for mudflats or construction worker for landfill)
T = $t_{1/2}$ (half-life) < 6 months; short-lived decay product

Table 6-3
COPC Screening for Tonawanda Vicinity Property - Subsurface Soil (> 2 feet bgs)

Analyte	$t_{1/2}$ (yrs)	Units	Results > Det. Limit	Minimum Detect	Maximum Detect	Average Result	Dist.	95% UCL of Mean	Gross EPC	Net EPC	Reference UTL	Max >UTL	$t_{1/2}$ >6mo	Freq >5%	Max >PRG	COPC	Reason Code
Exposure Unit 1																	
Am-241	4.32E+02	pCi/g	2/ 198	1.4E-01	2.40E-01	-5.74E-02	D	-2.9E-02	-2.93E-02	0.00E+00	8.12E-02	Y	Y	N	NA	N	F
Ac-227	2.18E+01	pCi/g			5.40E+00				2.68E-01	1.07E-01	2.15E+00	Y	Y	Y	NA	Y	
Pa-231	3.28E+04	pCi/g	23/ 198	5.4E-01	5.40E+00	1.66E-01	D	2.7E-01	2.68E-01	1.07E-01	2.15E+00	Y	Y	Y	NA	Y	
Pb-210	2.23E+01	pCi/g			2.00E+03				3.27E+01	3.17E+01	1.66E+00	Y	Y	Y	NA	Y	
Ra-226	1.60E+03	pCi/g	293/ 293	2.6E-01	2.00E+03	1.94E+01	X	3.3E+01	3.27E+01	3.17E+01	1.66E+00	Y	Y	Y	NA	Y	
Ra-228	5.75E+00	pCi/g	192/ 198	2.5E-01	4.30E+00	1.06E+00	X	1.2E+00	1.16E+00	4.42E-01	1.32E+00	Y	Y	Y	NA	Y	
Th-228	1.91E+00	pCi/g	198/ 198	3.7E-01	3.97E+00	1.22E+00	X	1.3E+00	1.31E+00	4.85E-01	1.14E+00	Y	Y	Y	NA	Y	
Th-230	7.70E+04	pCi/g	198/ 198	4.9E-01	7.10E+01	2.11E+00	X	2.8E+00	2.78E+00	1.86E+00	1.26E+00	Y	Y	Y	NA	Y	
Th-232	1.41E+10	pCi/g	198/ 198	4.0E-01	4.01E+00	1.14E+00	X	1.2E+00	1.23E+00	4.11E-01	1.09E+00	Y	Y	Y	NA	Y	
Th-234	6.60E-02	pCi/g	3/ 3	4.4E-01	1.30E+01	4.66E+00	L	1.5E+16	1.30E+01			Y	N	Y	NA	N	T
U-234	2.45E+05	pCi/g	195/ 195	4.3E-01	3.49E+02	7.62E+00	X	1.1E+01	1.13E+01	1.05E+01	1.50E+00	Y	Y	Y	NA	Y	
U-235	7.04E+08	pCi/g	160/ 198	3.0E-02	1.93E+01	4.02E-01	X	5.9E-01	5.91E-01	5.45E-01	1.69E-01	Y	Y	Y	NA	Y	
U-238	4.47E+09	pCi/g	281/ 290	3.5E-01	1.80E+03	2.33E+01	X	3.5E+01	3.50E+01	3.41E+01	1.62E+00	Y	Y	Y	NA	Y	
Uranium		mg/kg			5.37E+03				1.04E+02	1.02E+02	4.48E+00	Y	NA	Y	Y	Y	
Exposure Unit 2																	
Am-241	4.32E+02	pCi/g	4/ 36	1.2E-01	1.72E+00	5.87E-02	D	1.4E-01	1.41E-01	1.38E-01	8.12E-02	Y	Y	Y	NA	Y	
Ac-227	2.18E+01	pCi/g			2.90E+00				4.00E-01	2.39E-01	2.15E+00	Y	Y	Y	NA	Y	
Pa-231	3.28E+04	pCi/g	5/ 36	8.0E-01	2.90E+00	2.09E-01	D	4.0E-01	4.00E-01	2.39E-01	2.15E+00	Y	Y	Y	NA	Y	
Pb-210	2.23E+01	pCi/g			1.70E+00				9.46E-01	0.00E+00	1.66E+00	Y	Y	Y	NA	N	B
Ra-226	1.60E+03	pCi/g	87/ 87	5.2E-01	1.70E+00	9.11E-01	X	9.5E-01	9.46E-01	0.00E+00	1.66E+00	Y	Y	Y	NA	N	B
Ra-228	5.75E+00	pCi/g	33/ 36	2.5E-01	1.64E+00	5.94E-01	L	7.2E-01	7.19E-01	0.00E+00	1.32E+00	Y	Y	Y	NA	N	B
Th-228	1.91E+00	pCi/g	36/ 36	4.6E-01	1.34E+00	8.12E-01	L	8.7E-01	8.69E-01	4.31E-02	1.14E+00	Y	Y	Y	NA	Y	
Th-230	7.70E+04	pCi/g	36/ 36	6.2E-01	1.34E+00	8.72E-01	L	9.2E-01	9.21E-01	8.00E-04	1.26E+00	Y	Y	Y	NA	Y	
Th-232	1.41E+10	pCi/g	36/ 36	4.0E-01	1.24E+00	7.57E-01	L	8.2E-01	8.17E-01	0.00E+00	1.09E+00	Y	Y	Y	NA	N	B
U-234	2.45E+05	pCi/g	36/ 36	4.7E-01	1.17E+00	7.58E-01	L	8.1E-01	8.09E-01	0.00E+00	1.50E+00	N	Y	Y	NA	N	M
U-235	7.04E+08	pCi/g	20/ 36	3.9E-02	1.40E-01	5.05E-02	X	6.2E-02	6.23E-02	1.65E-02	1.69E-01	N	Y	Y	NA	N	M
U-238	4.47E+09	pCi/g	82/ 87	3.3E-01	3.30E+00	1.09E+00	L	1.2E+00	1.18E+00	3.20E-01	1.62E+00	Y	Y	Y	NA	Y	
Uranium		mg/kg			9.85E+00				3.51E+00	9.55E-01	4.48E+00	Y	NA	Y	N	N	P
Exposure Unit 3																	
Am-241	4.32E+02	pCi/g	0/ 40			-2.73E-03	D	1.6E-02	1.60E-02	1.30E-02	8.12E-02	N	Y	N	NA	N	M, F
Bi-212	1.15E-04	pCi/g	12/ 12	6.9E-01	2.80E+00	1.34E+00	L	1.7E+00	1.66E+00			Y	N	Y	NA	N	T
Bi-214	3.79E-05	pCi/g	39/ 39	4.5E-01	9.40E-01	6.68E-01	N	7.0E-01	6.99E-01			Y	N	Y	NA	N	T
Ac-227	2.18E+01	pCi/g			2.30E+00				-9.28E-02	0.00E+00	2.15E+00	Y	Y	N	NA	N	F
Pa-231	3.28E+04	pCi/g	1/ 40	2.3E+00	2.30E+00	-2.81E-01	D	-9.3E-02	-9.28E-02	0.00E+00	2.15E+00	Y	Y	N	NA	N	F
Pb-212	1.21E-03	pCi/g	40/ 40	3.8E-01	1.35E+00	8.57E-01	N	9.1E-01	9.06E-01			Y	N	Y	NA	N	T
Pb-214	5.10E-05	pCi/g	40/ 40	4.6E-01	1.02E+00	7.20E-01	L	7.5E-01	7.55E-01			Y	N	Y	NA	N	T
Pb-210	2.23E+01	pCi/g			1.23E+00				9.49E-01	0.00E+00	1.66E+00	N	Y	Y	NA	N	M
Ra-226	1.60E+03	pCi/g	40/ 40	2.4E-01	1.23E+00	8.97E-01	X	9.5E-01	9.49E-01	0.00E+00	1.66E+00	N	Y	Y	NA	N	M
Ra-228	5.75E+00	pCi/g	40/ 40	4.1E-01	1.15E+00	7.80E-01	N	8.2E-01	8.24E-01	1.02E-01	1.32E+00	N	Y	Y	NA	N	M
Th-228	1.91E+00	pCi/g	40/ 40	5.7E-01	1.29E+00	8.99E-01	L	9.5E-01	9.45E-01	1.20E-01	1.14E+00	Y	Y	Y	NA	Y	
Th-229	7.34E+03	pCi/g	40/ 40	6.7E-01	2.31E+00	1.53E+00	X	1.7E+00	1.72E+00			Y	Y	Y	NA	Y	
Th-230	7.70E+04	pCi/g	40/ 40	6.7E-01	1.23E+00	8.83E-01	L	9.2E-01	9.19E-01	0.00E+00	1.26E+00	N	Y	Y	NA	N	M
Th-232	1.41E+10	pCi/g	40/ 40	5.4E-01	1.24E+00	8.44E-01	L	8.8E-01	8.81E-01	6.41E-02	1.09E+00	Y	Y	Y	NA	Y	
Tl-208	5.84E-06	pCi/g	38/ 38	1.5E-01	3.50E-01	2.56E-01	N	2.7E-01	2.72E-01			Y	N	Y	NA	N	T
U-234	2.45E+05	pCi/g	40/ 40	6.3E-01	1.21E+00	8.42E-01	L	8.8E-01	8.76E-01	2.91E-02	1.50E+00	N	Y	Y	NA	N	M
U-235	7.04E+08	pCi/g	37/ 40	2.7E-02	2.00E-01	8.36E-02	N	9.4E-02	9.41E-02	4.82E-02	1.69E-01	Y	Y	Y	NA	Y	
U-238	4.47E+09	pCi/g	40/ 40	5.8E-01	1.06E+00	8.52E-01	N	8.9E-01	8.88E-01	3.28E-02	1.62E+00	N	Y	Y	NA	N	M
Uranium		mg/kg			3.16E+00				2.65E+00	9.79E-02	4.48E+00	N	NA	Y	N	N	M, P

Table 6-3
COPC Screening for Tonawanda Vicinity Property - Subsurface Soil (> 2 feet bgs)

Analyte	$t_{1/2}$ (yrs)	Units	Results > Det. Limit	Minimum Detect	Maximum Detect	Average Result	Dist.	95% UCL of Mean	Gross EPC	Net EPC	Reference UTL	Max >UTL	$t_{1/2}$ >6mo	Freq >5%	Max >PRG	COPC	Reason Code
Exposure Unit 4																	
Am-241	4.32E+02	pCi/g	2/ 40	1.2E-01	4.60E-01	1.02E-02	D	3.5E-02	3.47E-02	3.17E-02	8.12E-02	Y	Y	Y	NA	Y	
Bi-212	1.15E-04	pCi/g	15/ 16	5.9E-01	1.90E+00	1.06E+00	N	1.2E+00	1.23E+00			Y	N	Y	NA	N	T
Bi-214	3.79E-05	pCi/g	38/ 38	3.1E-01	9.30E-01	6.42E-01	N	6.8E-01	6.79E-01			Y	N	Y	NA	N	T
Ac-227	2.18E+01	pCi/g			0.00E+00				-3.11E-01	0.00E+00	2.15E+00	N	Y	N	NA	N	M
Pa-231	3.28E+04	pCi/g	0/ 40			-4.54E-01	D	-3.1E-01	-3.11E-01	0.00E+00	2.15E+00	N	Y	N	NA	N	M
Pb-212	1.21E-03	pCi/g	40/ 40	2.0E-01	1.20E+00	8.91E-01	X	9.4E-01	9.43E-01			Y	N	Y	NA	N	T
Pb-214	5.10E-05	pCi/g	40/ 40	2.9E-01	9.00E-01	7.04E-01	X	7.4E-01	7.40E-01			Y	N	Y	NA	N	T
Pb-210	2.23E+01	pCi/g			1.33E+00				9.37E-01	0.00E+00	1.66E+00	N	Y	Y	NA	N	M
Ra-226	1.60E+03	pCi/g	39/ 40	1.4E-01	1.33E+00	8.63E-01	X	9.4E-01	9.37E-01	0.00E+00	1.66E+00	N	Y	Y	NA	N	M
Ra-228	5.75E+00	pCi/g	40/ 40	1.4E-01	1.36E+00	7.90E-01	X	8.4E-01	8.39E-01	1.18E-01	1.32E+00	Y	Y	Y	NA	Y	
Th-228	1.91E+00	pCi/g	40/ 40	1.8E-01	1.27E+00	9.15E-01	X	9.7E-01	9.67E-01	1.41E-01	1.14E+00	Y	Y	Y	NA	Y	
Th-229	7.34E+03	pCi/g	40/ 40	5.9E-01	2.25E+00	1.42E+00	X	1.6E+00	1.61E+00			Y	Y	Y	NA	Y	
Th-230	7.70E+04	pCi/g	40/ 40	3.4E-01	1.38E+00	8.79E-01	X	9.3E-01	9.28E-01	7.90E-03	1.26E+00	Y	Y	Y	NA	Y	
Th-232	1.41E+10	pCi/g	40/ 40	2.5E-01	1.20E+00	8.97E-01	X	9.5E-01	9.51E-01	1.34E-01	1.09E+00	Y	Y	Y	NA	Y	
Tl-208	5.84E-06	pCi/g	38/ 38	2.0E-01	4.10E-01	2.87E-01	L	3.0E-01	3.03E-01			Y	N	Y	NA	N	T
U-234	2.45E+05	pCi/g	40/ 40	3.6E-01	1.08E+00	8.40E-01	N	8.8E-01	8.80E-01	3.31E-02	1.50E+00	N	Y	Y	NA	N	M
U-235	7.04E+08	pCi/g	39/ 40	2.9E-02	2.70E-01	1.10E-01	N	1.3E-01	1.26E-01	7.96E-02	1.69E-01	Y	Y	Y	NA	Y	
U-238	4.47E+09	pCi/g	40/ 40	3.9E-01	1.06E+00	8.45E-01	X	8.8E-01	8.83E-01	2.83E-02	1.62E+00	N	Y	Y	NA	N	M
Uranium		mg/kg			3.16E+00				2.64E+00	8.45E-02	4.48E+00	N	NA	Y	N	N	M, P
Exposure Unit 5																	
Am-241	4.32E+02	pCi/g	4/ 98	7.9E-02	4.70E-01	-3.83E-04	D	1.4E-02	1.41E-02	1.12E-02	8.12E-02	Y	Y	N	NA	N	F
Bi-212	1.15E-04	pCi/g	30/ 30	4.5E-01	2.10E+00	1.02E+00	L	1.2E+00	1.18E+00			Y	N	Y	NA	N	T
Bi-214	3.79E-05	pCi/g	95/ 95	2.7E-01	8.30E+00	6.77E-01	X	8.1E-01	8.13E-01			Y	N	Y	NA	N	T
Cd-109	1.27E+00	pCi/g	1/ 1	1.5E+00	1.53E+00	1.53E+00	X		1.53E+00			Y	Y	Y	NA	Y	
Ac-227	2.18E+01	pCi/g			1.50E+00				-6.38E-02	0.00E+00	2.15E+00	N	Y	N	NA	N	M, F
Pa-231	3.28E+04	pCi/g	3/ 98	1.3E+00	1.50E+00	-1.59E-01	D	-6.4E-02	-6.38E-02	0.00E+00	2.15E+00	N	Y	N	NA	N	M, F
Pb-212	1.21E-03	pCi/g	98/ 98	1.2E-01	1.19E+00	7.71E-01	X	8.1E-01	8.06E-01			Y	N	Y	NA	N	T
Pb-214	5.10E-05	pCi/g	98/ 98	3.3E-01	9.40E+00	7.51E-01	X	9.0E-01	9.01E-01			Y	N	Y	NA	N	T
Pb-210	2.23E+01	pCi/g			2.26E+01				1.44E+00	4.39E-01	1.66E+00	Y	Y	Y	NA	Y	
Ra-226	1.60E+03	pCi/g	97/ 98	1.8E-01	2.26E+01	1.07E+00	X	1.4E+00	1.44E+00	4.39E-01	1.66E+00	Y	Y	Y	NA	Y	
Ra-228	5.75E+00	pCi/g	97/ 98	1.4E-01	1.08E+00	6.57E-01	X	6.8E-01	6.84E-01	0.00E+00	1.32E+00	N	Y	Y	NA	N	M
Th-228	1.91E+00	pCi/g	97/ 98	1.4E-01	1.42E+00	8.31E-01	X	8.7E-01	8.73E-01	4.73E-02	1.14E+00	Y	Y	Y	NA	Y	
Th-229	7.34E+03	pCi/g	94/ 98	3.9E-01	6.56E+00	3.35E+00	X	3.7E+00	3.67E+00			Y	Y	Y	NA	Y	
Th-230	7.70E+04	pCi/g	98/ 98	5.0E-01	3.15E+01	1.25E+00	X	1.8E+00	1.77E+00	8.48E-01	1.26E+00	Y	Y	Y	NA	Y	
Th-232	1.41E+10	pCi/g	98/ 98	1.6E-01	1.29E+00	8.20E-01	X	8.6E-01	8.57E-01	4.01E-02	1.09E+00	Y	Y	Y	NA	Y	
Tl-208	5.84E-06	pCi/g	90/ 90	8.3E-02	3.90E-01	2.50E-01	N	2.6E-01	2.60E-01			Y	N	Y	NA	N	T
U-234	2.45E+05	pCi/g	98/ 98	4.9E-01	2.90E+01	1.20E+00	X	1.7E+00	1.67E+00	8.27E-01	1.50E+00	Y	Y	Y	NA	Y	
U-235	7.04E+08	pCi/g	89/ 98	3.7E-02	1.72E+00	1.19E-01	X	1.5E-01	1.50E-01	1.04E-01	1.69E-01	Y	Y	Y	NA	Y	
U-238	4.47E+09	pCi/g	98/ 98	3.9E-01	2.79E+01	1.16E+00	X	1.6E+00	1.62E+00	7.62E-01	1.62E+00	Y	Y	Y	NA	Y	
Uranium		mg/kg			8.33E+01				4.83E+00	2.27E+00	4.48E+00	Y	NA	Y	N	Y	

Distribution Codes:
D = fewer than 50% detected - distribution not determined (treated as Normal for UCL/UTL calculations)
L = lognormal distribution
N = normal distribution
X = neither normal nor lognormal (treated as Normal for UCL/UTL calculations)

Table 6-3
COPC Screening for Tonawanda Vicinity Property - Subsurface Soil (> 2 feet bgs)

Acronyms and Notes:
COPC = constituent of potential concern
Dist. = distribution of dataset
EPC = exposure point cpncentration; lesser of UCL and maximum detect; net value calculated by subtracting average background
NA = not applicable
UCL = upper confidence limit
UTL = upper tolerance limit
$t_{1/2}$ = radiological half-life
boxed radionuclides assumed to be in equilibrium
shaded rows are computed values
Mudflats reference average Pa-231 value set to 0.0 pCi/g to avoid calculational errors associated with subtracting negative values
Uranium = U-238 (pCi/g) / 0.335 (mg/kg per pCi/g); conversion factor derived assuming natural uranium abundance and a U-238 specific activity of 1.24E-8 pCi/g

COPC Reason Codes:
M = maximum detected result less than background UTL
T = $t_{1/2}$ (half-life) < 6 months; short-lived decay product
F = frequency of detects less than 5% and not a "hot spot"
O = other; non-site-related; could be qualitative COPC

Table 6-4
Non-carcinogenic Risk-based PRG for Uranium in Soil
(Ingestion Only)

Receptor	IR_{soil} mg/d	CF kg/mg	EF d/y	ED y	ET hr/hr	BW kg	AT days	RfD mg/kg-d	HI unitless	PRG mg/kg
Adult Resident	100	1E-06	350	30	1	70	10950	3.0E-03	1	2190
Child Resident	200	1E-06	350	6.0	1	15	2190	3.0E-03	1	235
Industrial Worker	100	1E-06	250	6.6	1	70	2409	3.0E-03	1	3066
Recreational	100	1E-06	350	30	0.012	70	10950	3.0E-03	1	182440
Construction Worker	480	1E-06	250	1.0	1	70	365	3.0E-03	1	639

Intake Equation

PRG = Soil Ingestion PRG = (THI * BW * AT) / (IR_{soil} * CF * EF * ED * ET * 1/RfD)

THI = target hazard index (unitless)
BW = body weight (kg)
AT = averaging time (days; 365 d/yr * ED)
IR_{soil} = ingestion rate (soil) (mg/day)
CF = conversion factor (kg/mg)
EF = exposure frequency (day/yr)
ED = exposure duration (yr)
ET = exposure time (hr/hr)
RfD = reference dose mg/kg-d

Table 6-5
COPCs for Landfill and Mudflats Exposure Units

COPCs for Landfill and Mudflats Exposure Units				
EU 1	**EU 2**	**EU 3**	**EU 4**	**EU 5**
Surface Soil				
Pb-210	**Am-241**[(1)]	**Th-229**	Ra-228	Pb-210
Ra-226			**Th-229**	Ra-226
Ra-228			U-235	**Th-229**
Th-228				Th-230
Th-230				U-234
Th-232				U-235
U-234				U-238
U-235				
U-238				
Utotal				
Subsurface Soil				
Ac-227	**Am-241**	Th-228	**Am-241**	**Cd-109**
Pa-231	Ac-227	**Th-229**	Ra-228	Pb-210
Pb-210	Pa-231	Th-232	Th-228	Ra-226
Ra-226	Th-228	U-235	**Th-229**	Th-228
Ra-228	Th-230		Th-230	**Th-229**
Th-228	U-238		Th-232	Th-230
Th-230			U-235	Th-232
Th-232				U-234
U-234				U-235
U-235				U-238
U-238				Utotal
Utotal				

[(1)] **Am-241**, **Th-229**, and **Cd-109** are not MED-related and are not carriedforward in risk/dose calculations.

Table 6-6
Carcinogenic Risk Estimate Summary for Surface and Subsurface Soil RME and CT Case

Surface Soil Carcinogenic Risk Estimate Summary (lifetime^{-1})						
Exposure Unit	Year	Resident Adult	Resident Child	Industrial Worker	Recreational	Construction Worker
		Surface Soil Risk - RME				
EU1	0	NA	NA	NA	1.3E-04	9.1E-05
	1000	NA	NA	NA	8.6E-05	5.9E-05
EU2	0	NA	NA	NA	0.0E+00	0.0E+00
	1000	NA	NA	NA	0.0E+00	0.0E+00
EU3	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	1000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
EU4	0	4.0E-06	1.9E-06	4.1E-07	1.1E-07	1.1E-07
	1000	4.2E-07	1.3E-07	2.8E-08	1.4E-08	9.4E-09
EU5	0	1.2E-05	2.9E-06	6.0E-07	3.0E-07	2.0E-07
	1000	1.1E-05	2.6E-06	5.5E-07	2.7E-07	1.9E-07
Exposure Unit	Year	Resident Adult	Resident Child	Industrial Worker	Recreational	Construction Worker
		Surface Soil Risk - CT				
EU1	0	NA	NA	NA	1.9E-05	8.8E-05
	1000	NA	NA	NA	1.2E-05	5.6E-05
EU2	0	NA	NA	NA	0.0E+00	0.0E+00
	1000	NA	NA	NA	0.0E+00	0.0E+00
EU3	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	1000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
EU4	0	1.8E-06	1.8E-06	4.0E-07	2.8E-08	1.1E-07
	1000	1.2E-07	1.2E-07	2.8E-08	2.0E-09	9.2E-09
EU5	0	2.8E-06	2.6E-06	5.9E-07	4.2E-08	1.9E-07
	1000	2.6E-06	2.4E-06	5.4E-07	3.8E-08	1.8E-07

Subsurface Soil Carcinogenic Risk Estimate Summary (lifetime^{-1})						
Exposure Unit	Year	Resident Adult	Resident Child	Industrial Worker	Recreational	Construction Worker
		Subsurface Soil Risk - RME				
EU1	0	NA	NA	NA	NA	6.5E-05
	1000	NA	NA	NA	NA	4.3E-05
EU2	0	NA	NA	NA	NA	1.7E-07
	1000	NA	NA	NA	NA	9.7E-08
EU3	0	8.2E-06	1.7E-06	3.7E-07	NA	1.8E-07
	1000	1.0E-05	2.5E-06	5.5E-07	NA	1.8E-07
EU4	0	2.1E-05	5.0E-06	1.1E-06	NA	3.7E-07
	1000	2.2E-05	5.3E-06	1.2E-06	NA	3.8E-07
EU5	0	6.1E-05	1.4E-05	2.9E-06	NA	9.9E-07
	1000	7.9E-05	1.8E-05	3.8E-06	NA	1.3E-06
Exposure Unit	Year	Resident Adult	Resident Child	Industrial Worker	Recreational	Construction Worker
		Subsurface Soil Risk - CT				
EU1	0	NA	NA	NA	NA	6.3E-05
	1000	NA	NA	NA	NA	4.2E-05
EU2	0	NA	NA	NA	NA	1.6E-07
	1000	NA	NA	NA	NA	9.3E-08
EU3	0	1.6E-06	1.7E-06	3.7E-07	NA	1.8E-07
	1000	2.5E-06	2.4E-06	5.4E-07	NA	1.8E-07
EU4	0	5.1E-06	4.8E-06	1.1E-06	NA	3.7E-07
	1000	5.4E-06	5.1E-06	1.1E-06	NA	3.7E-07
EU5	0	1.4E-05	1.3E-05	2.8E-06	NA	9.5E-07
	1000	1.8E-05	1.7E-05	3.8E-06	NA	1.2E-06

Table 6-7
Radiological Dose Estimate Summary for Surface and Subsurface Soil RME and CT Case

Surface Soil Radiological Dose Estimate Summary (mrem/yr)						
Exposure Unit	Year	Resident Adult	Resident Child	Industrial Worker	Recreational	Construction Worker
		Surface Soil Dose - RME				
EU1	0	NA	NA	NA	6.0E+00	1.3E+02
	1000	NA	NA	NA	3.9E+00	8.2E+01
EU2	0	NA	NA	NA	0.0E+00	0.0E+00
	1000	NA	NA	NA	0.0E+00	0.0E+00
EU3	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	1000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
EU4	0	3.2E-01	3.5E-01	6.8E-02	7.4E-03	1.5E-01
	1000	2.6E-02	3.4E-02	6.5E-03	6.9E-04	1.7E-02
EU5	0	6.8E-01	6.9E-01	1.2E-01	1.3E-02	2.9E-01
	1000	6.3E-01	6.3E-01	1.1E-01	1.2E-02	2.7E-01
Exposure Unit	Year	Resident Adult	Resident Child	Industrial Worker	Recreational	Construction Worker
		Surface Soil Dose - CT				
EU1	0	NA	NA	NA	2.8E+00	1.2E+02
	1000	NA	NA	NA	1.8E+00	7.7E+01
EU2	0	NA	NA	NA	0.0E+00	0.0E+00
	1000	NA	NA	NA	0.0E+00	0.0E+00
EU3	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	1000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
EU4	0	2.4E-01	3.3E-01	6.7E-02	3.5E-03	1.4E-01
	1000	2.1E-02	3.0E-02	6.2E-03	3.2E-04	1.5E-02
EU5	0	4.6E-01	6.1E-01	1.2E-01	6.2E-03	2.7E-01
	1000	4.2E-01	5.6E-01	1.1E-01	5.7E-03	2.5E-01

Subsurface Soil Radiological Dose Estimate Summary (mrem/yr)						
Exposure Unit	Year	Resident Adult	Resident Child	Industrial Worker	Recreational	Construction Worker
		Subsurface Soil Dose - RME				
EU1	0	NA	NA	NA	NA	9.2E+01
	1000	NA	NA	NA	NA	6.1E+01
EU2	0	NA	NA	NA	NA	6.4E-01
	1000	NA	NA	NA	NA	5.1E-01
EU3	0	3.7E-01	5.5E-01	1.1E-01	NA	2.6E-01
	1000	4.4E-01	5.6E-01	1.1E-01	NA	2.5E-01
EU4	0	8.9E-01	1.1E+00	2.3E-01	NA	5.2E-01
	1000	9.4E-01	1.2E+00	2.3E-01	NA	5.3E-01
EU5	0	3.3E+00	3.3E+00	6.1E-01	NA	1.4E+00
	1000	4.3E+00	4.3E+00	7.9E-01	NA	1.8E+00
Exposure Unit	Year	Resident Adult	Resident Child	Industrial Worker	Recreational	Construction Worker
		Subsurface Soil Dose - CT				
EU1	0	NA	NA	NA	NA	8.6E+01
	1000	NA	NA	NA	NA	5.7E+01
EU2	0	NA	NA	NA	NA	5.2E-01
	1000	NA	NA	NA	NA	4.0E-01
EU3	0	3.6E-01	5.4E-01	1.1E-01	NA	2.5E-01
	1000	3.7E-01	5.3E-01	1.1E-01	NA	2.5E-01
EU4	0	7.6E-01	1.1E+00	2.3E-01	NA	5.1E-01
	1000	7.8E-01	1.1E+00	2.3E-01	NA	5.2E-01
EU5	0	2.2E+00	2.9E+00	5.9E-01	NA	1.3E+00
	1000	2.9E+00	3.8E+00	7.7E-01	NA	1.7E+00

Table 6-8
Non-carcinogenic Risk Estimate Summary

Surface Soil Non-carcinogenic Risk Estimate Summary						
Exposure Unit	**Scenario**	**Resident Adult**	**Resident Child**	**Industrial Worker**	**Recreational**	**Construction Worker**
EU1	RME[(1)]	NA	NA	NA	1.3E-03	3.7E-01
	CT[(2)]	NA	NA	NA	6.5E-04	1.8E-01
EU2	RME	NA	NA	NA	0.0E+00	0.0E+00
	CT	NA	NA	NA	0.0E+00	0.0E+00
EU3	RME	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	CT	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
EU4	RME	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	CT	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
EU5	RME	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	CT	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Subsurface Soil Non-carcinogenic Risk Estimate Summary						
Exposure Unit	**Scenario**	**Resident Adult**	**Resident Child**	**Industrial Worker**	**Recreational**	**Construction Worker**
EU1	RME	NA	NA	NA	NA	8.0E-01
	CT	NA	NA	NA	NA	4.0E-01
EU2	RME	NA	NA	NA	NA	0.0E+00
	CT	NA	NA	NA	NA	0.0E+00
EU3	RME	0.0E+00	0.0E+00	0.0E+00	NA	0.0E+00
	CT	0.0E+00	0.0E+00	0.0E+00	NA	0.0E+00
EU4	RME	0.0E+00	0.0E+00	0.0E+00	NA	0.0E+00
	CT	0.0E+00	0.0E+00	0.0E+00	NA	0.0E+00
EU5	RME	5.2E-03	4.8E-02	3.7E-03	NA	1.8E-02
	CT	2.6E-03	2.4E-02	1.9E-03	NA	8.9E-03

[(1)] RME = Reasonable Maximum Exposure

[(2)] CT = Central Tendency

Table 6-9
Calculation of Screening Levels for Sediment and Aquatic Invertebrates

							Radionuclide Factor			Dose Factor		Screening Level	
Radionuclide	**BCF[a]**	**Kd[a]**	**Alpha energy[b]**	**Beta energy[b]**	**Gamma energy[b]**	**Gamma absorption[c]**	**External Sediment[d]**	**External Water[e]**	**Internal[f]**	**Sediment[g]**	**Water[h]**	**Sediment Invertebrates[i] (pCi/g)**	**Water Invertebrates[i] (pCi/L)**
Ac-227	1.50E+01	4.50E+02	6.91E-02	1.56E-02	0.00E+00	1.00E+00	7.99E-07	7.99E-10	7.14E-05	3.18E-06	1.07E-06	3.15E+04	9.33E+04
Pa-231	1.00E+01	5.40E+02	4.97E+00	6.50E-02	4.76E-02	1.30E-02	5.73E-06	5.73E-09	5.08E-03	9.98E-05	5.08E-05	1.00E+03	1.97E+03
Pb-210	3.00E+02	2.70E+02	0.00E+00	3.80E-02	4.81E-03	6.30E-01	2.04E-06	2.04E-09	2.10E-06	4.37E-06	6.31E-07	2.29E+04	1.58E+05
Ra-226	5.00E+01	5.00E+02	4.77E+00	3.59E-03	6.74E-03	6.30E-01	3.11E-07	3.11E-10	4.88E-03	4.88E-04	2.44E-04	2.05E+02	4.10E+02
Ra-228	5.00E+01	5.00E+02	0.00E+00	1.69E-02	0.00E+00	1.00E+00	8.65E-07	8.65E-10	8.64E-07	9.52E-07	4.40E-08	1.05E+05	2.27E+06
Th-228	1.00E+02	1.00E+04	5.40E+00	2.10E-02	3.00E-03	6.30E-01	1.13E-06	1.13E-09	5.52E-03	5.63E-05	5.52E-04	1.78E+03	1.81E+02
Th-230	1.00E+02	1.00E+04	4.67E+00	1.46E-02	1.55E-03	6.30E-01	7.77E-07	7.77E-10	4.77E-03	4.85E-05	4.77E-04	2.06E+03	2.09E+02
Th-232	1.00E+02	1.00E+04	4.00E+00	1.20E-02	1.33E-03	6.30E-01	6.40E-07	6.40E-10	4.09E-03	4.15E-05	4.09E-04	2.41E+03	2.45E+02
U-234	1.00E+01	5.00E+01	4.76E+00	1.30E-02	1.73E-03	6.30E-01	6.98E-07	6.98E-10	4.86E-03	9.73E-04	4.86E-05	1.03E+02	2.06E+03
U-235	1.00E+01	5.00E+01	4.40E+00	4.90E-02	1.56E-01	8.00E-03	1.04E-05	1.04E-08	4.50E-03	9.09E-04	4.50E-05	1.10E+02	2.22E+03
U-238	1.00E+01	5.00E+01	4.19E+00	1.00E-02	1.36E-03	6.30E-01	5.38E-07	5.38E-10	4.28E-03	8.56E-04	4.28E-05	1.17E+02	2.34E+03

Notes:

[a] Values from DOE 1998

[b] Decay energies (meV per disintegration) from Eckerman and Ryman (1993)

[c] Gamma absorption factors from Blaylock et al. (1993)

[d] Radionuclide factor for sediment external radiation = 0.0000512 x [Beta energy + Gamma energy x (1-Gamma absorption)]

[e] Radionuclide factor for surface water external radiation = 0.0000512 x 0.001 x [Beta energy + Gamma energy x (1-Gamma absorption)]

[f] Radionuclide factor for internal dose = 0.0000511 x (20 Alpha energy + Beta energy + Gamma energy x Gamma absorption)

[g] Dose factor for sediment = Radionuclide factor for external radiation + radionuclide factor for internal radiation x BCF/Kd

[h] Dose factor for surface water = Radionuclide factor for external radiation + radionuclide factor for internal radiation x BCF x 0.001

[i] Screening level = 0.1/Dose factor

Table 6-10
Comparison of Sediment and Surface Water Screening Levels for Sediment Invertebrates, Aquatic Invertebrates, and Small Fish[a]

Radionuclide	Screening Levels			
	Sediment (pCi/g)		Surface Water (pCi/L)	
	Sediment Invertebrates[b]	Small Fish[c]	Aquatic Invertebrates[d]	Small Fish[e]
Ac-227	3.15E+04	1.28E+04	9.33E+04	3.97E+01
Pa-231	1.00E+03	1.11E+05	1.97E+03	3.88E+02
Pb-210	2.29E+04	9.77E+05	1.58E+05	3.06E+03
Ra-226	2.05E+02	2.82E+03	4.10E+02	1.60E+01
Ra-228	1.05E+05	5.47E+03	2.27E+06	4.78E+01
Th-228	1.78E+03	3.31E+03	1.81E+02	6.00E+00
Th-230	2.06E+03	1.12E+07	2.09E+02	4.13E+01
Th-232	2.41E+03	5.47E+03	2.45E+02	4.78E+01
U-234	1.03E+02	1.00E+07	2.06E+03	4.04E+02
U-235	1.10E+02	2.96E+04	2.22E+03	4.37E+02
U-238	1.17E+02	1.75E+05	2.34E+03	4.55E+02

Notes:

[a] Screening levels calculated as described in the text

[b] Sediment screening values from Table 6-9

[c] Screening level = PRAAS Sediment NFA activity (DOE 2001) for aquatic vertebrates exposed to sediment (pCi/g)

[d] Surface water screening values from Table 6-9

[e] Screening level = PRAAS Surface Water NFA activity (DOE 2001) for aquatic vertebrates exposed to surface water (pCi/L)

Table 6-11
Screening Levels for Exposure of Small Mammals to COPCs in Soil at the Tonawanda Landfill

Radionuclide[a]	Dose Conversion Factor[b]	Alpha energy[c]	Beta energy[c]	Gamma energy[c]	Gamma absorption[d]	Uptake factors BAFi[e]	Uptake factors BAFmamm	Subsurface exposure[g]	Surface exposure[h]	Internal exposure[i]	Total exposure[j]	Screening level (pCi/g soil)[k]
Ac-227	2.62E-21	6.91E-02	1.56E-02	2.31E-04	1.00E+00	1.25E-01	1.25E-01	4.25E-07	9.39E-10	1.12E-06	1.54E-06	4.07E+01
Th-227 (98.62% of Ac-227)	2.65E-18	5.88E+00	5.30E-02	1.10E-01	1.00E-01	1.50E-06	3.00E-04	1.72E-06	9.50E-07	2.71E-12	2.63E-06	--
Fr-223 (1.38% of Ac-227)	1.01E-18	0.00E+00	4.00E-01	5.90E-02	1.00E-01	1.56E-02	1.25E-01	1.09E-05	3.62E-07	4.05E-08	1.56E-07	--
and Fr-223)	3.1E-18	5.67E+00	7.60E-02	1.34E-01	1.10E-01	1.56E-04	1.25E-02	2.43E-06	1.11E-06	1.13E-08	3.56E-06	--
Rn-219	1.54E-18	6.76E+00	6.30E-03	5.58E-02	1.10E-01	0.00E+00	0.00E+00	3.34E-07	5.52E-07	0.00E+00	8.86E-07	--
Po-215	4.98E-21	7.39E+00	6.30E-06	1.76E-04	1.00E+00	2.26E-03	4.75E-01	4.89E-09	1.78E-09	8.09E-06	8.10E-06	--
Pb-211	1.46E-18	0.00E+00	4.56E-01	5.10E-02	1.60E-01	3.00E-04	1.50E-02	1.25E-05	5.23E-07	1.07E-10	1.30E-05	--
Bi-211	1.28E-18	6.55E+00	9.78E-03	4.66E-02	1.90E-01	4.00E-04	2.00E-02	5.00E-07	4.59E-07	5.36E-08	1.01E-06	--
Tl-207 (99.72% of Bi-211)	9.48E-20	0.00E+00	4.93E-01	2.21E-03	9.40E-01	4.00E+00	2.00E+00	1.33E-05	3.40E-08	2.02E-04	2.15E-04	--
Po-211 (0.28% of Bi-211)	2.24E-19	7.44E+00	1.69E-04	7.79E-03	9.40E-01	2.26E-03	4.75E-01	2.01E-07	8.03E-08	8.15E-06	2.36E-08	--
Pa-231	9.62E-19	4.97E+00	6.50E-02	4.76E-02	1.80E-01	5.00E-02	5.00E-04	1.97E-06	3.45E-07	1.27E-07	2.45E-06	4.09E+03
Pb-210	1.31E-20	0.00E+00	3.80E-02	4.81E-03	9.40E-01	2.00E-02	1.50E-02	1.14E-06	4.70E-09	6.52E-10	1.15E-06	8.62E+02
Bi-210	1.86E-20	0.00E+00	3.89E-01	0.00E+00	0.00E+00	2.00E-02	2.00E-02	1.04E-05	6.67E-09	7.95E-09	1.05E-05	--
Ra-226[l]	1.65E-19	4.77E+00	3.59E-03	6.74E-03	9.40E-01	7.50E-02	1.25E-02	2.66E-07	5.91E-08	4.57E-06	4.90E-06	1.49E+02
Rn-222	1.1E-20	5.49E+00	1.09E-05	3.98E-04	1.00E+00	0.00E+00	0.00E+00	1.10E-08	3.94E-09	0.00E+00	1.49E-08	--
Po-218	2.63E-22	6.00E+00	1.42E-05	9.12E-06	1.00E+00	4.75E-03	4.75E-01	6.26E-10	9.43E-11	1.38E-05	1.38E-05	--
Pb-214 (99.98% of Po-218)	6.7E-18	0.00E+00	2.93E-01	2.50E-01	9.00E-02	2.00E-02	1.50E-02	8.46E-06	2.40E-06	4.84E-09	1.09E-05	--
At-218 (0.02% of Po-218)	3.13E-20	6.70E+00	4.00E-02	6.72E-03	9.40E-01	5.00E-01	5.00E-01	1.24E-06	1.12E-08	1.71E-03	3.43E-07	--
and At-218)	4.36E-17	0.00E+00	6.59E-01	1.51E+00	8.00E-02	2.00E-02	2.00E-02	2.09E-05	1.56E-05	1.59E-08	3.66E-05	--
Po-214	2.4E-21	7.69E+00	8.19E-07	8.33E-05	1.00E+00	4.75E-03	4.75E-03	2.26E-09	8.60E-10	1.77E-07	1.80E-07	--
Ra-228[m]	0.00E+00	0.00E+00	1.69E-02	4.14E-09	1.00E+00	7.50E-02	1.25E-02	4.53E-07	0.00E+00	8.10E-10	4.54E-07	2.20E+04
Th-228	4.17E-20	5.40E+00	2.10E-02	3.00E-03	9.40E-01	5.00E-03	3.00E-04	6.39E-07	1.49E-08	8.28E-09	6.62E-07	7.04E+01
Ra-224	2.62E-19	5.67E+00	2.00E-03	1.00E-02	9.40E-01	7.50E-02	1.25E-02	3.06E-07	9.39E-08	5.44E-06	5.84E-06	--
Rn-220	1.1E-20	6.29E+00	8.91E-06	3.85E-04	1.00E+00	0.00E+00	0.00E+00	1.06E-08	3.94E-09	0.00E+00	1.45E-08	--
Po-216	4.87E-22	6.79E+00	1.61E-07	1.69E-05	1.00E+00	4.75E-03	4.75E-01	4.58E-10	1.75E-10	1.57E-05	1.57E-05	--
Pb-212	3.62E-18	0.00E+00	1.76E-01	1.48E-01	1.00E-01	2.00E-02	1.50E-02	5.12E-06	1.30E-06	2.92E-09	6.42E-06	--
Bi-212	5.36E-18	2.17E+00	4.72E-01	1.86E-01	1.00E-01	2.00E-02	2.00E-02	1.32E-05	1.92E-06	8.99E-07	1.60E-05	--
Po-212 (64.07% of Bi-212)	0.00E+00	8.79E+00	0.00E+00	0.00E+00	0.00E+00	4.75E-03	4.75E-01	0.00E+00	0.00E+00	2.03E-05	1.30E-05	--
Tl-208 (35.93% of Bi-212)	9.68E-17	0.00E+00	5.98E-01	3.38E+00	8.00E-02	2.00E+00	2.00E+00	2.33E-05	3.47E-05	1.77E-04	8.46E-05	--

Table 6-11
Screening Levels for Exposure of Small Mammals to COPCs in Soil at the Tonawanda Landfill

Radionuclide[a]	Dose Conversion Factor[b]	Alpha energy[c]	Beta energy[c]	Gamma energy[c]	Gamma absorption[d]	Uptake factors BAFi[e]	Uptake factors BAFmamm	Subsurface exposure[g]	Surface exposure[h]	Internal exposure[i]	Total exposure[j]	Screening level (pCi/g soil)[k]
Th-230[l]	6.39E-21	4.67E+00	1.46E-02	1.55E-03	9.40E-01	5.00E-03	3.00E-04	4.31E-07	2.29E-09	7.16E-09	4.40E-07	1.49E+02
Th-232[m]	2.78E-21	4.00E+00	1.20E-02	1.33E-03	9.40E-01	5.00E-03	3.00E-04	3.55E-07	9.96E-10	6.13E-09	3.63E-07	3.80E+02
Ac-228	2.76E-17	0.00E+00	4.75E-01	9.71E-01	1.10E-01	1.25E-03	1.25E-03	1.56E-05	9.89E-06	4.65E-11	2.55E-05	--
U-234	2.14E-21	4.76E+00	1.30E-02	1.73E-03	9.40E-01	1.00E-02	1.00E-02	3.92E-07	7.67E-10	4.86E-07	8.79E-07	1.14E+04
U-235	3.75E-18	4.40E+00	4.90E-02	1.56E-01	1.00E-01	1.00E-02	1.00E-02	1.73E-06	1.34E-06	4.50E-07	3.53E-06	1.20E+03
Th-231	1.94E-19	0.00E+00	1.65E-01	2.60E-02	4.50E-01	5.00E-03	3.00E-04	4.74E-06	6.95E-08	1.35E-11	4.81E-06	--
U-238	5.52E-22	4.19E+00	1.00E-02	1.36E-03	9.40E-01	1.00E-02	1.00E-02	3.03E-07	1.98E-10	4.28E-07	7.31E-07	1.62E+02
Th-234	1.29E-19	0.00E+00	5.92E-02	9.34E-03	9.40E-01	5.00E-03	3.00E-04	1.82E-06	4.62E-08	5.21E-12	1.87E-06	--
Pa-234m	4.2E-19	0.00E+00	8.22E-01	1.20E-02	8.80E-01	5.00E-02	5.00E-04	2.23E-05	1.51E-07	1.06E-09	2.25E-05	--
Pa-234	5.38E-17	0.00E+00	4.94E-01	1.92E+00	8.00E-02	5.00E-02	5.00E-04	1.74E-05	1.93E-05	8.27E-10	3.67E-05	--

Notes:

[a] Daughter radionuclides are shown as indented entries

[b] Dose conversion factors from Eckerman and Ryman (1993)

[c] Decay energies (meV per disintegration) from Eckerman and Ryman (1993)

[d] Gamma absorption factors from Blaylock et al. (1993)

[e] Uptake factors for soil invertebrates from Table A2, DOE 2001

[f] Baes et al. 1984

[g] Subsurface exposure = 1.05 x $f_{belowground}$ x 0.0000511 x (Beta energy + Gamma energy x Gamma absorption)

$f_{belowground}$ = 0.5 = fraction of time animal is assumed to spend belowground

[h] Surface exposure = $f_{aboveground}$ x 0.7 x 5.12 x 10^{11} x DCF x 2

$f_{aboveground}$ = 0.5 = fraction of time animal is assumed to spend on ground surface

[i] Internal exposure = 0.0000511 x BAFi x BAFmamm x (20 x Alpha energy + Beta energy + Gamma energy x Gamma absorption)

[j] Sum of subsurface exposure, surface exposure, and internal exposure, multiplied by per cent yield of daughter radionuclides

[k] Screening level = activity (pCi/g) resulting in dose of 0.01 rad/d assuming secular equilibrium of parent and daughter products; calculated as 0.01/sum of total exposures for parent and daughters

[l] Ra-226 was combined with Th-230 as a daughter radionuclide

[m] Ra-228 was combined with Th-232 and Ac-228 as a daughter radionuclide

-- = Daughter radionuclide, not an ROPC

Table 6-12
Comparison of Soil Screening Levels for
Soil Invertebrates, Small Mammals, and Small Birds

Radio-nuclide	Screening Levels		
	Small Mammals[a]	Small Birds[b]	Soil Invertebrates[b]
Ac-227	4.07E+01	7.92E+01	2.55E+02
Pa-231	4.09E+03	2.12E+04	3.88E+02
Pb-210	8.62E+02	5.01E+05	4.25E+03
Ra-226	1.49E+02	2.70E+02	2.03E+02
Ra-228	2.20E+04	1.01E+03	1.88E+03
Th-228	7.04E+01	8.72E+01	1.56E+02
Th-230	1.49E+02	2.70E+02	4.05E+03
Th-232	3.80E+02	1.01E+03	1.88E+03
U-234	1.14E+04	2.05E+04	2.02E+03
U-235	1.20E+03	5.37E+03	1.76E+03
U-238	1.62E+02	5.02E+02	1.07E+03

Notes:

[a] Screening values from Table 6-11

[b] Screening levels calculated as described in the text

Table 6-13
Tonawanda Landfill - Ecological Risk Screen
for Radionuclides in Sediment From 2001 USACE Investigations

Radionuclide	Number of Results > Detection Limit	Minimum (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	UCL95 (pCi/g)	Background[a] (pCi/g)	EPC[b] (pCi/g)	Screening level[c] (pCi/g)	Maximum Exceeds Screening Level?
Ac-227[d]	--	--	--	--	--	--	5.26E-01	1.28E+04	No
Pa-231[d]	0/6	<Back-ground	<Back-ground	<Back-ground	<Back-ground	<Back-ground	5.26E-01	1.00E+03	No
Pb-210[e]	--	--	--	--	--	--	1.11E+00	2.29E+04	No
Ra-226	6/6	8.70E-01	2.77E+00	1.34E+00	1.91E+00	8.00E-01	1.11E+00	2.05E+02	No
Ra-228	3/6	5.50E-01	1.27E+00	8.37E-01	1.02E+00	1.10E+00	-7.59E-02	5.47E+03	No
Th-228	6/6	8.60E-01	1.55E+00	1.07E+00	1.27E+00	1.10E+00	1.74E-01	1.78E+03	No
Th-230	6/6	1.02E+00	3.90E+00	1.56E+00	2.47E+00	1.40E+00	1.07E+00	2.06E+03	No
Th-232	6/6	7.70E-01	1.49E+00	9.45E-01	1.16E+00	1.10E+00	6.13E-02	2.41E+03	No
U-234	6/6	8.50E-01	2.63E+01	5.64E+00	1.37E+01	1.80E+00	1.19E+01	1.03E+02	No
U-235	5/6	5.90E-02	1.27E+00	2.85E-01	6.68E-01	8.28E-02	5.85E-01	1.10E+02	No
U-238	6/6	7.70E-01	2.53E+01	5.52E+00	1.32E+01	1.80E+00	1.14E+01	1.17E+02	No

Notes:

[a] Background from 1993 BRA, Table 2-2; equilbrium assumed for Ra-228, Th-228, U-234, U-235

[b] EPC = UCL95 - background) or see notes d and e

[c] Screening level = smaller of sediment screening levels in Table 6-10 (Ac-227 and Ra-228 are values for sediment invertebrates)

[d] Assumed at 4.6 percent of U-238 specific activity

[e] Assumed to be in secular equilibrium with Ra-226

"--" = Not analyzed

Table 6-14
Tonawanda Landfill - Ecological Risk Screen
for Radionuclides in Surface Water From 2001 USACE Investigations

Radio-nuclide	Number of Results > Detection Limit	Minimum (pCi/L)	Maximum (pCi/L)	Mean (pCi/L)	UCL95 (pCi/L)	Background[a] (pCi/L)	EPC[b] (pCi/L)	Screening Level[c] (pCi/L)	Maximum Exceeds Screening Level?
Ac-227[d]	--	--	--	--	--	--	9.66E+00	3.97E+01	No
Pa-231[d]	--	--	--	--	--	--	9.66E+00	3.88E+02	No
Pb-210[e]	--	--	--	--	--	--	6.48E+00	3.06E+03	No
Ra-226	4/4	2.00E+00	7.20E+00	4.34E+00	6.78E+00	3.00E-01	6.48E+00	1.60E+01	No
Ra-228	1/4	1.89E+00	3.23E+01	9.95E+00	2.58E+01	1.00E-01	2.57E+01	4.78E+01	No
Th-228	1/4	1.13E-01	4.28E+00	1.22E+00	3.39E+00	1.00E-01	3.29E+00	6.00E+00	No
Th-230	2/4	2.20E-01	4.34E+00	1.39E+00	3.49E+00	1.00E-01	3.39E+00	4.13E+01	No
Th-232	1/4	7.69E-02	2.77E+00	7.70E-01	2.19E+00	1.00E-01	2.09E+00	4.78E+01	No
U-234	4/4	3.56E+00	2.17E+02	1.38E+02	2.37E+02 *	1.10E+00	2.16E+02	4.04E+02	No
U-235	4/4	3.25E-01	2.07E+01	1.14E+01	2.08E+01*	5.06E-02	2.06E+01	4.37E+02	No
U-238	4/4	3.21E+00	2.11E+02	1.37E+02	2.35E+02*	1.10E+00	2.10E+02	4.55E+02	No

Notes:

[a] Background from 1993 BRA, Table 2-2; equilbrium assumed for Ra-228, U-234, U-235

[b] EPC = (UCL95 - background) or see notes d and e

[c] Screening level = smaller of surface water screening levels in Table 6-10 (all are values for small fish)

[d] Assumed at 4.6 percent of U-238 specific activity

[e] Assumed to be in secular equilibrium with Ra-226

"--" = Not analyzed

* UCL95 exceeds maximum; maximum reading is used to determine EPC.

Table 6-15
Tonawanda Landfill - Ecological Risk Screen for Radionuclides in Soil

Radionuclide	Number of Results > Detection Limit	Minimum (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	UCL95 (pCi/g)	Background (pCi/g)	EPC[a] (pCi/g)	Screening level[b] (pCi/g)	Maximum Exceeds Screening Level?
A. From Radiological Human Health Assessment (1999) Table 2									
Ac-227[c]	--	--	--	--	--	--	8.97E-01	4.07E+01	--
Pa-231[c]	--	--	--	--	--	--	8.97E-01	3.88E+02	--
Pb-210[d]	--	--	--	--	--	--	6.55E+01	8.62E+02	--
Ra-226	136/136	3.60E-01	2.00E+03	3.79E+01	6.66E+01	1.10E+00	6.55E+01	1.49E+02	Yes
Ra-228[e]	--	--	--	--	--	--	--	1.01E+03	--
Th-228[e]	--	--	--	--	--	--	--	7.04E+01	--
Th-230	8/136	6.50E-01	4.30E+03	7.39E+01	1.31E+02	1.40E+00	1.30E+02	1.49E+02	Yes
Th-232	131/136	3.20E-01	2.60E+00	1.25E+00	1.75E+00	1.20E+00	5.50E-01	3.80E+02	No
U-234[f]	--	--	--	--	--	--	1.95E+01	2.02E+03	--
U-235[c]	--	--	--	--	--	--	8.97E-01	1.20E+03	--
U-238	121/136	3.30E-01	3.10E+02	1.55E+01	2.26E+01	3.10E+00	1.95E+01	1.62E+02	Yes
B. From 2001 USACE Investigations									
Ac-227[c]	--	--	--	--	--	--	2.02E-01	4.07E+01	--
Pa-231	4/86	-1.90E+00	5.40E+00	7.44E-02	2.36E-01	6.83E-02	1.68E-01	3.88E+02	No
Pb-210[d]	--	--	--	--	--	--	7.96E-01	8.62E+02	No
Ra-226	84/86	2.60E-01	1.49E+01	1.44E+00	1.75E+00	9.55E-01	7.96E-01	1.49E+02	No
Ra-228	63/86	3.60E-01	3.43E+00	8.74E-01	9.66E-01	8.19E-01	1.47E-01	1.01E+03	No
Th-228	86/86	3.70E-01	3.34E+00	1.02E+00	1.11E+00	8.67E-01	2.41E-01	7.04E+01	No
Th-230	86/86	4.90E-01	1.38E+01	1.36E+00	1.70E+00	9.25E-01	7.71E-01	1.49E+02	No
Th-232	86/86	4.40E-01	3.24E+00	9.43E-01	9.69E-01	8.87E-01	8.19E-02	3.80E+02	No
U-234	84/84	4.80E-01	7.20E+01	3.43E+00	5.19E+00	8.50E-01	4.34E+00	2.02E+03	No
U-235	35/86	-6.00E-03	2.71E+00	1.77E-01	2.49E-01	5.95E-02	1.90E-01	1.20E+03	No
U-238	84/84	4.20E-01	7.50E+01	3.46E+00	5.24E+00	8.59E-01	4.39E+00	1.62E+02	No

Notes:

[a] EPC = (UCL95 - background) or see notes c, d, e, and f

[b] Screening level = the smallest of the soil screening levels for soil invertebrates, small mammals, and small birds in Table 6-12

[c] Assumed at 4.6 percent of U-238 specific activity

[d] Assumed to be in secular equilibrium with Ra-226

[e] Assumed to be in secular equilibrium with Th-232

[f] Assumed to be in secular equilibrium with U-238

"--" = Not Analyzed

* Mean background from the 2001 investigations is used; these values are conservative.

Table 6-16
Calculation of Hazard Quotients for Samples from the Tonawanda Landfill
with at Least One Radionuclide Concentration Above the Screening Level

Location ID above screening level[a]	Radionuclides											
	Ac-227[a]	Pa-231[a]	Pb-210[b]	Ra-226	Ra-228[c]	Th-228[c]	Th-230	Th-232	U-234[d]	U-235[a]	U-238	
Allowable concentration[e]:	4.07E+02	3.88E+03	8.62E+03	1.49E+03	1.01E+04	7.04E+02	1.49E+03	3.80E+03	2.02E+04	1.20E+04	1.62E+03	Hazard Index[f]
Reported maximum concentrations												
B4	6.90E-01	6.90E-01	2.40E+02	2.40E+02	4.20E+01	4.20E+01	8.20E+02	4.20E+01	1.50E+01	6.90E-01	1.50E+01	
B5	3.59E+00	3.59E+00	4.40E+02	4.40E+02	9.60E-01	9.60E-01	1.30E+03	9.60E-01	7.80E+01	3.59E+00	7.80E+01	
B6	2.62E+00	2.62E+00	3.00E+02	3.00E+02	1.10E+00	1.10E+00	3.00E+02	1.10E+00	5.70E+01	2.62E+00	5.70E+01	
B7	1.43E+01	1.43E+01	2.00E+03	2.00E+03	5.30E+00	5.30E+00	4.30E+03	5.30E+00	3.10E+02	1.43E+01	3.10E+02	
B12	1.01E+01	1.01E+01	2.80E+00	2.80E+00	2.10E+00	2.10E+00	8.90E+01	2.10E+00	2.20E+02	1.01E+01	2.20E+02	
Hazard quotient[g]												
B4	1.70E-03	1.78E-04	2.78E-02	1.61E-01	4.16E-03	5.97E-02	5.50E-01	1.11E-02	7.41E-04	5.75E-05	9.26E-03	8.26E-01
B5	8.82E-03	9.24E-04	5.10E-02	2.95E-01	9.50E-05	1.36E-03	8.72E-01	2.53E-04	3.85E-03	2.99E-04	4.81E-02	**1.28E+00**
B6	6.44E-03	6.75E-04	3.48E-02	2.01E-01	1.09E-04	1.56E-03	2.01E-01	2.89E-04	2.82E-03	2.19E-04	3.52E-02	4.85E-01
B7	3.50E-02	3.67E-03	2.32E-01	**1.34E+00**	5.25E-04	7.53E-03	**2.89E+00**	1.39E-03	1.53E-02	1.19E-03	1.91E-01	**4.72E+00**
B12	2.49E-02	2.61E-03	3.25E-04	1.88E-03	2.08E-04	2.98E-03	5.97E-02	5.53E-04	1.09E-02	8.44E-04	1.36E-01	2.41E-01

Notes:

[a] Assumed at 4.6 percent of U-238 specific activity

[b] Assumed to be in secular equilibrium with Ra-226

[c] Assumed to be in secular equilibrium with Th-232

[d] Assumed to be in secular equilibrium with U-238

[e] Concentration resulting in a dose of 0.1 rad/d; = 10 x screening level for small mammals (pCi/g) (Table 6-12)

[f] Sum of hazard quotients

[g] Ratio of reported concentration to allowable concentration; values >1 are in bold font

Table 6-17
Summary of HQ Calculations for Radionuclides
in Tonawanda Landfill Soil Samples[a]

Location ID	Hazard Index <1	Hazard Index >1[b]
B4	0.83	
B5		1.28
B6	0.48	
B7		4.72
B12	0.24	

Notes:

[a] Soil samples with at least one concentration above the screening level, HIs from Table 6-16

[b] Predominantly Ra-226 and Th-230

Table 6-18

RME Risk Summary (lifetime^{-1}) - All Scenarios

		Current	Future			Additional	
Exposure Unit		**Recreational**	**Recreational**	**Construction Worker**	**Industrial Worker**	**Resident Adult**	**Resident Child**
1	Surface	**1.3E-04**	<< 1.0E-06 [a]	9.1E-05	NA	NA	NA
	Subsurface	NA	NA	6.5E-05	NA	NA	NA
2	Surface	0.0E+00	<< 1.0E-06	0.0E+00	NA	NA	NA
	Subsurface	NA	NA	1.7E-07	NA	NA	NA
3	Surface	0.0E+00	<< 1.0E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Subsurface	NA	NA	1.8E-07	5.5E-07	1.0E-05	2.5E-06
4	Surface	1.1E-07	1.1E-07	1.1E-07	4.1E-07	4.0E-06	1.9E-06
	Subsurface	NA	NA	3.8E-07	1.2E-06	2.2E-05	5.3E-06
5	Surface	3.0E-07	3.0E-07	2.0E-07	6.0E-07	1.2E-05	2.9E-06
	Subsurface	NA	NA	1.3E-06	3.8E-06	7.9E-05	1.8E-05

NA = not calculated - scenario not included

a) << 1.0E-06 because 3-ft maintained landfill cap precludes exposure.

Table 6-19

CTE Risk Summary (lifetime^{-1}) - All Scenarios

		Current	Future			Additional	
Exposure Unit		**Recreational**	**Recreational**	**Construction Worker**	**Industrial Worker**	**Resident Adult**	**Resident Child**
1	Surface	1.9E-05	<< 1.0E-06 [a]	8.8E-05	NA	NA	NA
	Subsurface	NA	NA	6.3E-05	NA	NA	NA
2	Surface	0.0E+00	<< 1.0E-06	0.0E+00	NA	NA	NA
	Subsurface	NA	NA	1.6E-07	NA	NA	NA
3	Surface	0.0E+00	<< 1.0E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Subsurface	NA	NA	1.8E-07	5.4E-07	2.5E-06	2.4E-06
4	Surface	2.8E-08	2.8E-08	1.1E-07	4.0E-07	1.8E-06	1.8E-06
	Subsurface	NA	NA	3.7E-07	1.1E-06	5.4E-06	5.1E-06
5	Surface	4.2E-08	4.2E-08	1.9E-07	5.9E-07	2.8E-06	2.6E-06
	Subsurface	NA	NA	1.2E-06	3.8E-06	1.8E-05	1.7E-05

NA = not calculated - scenario not included

a) << 1.0E-06 because 3-ft maintained landfill cap precludes exposure.

Table 6-20
COC Summary*

	Current and Future Uses	**Additional Scenario – Residential****
Surface (top 6" of soil)	Ra-226, Pb-210	None
Subsurface (below 6")	None	None

* Based on RME scenarios
** No scenarios exceed 1 x 10^{-4} risk level, so no COCs are identified.

7.0 SUMMARY AND CONCLUSIONS

The USACE conducted a field investigation at the Tonawanda Landfill Vicinity Property during 2001. This RI report documents the results of that investigation, summarizes the results of previous investigations, and describes the nature and extent of the potentially MED-related contamination in the Landfill and Mudflats OUs at the Site. This report also includes the radiological BRA conducted by USACE for the Tonawanda Landfill Vicinity Property. The investigation was conducted and this report was prepared in accordance with CERCLA guidance.

The results and conclusions of this RI report are summarized below.

7.1 Nature and Extent of Contamination

7.1.1 Soil

During the USACE investigations conducted in 2001, 210 borings were drilled at the Tonawanda Landfill Vicinity Property. All soil samples collected from the borings were analyzed for radiological contaminants. A small number of soil samples collected from the borings were analyzed for chemicals. Four sediment samples, collected from below wet areas and seeps in the Landfill OU, were also analyzed for radiological contaminants.

The soil sampling was conducted to supplement previous investigations at the Tonawanda Landfill Vicinity Property. Sampling locations were concentrated around areas where contamination had been previously encountered (designated as Areas A, B and C – refer to Figure 1-4), in order to bound the lateral extent of potential MED contamination. Additional samples were collected in areas where there was no known MED-like contamination (Class 3 areas).

The nature and extent of the contamination is described in Section 4. Based on 2001 and historic sampling, areas of elevated radiological activity in soils (exceeding background UTL 99/99.9 screening levels as described in Section 4) were observed in Areas A and B of the Landfill OU, and in the immediate vicinity of Area A. In Area A, exceedances of the UTL 99/99.9 background screening levels were found to extend to twenty-four feet bgs, based on historical sampling. The overall area in Area A where elevated levels of radiological contamination were found is less than 2,500 m^2, as shown in Figure 4-12. Sediment samples in Area A also showed elevated activity levels.

Radiological contamination in Area B soils consists of several discrete areas of elevated activity. These areas are non-contiguous, shallow (within three feet of the surface), and do not impact a large area.

Results of chemical analyses of soil samples indicate that there is the potential at some locations for the soils showing radiological contamination to also be classified as hazardous.

The radiological contamination in the Mudflats OU (Area C) which had been encountered by ORNL in 1991 (ORNL 1992) was not encountered during the 2001 USACE investigations. As discussed in Section 4, a sewer installation project in 1996 transected the area of contamination in the Mudflats OU. Piles of material, possibly from the sewer project, and imported fill material (street sweepings) now cover the areas of the Mudflats OU to a depth of 6-8 feet. USACE has concluded that the results of the 2001 investigation are representative of current radiological conditions in the Mudflats OU.

As described in Section 6, the BRA used radiological conditions as reported from the 2001 investigation in developing the radiological risk assessment for the Mudflats OU.

7.1.2 Groundwater

Groundwater samples were collected for radiological analysis from a total of fourteen existing monitoring wells located within the Landfill, along the Landfill perimeter, and in the Mudflats. The locations of these wells are shown on Figure 2-2. Samples were taken from wells screened in native formations and from wells screened in the landfilled waste and fill.

Based on the results of the 2001 USACE sampling, groundwater contamination at the site appears to be limited. A comparison of the sample results to the 40 CFR Part 192 groundwater standards, showed only one exceedance of the total uranium and combined U-234 + U-238 standards. This exceedance occurs at well L-3, in the sample of water/leachate from within the saturated landfilled waste in Area A.

7.2 Contaminant Fate and Transport

The contaminant fate and transport assessment and conceptual site model for the Tonawanda Landfill Vicinity Property are presented in Section 5. The summary and major conclusions are presented below:

7.2.1 Soil

The physical displacement of MED-like contaminated material is possible when activities such as construction are inadvertently conducted in contaminated areas. This appears to have occurred in the Mudflats area.

While most of the landfill areas where MED-like material has been identified in soils are vegetated, bare areas exist and access to these areas is not totally precluded. Thus, the potential for contaminated dust generation from off-road vehicles and other intrusive activities is not precluded. This, however, is not considered to be a major migration pathway.

The presence of gamma-emitting radionuclides in soils at the Site presents a continuing means for transport of electromagnetic energy to the space above and adjacent to contaminated areas at the Site. These emissions are addressed in the BRA as detailed in Section 6 and summarized below.

7.2.2 Water

A principal mechanism for release of MED-like contaminants at the Tonawanda Landfill Vicinity Property is by leaching of uranium from source areas in the vicinity of well L-3 (Area A of the Landfill OU). Uranium leached into the saturated landfill waste may be easily transported in dissolved form to the edges of the landfill. The dissolved uranium may then be transported, at a much slower rate, to groundwater in the Landfill vicinity. The presence of elevated levels of uranium in groundwater in close proximity to the Landfill suggests that some uranium may be transported. The presence of higher permeability strata at some locations could explain how groundwater may be impacted at more distant locations. However, the presence of such a high conductivity strata has not been observed.

Closure of the Landfill in accordance with current conceptual plans would significantly reduce precipitation into the landfilled waste and mounding in the water table in the Landfill would be decreased, resulting in a potential reduction in uranium leaching.

7.3 Radiological Baseline Risk Assessment

The BRA was performed using the 2001 and historical (ORNL 1992, BNI 1995) samples. The BRA consists of two key elements – a Human Health Assessment and a screening Ecological Risk Assessment. The risk to human health is determined using the RESRAD code, Version 6.1 (ANL 2001). The BRA is described in detail in Section 6 of this report.

7.3.1 Toxicity Assessment

Uranium, in soluble form, is a kidney toxin at concentrations slightly above background levels, and is the only radionuclide for which the chemical toxicity has been identified to be comparable to or greater than the radiotoxicity. Uranium toxicity did not exceed an HI of one for any exposure scenario identified in the BRA.

7.3.2 Risk Characterization.

Radiological risks are summarized by exposure unit and scenario in Table 6-18 (RME) and Table 6-19 (CT). These results indicate that for current and plausible future scenarios, all excess cancer risks are less than the 1×10^{-4} risk threshold except the risk for the recreational user, in EU 1, is at the CERCLA risk threshold. The recreational receptor producing the risk of 1×10^{-4} is conservatively assumed to visit the site 350 days per year for 30 years. This exposure includes 15 minutes per weekday and 46 minutes per weekend assuming all time on-site is spent within the contaminated zone. As discussed in the Uncertainty section, this risk is driven by a few hot spots derived from historical data which was not confirmed in the 2001 investigation and sampling. It is likely, therefore, that the risk level is well below the CERCLA risk threshold for all plausible scenarios.

Additional resident adult and child scenarios for EU's 3, 4 and 5 were also considered. Risks for these scenarios all were below the 10^{-4} CERLCA risk threshold.

7.3.3 Screening Ecological Risk Assessment

The ecological risk screening identified limited areas that pose a threat to terrestrial receptors. These areas are located within Exposure Unit 1. Ecological risk will be addressed when this portion of the landfill is capped, or it will be addressed if the material is removed.

7.4 Conclusions

Areas of radiologically contaminated material were encountered in Areas A and B of the Landfill OU. Area B contamination appears to be limited to localized hotspots, while contamination in Area A encompasses a larger area (refer to Figures 4-12 and 4-13).

The presence or location of radiologically impacted material previously detected by DOE in Area C could not be verified during the USACE 2001 investigations. Construction activities in that area appear to have displaced whatever material may have been there. Outside of Area C, no samples exceeded the soils screening criteria.

Radiologically contaminated soils may have impacted the water at the Landfill OU. The concentrations of total uranium and combined U-234 + U-238 in water/leachate exceed 40 CFR Part 192 groundwater standards at location L-3. L-3 is screened in landfill waste and is located in an area where elevated levels of radionuclides were identified in nearby soils. The concentrations at other monitoring wells do not

exceed these standards, although elevated levels of total uranium, and U-234 + U-238 are seen in wells across the Landfill and Mudflats OUs.

The ILCR was calculated for current and future site uses, which included recreational in the Landfill and recreational, industrial, and residential in the Mudflats. All calculated risks except for the Recreational User in EU-1 were within the CERCLA risk range of 10^{-6} to 10^{-4}. The risk for the recreational user, in EU-1, is at the CERCLA risk threshold. As discussed in the Uncertainty section, this risk is driven by a few hot spots derived from historical data which was not confirmed in the 2001 investigation and sampling. It is likely, therefore, that the risk level is well below the CERCLA risk threshold for all plausible scenarios.

8.0 REFERENCES

Argonne National Laboratory (ANL) 1993. C. Yu, C. Loureiro, J.-J. Cheng, L.G. Jones, Y.Y. Wang, Y.P. Chia, and E. Faillace, *Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil*, ANL/EAIS-8. Environmental Assessment Division Argonne National Laboratory, April.

ANL 2001. C. Yu, A.J. Zielen, J.-J. Cheng, D.J. LePoire, E. Gnanapragasam, S. Kamboj, J. Arnish, A. Wallo III, W.A. Williams, and H. Peterson, *User's Manual for RESRAD Version 6*, Environmental Assessment Division, Argonne National Laboratory, ANL/EAD-4, July.

Agency for Toxic Substances and Disease Registry (ATSDR) 1989. *Toxicological Profile for Uranium* (Draft). U.S. Public Health Services, U.S. Department of Health and Human Services, Atlanta, GA. 1989.

ATSDR 1990. *Toxicological Profile for Radium.* U.S. Public Health Services, U.S. Department of Health and Human Services, Atlanta, GA. 1990.

Baes, C.F., III, R.D. Sharp, A.L. Sjoren, and R.W. Shor. 1984. *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture.* Oak Ridge National Laboratory, Oak Ridge, TN. ORNL-5786.

Baily, Robert G. 1995. *Descriptions of Ecoregions of the United States.* USDA, Forest Service Miscellaneous Publication Number 1391. Washington, D.C. March. 108 pp.

Blaylock, B.G., M.L. Frank, and B.R. O'Neal, 1993. *Methodology for Estimating Radiation Dose Rates to Freshwater Biota Exposed to Radionuclides in the Environment.* ES/ER/TM-78. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Bechtel National, Inc. (BNI) 1993. *Remedial Investigation Report for the Tonawanda Site, Tonawanda, New York*. Bechtel National, Inc. February.

BNI 1995. Technical memorandum from Joann Sims, BNI Oak Ridge, TN (Tonawanda Landfill Field Sampling Results) to Eric T. Newberry, BNI Oak Ridge, TN, October 9.

BNI 1998. *Response to NYSDEC Questions About Groundwater at the Ashland Sites.* Bechtel National, Inc. Calculation No. 132-CV-004. March.

Department of Energy (DOE) 1992. *Document No. 098386, Memorandum – Designation of Tonawanda Vicinity Properties.* U.S. Department of Energy. December.

DOE 1993. *Baseline Risk Assessment for the Tonawanda Site*, DOE/OR/21950-003, Oak Ridge, Tennessee, August.

DOE 1994. *FUSRAP Fact Sheet.* November.

EG&G Energy Measurements Group 1984. *An Aerial Radiological Survey for 241 Am Contamination in Tonawanda, New York.* EGG-10282-1063, [EG&G Energy Measurements Group is now called Bechtel Nevada], October.

Eckerman, K.F., et al. 1988. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion and Ingestion,* EPA-520/1-88-020, Federal Guidance Report No. 11, prepared by Oak Ridge National Laboratory, Oak Ridge, Tenn., for U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, D.C.

Eckerman, K.F., and J.C. Ryman 1993. *External Exposure to Radionuclides in Air, Water, and Soil: Exposure to Dose Coefficients for General Application, Based on the 1987 Federal Radiation Protection Guidance,* EPA 402-R-93-081, Federal Guidance Report No. 12, prepared by Oak Ridge National Laboratory, Oak Ridge, Tenn., for U.S. Environmental Protection Agency, Office of Radiation and Indoor Air, Washington, D.C.

Eckerman, K.F., et al., 1999. *Cancer Risk Coefficients for Environmental Exposure to Radionuclides,* EPA 402-R-99-001, Federal Guidance Report No. 13, prepared by Oak Ridge National Laboratory, Oak Ridge, Tenn., for U.S. Environmental Protection Agency, Office of Radiation and Indoor Air, Washington, D.C., Sept.

EG&G Energy Measurements Group 1984. *An Aerial Radiological Survey for 241 Am Contamination in Tonawanda, New York*. EGG-10282-1063, [EG&G Energy Measurements Group is now called Bechtel Nevada, October.

Environmental Protection Agency (EPA). EPA 1989. *Risk Assessment Guidance for Superfund; Volume I — Human Health Evaluation Manual (RAGS/HHEM), Part A, Baseline Risk Assessment, EPA/540/1-89/002,* U.S. Environmental Protection Agency, Washington, D.C.

EPA 1990. *Exposure Factors Handbook,* EPA/600/8-89/043, Washington, D.C., July.

EPA 1992. Supplemental Guidance to RAGS: Calculating the Concentration Term

EPA 1993a. *Presumptive Remedy for CERCLA Municipal Landfill Sites.* Office of Solid Waste and Emergency Response. EPA 540-F-93-035. September 1993.

EPA 1993b. *Integrated Risk Information System (IRIS) on Uranium, Soluble Salts.* Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH. 1993.

EPA 1994. *Model Standards and Techniques for Control of Radon in New Residential Buildings.* EPA 402-R-94-009. Washington, D.C. March.

EPA 1995. *Health Effects Assessment Summary Tables FY-1995 Supplement,* EPA/540/R-95/142, Washington, D.C., Nov.

EPA 1996. *Radiation Exposure and Risk Assessment Manual.* Washington, D.C.

EPA 1997. *Exposure Factors Handbook,* Washington, D.C., August.

EPA 1999a. *Understanding Variation in Partition Coefficient (K_d) Values.* U.S. Environmental Protection Agency. Volume 1 and Volume II. August

EPA 1999b. *Distribution of OSWER Radiation Risk Assessments Q&A's Final Guidance.* Washington, D.C. December.

EPA 2000. Region 9 Preliminary Remediation Goals, http://ww.epa.gov/region09/waste/sfund/prg/s1-06.htm Updated November 22, 2000.

EPA 2000b. *Soil Screening Guidance for Radionuclides: Users Guide.* U.S. Environmental Protection Agency. October.

EPA 2000c. *Soil Screening Guidance for Radionuclides: Technical Background Document.* U.S. Environmental Protection Agency. October.

EPA 2002. USEPA website. Technology Transfer Network. http:/www.epa.gov/ttn/uatw/hlthef/radionuc.html.

Eyre, F.H. (editor) 1980. *Forest Cover Types of the United States and Canada.* Society of American Foresters, Washington, D.C. 148 pp.

Ford, Bacon, and Davis Utah. 1981. *Preliminary Engineering and Environmental Evaluation of the Remedial Action Alternatives for the Linde Air Products Site, Tonawanda, New York*. Bechtel Report No. 10-05-29-59A, Subcontractor Report No. 409-323, Salt Lake City, Utah. (December).

Galvin, M. 1979. *Management of Transmission Line Rights-of-Way for Fish and Wildlife, Vol. 2, Eastern United States,* FWS/OBS-79-22. U.S. Department of Interior, Fish and Wildlife Service, Biological Sciences Division Program, Washington, D.C.

GE 1983. General Electric Corporation, *Chart of the Nuclides, 13th Edition,* 1983.

Kocher, D.C. and Trabalka, J.R. 2000. "On the Application of a Radiation Weighting Factor for Alpha Particles in Protection of Non-Human Biota", *Health Physics Society Journal 79: 407-411.*

Linsley and Franzini 1979. *Water Resources Engineering.* Ray K. Linsley and Joseph B. Franzini. McGraw Hill Book Company. 1979.

Malcolm Pirnie 1999. *Landfill Closure Investigation*, Malcolm Pirnie, Inc. February.

Malcolm Pirnie 2000. *Town of Tonawanda Landfill Leachate Treatability Study.* Malcolm Pirnie, Inc. Buffalo, New York. June.

National Research Council (NRC) 1980. National Research Council "Committee on the Biological Effects of Ionizing Radiations," *The Effects of Populations of Exposure to Low Levels of Ionizing Radiation: BEIR III.* National Academy Press, Washington, D.C.

NRC 1988. "Committee on the Biological Effects of Ionizing Radiations," *Health Risks of Radon and Other Internally Deposited Alpha-Emitters: BEIR IV.* National Academy Press, Washington, D.C., 602 pp.

NRC 1990. "Committee on the Biological Effects of Ionizing Radiations," *Health Risks of Exposure to Low Levels of Ionizing Radiation: BEIR V.* National Academy Press, Washington, D.C., 420 pp.

NCRP (National Council on Radiation Protection and Measurements). 1991. *Effects of Ionizing Radiation on Aquatic Organisms*. NCRP Report No. 109, National Council on Radiation Protection and Measurements, Bethesda, Maryland.

Oak Ridge National Laboratory (ORNL) 1990. *Results of Mobile Gamma Scanning Activities in Tonawanda, New York*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, December 1990.

ORNL 1992. *Results of the Radiological Survey at the Town of Tonawanda Landfill, Tonawanda, New York (TNY001*), ORNL/RASA-92/12, Measurements Applications and Development Group, Oak Ridge, TN, October.

Paustenbach, D.J. 1989. *A Comprehensive Methodology for Assessing Risks to Humans and Wildlife Posted by Contaminated Soil: A Case Study Involving Dioxin,* in D.J. Paustenbach, (ed.), The Risk Assessment of Environmental and Human, Health Hazards: A Textbook of Case Studies, John Wiley and Sons, New York, NY, pp 296-328.

Sample, B.E., M.S. Aplin, R.A. Efroymson, G.W. Suter II, and C.J.E. Welsh, 1997. *Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants,* ORNL/TM-13391. Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

SAS Institute, Inc. 1990. *SAS Procedures Guide,* Vol. 6, 3rd Ed., Cary, NC.

Shleien, Bernard 1992. *The Health Physics and Radiological Health Handbook,* Revised Edition, Scinta, Inc., Silver Spring, MD.

Terzaghi and Peck 1948. *Soil Mechanics in Engineering Practice.* Karl Terzaghi and Ralph B. Peck. John Wiley and Sons. 1948.

TMA/Eberline 1998. *Radiological Characterization of the Municipal Landfill, Tonawanda, New York,* prepared for the Town of Tonawanda, NY. Albuquerque, NM. February.

Town of Tonawanda 1990. *Code of the Town of Tonawanda.* Chapter 215.

USACE 1999a. *Technical Memorandum. Radiological Human Health Assessment for the Town of Tonawanda Landfill, Tonawanda, New York*. Science Applications International Corporation for the U.S. Army Corps of Engineers, Buffalo District Office. February.

USACE 1999b. *Groundwater Hydrology.* Engineer Manual 1110-2-1421. U.S. Army Corps of Engineers. February.

USACE 2000. *Linde Site Radiological Assessment Technical Memorandum, Tonawanda, New York,* February.

USACE 2001a. *Sampling and Analysis Plan*, Tonawanda Landfill FUSRAP Site, Tonawanda, New York, June.

USACE 2001b. *Project Work Plan*, Tonawanda Landfill FUSRAP Site, Tonawanda, New York, September.

USACE 2001c. *Quality Assurance Project Plan,* Tonawanda Landfill FUSRAP Site, Tonawanda, New York. June.

USACE 2002, *Remedial Investigation for the Painesville, Ohio Site,* February.

U.S. Nuclear Regulatory Commission (USNRC) 1992. *Residual Radioactive Contamination from*

Decommissioning – Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent, NUREG/CR-5512, prepared by Pacific Northwest Laboratory for U.S. Nuclear Regulatory Commission, reproduced by U.S. Department of Commerce, Springfield, Virginia, October.

USNRC 2000, US Nuclear Regulatory Agency, US EPA, Department of Defense, US Department of Energy. *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Rev. 1.* NUREG-1575, Rev.1, EPA 402-R-97-016, Rev.1, DOE/EH-0624, Rev.1, August 2000.

Wehran 1994. *Town of Tonawanda Landfill – Draft Closure Plan.* March.

Yu et al. 2001. *Assessing the Impact of Hazardous Constituents on the Mobilization, Transport, and Fate of Radionuclides in RCRA Waste Disposal Units.* C. Yu, K.A. Arlandini, J.J. Cheng, and B.M. Biwer. Environmental Assessment Division, Argonne National Laboratory, Argonne, IL. August.

APPENDIX A

FIELD INVESTIGATION DETAILS
(bound separately)

APPENDIX B

QUALITY CONTROL SUMMARY REPORT AND USACE 2001 RI ANALYTICAL DATA AND QA/QC EVALUATION RESULTS

APPENDIX B
QUALITY CONTROL SUMMARY REPORT AND
USACE 2001 RI ANALYTICAL DATA AND QA/QC EVALUATION RESULTS

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Attachment I USACE 2001 RI Analytical Data and QA/QC Evaluation Results

ACRONYMS, ABBREVIATIONS AND SYMBOLS

σ	standard deviation
%D	percent difference
Ac	Actinium
Ag	Silver
Al	Aluminum
Am	Americium
As	Arsenic
Ba	Barium
Ca	Calcium
Cd	Cadmium
Co	Cobalt
Cr	Chromium
Cs	Cesium
Cu	Copper
DER	Duplicate Error Ratio
EPA	Environmental Protection Agency
Fe	Iron
IS	Internal Standard
K	Potassium
LCS	Laboratory Control Sample
MDL	Method Detection Limit
Mg	Magnesium
Mn	Manganese
MQO	Measurement Quality Objective
MS	Matrix Spike Sample
Na	Sodium
Pa	Protactinium
Pb	Lead
pCi/g	picocurie(s) per gram
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QCSR	Quality Control Summary Report
Ra	Radium
RPD	Relative Percent Difference
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
Sb	Antimony
SDG	Sample Delivery Group
Th	Thorium
U	Uranium
USACE	United States Army Corps of Engineers
VOC	Volatile Organic Compound
Zn	Zinc

APPENDIX B
QUALITY CONTROL SUMMARY REPORT AND USACE 2001 RI ANALYTICAL DATA AND QA/QC EVALUATION RESULTS

B.1 PURPOSE OF THIS REPORT

Environmental data must always be interpreted relative to its known limitations and its intended use. The analytical data review process and this data quality assessment are intended to provide assistance to current and future data users throughout the interpretation of these data. The purpose of this Quality Control Summary Report (QCSR) is to describe the following: (1) quality control (QC) procedures followed to ensure that the data generated by Science Applications International Corporation (SAIC) during these investigations for the Tonawanda Landfill Vicinity Property would meet project requirements; (2) the quality of the data collected; and (3) problems encountered during the course of the study and their solutions.

This appendix provides an assessment of the quality of the analytical information gathered during the course of these investigations and documents that the quality of the data employed for interpretation met project objectives. Evaluation of field and laboratory QC measures will constitute the majority of this assessment; however, references will also be directed toward those QA procedures that establish data credibility. The primary intent of this assessment is to illustrate that data generated for these investigations can withstand scientific scrutiny; are appropriate for their intended purpose; are technically defensible; and are of known and acceptable sensitivity, precision, and accuracy.

Multiple activities were performed to achieve the desired data quality in this project. As discussed in the previous report text, decisions were made during the initial scoping to define the quality and quantity of data required. Objectives were established in the Sampling and Analysis Plan (SAP) (USACE 2001a) to guide the implementation of the field sampling and laboratory analysis. A Quality Assurance (QA) program was established to standardize procedures and to document activities. This program provided a means of detecting and correcting any deficiencies in the process. Upon receipt by the project team, data were subjected to a verification and validation review that identified and qualified problems related to the analysis. These review steps contributed to this final QCSR, which concludes that data used in the investigations met the criteria and are appropriately employed.

B.2 QUALITY ASSURANCE PROGRAM

A Quality Assurance Project Plan (QAPP) was developed for this project and is included as part of the project SAP (USACE 2001a). The purpose of that document was to enumerate the quantity and type of samples to be taken during investigation of the site and to define the quantity and type of QA/QC samples to be used to evaluate the quality of the data obtained.

The QAPP established requirements for both field and laboratory QC procedures. In general, field QC duplicate samples were required for each environmental sample matrix collected at a frequency of approximately 10 percent, and volatile organic compound (VOC) trip blanks were to accompany each cooler containing water samples for VOC determinations. Analytical laboratory QC duplicates, matrix spikes, laboratory control samples, and method blanks were required for every twenty (20) samples or fewer of each matrix and analyte.

A primary goal of the QA program was to ensure that the quality of results for each environmental measurement was appropriate for its intended use. To this end, standardized field procedures were

compiled to guide the investigation. Through the process of readiness review, training, equipment calibration, QC implementation, and detailed documentation, the project has successfully accomplished the goals set by the QA program.

B.3 LABORATORY "DEFINITIVE" LEVEL DATA REPORTING

The QAPP for this project and the analytical laboratory statement of work (USACE 2001a) identified requirements for laboratory data reporting. Paragon Analytics, Inc. (Paragon) of Ft. Collins, Colorado; Acculabs, Inc. (Acculabs) of Golden, Colorado, and General Engineering Laboratories (GEL) of Charleston, South Carolina, were later identified as the laboratories for the project. U.S. Environmental Protection Agency (EPA) "definitive" data have been reported, including the following basic information:

- laboratory case narratives,
- sample results,
- laboratory method blank results,
- laboratory control standard results,
- laboratory sample matrix spike recoveries,
- laboratory duplicate results,
- surrogate, tracer, or chemical recoveries,
- sample extraction/preparation dates, and
- sample analysis dates.

This information from the laboratory, along with field information provided the basis for subsequent data evaluation relative to sensitivity, precision, accuracy, representativeness, and completeness. Electronic copies of all of the laboratory reports have been previously transmitted to USACE. An electronic database (Microsoft Access ©) of the results, showing laboratory and data validation data qualifiers, is included as part of Attachment I to this Appendix.

B.4 DATA VALIDATION

The objective when evaluating the quality of the project data is to determine its usability. The evaluation is based on the interpretation of laboratory QC measures, field QC measures, and project goals. Data validation reviews for each laboratory sample delivery group are being included as Attachment I to this Appendix.

B.4.1 Field Data Validation

Field-generated documents such as sampling logs, boring logs, daily health and safety summaries, daily safety inspections, equipment calibration and maintenance logs, and sample management logs were peer reviewed on-site. These logs and all associated field information are stored in the project file maintained by SAIC.

B.4.2 Laboratory Data Validation

Analytical data generated for this project have been subjected to a process of data verification, validation, and review. The following briefly describes this systematic process and the evaluation activities performed. Several criteria have been established against which the data are compared and from which a judgment is rendered regarding the acceptance and qualification of the data. Because it is beyond the

scope of this report to cite those criteria, the reader is directed to the following documents for specific detail:

- *USACE Requirements for the Preparation of Sampling and Analysis Plans, Appendix I Shell for Analytical Chemistry Requirements* (USACE 2001b);

- *EPA National Functional Guidelines for Inorganic Data Review* (EPA 1994a); and

- *EPA National Functional Guidelines for Organic Data Review* (EPA 1994b).

- *Laboratory Data Validation Guidelines for Evaluating Radionuclide Analyses* (SAIC 2002)

Upon receipt of field and analytical data, verification staff performed a systematic examination of the reports following standardized review process to ensure the content, presentation, and administrative validity of the data. Discrepancies identified during this process were recorded and documented.

During the validation phase of the review and evaluation process, data were subjected to a systematic technical review by examination of all field and analytical QC results and laboratory documentation in accordance with appropriate guidelines for laboratory data validation. These data validation guidelines define the technical review criteria, methods for evaluation of the criteria, and actions to be taken based on the review of these criteria. The primary objective of this phase was to assess and summarize the quality and reliability of the data for their intended uses and to document factors that might affect the usability of the data. Data verification/validation included, but was not necessarily limited to, the following parameters:

- data completeness;
- holding times and sample preservation;
- calibration (initial and continuing);
- method blanks;
- sample results verification;
- surrogate recovery;
- tracer recovery:
- chemical carrier recovery;
- laboratory control standard (LCS) analysis;
- internal standard performance;
- matrix spike (MS) recovery;
- duplicate analysis comparison;
- reported detection limits;
- compound, element, and isotope quantification;
- reported detection levels; and
- secondary dilutions.

As a result of this phase of the review, the data were qualified based on the technical assessment of the validation criteria. Electronic copies of the validation reports for the Paragon, Acculabs, and GEL data are included on the enclosed disk as part of Attachment I to this Appendix.

B.4.3 Definition of Data Qualifiers (Flags)

During the data validation process, all laboratory data were assigned appropriate data validation flags. Validation flags for radiological data are defined as follows:

- "U" indicates the analyte result is less than the critical level (critical level = 1.65*1σ total propagated uncertainty).

- "J" - indicates an unusually uncertain or biased, but usable result. The uncertainty associated with the result significantly (relative to the Measurement Quality Objectives [MQOs]) exceeds the reported uncertainty.

- "UJ" indicates an unusually uncertain or biased, but usable result. The uncertainty associated with the result significantly (relative to the MQOs) exceeds the reported uncertainty and the analyte result is less than the critical level (critical level = 1.65*1σ total propagated uncertainty).

- "R" indicates that the problems are so severe that the data cannot be used because it would significantly affect the decisions based on the data

Validation flags for chemical data are defined as follows:

- "U" indicates the analyte was analyzed for, but not detected above the level of the associated value.

- "J" - indicates that the analyte was positively identified, but that the associated numerical value is an approximate concentration of the analyte in the sample.

- "UJ" indicates that the analyte was analyzed for, but not detected above the associated value; however, the reported value is an estimate and demonstrates a decreased knowledge of its accuracy or precision.

- "R" indicates that the analyte value reported is unusable. The integrity of the analyte's identification, or the analysis accuracy problems are so severe that the data cannot be used because it would significantly affect the decisions based on the data

B.5 DATA QUALITY EVALUATION

Through data verification and validation processes, analytical accuracy, precision, selectivity, and sensitivity have been evaluated. The paragraphs below summarize this review by analyte group. Detailed data validation packages, by laboratory sample delivery group (SDG) are included in Attachment I to this Appendix. A sample delivery group is defined as a group of samples, no greater than twenty, designated by the lab as one result package work order.

B.5.1 Radiochemical Gamma Spectroscopy

<u>Soil Samples</u>

- Sample condition upon receipt by the laboratory was satisfactory.
- Analytical background counts were satisfactory and did not impact sample results.

- There were two radiochemical laboratories used for the soil samples. Acculabs used an empty chamber as their method blank. Paragon Analytics used an empty container for their method blank. A portion of the method blanks showed an indication of blank contamination. There was indication of method blank contamination for Thorium-234 (^{234}Th) causing the results for 103 samples to be qualified as estimated, Protactinium-231 (^{231}Pa) causing the results for 12 samples to be qualified as estimated, ^{234m}Pa causing the results for 13 samples to be qualified as estimated, and Uranium-235 (^{235}U) causing the results for seven samples to be qualified as estimated.
- A portion of the equipment rinsate blanks showed an indication of blank contamination. There was indication of method blank contamination for Radium-228 (^{228}Ra) causing the results for two samples to be qualified as estimated, ^{234}Th causing the results for 68 samples to be qualified as estimated, and ^{234m}Pa causing the results for 131 samples to be qualified as estimated.
- All holding times were met.
- Method calibration was performed appropriately.
- LCS recoveries and performance were acceptable.
- Duplicate error ratios (DERs) and relative percent differences (RPDs) were outside criteria, for ^{228}Ra, ^{234}Th, ^{231}Pa, and ^{235}U comparisons. Associated results were qualified as estimated for ^{228}Ra for 20 samples, ^{234}Th for 40 samples, ^{231}Pa for 15 samples, and ^{235}U for ten samples.
- Potassium-40 (^{40}K) and Cesium-137 (^{137}Cs) were identified above the decision level in a portion of the samples but were not reported by the laboratory.
- ^{231}Pa, ^{235}U, and Americium (^{241}Am) results were qualified as estimated due to improper background subtraction for several samples.
- All data are considered usable.

<u>Water Samples</u>

- Sample condition upon receipt by the laboratory was satisfactory.
- Analytical background counts and method blank activities were satisfactory and did not impact target radionuclides sample results. The laboratory that performed the water sample analyses used a DI water in the appropriate geometry used for the samples.
- All holding times were met.
- Method calibration was performed appropriately.
- LCS recoveries and performance was outside acceptable limits for ^{241}Am for one SDG. One ^{241}Am result was qualified as estimated.
- DERs and RPDs were within acceptable limits – except for Actinium-228 (^{228}Ac). ^{228}Ac results for eight samples were qualified as estimated.
- Matrix Spike Sample (MS) for one SDG has a percent recovery for ^{241}Am outside acceptable limits. One ^{241}Am result was qualified as estimated.
- All data are considered usable.

B.5.2 Radiochemical Alpha Spectroscopy

<u>Soil Samples</u>

- Sample condition upon receipt by the laboratory was satisfactory.
- Analytical background counts and method blank activities were satisfactory, however, some results were qualified as estimated due to activities observed in the method blank or field equipment rinsate sample. These qualifications included the isotopes $^{228/230/232}$Th and $^{234/235/238}$U in a small number of samples.
- All holding times were met.

- Method calibration was performed appropriately.
- LCS recoveries and performance were acceptable.
- DERs and RPDs were within criteria, with the exception of ^{230}Th for one SDG. The 20 associated ^{230}Th results were qualified as estimated.
- Method chemical recovery data were within criteria except for two samples for isotopic uranium, but the uncertainty in the chemical recovery is greater than ten percent for a few samples for $^{228/230/232}$Th and $^{234/235/238}$U. Associated $^{228/230/232}$Th and $^{234/235/238}$U results were qualified as estimated. Three samples' (TLF-0585, TLF-0511, and TLF-0697) $^{234/235/238}$U results were qualified as rejected.
- Spectral analysis indicated some spectral interferences due to peak tailing. Associated results for ^{230}Th and ^{235}U were estimated except for two samples results for ^{235}U which were rejected (TLF-0689 and TLF-9717).
- All data are considered usable, with the exception of those listed above as required.

Water Samples

- Sample condition upon receipt by the laboratory was satisfactory.
- Analytical background counts and method blank activities were satisfactory, however, some results were qualified as estimated due to activities observed in the method blank or field equipment rinsate sample. These qualifications included the isotopes ^{230}Th in a number of samples.
- All holding times were met.
- Method calibration was performed appropriately.
- LCS recoveries and performance were acceptable.
- DERs and RPDs were within criteria, with the exception of ^{234}U comparisons. Associated results were qualified as estimated.
- Method chemical recovery data were within criteria for all determinations, but the uncertainty in the chemical recovery is greater than ten percent. This caused several of the isotopic uranium and isotopic uranium results to be qualified as estimated.
- All data are considered usable.

B.5.3 Radiochemical Radium-226 and –228

Soil Samples (Radium-226)

- Sample condition upon receipt by the laboratory was satisfactory.
- All holding times were met.
- Method calibration was performed appropriately.
- There was an indication of blank contamination in the method blank for ^{226}Ra analyses. Several samples are qualified as estimated (J). There was an indication of blank contamination in the equipment rinsate blank for ^{226}Ra analyses. No qualification of the ^{226}Ra due to equipment rinsate blank contamination is required.
- LCS recoveries and performance were acceptable.
- DERs and RPDs were within criteria, with the exception of a few ^{226}Ra comparisons. Associated results were qualified as estimated (J).
- Method chemical recovery data were within criteria, with the exception of a few samples. The associated ^{226}Ra result was qualified as estimated "J".
- All samples met the required Method Detection Limit (MDL) except for sample TMF-0024 with an MDL of 0.56 picoCuries/gram (pCi/g).
- All data are considered usable.

Water Samples (Radium-226 and -228)

- Sample condition upon receipt by the laboratory was satisfactory.
- Analytical background counts and method blank activities were satisfactory, however, some results were qualified as estimated due to $^{226/228}$Ra activities observed in the method blank or field equipment rinsate sample.
- All holding times were met.
- Method calibration was performed appropriately.
- LCS recoveries and performance were acceptable.
- DERs and RPDs were within acceptable limits.
- Method chemical recoveries were within criteria, but there was greater than ten percent uncertainty in the chemical recovery. The associated ^{228}Ra activities were qualified as estimated J.
- All data are considered usable.

B.5.4 Gross Alpha

Water Sample

- Sample condition upon receipt by the laboratory was satisfactory.
- There was no indication of contamination in the method blank.
- There was an indication of contamination in the equipment rinsate blank for gross alpha; some samples were qualified as estimated.
- LCS recoveries and performance were within acceptable limits.
- The duplicate DERs for gross alpha analyses and the RPDs were outside acceptable limits some samples were qualified as estimated.
- Some MS recoveries were outside acceptable limits for the gross alpha analyses; some samples were qualified as estimated.
- Some samples did not meet the required MDL, but since the gross alpha analyses are estimates, no further qualification was recommended.
- All data are considered usable.

B.5.5 Total Uranium by KPA

Water Samples

- Sample condition upon receipt by the laboratory was satisfactory.
- There was an indication of method blank contamination. Some of the total uranium results were qualified as estimated.
- There was an indication of equipment rinsate blank contamination. Some of the total uranium results were qualified as estimated.
- All holding times were met.
- Method calibration was performed appropriately.
- LCS recoveries and performance were acceptable.
- DERs and RPDs were outside acceptable limits, but the duplicate sample was on a water sample from another project. No qualification of the total uranium results was required.
- Matrix spike evaluations were within acceptable limits.
- All data are considered usable.

B.5.6 Radiochemical Data Intercomparison

Soil Samples

- U alpha and U gamma determinations were in good agreement within the associated uncertainties. Although three sample results for ^{234}Th and ^{238}U were estimated, due to comparisons being less than desired.
- Comparison of ^{228}Ac gamma results to ^{232}Th was acceptable for most analyses. No further qualification of the ^{228}Ac of ^{232}Th results was required.
- Comparison of ^{231}Pa gamma results to ^{235}U alpha results was not acceptable for all samples, but no qualification of results is required.

Water Samples

- Comparisons of U Alpha to U Gamma were all within the uncertainties.
- Comparisons of ^{228}Ac Gamma to ^{228}Ra Beta and ^{232}Th were all within limits.
- Comparisons of ^{231}Pa Gamma to ^{235}U Alpha were all within limits.
- Comparisons of Alpha/Beta Sums to gross alpha/beta analysis were all in agreement, except that unidentified activity was noted for sample TLW-0168.
- Comparisons of Total Activity to sum of alpha and beta emitters were all in agreement

B.5.7 Organic Compound Analyses (VOC, SVOC, Pesticides, PCBs, Herbicides)

Soil Samples

- Sample condition upon receipt by the laboratory was satisfactory, including temperature and preservation.
- Analytical data for method blanks were satisfactory except for one VOC method blank for methylene chloride in one of the two SDGs causing two samples for methylene chloride results to be qualified as UJ.
- All holding times were met.
- Initial and continuing calibration criteria were achieved for all analyses except for pesticides and VOCs in both SDGs and SVOCs in one SDG. The delta-BHC results for three samples were qualified as "UJ." 4,4'-DDT for one sample was qualified as "J"and two samples were qualified as "UJ." Methoxychlor and edrin ketone for three samples were qualified as "UJ."
- Methylene chloride results for one sample was qualified as "J" and sample TMF-0282 was qualified as "R." Bromomethane for two samples were qualified as "J" and two samples were qualified as "UJ."
- 4-chloroaniline, 3-nitroaniline, 2,4-dinitrophenol, and 3,3'-dichlorobenzidine for four samples were qualified as "UJ."
- LCS recoveries and performance were acceptable except for phenol and 2,4-dinitrotoluene results for four samples were qualified as "UJ."
- Surrogate compound information was acceptable, with the exception of two low VOC surrogate values. All VOC results were qualified as "J" for detects or "UJ" for non-detects for samples TLF-0661, TLF-9716, and TLF-0677 in these instances.
- MS and MSD performance was within criteria except for PCBs for both SDGs and SVOCs for one SDG. All or the PCB results were qualified as "J" or "UJ." The 2,4-dinitrotoluene results for four samples were qualified as "UJ." The pyrene results for one sample was qualified as "UJ" and three samples were qualified as "J."

- GC column percent difference (%D) for Aroclor 1260 exceeded acceptable limits (± 25%) causing the qualification of two results as "J" and three results as "UJ."
- The %D for heptachlor epoxide, gamma-chlordane, alpha-chlordane, dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, and endosulfan are also outside acceptable limits. Only one sample result for each analyte was qualified as "J" except for 4,4'-DDE has four results and 4,4'-DDD has five results qualified as "J."
- The percent Endrin and 4,4'-DDT Breakdown were within acceptable limits.
- Internal Standard (IS) Area was outside acceptable limits causing the qualification of five results for each di-n-octyl phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno (1,2,3-cd) pyrene, dibenzo(a,h)anthracene, benzo(g,h,i)perylene; four results for each 1,2 dichlorobenzene, 1,4 dichlorobenzene, 1,2-dibromo-3-chloropropane; and three results for each chlorobenzene, ethylbenzene, m,p-xylene, o-xylene, styrene, bromoform, 1,1,2,2-tetrachloroethane, 1,3 dichlorobenzene, and two results for each benzidine, pyrene, butylbenzylphthalate, benzo(a)anthracene, 3,3' dichlorobenzidine, chrysene, and bis(2-ethylhexyl)phthalate as either "J" or "UJ."

B.5.8 Metals

Soil Samples

- Sample condition upon receipt by the laboratory was satisfactory.
- Observed method blank concentrations did not impact soil sample results, however, some leachate sample values were qualified as non-detect "U", due to similar values being observed in the associated method blanks. These elements included aluminum (Al), barium (Ba), cobalt (Co), chromium (Cr), iron (Fe), K, silver (Ag), sodium (Na), and zinc (Zn).
- LCS recoveries and performance were acceptable except antimony (Sb), causing four results to be qualified as "J."
- The duplicate RPD is outside acceptable limits for lead (Pb), causing four lead results to be qualified as "J."
- MS/MSD recoveries were outside acceptable limits for arsenic (As), cadmium (Cd), manganese (Mn), potassium, and zinc. The As, Cd, Mn, K, and Zn results for four samples are qualified as "J."
- The serial dilution RPD was outside acceptable limits for Al, calcium (Ca), copper (Cu), Fe, magnesium (Mg), Mn, K, and Zn. The Al, Ca, Cu, Fe, Mg, Mn, K, and Zn results for four samples were qualified as "J."
- All data are considered usable.

B.5.9 Miscellaneous Analysis (Total Cyanide and Percent Moisture)

Soil Samples

- Sample condition upon receipt by the laboratory was satisfactory.
- Analytical data for method blanks were satisfactory.
- Normal analytical holding times were met for these analyses.
- Initial and continuing calibration criteria were achieved for all analyses.
- LCS recoveries and performance were acceptable.
- All other analytical QC documentation is considered acceptable.
- All data are considered usable.

B.5.10 Sensitivity

Determination of minimum detectable values allows the investigation to assess the relative confidence that can be placed in a value relative to the magnitude or level of analyte concentration observed. The closer a measured value comes to the minimum detectable concentration, the less confidence and more variation the measurement will have. Project sensitivity goals were expressed as quantitation level goals in the QAPP (USACE 2001a). These levels were achieved or exceeded throughout the analytical process. There were, however, individual exceptions that have generated qualification of the data or elevation of detection levels when the original goal was not achieved. Variations observed were caused by fluctuations in moisture content, the need to dilute samples due to matrix interference, or high levels of specific analytes.

Variations in observed detection levels have not impacted the usability of the data for the project. Moisture content and blank levels also did not impact data usability.

B.5.11 Representativeness and Comparability

Representativeness expresses the degree to which data accurately reflect the analyte or parameter of interest for the environmental site and is the qualitative term most concerned with the proper design of the sampling program. Factors that affect the representativeness of analytical data include proper preservation, holding times, use of standard sampling and analytical methods, and determination of matrix or analyte interferences. Although some data was qualified due to extended holding times, none of the results required rejection due to these aberrations. Sample preservation, analytical methodologies, and sediment sampling methodologies were documented to be adequate and to have been consistently applied. Both soil and soil leachate analytical methods have been effectively applied for this study.

Comparability, like representativeness, is a qualitative term relative to a project data set as an individual. These investigations employed appropriate sampling methodologies, site surveillance, use of standard sampling devices, uniform training, documentation of sampling, standard analytical protocols/procedures, QC checks with standard control limits, and universally accepted data reporting units to ensure comparability to other data sets. Through the proper implementation and documentation of these standard practices, the project has an established confidence that the data will be comparable to other project and programmatic information.

B.5.12 Completeness

Usable data are defined as those data that pass individual scrutiny during the verification and validation process and are therefore accepted for unrestricted application. It is considered that estimated data are acceptable for project objectives. Only three $^{234/238}U$ results and five ^{235}U results were rejected in this data set for the radiological data and one result for methylene chloride for the chemical data. Therefore, the project produced valid results for more than 99 percent of the sample radiological analyses, more than 85 percent of the methylene chloride results performed, and successfully collected all of the projected investigation analyses. The completeness objectives for these investigations have been achieved.

B.6 DATA QUALITY ASSESSMENT SUMMARY

The overall quality of this Tonawanda Landfill data exceeds the established project objectives. Through proper implementation of the project data verification, validation, and assessment process, project information has been determined to be acceptable for use. Data, as presented, have been qualified as usable, but estimated when necessary. Data that have been estimated provide indications of accuracy, precision, or sensitivity being less than desired but adequate for interpretation.

Data produced for these investigations demonstrate that they can withstand scientific scrutiny; are appropriate for their intended purposes; are technically defensible; and are of known and acceptable sensitivity, precision, and accuracy. Data integrity has been documented through proper implementation of QA and QC measures. The environmental information presented has an established confidence that allows its use for the project objectives and to provide data for future needs.

B.7 REFERENCES

EPA 1994a. *EPA National Functional Guidelines for Inorganic Data Review*

EPA 1994b. *EPA National Functional Guidelines for Organic Data Review*

SAIC 2002. *Laboratory Data Validation Guidelines for Evaluating Radionuclide Analyses, Doc. #143.2002.0404.001*. April 4, 2002. Rucker and Johnson.

USACE 2001a. *Sampling and Analysis Plan*, Tonawanda Landfill FUSRAP Site, Tonawanda, New York, June

USACE 2001b. *USACE Requirements for the Preparation of Sampling and Analysis Plans, Appendix I Shell for Analytical Chemistry Requirements*

ATTACHMENT I

USACE 2001 RI Analytical Data and

QA/QC Evaluation Results

Attachment I - Instructions

The attached CD contains Attachment I of Appendix B, which includes data validation packages of results from the USACE 2001 field investigation for each laboratory sample delivery group and the Tonawanda Landfill Laboratory Results Database of results from the USACE 2001 field investigation.

Data Validation Packages

An index of data validation packages (filename: DV Index) is included and must be read with an Adobe Acrobat® Reader. The index lists each Lab ID with the investigation areas from which the samples reported in the lab sample delivery group were collected.

In Adobe Acrobat® Reader V. 5.0, to open the individual data validation packages, click on the Lab ID number in the DV Index.pdf file. To return to the DV Index file, click "Go to previous document" under "Document" on the menu bar.

Tonawanda Landfill Laboratory Results Database

The database (filename: Tonawanda_SecData) must be read with Microsoft Access ™. Due to the nature of Microsoft Access ™, the database cannot be read directly from the CD. Follow the instructions below to make the database readable.

- Copy the file to the hard drive of your computer.
- Right-click the file and select Properties.
- Un-click the Read-only attribute.
- Click Apply and OK.

The database is now loaded on your computer and may be opened by double clicking on the file icon.

APPENDIX C

BASELINE RISK ASSESSMENT SUPPORTING INFORMATION

APPENDIX C.1

RESRAD PARAMETERS
FOR RADIOLOGICAL EXPOSURES

Table C1-1
Reasonable Maximum Exposure RESRAD Parameters for Radiological Exposures

RESRAD Parameter	Units	Value	Receptor	Comment/Reference
Area of contaminated zone	m^2	10,000	All	RESRAD default; results insensitive to areas above 10,000 m^2
Thickness of contaminated zone	m	2	All	RESRAD default; conservative based on-site-specific data
Length parallel to aquifer flow	m	100	All	RESRAD default
Time since placement of material	yr	0	All	RESRAD default
Cover depth	m	Varies	Construction	Ranges from 0 to 0.76 m during landfill closure activities
		0.9	Recreational (post)	Post-closure landfill only (Wehran 1994)
		0.0	All others	Pre-landfill-closure or mudflats
Density of cover material	g/cm^3	1.5	All	RESRAD default
Cover depth erosion rate	m/yr	0.0	All	Assumes cover is maintained, when used
Density of contaminated zone	g/cm^3	1.5	All	RESRAD default
Contaminated zone erosion rate	m/yr	0.001	All	RESRAD default
Contaminated zone total porosity	unitless	0.45	All	DOE 1993
Contaminated zone field capacity	unitless	0.2	All	RESRAD default
Contaminated zone hydraulic conductivity	m/yr	3154	All	Malcolm-Pirnie (1999) landfill closure reports
Contaminated zone b parameter	unitless	5.3	All	RESRAD default
Average annual wind speed	m/sec	2	All	RESRAD default
Humidity in air	g/m^3	NU	All	Not used
Evapotranspiration coefficient	unitless	0.46	All	DOE 1993
Precipitation	m/yr	1.23	All	DOE 1993
Irrigation	m/yr	0.2	All	RESRAD default
Irrigation mode	unitless	Overhead	All	RESRAD default
Runoff coefficient	unitless	0.25	All	DOE 1993
Watershed area for nearby stream or pond	m^2	1.00E+06	All	RESRAD default
Accuracy for water/soil computations	unitless	0.001	All	RESRAD default
Saturated zone density *	g/cm^3	1.5	All	RESRAD default
Saturated zone total porosity	unitless	0.4	All	RESRAD default
Saturated zone effective porosity	unitless	0.2	All	RESRAD default
Saturated zone field capacity	unitless	0.2	All	RESRAD default
Saturated zone hydraulic conductivity	m/yr	100	All	RESRAD default
Saturated zone hydraulic gradient	unitless	0.02	All	RESRAD default
Saturated zone b parameter	unitless	5.3	All	RESRAD default

Table C1-1
Reasonable Maximum Exposure RESRAD Parameters for Radiological Exposures

RESRAD Parameter	Units	Value	Receptor	Comment/Reference
Water table drop rate	m/yr	0.001	All	RESRAD default
Well pump intake depth (m below water table)	m	10	All	RESRAD default
Model: Nondispersion (ND) or Mass-Balance (MB)	unitless	ND	All	RESRAD default
Well pumping rate	m^3/yr	250	All	RESRAD default
Number of unsaturated zone strata *	unitless	1	All	RESRAD default
Unsaturated zone thickness	m	4	All	RESRAD default
Unsaturated zone soil density	g/cm^3	1.5	All	RESRAD default
Unsaturated zone total porosity	unitless	0.4	All	RESRAD default
Unsaturated zone effective porosity	unitless	0.2	All	RESRAD default
Unsaturated zone field capacity	unitless	0.2	All	RESRAD default
Unsaturated zone b parameter	unitless	10	All	RESRAD default
Unsaturated zone hydraulic conductivity	m/yr	5.3	All	RESRAD default
Distribution coefficient – actinium	cm^3/g	2,400	All	USACE 1999
Distribution coefficient – protactinium	cm^3/g	2,700	All	USACE 1999
Distribution coefficient – lead	cm^3/g	550	All	USACE 1999
Distribution coefficient – radium	cm^3/g	9,100	All	USACE 1999
Distribution coefficient – thorium	cm^3/g	10,000	All	USACE 1999
Distribution coefficient – uranium	cm^3/g	3,000	All	USACE 1999
Distribution coefficient – others, if applicable	cm^3/g	TBD	All	Clay assumed (DCH, Table 32.1)
Inhalation rate	m^3/yr	8,400	Resident Adult	RESRAD default
		4,800	Resident Child	Adult rate scaled by EFH Table 1-2 daily rates (8.7/15.2)
		11,400	Industrial Worker	Assuming outdoor hourly rate of 1.3 m^3/hr (EFH, Table 5-23)
		14,000	Construction	Assuming moderate rate of 1.6 m^3/hr (EFH, Table 5-23)
		14,000	Recreational	Assuming moderate rate of 1.6 m^3/hr (EFH, Table 5-23)
Mass loading for inhalation	g/m^3	1.8E-04	Construction	DCH with 30% respirable fraction (Paustenbach 1989)
		3.0E-05	All others	NRC 1992 with 30% respirable fraction (Paustenbach 1989)
Exposure duration	yr	30	Resident Adult	RME duration for resident (EFH, RAGS)
		6.0	Resident Child	Assuming 6 years of childhood spend at site
		6.6	Industrial Worker	Occupational tenure (EFH Table 15-176)
		1.0	Construction	Assuming construction activities during one calendar year
		30	Recreational	RME duration for (off-site) resident (EFH, RAGS)
Shielding factor, inhalation	unitless	0.4	All	RESRAD default
Shielding factor, external gamma	unitless	0.4	All	60% shielding per SSG-2000 for all indoor receptors

Table C1-1
Reasonable Maximum Exposure RESRAD Parameters for Radiological Exposures

RESRAD Parameter	Units	Value	Receptor	Comment/Reference
Fraction of time spent indoors	unitless	0.655	Resident Adult	16.4 hr/day for 350 days/yr for resident (EFH, Table 1-2)
		0.736	Resident Child	19 hr/day (weekday) and 17 hr/day (weekend) for 350 days/yr for resident (EFH, Table 1-2)
		0.200	Industrial Worker	7 of 8 hours per day for 250 days per year (assumed)
		0.0	Construction	No indoor exposure
		0.0	Recreational	No indoor exposure
Fraction of time spent outdoors (on site)	unitless	0.0799	Resident Adult	2 hrs/day for 350 days/yr for resident (EFH, Table 1-2)
		0.223	Resident Child	5 hrs/day (weekday) or 7 hrs/day (weekend) for 350 days per year for children ages 3-11 (EFH Table 1-2)
		0.0285	Industrial Worker	1 of 8 hrs/day for 250 days/yr (assumed)
		0.228	Construction	Assumes one full year of activity
		0.0120	Recreational	15 min/weekday and 23 min/weekend day (EFH Table 15-9)
Shape factor flag, external gamma	unitless	1	All	RESRAD default
Fruits, vegetables and grain consumption	kg/yr	452	Resident Adult	RME rate of 18.6 g/kg-day (11.1 for fruit and 7.5 for vegetables) minus RME leafy vegetable rate for 70 kg adult (EFH, Table 1-2)
		99	Resident Child	RME rate of 18.6 g/kg-day (11.1 for fruit and 7.5 for vegetables) minus RME leafy vegetable rate for 15 kg child (EFH, Table 1-2)
		NU	All others	Not used
Leafy vegetable consumption	kg/yr	14	Resident Adult	RESRAD default; conservative compared to EFH values
		3.0	Resident Child	Adult value scaled by body weights (15/70)
		NU	All others	Not used
Milk consumption	L/yr	NU	All	Not used
Meat and poultry consumption	kg/yr	NU	All	Not used
Fish consumption	kg/yr	NU	All	Not used
Other seafood consumption	kg/yr	NU	All	Not used
Soil ingestion rate	g/yr	36.5	Resident Adult	100 mg/day for RME residential adult (RAGS)
		73.0	Resident Child	200 mg/day for RME residential child (RAGS)
		36.5	Industrial Worker	100 mg/day for RME adult rate (RAGS)
		175.2	Construction	480 mg/day for RME assuming outdoor summer activities (EFH, Table 4-16)
		36.5	Recreational	100 mg/day for RME adult rate (RAGS)
Drinking water intake	L/yr	NU	All	Not used; water non-potable
Contamination fraction of drinking water	unitless	NU	All	Not used
Contamination fraction of household water	unitless	NU	All	Not used

Table C1-1
Reasonable Maximum Exposure RESRAD Parameters for Radiological Exposures

RESRAD Parameter	Units	Value	Receptor	Comment/Reference
Contamination fraction of livestock water	unitless	NU	All	Not used
Contamination fraction of irrigation water	unitless	0.0	All	Not used
Contamination fraction of aquatic food	unitless	NU	All	Not used
Contamination fraction of plant food	unitless	0.05	Resident Adult	Suburban rate for fruits and vegetable (EFH, Table 13-71)
		0.05	Resident Child	Suburban rate for fruits and vegetable (EFH, Table 13-71)
		NU	All others	Not used
Contamination fraction of meat	unitless	NU	All	Not used
Contamination fraction of milk	unitless	NU	All	Not used
Pathway – external gamma	unitless	Active	All	Assumed complete for all receptors
Pathway – inhalation (w/o radon)	unitless	Active	All	Assumed complete for all receptors
Pathway – plant ingestion	unitless	Active	Resident Adult	Assumed complete for gardening receptors
		Active	Resident Child	Assumed complete for gardening receptors
		Inactive	All others	Assumed incomplete for all other receptors
Pathway – meat ingestion	unitless	Inactive	All	Assumed incomplete for all receptors
Pathway – milk ingestion	unitless	Inactive	All	Assumed incomplete for all receptors
Pathway – aquatic foods	unitless	Inactive	All	Assumed incomplete for all receptors
Pathway – drinking water	unitless	Inactive	All	Assumed incomplete for all receptors
Pathway – soil ingestion	unitless	Active	All	Assumed complete for all receptors
Pathway – radon	unitless	Inactive	All	Inactive for all receptors

* Saturated and unsaturated zone parameters are only relevant for groundwater-related pathways. Because the groundwater is not potable at this site the parameters are not considered in risk calculations and are listed only for informational purposes.

DCH = Data Collection Handbook (ANL 1993)
EFH = Exposure Factors Handbook (EPA 1997)
NU = not used
RAGS = Risk Assessment Guidance for Superfund, specifically Volume 1 Part B (EPA 1991)
RME = reasonable maximum exposure
SSG-2000 = Soil Screening Guidance for Radionuclides: Technical Background Document (EPA 2000c)
TBD = to be determined

Table C1-2
Central Tendency RESRAD Parameters for Radiological Exposures

RESRAD Parameter	Units	Value	Receptor	Comment/Reference
Area of contaminated zone	m^2	10,000	All	RESRAD default; results insensitive to areas above 10,000 m^2
Thickness of contaminated zone	m	2	All	RESRAD default; conservative based on-site-specific data
Length parallel to aquifer flow	m	100	All	RESRAD default
Time since placement of material	yr	0	All	RESRAD default
Cover depth	m	Varies	Construction	Ranges from 0 to 0.76 m during landfill closure activities
		0.9	Recreational (post)	Post-closure landfill only (Wehran 1994)
		0.0	All others	Pre-landfill-closure or mudflats
Density of cover material	g/cm^3	1.5	All	RESRAD default
Cover depth erosion rate	m/yr	0.0	All	Assumes cover is maintained, when used
Density of contaminated zone	g/cm^3	1.5	All	RESRAD default
Contaminated zone erosion rate	m/yr	0.001	All	RESRAD default
Contaminated zone total porosity	unitless	0.45	All	DOE 1993
Contaminated zone field capacity	unitless	0.2	All	RESRAD default
Contaminated zone hydraulic conductivity	m/yr	3154	All	Malcolm-Pirnie landfill closure reports
Contaminated zone b parameter	unitless	5.3	All	RESRAD default
Average annual wind speed	m/sec	2	All	RESRAD default
Humidity in air	g/m^3	NU	All	Not used
Evapotranspiration coefficient	unitless	0.46	All	DOE 1993
Precipitation	m/yr	1.23	All	DOE 1993
Irrigation	m/yr	0.2	All	RESRAD default
Irrigation mode	unitless	Overhead	All	RESRAD default
Runoff coefficient	unitless	0.25	All	DOE 1993
Watershed area for nearby stream or pond	m^2	1.00E+06	All	RESRAD default
Accuracy for water/soil computations	unitless	0.001	All	RESRAD default
Saturated zone density	g/cm^3	1.5	All	RESRAD default
Saturated zone total porosity	unitless	0.4	All	RESRAD default
Saturated zone effective porosity	unitless	0.2	All	RESRAD default
Saturated zone field capacity	unitless	0.2	All	RESRAD default
Saturated zone hydraulic conductivity	m/yr	100	All	RESRAD default
Saturated zone hydraulic gradient	unitless	0.02	All	RESRAD default

Table C1-2
Central Tendency RESRAD Parameters for Radiological Exposures

RESRAD Parameter	Units	Value	Receptor	Comment/Reference
Saturated zone b parameter	unitless	5.3	All	RESRAD default
Water table drop rate	m/yr	0.001	All	RESRAD default
Well pump intake depth (m below water table)	m	10	All	RESRAD default
Model: Nondispersion (ND) or Mass-Balance (MB)	unitless	ND	All	RESRAD default
Well pumping rate	m^3/yr	250	All	RESRAD default
Number of unsaturated zone strata	unitless	1	All	RESRAD default
Unsaturated zone thickness	m	4	All	RESRAD default
Unsaturated zone soil density	g/cm^3	1.5	All	RESRAD default
Unsaturated zone total porosity	unitless	0.4	All	RESRAD default
Unsaturated zone effective porosity	unitless	0.2	All	RESRAD default
Unsaturated zone field capacity	unitless	0.2	All	RESRAD default
Unsaturated zone b parameter	unitless	10	All	RESRAD default
Unsaturated zone hydraulic conductivity	m/yr	5.3	All	RESRAD default
Distribution coefficient – actinium	cm^3/g	2,400	All	USACE 1999
Distribution coefficient – protactinium	cm^3/g	2,700	All	USACE 1999
Distribution coefficient – lead	cm^3/g	550	All	USACE 1999
Distribution coefficient – radium	cm^3/g	9,100	All	USACE 1999
Distribution coefficient – thorium	cm^3/g	10,000	All	USACE 1999
Distribution coefficient – uranium	cm^3/g	3,000	All	USACE 1999
Distribution coefficient – others, if applicable	cm^3/g	TBD	All	Clay assumed (DCH, Table 32.1)
Inhalation rate	m^3/yr	5,550	Resident Adult	Assuming male hourly rate of 15.2 m^3/day (EFH, Table 1-2)
		3,180	Resident Child	Assuming child hourly rate of 8.7 m^3/day (EFH, Table 1-2)
		11,400	Industrial Worker	Assuming outdoor hourly rate of 1.3 m^3/hr (EFH, Table 5-23)
		14,000	Construction	Assuming moderate rate of 1.6 m^3/hr (EFH, Table 5-23)
		14,000	Recreational	Assuming moderate rate of 1.6 m^3/hr (EFH, Table 5-23)
Mass loading for inhalation	g/m^3	1.8E-04	Construction	DCH with 30% respirable fraction (Paustenbach 1989)
		3.0E-05	All others	NRC 1992 with 30% respirable fraction (Paustenbach 1989)
Exposure duration	yr	9.0	Resident Adult	Average residential durations (EFH, Table 1-2)
		6.0	Resident Child	Assuming 6 years of childhood spend at site
		6.6	Industrial Worker	Occupational tenure (EFH Table 15-176)
		1.0	Construction	Assuming construction activities during one calendar year
		9.0	Recreational	Average residential durations (EFH, Table 1-2)
Shielding factor, inhalation	unitless	0.4	All	RESRAD default

Table C1-2
Central Tendency RESRAD Parameters for Radiological Exposures

RESRAD Parameter	Units	Value	Receptor	Comment/Reference
Shielding factor, external gamma	unitless	0.4	All	60% shielding per SSG-2000 for all indoor receptors
Fraction of time spent indoors	unitless	0.655	Resident Adult	16.4 hr/day for 350 days/yr for resident (EFH, Table 1-2)
		0.736	Resident Child	19 hr/day (weekday) and 17 hr/day (weekend) for 350 days/yr for resident (EFH, Table 1-2)
		0.200	Industrial Worker	7 of 8 hours per day for 250 days per year (assumed)
		0.0	Construction	No indoor exposure
		0.0	Recreational	No indoor exposure
Fraction of time spent outdoors (on site)	unitless	0.0799	Resident Adult	2 hrs/day for 350 days/yr for resident (EFH, Table 1-2)
		0.223	Resident Child	5 hrs/day (weekday) or 7 hrs/day (weekend) for 350 days per year for children ages 3-11 (EFH Table 1-2)
		0.0285	Industrial Worker	1 of 8 hrs/day for 250 days/yr (assumed)
		0.228	Construction	Assumes one full year of activity
		0.0057	Recreational	Assumes 50 hrs/year on-site (ANL 2001)
Shape factor flag, external gamma	unitless	1	All	RESRAD default
Fruits, vegetables and grain consumption	kg/yr	115	Resident Adult	Average rate of 4.8 g/kg-day (2.7 for fruit and 2.1 for vegetables) minus RME leafy vegetable rate for 70 kg adult (EFH, Table 1-2)
		24.8	Resident Child	Average rate of 4.8 g/kg-day (2.7 for fruit and 2.1 for vegetables) minus RME leafy vegetable rate for 15 kg child (EFH, Table 1-2)
		NU	All others	Not used
Leafy vegetable consumption	kg/yr	8.0	Resident Adult	Average rate of 0.312 g/kg-day (0.224 for lettuce and 0.088 for cabbage) for 70 kg adult (EFH, Table 9-5)
		1.7	Resident Child	Average rate of 0.312 g/kg-day (0.224 for lettuce and 0.088 for cabbage) for 15 kg adult (EFH, Table 9-5)
		NU	All others	Not used
Milk consumption	L/yr	NU	All	Not used
Meat and poultry consumption	kg/yr	NU	All	Not used
Fish consumption	kg/yr	NU	All	Not used
Other seafood consumption	kg/yr	NU	All	Not used
Soil ingestion rate	g/yr	18.25	Resident Adult	50 mg/day for average adult (EFH, Table 1-2)
		36.5	Resident Child	100 mg/day for average child (EFH, Table 1-2)
		18.25	Industrial Worker	50 mg/day for average rate (EFH, Table 1-2)
		87.6	Construction	Half of assumed 480 mg/day rate (EFH, Table 4-16)
		18.25	Recreational	50 mg/day for average adult (EFH, Table 1-2)
Drinking water intake	L/yr	NU	All	Not used; water non-potable

Table C1-2
Central Tendency RESRAD Parameters for Radiological Exposures

RESRAD Parameter	Units	Value	Receptor	Comment/Reference
Contamination fraction of drinking water	unitless	NU	All	Not used
Contamination fraction of household water	unitless	NU	All	Not used
Contamination fraction of livestock water	unitless	NU	All	Not used
Contamination fraction of irrigation water	unitless	0.0	All	Not used
Contamination fraction of aquatic food	unitless	NU	All	Not used
Contamination fraction of plant food	unitless	0.05	Resident Adult	Suburban rate for fruits and vegetable (EFH, Table 13-71)
		0.05	Resident Child	Suburban rate for fruits and vegetable (EFH, Table 13-71)
		NU	All others	Not used
Contamination fraction of meat	unitless	NU	All	Not used
Contamination fraction of milk	unitless	NU	All	Not used
Pathway – external gamma	unitless	Active	All	Assumed complete for all receptors
Pathway – inhalation (w/o radon)	unitless	Active	All	Assumed complete for all receptors
Pathway – plant ingestion	unitless	Active	Resident Adult	Assumed complete for gardening receptors
		Active	Resident Child	Assumed complete for gardening receptors
		Inactive	All others	Assumed incomplete for all other receptors
Pathway – meat ingestion	unitless	Inactive	All	Assumed incomplete for all receptors
Pathway – milk ingestion	unitless	Inactive	All	Assumed incomplete for all receptors
Pathway – aquatic foods	unitless	Inactive	All	Assumed incomplete for all receptors
Pathway – drinking water	unitless	Inactive	All	Assumed incomplete for all receptors
Pathway – soil ingestion	unitless	Active	All	Assumed complete for all receptors
Pathway – radon	unitless	Inactive	All	Inactive for all receptors

* Saturated and unsaturated zone parameters are only relevant for groundwater-related pathways. Because the groundwater is not potable at this site the parameters are not considered in risk calculations and are listed only for informational purposes.

DCH = Data Collection Handbook (ANL 1993)
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NU = not used
RAGS = Risk Assessment Guidance for Superfund, specifically Volume 1 Part B (EPA 1991)
RME = reasonable maximum exposure
SSG-2000 = Soil Screening Guidance for Radionuclides: Technical Background Document (EPA 2000c)
TBD = to be determined

APPENDIX C.2

RISK AND DOSE CALCULATION DETAILS

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Adult	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Resident Adult	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Adult	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	Ra-228	8.21E-02	2.6E-06	3.8E-09	8.9E-07	3.3E-08	3.5E-06
EU4	Resident Adult	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	U-235	7.59E-02	4.0E-07	8.3E-10	1.3E-08	5.9E-09	4.2E-07
EU4	Resident Adult	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										4.0E-06
EU4	Resident Adult	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Ra-228	8.21E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	U-235	7.59E-02	4.0E-07	9.6E-10	1.6E-08	6.6E-09	4.2E-07
EU4	Resident Adult	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										4.2E-07

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Adult	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	0	Pb-210	9.56E-02	2.6E-09	8.3E-10	1.5E-06	1.7E-07	1.7E-06
EU5	Resident Adult	RME-SS	0	Ra-226	9.56E-02	7.8E-06	1.6E-09	2.2E-06	1.3E-07	1.0E-05
EU5	Resident Adult	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	0	Th-230	7.65E-02	4.1E-08	1.1E-09	1.6E-08	7.9E-09	6.7E-08
EU5	Resident Adult	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	0	U-234	1.87E-01	4.8E-10	2.3E-09	3.1E-08	1.4E-08	4.8E-08
EU5	Resident Adult	RME-SS	0	U-235	5.94E-02	3.1E-07	6.5E-10	1.0E-08	4.7E-09	3.3E-07
EU5	Resident Adult	RME-SS	0	U-238	1.45E-01	1.2E-07	1.5E-09	3.0E-08	1.4E-08	1.7E-07
										1.2E-05
EU5	Resident Adult	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	1000	Pb-210	9.56E-02	5.7E-23	1.8E-23	3.3E-20	3.8E-21	3.7E-20
EU5	Resident Adult	RME-SS	1000	Ra-226	9.56E-02	4.9E-06	1.6E-09	2.3E-06	1.9E-07	7.5E-06
EU5	Resident Adult	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	1000	Th-230	7.65E-02	2.2E-06	1.8E-09	1.0E-06	8.9E-08	3.3E-06
EU5	Resident Adult	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	1000	U-234	1.87E-01	2.6E-08	2.2E-09	4.1E-08	1.4E-08	8.4E-08
EU5	Resident Adult	RME-SS	1000	U-235	5.94E-02	3.1E-07	7.5E-10	1.3E-08	5.2E-09	3.3E-07
EU5	Resident Adult	RME-SS	1000	U-238	1.45E-01	1.1E-07	1.4E-09	2.9E-08	1.3E-08	1.6E-07
										1.1E-05

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Adult	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	Th-228	1.20E-01	8.3E-07	1.7E-09	3.2E-09	3.7E-09	8.4E-07
EU3	Resident Adult	RME-SB	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	Th-232	6.41E-02	5.2E-06	8.6E-09	1.9E-06	7.5E-08	7.1E-06
EU3	Resident Adult	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	U-235	4.82E-02	2.6E-07	5.3E-10	8.2E-09	3.8E-09	2.7E-07
EU3	Resident Adult	RME-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										8.2E-06
EU3	Resident Adult	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Th-228	1.20E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Th-232	6.41E-02	7.5E-06	1.2E-08	2.5E-06	1.0E-07	1.0E-05
EU3	Resident Adult	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	U-235	4.82E-02	2.5E-07	6.1E-10	1.0E-08	4.2E-09	2.7E-07
EU3	Resident Adult	RME-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.0E-05

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Adult	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	0	Ra-228	1.18E-01	3.7E-06	5.5E-09	1.3E-06	4.7E-08	5.1E-06
EU4	Resident Adult	RME-SB	0	Th-228	1.41E-01	9.8E-07	2.0E-09	3.8E-09	4.4E-09	9.9E-07
EU4	Resident Adult	RME-SB	0	Th-230	7.90E-03	4.3E-09	1.2E-10	1.7E-09	8.1E-10	6.9E-09
EU4	Resident Adult	RME-SB	0	Th-232	1.34E-01	1.1E-05	1.8E-08	3.9E-06	1.6E-07	1.5E-05
EU4	Resident Adult	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	0	U-235	7.96E-02	4.2E-07	8.7E-10	1.4E-08	6.2E-09	4.4E-07
EU4	Resident Adult	RME-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.1E-05
EU4	Resident Adult	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	Ra-228	1.18E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	Th-228	1.41E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	Th-230	7.90E-03	2.2E-07	1.8E-10	1.0E-07	9.2E-09	3.4E-07
EU4	Resident Adult	RME-SB	1000	Th-232	1.34E-01	1.6E-05	2.6E-08	5.3E-06	2.1E-07	2.1E-05
EU4	Resident Adult	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	U-235	7.96E-02	4.2E-07	1.0E-09	1.7E-08	6.9E-09	4.4E-07
EU4	Resident Adult	RME-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.2E-05

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Adult	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	0	Pb-210	4.39E-01	1.2E-08	3.8E-09	6.8E-06	7.9E-07	7.6E-06
EU5	Resident Adult	RME-SB	0	Ra-226	4.39E-01	3.6E-05	7.4E-09	1.0E-05	6.0E-07	4.6E-05
EU5	Resident Adult	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	0	Th-228	4.73E-02	3.3E-07	6.8E-10	1.3E-09	1.5E-09	3.3E-07
EU5	Resident Adult	RME-SB	0	Th-230	8.48E-01	4.6E-07	1.3E-08	1.8E-07	8.7E-08	7.4E-07
EU5	Resident Adult	RME-SB	0	Th-232	4.01E-02	3.2E-06	5.4E-09	1.2E-06	4.7E-08	4.5E-06
EU5	Resident Adult	RME-SB	0	U-234	8.27E-01	2.1E-09	1.0E-08	1.4E-07	6.3E-08	2.1E-07
EU5	Resident Adult	RME-SB	0	U-235	1.04E-01	5.5E-07	1.1E-09	1.8E-08	8.1E-09	5.8E-07
EU5	Resident Adult	RME-SB	0	U-238	7.62E-01	6.4E-07	7.9E-09	1.6E-07	7.4E-08	8.8E-07
										6.1E-05
EU5	Resident Adult	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	1000	Pb-210	4.39E-01	2.6E-22	8.4E-23	1.5E-19	1.7E-20	1.7E-19
EU5	Resident Adult	RME-SB	1000	Ra-226	4.39E-01	2.3E-05	7.2E-09	1.1E-05	8.8E-07	3.4E-05
EU5	Resident Adult	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	1000	Th-228	4.73E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	1000	Th-230	8.48E-01	2.4E-05	2.0E-08	1.1E-05	9.8E-07	3.6E-05
EU5	Resident Adult	RME-SB	1000	Th-232	4.01E-02	4.7E-06	7.7E-09	1.6E-06	6.3E-08	6.3E-06
EU5	Resident Adult	RME-SB	1000	U-234	8.27E-01	1.2E-07	9.5E-09	1.8E-07	6.4E-08	3.7E-07
EU5	Resident Adult	RME-SB	1000	U-235	1.04E-01	5.5E-07	1.3E-09	2.2E-08	9.0E-09	5.8E-07
EU5	Resident Adult	RME-SB	1000	U-238	7.62E-01	6.0E-07	7.4E-09	1.5E-07	6.9E-08	8.2E-07
										7.9E-05

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Child	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Resident Child	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Child	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	Ra-228	8.2E-02	1.6E-06	1.2E-09	1.0E-07	4.2E-08	1.8E-06
EU4	Resident Child	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	U-235	7.6E-02	1.2E-07	1.4E-10	5.7E-10	3.1E-09	1.3E-07
EU4	Resident Child	RME-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.9E-06
EU4	Resident Child	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Ra-228	8.2E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	U-235	7.6E-02	1.2E-07	1.7E-10	7.0E-10	3.4E-09	1.3E-07
EU4	Resident Child	RME-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.3E-07

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Child	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	0	Pb-210	9.6E-02	1.1E-09	2.0E-10	9.2E-08	1.3E-07	2.2E-07
EU5	Resident Child	RME-SS	0	Ra-226	9.6E-02	2.4E-06	2.2E-10	6.9E-08	3.3E-08	2.5E-06
EU5	Resident Child	RME-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	0	Th-230	7.6E-02	2.7E-09	2.0E-10	3.5E-10	3.9E-09	7.0E-09
EU5	Resident Child	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	0	U-234	1.9E-01	1.4E-10	3.9E-10	1.4E-09	7.5E-09	9.4E-09
EU5	Resident Child	RME-SS	0	U-235	5.9E-02	9.5E-08	1.1E-10	4.4E-10	2.4E-09	9.8E-08
EU5	Resident Child	RME-SS	0	U-238	1.5E-01	3.7E-08	2.6E-10	1.3E-09	7.3E-09	4.6E-08
										2.9E-06
EU5	Resident Child	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	1000	Pb-210	9.6E-02	2.4E-23	4.5E-24	2.0E-21	2.8E-21	4.8E-21
EU5	Resident Child	RME-SS	1000	Ra-226	9.6E-02	1.5E-06	2.7E-10	1.0E-07	1.0E-07	1.7E-06
EU5	Resident Child	RME-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	1000	Th-230	7.6E-02	6.5E-07	3.1E-10	4.4E-08	4.6E-08	7.4E-07
EU5	Resident Child	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	1000	U-234	1.9E-01	7.7E-09	3.7E-10	1.8E-09	7.6E-09	1.7E-08
EU5	Resident Child	RME-SS	1000	U-235	5.9E-02	9.4E-08	1.3E-10	5.5E-10	2.7E-09	9.8E-08
EU5	Resident Child	RME-SS	1000	U-238	1.5E-01	3.4E-08	2.4E-10	1.3E-09	6.9E-09	4.3E-08
										2.6E-06

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Child	RME-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	Th-228	1.2E-01	1.1E-06	1.3E-09	6.3E-10	8.6E-09	1.1E-06
EU3	Resident Child	RME-SB	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	Th-232	6.4E-02	4.4E-07	5.1E-10	3.2E-08	1.6E-08	4.9E-07
EU3	Resident Child	RME-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	U-235	4.8E-02	7.7E-08	9.1E-11	3.6E-10	2.0E-09	8.0E-08
EU3	Resident Child	RME-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.7E-06
EU3	Resident Child	RME-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Th-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Th-232	6.4E-02	2.3E-06	2.1E-09	1.1E-07	5.2E-08	2.4E-06
EU3	Resident Child	RME-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	U-235	4.8E-02	7.7E-08	1.1E-10	4.5E-10	2.2E-09	7.9E-08
EU3	Resident Child	RME-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.5E-06

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Child	RME-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	0	Ra-228	1.2E-01	2.3E-06	1.7E-09	1.5E-07	6.0E-08	2.5E-06
EU4	Resident Child	RME-SB	0	Th-228	1.4E-01	1.3E-06	1.6E-09	7.4E-10	1.0E-08	1.3E-06
EU4	Resident Child	RME-SB	0	Th-230	7.9E-03	2.7E-10	2.0E-11	3.6E-11	4.0E-10	7.3E-10
EU4	Resident Child	RME-SB	0	Th-232	1.3E-01	9.3E-07	1.1E-09	6.8E-08	3.4E-08	1.0E-06
EU4	Resident Child	RME-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	0	U-235	8.0E-02	1.3E-07	1.5E-10	5.9E-10	3.3E-09	1.3E-07
EU4	Resident Child	RME-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.0E-06
EU4	Resident Child	RME-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	Ra-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	Th-228	1.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	Th-230	7.9E-03	6.7E-08	3.2E-11	4.5E-09	4.7E-09	7.7E-08
EU4	Resident Child	RME-SB	1000	Th-232	1.3E-01	4.7E-06	4.4E-09	2.3E-07	1.1E-07	5.1E-06
EU4	Resident Child	RME-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	U-235	8.0E-02	1.3E-07	1.7E-10	7.4E-10	3.6E-09	1.3E-07
EU4	Resident Child	RME-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.3E-06

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Child	RME-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	0	Pb-210	4.4E-01	5.1E-09	9.3E-10	4.2E-07	5.8E-07	1.0E-06
EU5	Resident Child	RME-SB	0	Ra-226	4.4E-01	1.1E-05	1.0E-09	3.2E-07	1.5E-07	1.1E-05
EU5	Resident Child	RME-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	0	Th-228	4.7E-02	4.4E-07	5.2E-10	2.5E-10	3.4E-09	4.4E-07
EU5	Resident Child	RME-SB	0	Th-230	8.5E-01	2.9E-08	2.2E-09	3.8E-09	4.3E-08	7.8E-08
EU5	Resident Child	RME-SB	0	Th-232	4.0E-02	2.8E-07	3.2E-10	2.0E-08	1.0E-08	3.1E-07
EU5	Resident Child	RME-SB	0	U-234	8.3E-01	6.3E-10	1.7E-09	6.0E-09	3.3E-08	4.2E-08
EU5	Resident Child	RME-SB	0	U-235	1.0E-01	1.7E-07	2.0E-10	7.7E-10	4.2E-09	1.7E-07
EU5	Resident Child	RME-SB	0	U-238	7.6E-01	1.9E-07	1.4E-09	7.0E-09	3.8E-08	2.4E-07
										1.4E-05
EU5	Resident Child	RME-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	1000	Pb-210	4.4E-01	1.1E-22	2.0E-23	9.2E-21	1.3E-20	2.2E-20
EU5	Resident Child	RME-SB	1000	Ra-226	4.4E-01	6.9E-06	1.2E-09	4.7E-07	4.6E-07	7.8E-06
EU5	Resident Child	RME-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	1000	Th-228	4.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	1000	Th-230	8.5E-01	7.2E-06	3.4E-09	4.8E-07	5.1E-07	8.2E-06
EU5	Resident Child	RME-SB	1000	Th-232	4.0E-02	1.4E-06	1.3E-09	6.9E-08	3.3E-08	1.5E-06
EU5	Resident Child	RME-SB	1000	U-234	8.3E-01	3.4E-08	1.6E-09	7.8E-09	3.3E-08	7.7E-08
EU5	Resident Child	RME-SB	1000	U-235	1.0E-01	1.7E-07	2.3E-10	9.6E-10	4.7E-09	1.7E-07
EU5	Resident Child	RME-SB	1000	U-238	7.6E-01	1.8E-07	1.3E-09	6.6E-09	3.6E-08	2.2E-07
										1.8E-05

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Industrial	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SS	0	Pb-210	4.5E+01	1.2E-07	5.2E-08	0.0E+00	7.8E-06	8.0E-06
EU1	Industrial	RME-SS	0	Ra-226	4.5E+01	2.6E-04	5.9E-08	0.0E+00	2.1E-06	2.6E-04
EU1	Industrial	RME-SS	0	Ra-228	1.3E-01	5.7E-07	1.0E-09	0.0E+00	8.2E-09	5.8E-07
EU1	Industrial	RME-SS	0	Th-228	2.4E-01	4.7E-07	1.3E-09	0.0E+00	2.1E-09	4.7E-07
EU1	Industrial	RME-SS	0	Th-230	7.1E-01	6.2E-09	1.0E-09	0.0E+00	4.7E-09	1.2E-08
EU1	Industrial	RME-SS	0	Th-232	1.6E-01	2.8E-07	7.4E-10	0.0E+00	5.6E-09	2.9E-07
EU1	Industrial	RME-SS	0	U-234	4.0E+00	7.1E-10	4.7E-09	0.0E+00	2.1E-08	2.7E-08
EU1	Industrial	RME-SS	0	U-235	1.9E-01	6.9E-08	1.9E-10	0.0E+00	9.9E-10	7.0E-08
EU1	Industrial	RME-SS	0	U-238	1.6E+01	9.2E-07	1.5E-08	0.0E+00	1.0E-07	1.0E-06
										2.7E-04
EU1	Industrial	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SS	1000	Pb-210	4.5E+01	2.7E-21	1.2E-21	0.0E+00	1.7E-19	1.7E-19
EU1	Industrial	RME-SS	1000	Ra-226	4.5E+01	1.6E-04	7.1E-08	0.0E+00	6.3E-06	1.7E-04
EU1	Industrial	RME-SS	1000	Ra-228	1.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SS	1000	Th-228	2.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SS	1000	Th-230	7.1E-01	1.4E-06	1.6E-09	0.0E+00	5.6E-08	1.5E-06
EU1	Industrial	RME-SS	1000	Th-232	1.6E-01	1.3E-06	2.9E-09	0.0E+00	1.7E-08	1.3E-06
EU1	Industrial	RME-SS	1000	U-234	4.0E+00	3.9E-08	4.4E-09	0.0E+00	2.1E-08	6.4E-08
EU1	Industrial	RME-SS	1000	U-235	1.9E-01	6.8E-08	2.2E-10	0.0E+00	1.1E-09	6.9E-08
EU1	Industrial	RME-SS	1000	U-238	1.6E+01	8.6E-07	1.4E-08	0.0E+00	9.8E-08	9.7E-07
										1.8E-04

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Industrial	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU2	Industrial	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Industrial	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Industrial	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Industrial	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	Ra-228	8.2E-02	3.7E-07	6.7E-10	0.0E+00	5.3E-09	3.8E-07
EU4	Industrial	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	U-235	7.6E-02	2.8E-08	7.9E-11	0.0E+00	4.1E-10	2.9E-08
EU4	Industrial	RME-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										4.1E-07
EU4	Industrial	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Ra-228	8.2E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	U-235	7.6E-02	2.8E-08	9.1E-11	0.0E+00	4.5E-10	2.8E-08
EU4	Industrial	RME-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.8E-08

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Industrial	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	0	Pb-210	9.6E-02	2.5E-10	1.1E-10	0.0E+00	1.6E-08	1.7E-08
EU5	Industrial	RME-SS	0	Ra-226	9.6E-02	5.5E-07	1.2E-10	0.0E+00	4.4E-09	5.5E-07
EU5	Industrial	RME-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	0	Th-230	7.6E-02	6.7E-10	1.1E-10	0.0E+00	5.1E-10	1.3E-09
EU5	Industrial	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	0	U-234	1.9E-01	3.3E-11	2.2E-10	0.0E+00	9.8E-10	1.2E-09
EU5	Industrial	RME-SS	0	U-235	5.9E-02	2.2E-08	6.2E-11	0.0E+00	3.2E-10	2.2E-08
EU5	Industrial	RME-SS	0	U-238	1.5E-01	8.5E-09	1.4E-10	0.0E+00	9.6E-10	9.6E-09
										6.0E-07
EU5	Industrial	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	1000	Pb-210	9.6E-02	5.6E-24	2.4E-24	0.0E+00	3.6E-22	3.7E-22
EU5	Industrial	RME-SS	1000	Ra-226	9.6E-02	3.5E-07	1.5E-10	0.0E+00	1.3E-08	3.6E-07
EU5	Industrial	RME-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	1000	Th-230	7.6E-02	1.5E-07	1.7E-10	0.0E+00	6.0E-09	1.6E-07
EU5	Industrial	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	1000	U-234	1.9E-01	1.8E-09	2.0E-10	0.0E+00	9.9E-10	3.0E-09
EU5	Industrial	RME-SS	1000	U-235	5.9E-02	2.2E-08	7.1E-11	0.0E+00	3.5E-10	2.2E-08
EU5	Industrial	RME-SS	1000	U-238	1.5E-01	7.9E-09	1.3E-10	0.0E+00	9.0E-10	9.0E-09
										5.5E-07

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Industrial	RME-SB	0	Ac-227	1.1E-01	9.6E-08	8.5E-10	0.0E+00	3.4E-09	1.0E-07
EU1	Industrial	RME-SB	0	Pa-231	1.1E-01	2.0E-08	4.3E-10	0.0E+00	1.7E-09	2.3E-08
EU1	Industrial	RME-SB	0	Pb-210	3.2E+01	8.5E-08	3.7E-08	0.0E+00	5.4E-06	5.5E-06
EU1	Industrial	RME-SB	0	Ra-226	3.2E+01	1.8E-04	4.1E-08	0.0E+00	1.5E-06	1.8E-04
EU1	Industrial	RME-SB	0	Ra-228	4.4E-01	2.0E-06	3.6E-09	0.0E+00	2.9E-08	2.0E-06
EU1	Industrial	RME-SB	0	Th-228	4.9E-01	9.7E-07	2.7E-09	0.0E+00	4.3E-09	9.8E-07
EU1	Industrial	RME-SB	0	Th-230	1.9E+00	1.6E-08	2.6E-09	0.0E+00	1.2E-08	3.1E-08
EU1	Industrial	RME-SB	0	Th-232	4.1E-01	7.3E-07	1.9E-09	0.0E+00	1.5E-08	7.4E-07
EU1	Industrial	RME-SB	0	U-234	1.0E+01	1.8E-09	1.2E-08	0.0E+00	5.5E-08	6.9E-08
EU1	Industrial	RME-SB	0	U-235	5.5E-01	2.0E-07	5.7E-10	0.0E+00	2.9E-09	2.1E-07
EU1	Industrial	RME-SB	0	U-238	3.4E+01	2.0E-06	3.3E-08	0.0E+00	2.3E-07	2.3E-06
										1.9E-04
EU1	Industrial	RME-SB	1000	Ac-227	1.1E-01	1.3E-21	1.2E-23	0.0E+00	4.7E-23	1.4E-21
EU1	Industrial	RME-SB	1000	Pa-231	1.1E-01	1.1E-07	1.2E-09	0.0E+00	4.7E-09	1.1E-07
EU1	Industrial	RME-SB	1000	Pb-210	3.2E+01	1.9E-21	8.0E-22	0.0E+00	1.2E-19	1.2E-19
EU1	Industrial	RME-SB	1000	Ra-226	3.2E+01	1.2E-04	4.9E-08	0.0E+00	4.4E-06	1.2E-04
EU1	Industrial	RME-SB	1000	Ra-228	4.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SB	1000	Th-228	4.9E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SB	1000	Th-230	1.9E+00	3.7E-06	4.1E-09	0.0E+00	1.5E-07	3.8E-06
EU1	Industrial	RME-SB	1000	Th-232	4.1E-01	3.3E-06	7.4E-09	0.0E+00	4.4E-08	3.4E-06
EU1	Industrial	RME-SB	1000	U-234	1.0E+01	1.0E-07	1.1E-08	0.0E+00	5.5E-08	1.7E-07
EU1	Industrial	RME-SB	1000	U-235	5.5E-01	2.0E-07	6.5E-10	0.0E+00	3.2E-09	2.0E-07
EU1	Industrial	RME-SB	1000	U-238	3.4E+01	1.9E-06	3.1E-08	0.0E+00	2.1E-07	2.1E-06
										1.3E-04

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Industrial	RME-SB	0	Ac-227	2.4E-01	2.1E-07	1.9E-09	0.0E+00	7.7E-09	2.2E-07
EU2	Industrial	RME-SB	0	Pa-231	2.4E-01	4.6E-08	9.6E-10	0.0E+00	3.8E-09	5.1E-08
EU2	Industrial	RME-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	0	Th-228	4.3E-02	8.6E-08	2.4E-10	0.0E+00	3.8E-10	8.7E-08
EU2	Industrial	RME-SB	0	Th-230	8.0E-04	7.0E-12	1.1E-12	0.0E+00	5.3E-12	1.3E-11
EU2	Industrial	RME-SB	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	0	U-238	3.2E-01	1.9E-08	3.1E-10	0.0E+00	2.1E-09	2.1E-08
										3.8E-07
EU2	Industrial	RME-SB	1000	Ac-227	2.4E-01	2.9E-21	2.6E-23	0.0E+00	1.1E-22	3.1E-21
EU2	Industrial	RME-SB	1000	Pa-231	2.4E-01	2.4E-07	2.6E-09	0.0E+00	1.0E-08	2.5E-07
EU2	Industrial	RME-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	Th-228	4.3E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	Th-230	8.0E-04	1.6E-09	1.8E-12	0.0E+00	6.3E-11	1.6E-09
EU2	Industrial	RME-SB	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	U-238	3.2E-01	1.7E-08	2.9E-10	0.0E+00	2.0E-09	2.0E-08
										2.7E-07

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Industrial	RME-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	Th-228	1.2E-01	2.4E-07	6.7E-10	0.0E+00	1.1E-09	2.4E-07
EU3	Industrial	RME-SB	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	Th-232	6.4E-02	1.1E-07	3.0E-10	0.0E+00	2.3E-09	1.2E-07
EU3	Industrial	RME-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	U-235	4.8E-02	1.8E-08	5.0E-11	0.0E+00	2.6E-10	1.8E-08
EU3	Industrial	RME-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.7E-07
EU3	Industrial	RME-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Th-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Th-232	6.4E-02	5.2E-07	1.2E-09	0.0E+00	6.9E-09	5.3E-07
EU3	Industrial	RME-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	U-235	4.8E-02	1.8E-08	5.8E-11	0.0E+00	2.9E-10	1.8E-08
EU3	Industrial	RME-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.5E-07

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Industrial	RME-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	0	Ra-228	1.2E-01	5.3E-07	9.6E-10	0.0E+00	7.7E-09	5.4E-07
EU4	Industrial	RME-SB	0	Th-228	1.4E-01	2.8E-07	8.0E-10	0.0E+00	1.2E-09	2.8E-07
EU4	Industrial	RME-SB	0	Th-230	7.9E-03	6.9E-11	1.1E-11	0.0E+00	5.2E-11	1.3E-10
EU4	Industrial	RME-SB	0	Th-232	1.3E-01	2.4E-07	6.3E-10	0.0E+00	4.7E-09	2.4E-07
EU4	Industrial	RME-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	0	U-235	8.0E-02	2.9E-08	8.3E-11	0.0E+00	4.3E-10	3.0E-08
EU4	Industrial	RME-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.1E-06
EU4	Industrial	RME-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	Ra-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	Th-228	1.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	Th-230	7.9E-03	1.6E-08	1.7E-11	0.0E+00	6.2E-10	1.6E-08
EU4	Industrial	RME-SB	1000	Th-232	1.3E-01	1.1E-06	2.4E-09	0.0E+00	1.4E-08	1.1E-06
EU4	Industrial	RME-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	U-235	8.0E-02	2.9E-08	9.5E-11	0.0E+00	4.7E-10	3.0E-08
EU4	Industrial	RME-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.2E-06

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Industrial	RME-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	0	Pb-210	4.4E-01	1.2E-09	5.1E-10	0.0E+00	7.5E-08	7.7E-08
EU5	Industrial	RME-SB	0	Ra-226	4.4E-01	2.5E-06	5.7E-10	0.0E+00	2.0E-08	2.5E-06
EU5	Industrial	RME-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	0	Th-228	4.7E-02	9.5E-08	2.7E-10	0.0E+00	4.2E-10	9.5E-08
EU5	Industrial	RME-SB	0	Th-230	8.5E-01	7.4E-09	1.2E-09	0.0E+00	5.6E-09	1.4E-08
EU5	Industrial	RME-SB	0	Th-232	4.0E-02	7.1E-08	1.9E-10	0.0E+00	1.4E-09	7.3E-08
EU5	Industrial	RME-SB	0	U-234	8.3E-01	1.4E-10	9.5E-10	0.0E+00	4.3E-09	5.4E-09
EU5	Industrial	RME-SB	0	U-235	1.0E-01	3.8E-08	1.1E-10	0.0E+00	5.6E-10	3.9E-08
EU5	Industrial	RME-SB	0	U-238	7.6E-01	4.5E-08	7.5E-10	0.0E+00	5.0E-09	5.0E-08
										2.9E-06
EU5	Industrial	RME-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	1000	Pb-210	4.4E-01	2.6E-23	1.1E-23	0.0E+00	1.6E-21	1.7E-21
EU5	Industrial	RME-SB	1000	Ra-226	4.4E-01	1.6E-06	6.8E-10	0.0E+00	6.1E-08	1.7E-06
EU5	Industrial	RME-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	1000	Th-228	4.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	1000	Th-230	8.5E-01	1.7E-06	1.9E-09	0.0E+00	6.7E-08	1.7E-06
EU5	Industrial	RME-SB	1000	Th-232	4.0E-02	3.3E-07	7.3E-10	0.0E+00	4.3E-09	3.3E-07
EU5	Industrial	RME-SB	1000	U-234	8.3E-01	7.9E-09	9.0E-10	0.0E+00	4.4E-09	1.3E-08
EU5	Industrial	RME-SB	1000	U-235	1.0E-01	3.8E-08	1.2E-10	0.0E+00	6.2E-10	3.9E-08
EU5	Industrial	RME-SB	1000	U-238	7.6E-01	4.2E-08	7.0E-10	0.0E+00	4.7E-09	4.7E-08
										3.8E-06

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Recreational	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SS	0	Pb-210	4.5E+01	4.4E-08	2.3E-08	0.0E+00	1.3E-06	1.4E-06
EU1	Recreational	RME-SS	0	Ra-226	4.5E+01	1.3E-04	4.5E-08	0.0E+00	1.0E-06	1.3E-04
EU1	Recreational	RME-SS	0	Ra-228	1.3E-01	1.4E-07	3.5E-10	0.0E+00	8.2E-10	1.4E-07
EU1	Recreational	RME-SS	0	Th-228	2.4E-01	5.7E-08	2.0E-10	0.0E+00	1.2E-10	5.8E-08
EU1	Recreational	RME-SS	0	Th-230	7.1E-01	1.3E-08	6.2E-10	0.0E+00	1.2E-09	1.5E-08
EU1	Recreational	RME-SS	0	Th-232	1.6E-01	4.5E-07	1.2E-09	0.0E+00	3.0E-09	4.5E-07
EU1	Recreational	RME-SS	0	U-234	4.0E+00	3.6E-10	2.9E-09	0.0E+00	5.1E-09	8.3E-09
EU1	Recreational	RME-SS	0	U-235	1.9E-01	3.5E-08	1.2E-10	0.0E+00	2.4E-10	3.5E-08
EU1	Recreational	RME-SS	0	U-238	1.6E+01	4.6E-07	9.5E-09	0.0E+00	2.5E-08	5.0E-07
										1.3E-04
EU1	Recreational	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SS	1000	Pb-210	4.5E+01	9.6E-22	5.1E-22	0.0E+00	2.9E-20	3.1E-20
EU1	Recreational	RME-SS	1000	Ra-226	4.5E+01	8.3E-05	4.3E-08	0.0E+00	1.5E-06	8.4E-05
EU1	Recreational	RME-SS	1000	Ra-228	1.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SS	1000	Th-228	2.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SS	1000	Th-230	7.1E-01	7.1E-07	9.6E-10	0.0E+00	1.3E-08	7.2E-07
EU1	Recreational	RME-SS	1000	Th-232	1.6E-01	6.5E-07	1.8E-09	0.0E+00	4.0E-09	6.5E-07
EU1	Recreational	RME-SS	1000	U-234	4.0E+00	2.0E-08	2.7E-09	0.0E+00	5.1E-09	2.8E-08
EU1	Recreational	RME-SS	1000	U-235	1.9E-01	3.4E-08	1.4E-10	0.0E+00	2.6E-10	3.5E-08
EU1	Recreational	RME-SS	1000	U-238	1.6E+01	4.3E-07	8.9E-09	0.0E+00	2.3E-08	4.7E-07
										8.6E-05

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Recreational	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU2	Recreational	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Recreational	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Recreational	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Recreational	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	Ra-228	8.2E-02	9.2E-08	2.2E-10	0.0E+00	5.4E-10	9.2E-08
EU4	Recreational	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	U-235	7.6E-02	1.4E-08	4.9E-11	0.0E+00	9.7E-11	1.4E-08
EU4	Recreational	RME-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.1E-07
EU4	Recreational	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Ra-228	8.2E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	U-235	7.6E-02	1.4E-08	5.6E-11	0.0E+00	1.1E-10	1.4E-08
EU4	Recreational	RME-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.4E-08

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Recreational	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	0	Pb-210	9.6E-02	9.2E-11	4.9E-11	0.0E+00	2.8E-09	2.9E-09
EU5	Recreational	RME-SS	0	Ra-226	9.6E-02	2.7E-07	9.5E-11	0.0E+00	2.1E-09	2.8E-07
EU5	Recreational	RME-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	0	Th-230	7.6E-02	1.4E-09	6.7E-11	0.0E+00	1.3E-10	1.6E-09
EU5	Recreational	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	0	U-234	1.9E-01	1.7E-11	1.3E-10	0.0E+00	2.3E-10	3.8E-10
EU5	Recreational	RME-SS	0	U-235	5.9E-02	1.1E-08	3.8E-11	0.0E+00	7.6E-11	1.1E-08
EU5	Recreational	RME-SS	0	U-238	1.5E-01	4.3E-09	8.8E-11	0.0E+00	2.3E-10	4.6E-09
										3.0E-07
EU5	Recreational	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	1000	Pb-210	9.6E-02	2.0E-24	1.1E-24	0.0E+00	6.1E-23	6.4E-23
EU5	Recreational	RME-SS	1000	Ra-226	9.6E-02	1.7E-07	9.1E-11	0.0E+00	3.1E-09	1.8E-07
EU5	Recreational	RME-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	1000	Th-230	7.6E-02	7.6E-08	1.0E-10	0.0E+00	1.5E-09	7.8E-08
EU5	Recreational	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	1000	U-234	1.9E-01	9.2E-10	1.3E-10	0.0E+00	2.4E-10	1.3E-09
EU5	Recreational	RME-SS	1000	U-235	5.9E-02	1.1E-08	4.4E-11	0.0E+00	8.4E-11	1.1E-08
EU5	Recreational	RME-SS	1000	U-238	1.5E-01	4.0E-09	8.2E-11	0.0E+00	2.1E-10	4.3E-09
										2.7E-07

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Recreational	RME-SB	0	Ac-227	1.1E-01	3.4E-08	3.7E-10	0.0E+00	5.9E-10	3.5E-08
EU1	Recreational	RME-SB	0	Pa-231	1.1E-01	2.4E-08	4.1E-10	0.0E+00	6.4E-10	2.5E-08
EU1	Recreational	RME-SB	0	Pb-210	3.2E+01	3.0E-08	1.6E-08	0.0E+00	9.3E-07	9.7E-07
EU1	Recreational	RME-SB	0	Ra-226	3.2E+01	9.1E-05	3.1E-08	0.0E+00	7.1E-07	9.1E-05
EU1	Recreational	RME-SB	0	Ra-228	4.4E-01	4.9E-07	1.2E-09	0.0E+00	2.9E-09	5.0E-07
EU1	Recreational	RME-SB	0	Th-228	4.9E-01	1.2E-07	4.1E-10	0.0E+00	2.5E-10	1.2E-07
EU1	Recreational	RME-SB	0	Th-230	1.9E+00	3.5E-08	1.6E-09	0.0E+00	3.1E-09	4.0E-08
EU1	Recreational	RME-SB	0	Th-232	4.1E-01	1.2E-06	3.2E-09	0.0E+00	7.8E-09	1.2E-06
EU1	Recreational	RME-SB	0	U-234	1.0E+01	9.4E-10	7.5E-09	0.0E+00	1.3E-08	2.2E-08
EU1	Recreational	RME-SB	0	U-235	5.5E-01	1.0E-07	3.5E-10	0.0E+00	7.0E-10	1.0E-07
EU1	Recreational	RME-SB	0	U-238	3.4E+01	1.0E-06	2.1E-08	0.0E+00	5.4E-08	1.1E-06
										9.5E-05
EU1	Recreational	RME-SB	1000	Ac-227	1.1E-01	4.7E-22	5.1E-24	0.0E+00	8.0E-24	4.8E-22
EU1	Recreational	RME-SB	1000	Pa-231	1.1E-01	5.3E-08	7.2E-10	0.0E+00	1.1E-09	5.5E-08
EU1	Recreational	RME-SB	1000	Pb-210	3.2E+01	6.7E-22	3.6E-22	0.0E+00	2.0E-20	2.1E-20
EU1	Recreational	RME-SB	1000	Ra-226	3.2E+01	5.8E-05	3.0E-08	0.0E+00	1.0E-06	5.9E-05
EU1	Recreational	RME-SB	1000	Ra-228	4.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SB	1000	Th-228	4.9E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SB	1000	Th-230	1.9E+00	1.9E-06	2.5E-09	0.0E+00	3.5E-08	1.9E-06
EU1	Recreational	RME-SB	1000	Th-232	4.1E-01	1.7E-06	4.6E-09	0.0E+00	1.1E-08	1.7E-06
EU1	Recreational	RME-SB	1000	U-234	1.0E+01	5.1E-08	7.1E-09	0.0E+00	1.3E-08	7.2E-08
EU1	Recreational	RME-SB	1000	U-235	5.5E-01	1.0E-07	4.0E-10	0.0E+00	7.7E-10	1.0E-07
EU1	Recreational	RME-SB	1000	U-238	3.4E+01	9.4E-07	1.9E-08	0.0E+00	5.0E-08	1.0E-06
										6.3E-05

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Recreational	RME-SB	0	Ac-227	2.4E-01	7.7E-08	8.4E-10	0.0E+00	1.3E-09	7.9E-08
EU2	Recreational	RME-SB	0	Pa-231	2.4E-01	5.4E-08	9.3E-10	0.0E+00	1.4E-09	5.6E-08
EU2	Recreational	RME-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	0	Th-228	4.3E-02	1.0E-08	3.6E-11	0.0E+00	2.2E-11	1.1E-08
EU2	Recreational	RME-SB	0	Th-230	8.0E-04	1.5E-11	7.0E-13	0.0E+00	1.3E-12	1.7E-11
EU2	Recreational	RME-SB	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	0	U-238	3.2E-01	9.4E-09	1.9E-10	0.0E+00	5.0E-10	1.0E-08
										1.6E-07
EU2	Recreational	RME-SB	1000	Ac-227	2.4E-01	1.1E-21	1.1E-23	0.0E+00	1.8E-23	1.1E-21
EU2	Recreational	RME-SB	1000	Pa-231	2.4E-01	1.2E-07	1.6E-09	0.0E+00	2.5E-09	1.2E-07
EU2	Recreational	RME-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	Th-228	4.3E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	Th-230	8.0E-04	8.0E-10	1.1E-12	0.0E+00	1.5E-11	8.1E-10
EU2	Recreational	RME-SB	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	U-238	3.2E-01	8.8E-09	1.8E-10	0.0E+00	4.7E-10	9.4E-09
										1.3E-07

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Recreational	RME-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	Th-228	1.2E-01	2.9E-08	1.0E-10	0.0E+00	6.1E-11	2.9E-08
EU3	Recreational	RME-SB	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	Th-232	6.4E-02	1.8E-07	5.0E-10	0.0E+00	1.2E-09	1.8E-07
EU3	Recreational	RME-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	U-235	4.8E-02	9.0E-09	3.1E-11	0.0E+00	6.2E-11	9.1E-09
EU3	Recreational	RME-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.2E-07
EU3	Recreational	RME-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Th-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Th-232	6.4E-02	2.6E-07	7.2E-10	0.0E+00	1.6E-09	2.6E-07
EU3	Recreational	RME-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	U-235	4.8E-02	8.9E-09	3.6E-11	0.0E+00	6.8E-11	9.0E-09
EU3	Recreational	RME-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.7E-07

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Recreational	RME-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	0	Ra-228	1.2E-01	1.3E-07	3.2E-10	0.0E+00	7.7E-10	1.3E-07
EU4	Recreational	RME-SB	0	Th-228	1.4E-01	3.4E-08	1.2E-10	0.0E+00	7.2E-11	3.5E-08
EU4	Recreational	RME-SB	0	Th-230	7.9E-03	1.5E-10	6.9E-12	0.0E+00	1.3E-11	1.7E-10
EU4	Recreational	RME-SB	0	Th-232	1.3E-01	3.8E-07	1.0E-09	0.0E+00	2.6E-09	3.8E-07
EU4	Recreational	RME-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	0	U-235	8.0E-02	1.5E-08	5.1E-11	0.0E+00	1.0E-10	1.5E-08
EU4	Recreational	RME-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.6E-07
EU4	Recreational	RME-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	Ra-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	Th-228	1.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	Th-230	7.9E-03	7.9E-09	1.1E-11	0.0E+00	1.5E-10	8.0E-09
EU4	Recreational	RME-SB	1000	Th-232	1.3E-01	5.5E-07	1.5E-09	0.0E+00	3.4E-09	5.5E-07
EU4	Recreational	RME-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	U-235	8.0E-02	1.5E-08	5.9E-11	0.0E+00	1.1E-10	1.5E-08
EU4	Recreational	RME-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.8E-07

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Recreational	RME-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	0	Pb-210	4.4E-01	4.2E-10	2.2E-10	0.0E+00	1.3E-08	1.3E-08
EU5	Recreational	RME-SB	0	Ra-226	4.4E-01	1.3E-06	4.3E-10	0.0E+00	9.8E-09	1.3E-06
EU5	Recreational	RME-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	0	Th-228	4.7E-02	1.2E-08	4.0E-11	0.0E+00	2.4E-11	1.2E-08
EU5	Recreational	RME-SB	0	Th-230	8.5E-01	1.6E-08	7.4E-10	0.0E+00	1.4E-09	1.8E-08
EU5	Recreational	RME-SB	0	Th-232	4.0E-02	1.1E-07	3.1E-10	0.0E+00	7.6E-10	1.1E-07
EU5	Recreational	RME-SB	0	U-234	8.3E-01	7.4E-11	5.9E-10	0.0E+00	1.0E-09	1.7E-09
EU5	Recreational	RME-SB	0	U-235	1.0E-01	1.9E-08	6.7E-11	0.0E+00	1.3E-10	2.0E-08
EU5	Recreational	RME-SB	0	U-238	7.6E-01	2.2E-08	4.6E-10	0.0E+00	1.2E-09	2.4E-08
										1.5E-06
EU5	Recreational	RME-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	1000	Pb-210	4.4E-01	9.3E-24	4.9E-24	0.0E+00	2.8E-22	3.0E-22
EU5	Recreational	RME-SB	1000	Ra-226	4.4E-01	8.0E-07	4.2E-10	0.0E+00	1.4E-08	8.1E-07
EU5	Recreational	RME-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	1000	Th-228	4.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	1000	Th-230	8.5E-01	8.5E-07	1.2E-09	0.0E+00	1.6E-08	8.6E-07
EU5	Recreational	RME-SB	1000	Th-232	4.0E-02	1.6E-07	4.5E-10	0.0E+00	1.0E-09	1.7E-07
EU5	Recreational	RME-SB	1000	U-234	8.3E-01	4.1E-09	5.6E-10	0.0E+00	1.0E-09	5.7E-09
EU5	Recreational	RME-SB	1000	U-235	1.0E-01	1.9E-08	7.7E-11	0.0E+00	1.5E-10	1.9E-08
EU5	Recreational	RME-SB	1000	U-238	7.6E-01	2.1E-08	4.3E-10	0.0E+00	1.1E-09	2.2E-08
										1.9E-06

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Construction	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SS	0	Pb-210	4.5E+01	4.2E-08	1.3E-07	0.0E+00	6.2E-06	6.3E-06
EU1	Construction	RME-SS	0	Ra-226	4.5E+01	8.3E-05	1.3E-07	0.0E+00	1.0E-06	8.4E-05
EU1	Construction	RME-SS	0	Ra-228	1.3E-01	1.5E-07	1.2E-09	0.0E+00	7.1E-09	1.6E-07
EU1	Construction	RME-SS	0	Th-228	2.4E-01	3.3E-07	6.9E-09	0.0E+00	3.3E-09	3.4E-07
EU1	Construction	RME-SS	0	Th-230	7.1E-01	4.1E-10	2.3E-09	0.0E+00	3.4E-09	6.1E-09
EU1	Construction	RME-SS	0	Th-232	1.6E-01	1.1E-08	7.4E-10	0.0E+00	1.4E-09	1.3E-08
EU1	Construction	RME-SS	0	U-234	4.0E+00	2.2E-10	1.1E-08	0.0E+00	1.5E-08	2.7E-08
EU1	Construction	RME-SS	0	U-235	1.9E-01	2.2E-08	4.5E-10	0.0E+00	7.2E-10	2.3E-08
EU1	Construction	RME-SS	0	U-238	1.6E+01	2.9E-07	3.6E-08	0.0E+00	7.6E-08	4.1E-07
										9.1E-05
EU1	Construction	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SS	1000	Pb-210	4.5E+01	9.2E-22	2.9E-21	0.0E+00	1.4E-19	1.4E-19
EU1	Construction	RME-SS	1000	Ra-226	4.5E+01	5.3E-05	1.7E-07	0.0E+00	4.6E-06	5.7E-05
EU1	Construction	RME-SS	1000	Ra-228	1.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SS	1000	Th-228	2.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SS	1000	Th-230	7.1E-01	4.4E-07	3.7E-09	0.0E+00	4.0E-08	4.9E-07
EU1	Construction	RME-SS	1000	Th-232	1.6E-01	4.1E-07	6.7E-09	0.0E+00	1.2E-08	4.3E-07
EU1	Construction	RME-SS	1000	U-234	4.0E+00	1.2E-08	1.0E-08	0.0E+00	1.6E-08	3.8E-08
EU1	Construction	RME-SS	1000	U-235	1.9E-01	2.2E-08	5.2E-10	0.0E+00	8.0E-10	2.3E-08
EU1	Construction	RME-SS	1000	U-238	1.6E+01	2.7E-07	3.4E-08	0.0E+00	7.1E-08	3.8E-07
										5.9E-05

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Construction	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU2	Construction	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Construction	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Construction	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Construction	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	Ra-228	8.2E-02	9.6E-08	7.7E-10	0.0E+00	4.6E-09	1.0E-07
EU4	Construction	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	U-235	7.6E-02	9.0E-09	1.8E-10	0.0E+00	3.0E-10	9.4E-09
EU4	Construction	RME-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.1E-07
EU4	Construction	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Ra-228	8.2E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	U-235	7.6E-02	8.9E-09	2.1E-10	0.0E+00	3.3E-10	9.4E-09
EU4	Construction	RME-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										9.4E-09

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Construction	RME-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	0	Pb-210	9.6E-02	8.8E-11	2.8E-10	0.0E+00	1.3E-08	1.3E-08
EU5	Construction	RME-SS	0	Ra-226	9.6E-02	1.7E-07	2.7E-10	0.0E+00	2.2E-09	1.8E-07
EU5	Construction	RME-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	0	Th-230	7.6E-02	4.4E-11	2.5E-10	0.0E+00	3.6E-10	6.6E-10
EU5	Construction	RME-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	0	U-234	1.9E-01	1.0E-11	5.1E-10	0.0E+00	7.1E-10	1.2E-09
EU5	Construction	RME-SS	0	U-235	5.9E-02	7.0E-09	1.4E-10	0.0E+00	2.3E-10	7.4E-09
EU5	Construction	RME-SS	0	U-238	1.5E-01	2.7E-09	3.3E-10	0.0E+00	7.0E-10	3.7E-09
										2.0E-07
EU5	Construction	RME-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	1000	Pb-210	9.6E-02	1.9E-24	6.2E-24	0.0E+00	2.8E-22	2.9E-22
EU5	Construction	RME-SS	1000	Ra-226	9.6E-02	1.1E-07	3.5E-10	0.0E+00	9.6E-09	1.2E-07
EU5	Construction	RME-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	1000	Th-230	7.6E-02	4.8E-08	3.9E-10	0.0E+00	4.4E-09	5.3E-08
EU5	Construction	RME-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	1000	U-234	1.9E-01	5.7E-10	4.8E-10	0.0E+00	7.2E-10	1.8E-09
EU5	Construction	RME-SS	1000	U-235	5.9E-02	6.9E-09	1.7E-10	0.0E+00	2.6E-10	7.4E-09
EU5	Construction	RME-SS	1000	U-238	1.5E-01	2.5E-09	3.1E-10	0.0E+00	6.5E-10	3.5E-09
										1.9E-07

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Construction	RME-SB	0	Ac-227	1.1E-01	3.3E-08	2.2E-09	0.0E+00	2.7E-09	3.8E-08
EU1	Construction	RME-SB	0	Pa-231	1.1E-01	3.7E-09	8.2E-10	0.0E+00	1.0E-09	5.6E-09
EU1	Construction	RME-SB	0	Pb-210	3.2E+01	2.9E-08	9.4E-08	0.0E+00	4.3E-06	4.4E-06
EU1	Construction	RME-SB	0	Ra-226	3.2E+01	5.8E-05	8.8E-08	0.0E+00	7.2E-07	5.9E-05
EU1	Construction	RME-SB	0	Ra-228	4.4E-01	5.2E-07	4.1E-09	0.0E+00	2.5E-08	5.5E-07
EU1	Construction	RME-SB	0	Th-228	4.9E-01	6.8E-07	1.4E-08	0.0E+00	6.9E-09	7.0E-07
EU1	Construction	RME-SB	0	Th-230	1.9E+00	1.1E-09	6.2E-09	0.0E+00	8.9E-09	1.6E-08
EU1	Construction	RME-SB	0	Th-232	4.1E-01	2.8E-08	1.9E-09	0.0E+00	3.6E-09	3.3E-08
EU1	Construction	RME-SB	0	U-234	1.0E+01	5.8E-10	2.8E-08	0.0E+00	4.0E-08	6.9E-08
EU1	Construction	RME-SB	0	U-235	5.5E-01	6.4E-08	1.3E-09	0.0E+00	2.1E-09	6.8E-08
EU1	Construction	RME-SB	0	U-238	3.4E+01	6.4E-07	7.8E-08	0.0E+00	1.6E-07	8.8E-07
										6.5E-05
EU1	Construction	RME-SB	1000	Ac-227	1.1E-01	4.6E-22	3.0E-23	0.0E+00	3.7E-23	5.2E-22
EU1	Construction	RME-SB	1000	Pa-231	1.1E-01	3.4E-08	2.7E-09	0.0E+00	3.4E-09	4.0E-08
EU1	Construction	RME-SB	1000	Pb-210	3.2E+01	6.4E-22	2.1E-21	0.0E+00	9.4E-20	9.7E-20
EU1	Construction	RME-SB	1000	Ra-226	3.2E+01	3.7E-05	1.2E-07	0.0E+00	3.2E-06	4.0E-05
EU1	Construction	RME-SB	1000	Ra-228	4.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SB	1000	Th-228	4.9E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SB	1000	Th-230	1.9E+00	1.2E-06	9.6E-09	0.0E+00	1.1E-07	1.3E-06
EU1	Construction	RME-SB	1000	Th-232	4.1E-01	1.1E-06	1.7E-08	0.0E+00	3.2E-08	1.1E-06
EU1	Construction	RME-SB	1000	U-234	1.0E+01	3.2E-08	2.7E-08	0.0E+00	4.0E-08	9.9E-08
EU1	Construction	RME-SB	1000	U-235	5.5E-01	6.4E-08	1.5E-09	0.0E+00	2.3E-09	6.8E-08
EU1	Construction	RME-SB	1000	U-238	3.4E+01	5.9E-07	7.3E-08	0.0E+00	1.5E-07	8.2E-07
										4.3E-05

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Construction	RME-SB	0	Ac-227	2.4E-01	7.5E-08	4.9E-09	0.0E+00	6.1E-09	8.6E-08
EU2	Construction	RME-SB	0	Pa-231	2.4E-01	8.4E-09	1.8E-09	0.0E+00	2.3E-09	1.2E-08
EU2	Construction	RME-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	0	Th-228	4.3E-02	6.1E-08	1.3E-09	0.0E+00	6.1E-10	6.2E-08
EU2	Construction	RME-SB	0	Th-230	8.0E-04	4.6E-13	2.6E-12	0.0E+00	3.8E-12	6.9E-12
EU2	Construction	RME-SB	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	0	U-238	3.2E-01	6.0E-09	7.3E-10	0.0E+00	1.5E-09	8.2E-09
										1.7E-07
EU2	Construction	RME-SB	1000	Ac-227	2.4E-01	1.0E-21	6.7E-23	0.0E+00	8.4E-23	1.2E-21
EU2	Construction	RME-SB	1000	Pa-231	2.4E-01	7.5E-08	6.1E-09	0.0E+00	7.6E-09	8.9E-08
EU2	Construction	RME-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	Th-228	4.3E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	Th-230	8.0E-04	5.0E-10	4.1E-12	0.0E+00	4.6E-11	5.5E-10
EU2	Construction	RME-SB	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	U-238	3.2E-01	5.6E-09	6.9E-10	0.0E+00	1.4E-09	7.7E-09
										9.7E-08

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Construction	RME-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	Th-228	1.2E-01	1.7E-07	3.5E-09	0.0E+00	1.7E-09	1.7E-07
EU3	Construction	RME-SB	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	Th-232	6.4E-02	4.3E-09	3.0E-10	0.0E+00	5.6E-10	5.2E-09
EU3	Construction	RME-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	U-235	4.8E-02	5.7E-09	1.2E-10	0.0E+00	1.9E-10	6.0E-09
EU3	Construction	RME-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.8E-07
EU3	Construction	RME-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Th-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Th-232	6.4E-02	1.7E-07	2.7E-09	0.0E+00	5.0E-09	1.7E-07
EU3	Construction	RME-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	U-235	4.8E-02	5.6E-09	1.4E-10	0.0E+00	2.1E-10	6.0E-09
EU3	Construction	RME-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.8E-07

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Construction	RME-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	0	Ra-228	1.2E-01	1.4E-07	1.1E-09	0.0E+00	6.6E-09	1.5E-07
EU4	Construction	RME-SB	0	Th-228	1.4E-01	2.0E-07	4.1E-09	0.0E+00	2.0E-09	2.0E-07
EU4	Construction	RME-SB	0	Th-230	7.9E-03	4.5E-12	2.6E-11	0.0E+00	3.8E-11	6.8E-11
EU4	Construction	RME-SB	0	Th-232	1.3E-01	9.0E-09	6.3E-10	0.0E+00	1.2E-09	1.1E-08
EU4	Construction	RME-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	0	U-235	8.0E-02	9.4E-09	1.9E-10	0.0E+00	3.1E-10	9.9E-09
EU4	Construction	RME-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.7E-07
EU4	Construction	RME-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	Ra-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	Th-228	1.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	Th-230	7.9E-03	4.9E-09	4.1E-11	0.0E+00	4.5E-10	5.4E-09
EU4	Construction	RME-SB	1000	Th-232	1.3E-01	3.5E-07	5.7E-09	0.0E+00	1.0E-08	3.6E-07
EU4	Construction	RME-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	U-235	8.0E-02	9.3E-09	2.2E-10	0.0E+00	3.4E-10	9.9E-09
EU4	Construction	RME-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.8E-07

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-1
Risk Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Construction	RME-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	0	Pb-210	4.4E-01	4.1E-10	1.3E-09	0.0E+00	5.9E-08	6.1E-08
EU5	Construction	RME-SB	0	Ra-226	4.4E-01	8.0E-07	1.2E-09	0.0E+00	9.9E-09	8.1E-07
EU5	Construction	RME-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	0	Th-228	4.7E-02	6.6E-08	1.4E-09	0.0E+00	6.7E-10	6.8E-08
EU5	Construction	RME-SB	0	Th-230	8.5E-01	4.9E-10	2.8E-09	0.0E+00	4.0E-09	7.3E-09
EU5	Construction	RME-SB	0	Th-232	4.0E-02	2.7E-09	1.9E-10	0.0E+00	3.5E-10	3.2E-09
EU5	Construction	RME-SB	0	U-234	8.3E-01	4.6E-11	2.2E-09	0.0E+00	3.2E-09	5.4E-09
EU5	Construction	RME-SB	0	U-235	1.0E-01	1.2E-08	2.5E-10	0.0E+00	4.0E-10	1.3E-08
EU5	Construction	RME-SB	0	U-238	7.6E-01	1.4E-08	1.7E-09	0.0E+00	3.7E-09	2.0E-08
										9.9E-07
EU5	Construction	RME-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	1000	Pb-210	4.4E-01	8.9E-24	2.8E-23	0.0E+00	1.3E-21	1.3E-21
EU5	Construction	RME-SB	1000	Ra-226	4.4E-01	5.1E-07	1.6E-09	0.0E+00	4.4E-08	5.5E-07
EU5	Construction	RME-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	1000	Th-228	4.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	1000	Th-230	8.5E-01	5.3E-07	4.4E-09	0.0E+00	4.8E-08	5.8E-07
EU5	Construction	RME-SB	1000	Th-232	4.0E-02	1.0E-07	1.7E-09	0.0E+00	3.1E-09	1.1E-07
EU5	Construction	RME-SB	1000	U-234	8.3E-01	2.5E-09	2.1E-09	0.0E+00	3.2E-09	7.8E-09
EU5	Construction	RME-SB	1000	U-235	1.0E-01	1.2E-08	2.9E-10	0.0E+00	4.5E-10	1.3E-08
EU5	Construction	RME-SB	1000	U-238	7.6E-01	1.3E-08	1.6E-09	0.0E+00	3.4E-09	1.8E-08
										1.3E-06

COCP = constituent of potential concern
Net EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Adult	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Resident Adult	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Adult	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	Ra-228	8.2E-02	1.5E-06	1.4E-09	1.6E-07	1.1E-08	1.7E-06
EU4	Resident Adult	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	U-235	7.6E-02	1.2E-07	1.6E-10	1.0E-09	8.9E-10	1.2E-07
EU4	Resident Adult	CT-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.8E-06
EU4	Resident Adult	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Ra-228	8.2E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	U-235	7.6E-02	1.2E-07	1.9E-10	1.3E-09	9.9E-10	1.2E-07
EU4	Resident Adult	CT-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.2E-07

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Adult	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	0	Pb-210	9.6E-02	1.1E-09	2.2E-10	1.6E-07	3.5E-08	1.9E-07
EU5	Resident Adult	CT-SS	0	Ra-226	9.6E-02	2.3E-06	2.7E-10	1.3E-07	1.1E-08	2.5E-06
EU5	Resident Adult	CT-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	0	Th-230	7.6E-02	3.8E-09	2.3E-10	7.0E-10	1.1E-09	5.9E-09
EU5	Resident Adult	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	0	U-234	1.9E-01	1.4E-10	4.5E-10	2.5E-09	2.2E-09	5.2E-09
EU5	Resident Adult	CT-SS	0	U-235	5.9E-02	9.4E-08	1.3E-10	8.0E-10	7.0E-10	9.6E-08
EU5	Resident Adult	CT-SS	0	U-238	1.5E-01	3.7E-08	3.0E-10	2.4E-09	2.1E-09	4.1E-08
										2.8E-06
EU5	Resident Adult	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	1000	Pb-210	9.6E-02	2.3E-23	4.9E-24	3.5E-21	7.6E-22	4.3E-21
EU5	Resident Adult	CT-SS	1000	Ra-226	9.6E-02	1.5E-06	3.1E-10	1.8E-07	2.9E-08	1.7E-06
EU5	Resident Adult	CT-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	1000	Th-230	7.6E-02	6.5E-07	3.5E-10	7.9E-08	1.3E-08	7.4E-07
EU5	Resident Adult	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	1000	U-234	1.9E-01	7.7E-09	4.3E-10	3.2E-09	2.2E-09	1.4E-08
EU5	Resident Adult	CT-SS	1000	U-235	5.9E-02	9.4E-08	1.5E-10	1.0E-09	7.7E-10	9.6E-08
EU5	Resident Adult	CT-SS	1000	U-238	1.5E-01	3.4E-08	2.8E-10	2.3E-09	2.0E-09	3.9E-08
										2.6E-06

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Adult	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	Th-228	1.2E-01	8.0E-07	1.1E-09	8.2E-10	1.8E-09	8.0E-07
EU3	Resident Adult	CT-SB	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	Th-232	6.4E-02	6.6E-07	8.0E-10	7.9E-08	6.1E-09	7.5E-07
EU3	Resident Adult	CT-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	U-235	4.8E-02	7.7E-08	1.0E-10	6.5E-10	5.7E-10	7.8E-08
EU3	Resident Adult	CT-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.6E-06
EU3	Resident Adult	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Th-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Th-232	6.4E-02	2.2E-06	2.4E-09	2.0E-07	1.5E-08	2.5E-06
EU3	Resident Adult	CT-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	U-235	4.8E-02	7.6E-08	1.2E-10	8.1E-10	6.3E-10	7.8E-08
EU3	Resident Adult	CT-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.5E-06

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Adult	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	0	Ra-228	1.2E-01	2.2E-06	2.0E-09	2.3E-07	1.5E-08	2.4E-06
EU4	Resident Adult	CT-SB	0	Th-228	1.4E-01	9.4E-07	1.3E-09	9.7E-10	2.1E-09	9.5E-07
EU4	Resident Adult	CT-SB	0	Th-230	7.9E-03	4.0E-10	2.3E-11	7.2E-11	1.1E-10	6.1E-10
EU4	Resident Adult	CT-SB	0	Th-232	1.3E-01	1.4E-06	1.7E-09	1.7E-07	1.3E-08	1.6E-06
EU4	Resident Adult	CT-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	0	U-235	8.0E-02	1.3E-07	1.7E-10	1.1E-09	9.3E-10	1.3E-07
EU4	Resident Adult	CT-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.1E-06
EU4	Resident Adult	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	Ra-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	Th-228	1.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	Th-230	7.9E-03	6.7E-08	3.6E-11	8.1E-09	1.4E-09	7.6E-08
EU4	Resident Adult	CT-SB	1000	Th-232	1.3E-01	4.7E-06	5.1E-09	4.2E-07	3.1E-08	5.1E-06
EU4	Resident Adult	CT-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	U-235	8.0E-02	1.3E-07	2.0E-10	1.3E-09	1.0E-09	1.3E-07
EU4	Resident Adult	CT-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.4E-06

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Adult	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	0	Pb-210	4.4E-01	4.9E-09	1.0E-09	7.3E-07	1.6E-07	8.9E-07
EU5	Resident Adult	CT-SB	0	Ra-226	4.4E-01	1.1E-05	1.2E-09	6.1E-07	5.0E-08	1.1E-05
EU5	Resident Adult	CT-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	0	Th-228	4.7E-02	3.2E-07	4.3E-10	3.3E-10	7.1E-10	3.2E-07
EU5	Resident Adult	CT-SB	0	Th-230	8.5E-01	4.3E-08	2.5E-09	7.7E-09	1.2E-08	6.5E-08
EU5	Resident Adult	CT-SB	0	Th-232	4.0E-02	4.2E-07	5.0E-10	5.0E-08	3.8E-09	4.7E-07
EU5	Resident Adult	CT-SB	0	U-234	8.3E-01	6.2E-10	2.0E-09	1.1E-08	9.5E-09	2.3E-08
EU5	Resident Adult	CT-SB	0	U-235	1.0E-01	1.7E-07	2.3E-10	1.4E-09	1.2E-09	1.7E-07
EU5	Resident Adult	CT-SB	0	U-238	7.6E-01	1.9E-07	1.6E-09	1.3E-08	1.1E-08	2.2E-07
										1.4E-05
EU5	Resident Adult	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	1000	Pb-210	4.4E-01	1.1E-22	2.2E-23	1.6E-20	3.5E-21	2.0E-20
EU5	Resident Adult	CT-SB	1000	Ra-226	4.4E-01	6.8E-06	1.4E-09	8.5E-07	1.3E-07	7.8E-06
EU5	Resident Adult	CT-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	1000	Th-228	4.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	1000	Th-230	8.5E-01	7.2E-06	3.9E-09	8.7E-07	1.5E-07	8.2E-06
EU5	Resident Adult	CT-SB	1000	Th-232	4.0E-02	1.4E-06	1.5E-09	1.3E-07	9.4E-09	1.5E-06
EU5	Resident Adult	CT-SB	1000	U-234	8.3E-01	3.4E-08	1.9E-09	1.4E-08	9.6E-09	6.0E-08
EU5	Resident Adult	CT-SB	1000	U-235	1.0E-01	1.6E-07	2.6E-10	1.7E-09	1.4E-09	1.7E-07
EU5	Resident Adult	CT-SB	1000	U-238	7.6E-01	1.8E-07	1.5E-09	1.2E-08	1.0E-08	2.0E-07
										1.8E-05

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Child	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Resident Child	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Child	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	Ra-228	8.2E-02	1.6E-06	8.0E-10	2.7E-08	2.1E-08	1.7E-06
EU4	Resident Child	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	U-235	7.6E-02	1.2E-07	9.5E-11	1.5E-10	1.6E-09	1.2E-07
EU4	Resident Child	CT-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.8E-06
EU4	Resident Child	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Ra-228	8.2E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	U-235	7.6E-02	1.2E-07	1.1E-10	1.8E-10	1.7E-09	1.2E-07
EU4	Resident Child	CT-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.2E-07

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Child	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	0	Pb-210	9.6E-02	1.1E-09	1.3E-10	2.4E-08	6.3E-08	8.8E-08
EU5	Resident Child	CT-SS	0	Ra-226	9.6E-02	2.4E-06	1.5E-10	1.8E-08	1.6E-08	2.4E-06
EU5	Resident Child	CT-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	0	Th-230	7.6E-02	2.7E-09	1.3E-10	9.0E-11	1.9E-09	4.8E-09
EU5	Resident Child	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	0	U-234	1.9E-01	1.4E-10	2.6E-10	3.6E-10	3.8E-09	4.5E-09
EU5	Resident Child	CT-SS	0	U-235	5.9E-02	9.5E-08	7.5E-11	1.2E-10	1.2E-09	9.7E-08
EU5	Resident Child	CT-SS	0	U-238	1.5E-01	3.7E-08	1.7E-10	3.5E-10	3.7E-09	4.1E-08
										2.6E-06
EU5	Resident Child	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	1000	Pb-210	9.6E-02	2.4E-23	3.0E-24	5.2E-22	1.4E-21	1.9E-21
EU5	Resident Child	CT-SS	1000	Ra-226	9.6E-02	1.5E-06	1.8E-10	2.7E-08	5.0E-08	1.6E-06
EU5	Resident Child	CT-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	1000	Th-230	7.6E-02	6.5E-07	2.0E-10	1.1E-08	2.3E-08	6.9E-07
EU5	Resident Child	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	1000	U-234	1.9E-01	7.7E-09	2.5E-10	4.6E-10	3.8E-09	1.2E-08
EU5	Resident Child	CT-SS	1000	U-235	5.9E-02	9.4E-08	8.6E-11	1.4E-10	1.3E-09	9.6E-08
EU5	Resident Child	CT-SS	1000	U-238	1.5E-01	3.4E-08	1.6E-10	3.3E-10	3.4E-09	3.8E-08
										2.4E-06

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Child	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	Th-228	1.2E-01	1.1E-06	8.7E-10	1.6E-10	4.3E-09	1.1E-06
EU3	Resident Child	CT-SB	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	Th-232	6.4E-02	4.4E-07	3.4E-10	8.4E-09	8.1E-09	4.6E-07
EU3	Resident Child	CT-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	U-235	4.8E-02	7.7E-08	6.0E-11	9.3E-11	9.9E-10	7.9E-08
EU3	Resident Child	CT-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.7E-06
EU3	Resident Child	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Th-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Th-232	6.4E-02	2.3E-06	1.4E-09	2.9E-08	2.6E-08	2.3E-06
EU3	Resident Child	CT-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	U-235	4.8E-02	7.7E-08	7.0E-11	1.2E-10	1.1E-09	7.8E-08
EU3	Resident Child	CT-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.4E-06

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Child	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	0	Ra-228	1.2E-01	2.3E-06	1.1E-09	3.8E-08	3.0E-08	2.4E-06
EU4	Resident Child	CT-SB	0	Th-228	1.4E-01	1.3E-06	1.0E-09	1.9E-10	5.1E-09	1.3E-06
EU4	Resident Child	CT-SB	0	Th-230	7.9E-03	2.7E-10	1.3E-11	9.3E-12	2.0E-10	5.0E-10
EU4	Resident Child	CT-SB	0	Th-232	1.3E-01	9.3E-07	7.0E-10	1.8E-08	1.7E-08	9.6E-07
EU4	Resident Child	CT-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	0	U-235	8.0E-02	1.3E-07	1.0E-10	1.5E-10	1.6E-09	1.3E-07
EU4	Resident Child	CT-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										4.8E-06
EU4	Resident Child	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	Ra-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	Th-228	1.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	Th-230	7.9E-03	6.7E-08	2.1E-11	1.2E-09	2.4E-09	7.1E-08
EU4	Resident Child	CT-SB	1000	Th-232	1.3E-01	4.7E-06	2.9E-09	6.0E-08	5.5E-08	4.9E-06
EU4	Resident Child	CT-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	U-235	8.0E-02	1.3E-07	1.2E-10	1.9E-10	1.8E-09	1.3E-07
EU4	Resident Child	CT-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.1E-06

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Child	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	0	Pb-210	4.4E-01	5.1E-09	6.2E-10	1.1E-07	2.9E-07	4.0E-07
EU5	Resident Child	CT-SB	0	Ra-226	4.4E-01	1.1E-05	6.8E-10	8.3E-08	7.5E-08	1.1E-05
EU5	Resident Child	CT-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	0	Th-228	4.7E-02	4.4E-07	3.5E-10	6.5E-11	1.7E-09	4.4E-07
EU5	Resident Child	CT-SB	0	Th-230	8.5E-01	2.9E-08	1.4E-09	1.0E-09	2.1E-08	5.3E-08
EU5	Resident Child	CT-SB	0	Th-232	4.0E-02	2.8E-07	2.1E-10	5.3E-09	5.1E-09	2.9E-07
EU5	Resident Child	CT-SB	0	U-234	8.3E-01	6.3E-10	1.2E-09	1.6E-09	1.7E-08	2.0E-08
EU5	Resident Child	CT-SB	0	U-235	1.0E-01	1.7E-07	1.3E-10	2.0E-10	2.1E-09	1.7E-07
EU5	Resident Child	CT-SB	0	U-238	7.6E-01	1.9E-07	9.0E-10	1.8E-09	1.9E-08	2.2E-07
										1.3E-05
EU5	Resident Child	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	1000	Pb-210	4.4E-01	1.1E-22	1.4E-23	2.4E-21	6.3E-21	8.9E-21
EU5	Resident Child	CT-SB	1000	Ra-226	4.4E-01	6.9E-06	8.2E-10	1.2E-07	2.3E-07	7.3E-06
EU5	Resident Child	CT-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	1000	Th-228	4.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	1000	Th-230	8.5E-01	7.2E-06	2.2E-09	1.3E-07	2.5E-07	7.6E-06
EU5	Resident Child	CT-SB	1000	Th-232	4.0E-02	1.4E-06	8.8E-10	1.8E-08	1.6E-08	1.5E-06
EU5	Resident Child	CT-SB	1000	U-234	8.3E-01	3.4E-08	1.1E-09	2.0E-09	1.7E-08	5.4E-08
EU5	Resident Child	CT-SB	1000	U-235	1.0E-01	1.7E-07	1.5E-10	2.5E-10	2.4E-09	1.7E-07
EU5	Resident Child	CT-SB	1000	U-238	7.6E-01	1.8E-07	8.5E-10	1.7E-09	1.8E-08	2.0E-07
										1.7E-05

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Industrial	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SS	0	Pb-210	4.5E+01	1.2E-07	5.2E-08	0.0E+00	3.9E-06	4.1E-06
EU1	Industrial	CT-SS	0	Ra-226	4.5E+01	2.6E-04	5.9E-08	0.0E+00	1.1E-06	2.6E-04
EU1	Industrial	CT-SS	0	Ra-228	1.3E-01	5.7E-07	1.0E-09	0.0E+00	4.1E-09	5.8E-07
EU1	Industrial	CT-SS	0	Th-228	2.4E-01	4.7E-07	1.3E-09	0.0E+00	1.0E-09	4.7E-07
EU1	Industrial	CT-SS	0	Th-230	7.1E-01	6.2E-09	1.0E-09	0.0E+00	2.3E-09	9.6E-09
EU1	Industrial	CT-SS	0	Th-232	1.6E-01	2.8E-07	7.4E-10	0.0E+00	2.8E-09	2.8E-07
EU1	Industrial	CT-SS	0	U-234	4.0E+00	7.1E-10	4.7E-09	0.0E+00	1.1E-08	1.6E-08
EU1	Industrial	CT-SS	0	U-235	1.9E-01	6.9E-08	1.9E-10	0.0E+00	5.0E-10	6.9E-08
EU1	Industrial	CT-SS	0	U-238	1.6E+01	9.2E-07	1.5E-08	0.0E+00	5.2E-08	9.9E-07
										2.7E-04
EU1	Industrial	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SS	1000	Pb-210	4.5E+01	2.7E-21	1.2E-21	0.0E+00	8.5E-20	8.9E-20
EU1	Industrial	CT-SS	1000	Ra-226	4.5E+01	1.6E-04	7.1E-08	0.0E+00	3.1E-06	1.7E-04
EU1	Industrial	CT-SS	1000	Ra-228	1.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SS	1000	Th-228	2.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SS	1000	Th-230	7.1E-01	1.4E-06	1.6E-09	0.0E+00	2.8E-08	1.4E-06
EU1	Industrial	CT-SS	1000	Th-232	1.6E-01	1.3E-06	2.9E-09	0.0E+00	8.5E-09	1.3E-06
EU1	Industrial	CT-SS	1000	U-234	4.0E+00	3.9E-08	4.4E-09	0.0E+00	1.1E-08	5.4E-08
EU1	Industrial	CT-SS	1000	U-235	1.9E-01	6.8E-08	2.2E-10	0.0E+00	5.5E-10	6.9E-08
EU1	Industrial	CT-SS	1000	U-238	1.6E+01	8.6E-07	1.4E-08	0.0E+00	4.9E-08	9.3E-07
										1.7E-04

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Industrial	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU2	Industrial	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Industrial	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Industrial	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Industrial	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	Ra-228	8.2E-02	3.7E-07	6.7E-10	0.0E+00	2.7E-09	3.8E-07
EU4	Industrial	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	U-235	7.6E-02	2.8E-08	7.9E-11	0.0E+00	2.0E-10	2.8E-08
EU4	Industrial	CT-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										4.0E-07
EU4	Industrial	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Ra-228	8.2E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	U-235	7.6E-02	2.8E-08	9.1E-11	0.0E+00	2.3E-10	2.8E-08
EU4	Industrial	CT-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.8E-08

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Industrial	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	0	Pb-210	9.6E-02	2.5E-10	1.1E-10	0.0E+00	8.2E-09	8.5E-09
EU5	Industrial	CT-SS	0	Ra-226	9.6E-02	5.5E-07	1.2E-10	0.0E+00	2.2E-09	5.5E-07
EU5	Industrial	CT-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	0	Th-230	7.6E-02	6.7E-10	1.1E-10	0.0E+00	2.5E-10	1.0E-09
EU5	Industrial	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	0	U-234	1.9E-01	3.3E-11	2.2E-10	0.0E+00	4.9E-10	7.4E-10
EU5	Industrial	CT-SS	0	U-235	5.9E-02	2.2E-08	6.2E-11	0.0E+00	1.6E-10	2.2E-08
EU5	Industrial	CT-SS	0	U-238	1.5E-01	8.5E-09	1.4E-10	0.0E+00	4.8E-10	9.1E-09
										5.9E-07
EU5	Industrial	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	1000	Pb-210	9.6E-02	5.6E-24	2.4E-24	0.0E+00	1.8E-22	1.9E-22
EU5	Industrial	CT-SS	1000	Ra-226	9.6E-02	3.5E-07	1.5E-10	0.0E+00	6.6E-09	3.5E-07
EU5	Industrial	CT-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	1000	Th-230	7.6E-02	1.5E-07	1.7E-10	0.0E+00	3.0E-09	1.5E-07
EU5	Industrial	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	1000	U-234	1.9E-01	1.8E-09	2.0E-10	0.0E+00	5.0E-10	2.5E-09
EU5	Industrial	CT-SS	1000	U-235	5.9E-02	2.2E-08	7.1E-11	0.0E+00	1.8E-10	2.2E-08
EU5	Industrial	CT-SS	1000	U-238	1.5E-01	7.9E-09	1.3E-10	0.0E+00	4.5E-10	8.5E-09
										5.4E-07

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Industrial	CT-SB	0	Ac-227	1.1E-01	9.6E-08	8.5E-10	0.0E+00	1.7E-09	9.8E-08
EU1	Industrial	CT-SB	0	Pa-231	1.1E-01	2.0E-08	4.3E-10	0.0E+00	8.5E-10	2.2E-08
EU1	Industrial	CT-SB	0	Pb-210	3.2E+01	8.5E-08	3.7E-08	0.0E+00	2.7E-06	2.8E-06
EU1	Industrial	CT-SB	0	Ra-226	3.2E+01	1.8E-04	4.1E-08	0.0E+00	7.4E-07	1.8E-04
EU1	Industrial	CT-SB	0	Ra-228	4.4E-01	2.0E-06	3.6E-09	0.0E+00	1.4E-08	2.0E-06
EU1	Industrial	CT-SB	0	Th-228	4.9E-01	9.7E-07	2.7E-09	0.0E+00	2.1E-09	9.8E-07
EU1	Industrial	CT-SB	0	Th-230	1.9E+00	1.6E-08	2.6E-09	0.0E+00	6.2E-09	2.5E-08
EU1	Industrial	CT-SB	0	Th-232	4.1E-01	7.3E-07	1.9E-09	0.0E+00	7.3E-09	7.4E-07
EU1	Industrial	CT-SB	0	U-234	1.0E+01	1.8E-09	1.2E-08	0.0E+00	2.8E-08	4.1E-08
EU1	Industrial	CT-SB	0	U-235	5.5E-01	2.0E-07	5.7E-10	0.0E+00	1.5E-09	2.0E-07
EU1	Industrial	CT-SB	0	U-238	3.4E+01	2.0E-06	3.3E-08	0.0E+00	1.1E-07	2.1E-06
										1.9E-04
EU1	Industrial	CT-SB	1000	Ac-227	1.1E-01	1.3E-21	1.2E-23	0.0E+00	2.4E-23	1.3E-21
EU1	Industrial	CT-SB	1000	Pa-231	1.1E-01	1.1E-07	1.2E-09	0.0E+00	2.3E-09	1.1E-07
EU1	Industrial	CT-SB	1000	Pb-210	3.2E+01	1.9E-21	8.0E-22	0.0E+00	6.0E-20	6.2E-20
EU1	Industrial	CT-SB	1000	Ra-226	3.2E+01	1.2E-04	4.9E-08	0.0E+00	2.2E-06	1.2E-04
EU1	Industrial	CT-SB	1000	Ra-228	4.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SB	1000	Th-228	4.9E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SB	1000	Th-230	1.9E+00	3.7E-06	4.1E-09	0.0E+00	7.3E-08	3.7E-06
EU1	Industrial	CT-SB	1000	Th-232	4.1E-01	3.3E-06	7.4E-09	0.0E+00	2.2E-08	3.4E-06
EU1	Industrial	CT-SB	1000	U-234	1.0E+01	1.0E-07	1.1E-08	0.0E+00	2.8E-08	1.4E-07
EU1	Industrial	CT-SB	1000	U-235	5.5E-01	2.0E-07	6.5E-10	0.0E+00	1.6E-09	2.0E-07
EU1	Industrial	CT-SB	1000	U-238	3.4E+01	1.9E-06	3.1E-08	0.0E+00	1.1E-07	2.0E-06
										1.3E-04

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Industrial	CT-SB	0	Ac-227	2.4E-01	2.1E-07	1.9E-09	0.0E+00	3.9E-09	2.2E-07
EU2	Industrial	CT-SB	0	Pa-231	2.4E-01	4.6E-08	9.6E-10	0.0E+00	1.9E-09	4.9E-08
EU2	Industrial	CT-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	0	Th-228	4.3E-02	8.6E-08	2.4E-10	0.0E+00	1.9E-10	8.7E-08
EU2	Industrial	CT-SB	0	Th-230	8.0E-04	7.0E-12	1.1E-12	0.0E+00	2.6E-12	1.1E-11
EU2	Industrial	CT-SB	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	0	U-238	3.2E-01	1.9E-08	3.1E-10	0.0E+00	1.1E-09	2.0E-08
										3.8E-07
EU2	Industrial	CT-SB	1000	Ac-227	2.4E-01	2.9E-21	2.6E-23	0.0E+00	5.3E-23	3.0E-21
EU2	Industrial	CT-SB	1000	Pa-231	2.4E-01	2.4E-07	2.6E-09	0.0E+00	5.2E-09	2.4E-07
EU2	Industrial	CT-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	Th-228	4.3E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	Th-230	8.0E-04	1.6E-09	1.8E-12	0.0E+00	3.2E-11	1.6E-09
EU2	Industrial	CT-SB	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	U-238	3.2E-01	1.7E-08	2.9E-10	0.0E+00	9.9E-10	1.9E-08
										2.6E-07

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Industrial	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	Th-228	1.2E-01	2.4E-07	6.7E-10	0.0E+00	5.3E-10	2.4E-07
EU3	Industrial	CT-SB	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	Th-232	6.4E-02	1.1E-07	3.0E-10	0.0E+00	1.1E-09	1.1E-07
EU3	Industrial	CT-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	U-235	4.8E-02	1.8E-08	5.0E-11	0.0E+00	1.3E-10	1.8E-08
EU3	Industrial	CT-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.7E-07
EU3	Industrial	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Th-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Th-232	6.4E-02	5.2E-07	1.2E-09	0.0E+00	3.4E-09	5.3E-07
EU3	Industrial	CT-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	U-235	4.8E-02	1.8E-08	5.8E-11	0.0E+00	1.4E-10	1.8E-08
EU3	Industrial	CT-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.4E-07

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Industrial	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	0	Ra-228	1.2E-01	5.3E-07	9.6E-10	0.0E+00	3.8E-09	5.4E-07
EU4	Industrial	CT-SB	0	Th-228	1.4E-01	2.8E-07	8.0E-10	0.0E+00	6.2E-10	2.8E-07
EU4	Industrial	CT-SB	0	Th-230	7.9E-03	6.9E-11	1.1E-11	0.0E+00	2.6E-11	1.1E-10
EU4	Industrial	CT-SB	0	Th-232	1.3E-01	2.4E-07	6.3E-10	0.0E+00	2.4E-09	2.4E-07
EU4	Industrial	CT-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	0	U-235	8.0E-02	2.9E-08	8.3E-11	0.0E+00	2.1E-10	3.0E-08
EU4	Industrial	CT-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.1E-06
EU4	Industrial	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	Ra-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	Th-228	1.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	Th-230	7.9E-03	1.6E-08	1.7E-11	0.0E+00	3.1E-10	1.6E-08
EU4	Industrial	CT-SB	1000	Th-232	1.3E-01	1.1E-06	2.4E-09	0.0E+00	7.2E-09	1.1E-06
EU4	Industrial	CT-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	U-235	8.0E-02	2.9E-08	9.5E-11	0.0E+00	2.4E-10	3.0E-08
EU4	Industrial	CT-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.1E-06

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Industrial	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	0	Pb-210	4.4E-01	1.2E-09	5.1E-10	0.0E+00	3.8E-08	3.9E-08
EU5	Industrial	CT-SB	0	Ra-226	4.4E-01	2.5E-06	5.7E-10	0.0E+00	1.0E-08	2.5E-06
EU5	Industrial	CT-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	0	Th-228	4.7E-02	9.5E-08	2.7E-10	0.0E+00	2.1E-10	9.5E-08
EU5	Industrial	CT-SB	0	Th-230	8.5E-01	7.4E-09	1.2E-09	0.0E+00	2.8E-09	1.1E-08
EU5	Industrial	CT-SB	0	Th-232	4.0E-02	7.1E-08	1.9E-10	0.0E+00	7.1E-10	7.2E-08
EU5	Industrial	CT-SB	0	U-234	8.3E-01	1.4E-10	9.5E-10	0.0E+00	2.2E-09	3.3E-09
EU5	Industrial	CT-SB	0	U-235	1.0E-01	3.8E-08	1.1E-10	0.0E+00	2.8E-10	3.9E-08
EU5	Industrial	CT-SB	0	U-238	7.6E-01	4.5E-08	7.5E-10	0.0E+00	2.5E-09	4.8E-08
										2.8E-06
EU5	Industrial	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	1000	Pb-210	4.4E-01	2.6E-23	1.1E-23	0.0E+00	8.2E-22	8.6E-22
EU5	Industrial	CT-SB	1000	Ra-226	4.4E-01	1.6E-06	6.8E-10	0.0E+00	3.0E-08	1.6E-06
EU5	Industrial	CT-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	1000	Th-228	4.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	1000	Th-230	8.5E-01	1.7E-06	1.9E-09	0.0E+00	3.3E-08	1.7E-06
EU5	Industrial	CT-SB	1000	Th-232	4.0E-02	3.3E-07	7.3E-10	0.0E+00	2.1E-09	3.3E-07
EU5	Industrial	CT-SB	1000	U-234	8.3E-01	7.9E-09	9.0E-10	0.0E+00	2.2E-09	1.1E-08
EU5	Industrial	CT-SB	1000	U-235	1.0E-01	3.8E-08	1.2E-10	0.0E+00	3.1E-10	3.9E-08
EU5	Industrial	CT-SB	1000	U-238	7.6E-01	4.2E-08	7.0E-10	0.0E+00	2.4E-09	4.5E-08
										3.8E-06

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Recreational	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SS	0	Pb-210	4.5E+01	8.4E-09	4.5E-09	0.0E+00	1.3E-07	1.4E-07
EU1	Recreational	CT-SS	0	Ra-226	4.5E+01	1.9E-05	5.3E-09	0.0E+00	4.1E-08	1.9E-05
EU1	Recreational	CT-SS	0	Ra-228	1.3E-01	3.9E-08	9.0E-11	0.0E+00	1.3E-10	4.0E-08
EU1	Recreational	CT-SS	0	Th-228	2.4E-01	2.6E-08	9.1E-11	0.0E+00	2.7E-11	2.6E-08
EU1	Recreational	CT-SS	0	Th-230	7.1E-01	6.0E-10	8.8E-11	0.0E+00	8.0E-11	7.6E-10
EU1	Recreational	CT-SS	0	Th-232	1.6E-01	2.7E-08	8.3E-11	0.0E+00	1.2E-10	2.8E-08
EU1	Recreational	CT-SS	0	U-234	4.0E+00	5.1E-11	4.1E-10	0.0E+00	3.6E-10	8.2E-10
EU1	Recreational	CT-SS	0	U-235	1.9E-01	4.9E-09	1.7E-11	0.0E+00	1.7E-11	5.0E-09
EU1	Recreational	CT-SS	0	U-238	1.6E+01	6.6E-08	1.4E-09	0.0E+00	1.8E-09	6.9E-08
										1.9E-05
EU1	Recreational	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SS	1000	Pb-210	4.5E+01	1.8E-22	9.8E-23	0.0E+00	2.8E-21	3.1E-21
EU1	Recreational	CT-SS	1000	Ra-226	4.5E+01	1.2E-05	6.2E-09	0.0E+00	1.1E-07	1.2E-05
EU1	Recreational	CT-SS	1000	Ra-228	1.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SS	1000	Th-228	2.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SS	1000	Th-230	7.1E-01	1.0E-07	1.4E-10	0.0E+00	9.5E-10	1.0E-07
EU1	Recreational	CT-SS	1000	Th-232	1.6E-01	9.2E-08	2.5E-10	0.0E+00	2.9E-10	9.3E-08
EU1	Recreational	CT-SS	1000	U-234	4.0E+00	2.8E-09	3.9E-10	0.0E+00	3.6E-10	3.5E-09
EU1	Recreational	CT-SS	1000	U-235	1.9E-01	4.9E-09	2.0E-11	0.0E+00	1.9E-11	4.9E-09
EU1	Recreational	CT-SS	1000	U-238	1.6E+01	6.2E-08	1.3E-09	0.0E+00	1.7E-09	6.5E-08
										1.2E-05

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Recreational	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU2	Recreational	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Recreational	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Recreational	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Recreational	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	Ra-228	8.2E-02	2.6E-08	5.9E-11	0.0E+00	8.2E-11	2.6E-08
EU4	Recreational	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	U-235	7.6E-02	2.0E-09	6.9E-12	0.0E+00	6.9E-12	2.0E-09
EU4	Recreational	CT-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.8E-08
EU4	Recreational	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Ra-228	8.2E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	U-235	7.6E-02	2.0E-09	8.0E-12	0.0E+00	7.7E-12	2.0E-09
EU4	Recreational	CT-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.0E-09

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Recreational	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	0	Pb-210	9.6E-02	1.8E-11	9.4E-12	0.0E+00	2.7E-10	3.0E-10
EU5	Recreational	CT-SS	0	Ra-226	9.6E-02	3.9E-08	1.1E-11	0.0E+00	8.5E-11	3.9E-08
EU5	Recreational	CT-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	0	Th-230	7.6E-02	6.4E-11	9.5E-12	0.0E+00	8.6E-12	8.2E-11
EU5	Recreational	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	0	U-234	1.9E-01	2.3E-12	1.9E-11	0.0E+00	1.7E-11	3.8E-11
EU5	Recreational	CT-SS	0	U-235	5.9E-02	1.6E-09	5.4E-12	0.0E+00	5.4E-12	1.6E-09
EU5	Recreational	CT-SS	0	U-238	1.5E-01	6.1E-10	1.3E-11	0.0E+00	1.6E-11	6.4E-10
										4.2E-08
EU5	Recreational	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	1000	Pb-210	9.6E-02	3.9E-25	2.1E-25	0.0E+00	5.9E-24	6.5E-24
EU5	Recreational	CT-SS	1000	Ra-226	9.6E-02	2.5E-08	1.3E-11	0.0E+00	2.2E-10	2.5E-08
EU5	Recreational	CT-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	1000	Th-230	7.6E-02	1.1E-08	1.5E-11	0.0E+00	1.0E-10	1.1E-08
EU5	Recreational	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	1000	U-234	1.9E-01	1.3E-10	1.8E-11	0.0E+00	1.7E-11	1.6E-10
EU5	Recreational	CT-SS	1000	U-235	5.9E-02	1.6E-09	6.3E-12	0.0E+00	6.0E-12	1.6E-09
EU5	Recreational	CT-SS	1000	U-238	1.5E-01	5.7E-10	1.2E-11	0.0E+00	1.5E-11	6.0E-10
										3.8E-08

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Recreational	CT-SB	0	Ac-227	1.1E-01	6.6E-09	7.2E-11	0.0E+00	5.6E-11	6.7E-09
EU1	Recreational	CT-SB	0	Pa-231	1.1E-01	1.7E-09	4.0E-11	0.0E+00	3.1E-11	1.8E-09
EU1	Recreational	CT-SB	0	Pb-210	3.2E+01	5.8E-09	3.1E-09	0.0E+00	8.9E-08	9.8E-08
EU1	Recreational	CT-SB	0	Ra-226	3.2E+01	1.3E-05	3.7E-09	0.0E+00	2.8E-08	1.3E-05
EU1	Recreational	CT-SB	0	Ra-228	4.4E-01	1.4E-07	3.2E-10	0.0E+00	4.4E-10	1.4E-07
EU1	Recreational	CT-SB	0	Th-228	4.9E-01	5.4E-08	1.9E-10	0.0E+00	5.7E-11	5.4E-08
EU1	Recreational	CT-SB	0	Th-230	1.9E+00	1.6E-09	2.3E-10	0.0E+00	2.1E-10	2.0E-09
EU1	Recreational	CT-SB	0	Th-232	4.1E-01	7.1E-08	2.2E-10	0.0E+00	3.0E-10	7.2E-08
EU1	Recreational	CT-SB	0	U-234	1.0E+01	1.3E-10	1.1E-09	0.0E+00	9.4E-10	2.1E-09
EU1	Recreational	CT-SB	0	U-235	5.5E-01	1.4E-08	5.0E-11	0.0E+00	5.0E-11	1.5E-08
EU1	Recreational	CT-SB	0	U-238	3.4E+01	1.4E-07	2.9E-09	0.0E+00	3.8E-09	1.5E-07
										1.4E-05
EU1	Recreational	CT-SB	1000	Ac-227	1.1E-01	9.1E-23	9.9E-25	0.0E+00	7.7E-25	9.3E-23
EU1	Recreational	CT-SB	1000	Pa-231	1.1E-01	7.6E-09	1.0E-10	0.0E+00	7.9E-11	7.7E-09
EU1	Recreational	CT-SB	1000	Pb-210	3.2E+01	1.3E-22	6.8E-23	0.0E+00	2.0E-21	2.1E-21
EU1	Recreational	CT-SB	1000	Ra-226	3.2E+01	8.2E-06	4.3E-09	0.0E+00	7.4E-08	8.3E-06
EU1	Recreational	CT-SB	1000	Ra-228	4.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SB	1000	Th-228	4.9E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SB	1000	Th-230	1.9E+00	2.6E-07	3.6E-10	0.0E+00	2.5E-09	2.7E-07
EU1	Recreational	CT-SB	1000	Th-232	4.1E-01	2.4E-07	6.5E-10	0.0E+00	7.5E-10	2.4E-07
EU1	Recreational	CT-SB	1000	U-234	1.0E+01	7.2E-09	1.0E-09	0.0E+00	9.4E-10	9.1E-09
EU1	Recreational	CT-SB	1000	U-235	5.5E-01	1.4E-08	5.7E-11	0.0E+00	5.5E-11	1.4E-08
EU1	Recreational	CT-SB	1000	U-238	3.4E+01	1.3E-07	2.8E-09	0.0E+00	3.6E-09	1.4E-07
										9.0E-06

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Recreational	CT-SB	0	Ac-227	2.4E-01	1.5E-08	1.6E-10	0.0E+00	1.3E-10	1.5E-08
EU2	Recreational	CT-SB	0	Pa-231	2.4E-01	3.8E-09	9.0E-11	0.0E+00	6.9E-11	4.0E-09
EU2	Recreational	CT-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	0	Th-228	4.3E-02	4.8E-09	1.7E-11	0.0E+00	5.0E-12	4.8E-09
EU2	Recreational	CT-SB	0	Th-230	8.0E-04	6.7E-13	9.9E-14	0.0E+00	9.0E-14	8.6E-13
EU2	Recreational	CT-SB	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	0	U-238	3.2E-01	1.3E-09	2.8E-11	0.0E+00	3.6E-11	1.4E-09
										2.5E-08
EU2	Recreational	CT-SB	1000	Ac-227	2.4E-01	2.0E-22	2.2E-24	0.0E+00	1.7E-24	2.1E-22
EU2	Recreational	CT-SB	1000	Pa-231	2.4E-01	1.7E-08	2.3E-10	0.0E+00	1.8E-10	1.7E-08
EU2	Recreational	CT-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	Th-228	4.3E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	Th-230	8.0E-04	1.1E-10	1.5E-13	0.0E+00	1.1E-12	1.1E-10
EU2	Recreational	CT-SB	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	U-238	3.2E-01	1.3E-09	2.6E-11	0.0E+00	3.4E-11	1.3E-09
										1.9E-08

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Recreational	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	Th-228	1.2E-01	1.3E-08	4.6E-11	0.0E+00	1.4E-11	1.3E-08
EU3	Recreational	CT-SB	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	Th-232	6.4E-02	1.1E-08	3.4E-11	0.0E+00	4.7E-11	1.1E-08
EU3	Recreational	CT-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	U-235	4.8E-02	1.3E-09	4.4E-12	0.0E+00	4.4E-12	1.3E-09
EU3	Recreational	CT-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.6E-08
EU3	Recreational	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Th-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Th-232	6.4E-02	3.7E-08	1.0E-10	0.0E+00	1.2E-10	3.8E-08
EU3	Recreational	CT-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	U-235	4.8E-02	1.3E-09	5.1E-12	0.0E+00	4.9E-12	1.3E-09
EU3	Recreational	CT-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.9E-08

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Recreational	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	0	Ra-228	1.2E-01	3.7E-08	8.4E-11	0.0E+00	1.2E-10	3.7E-08
EU4	Recreational	CT-SB	0	Th-228	1.4E-01	1.6E-08	5.4E-11	0.0E+00	1.6E-11	1.6E-08
EU4	Recreational	CT-SB	0	Th-230	7.9E-03	6.6E-12	9.8E-13	0.0E+00	8.9E-13	8.5E-12
EU4	Recreational	CT-SB	0	Th-232	1.3E-01	2.3E-08	7.0E-11	0.0E+00	9.9E-11	2.3E-08
EU4	Recreational	CT-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	0	U-235	8.0E-02	2.1E-09	7.3E-12	0.0E+00	7.3E-12	2.1E-09
EU4	Recreational	CT-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										7.8E-08
EU4	Recreational	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	Ra-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	Th-228	1.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	Th-230	7.9E-03	1.1E-09	1.5E-12	0.0E+00	1.1E-11	1.1E-09
EU4	Recreational	CT-SB	1000	Th-232	1.3E-01	7.8E-08	2.1E-10	0.0E+00	2.4E-10	7.9E-08
EU4	Recreational	CT-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	U-235	8.0E-02	2.1E-09	8.4E-12	0.0E+00	8.0E-12	2.1E-09
EU4	Recreational	CT-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										8.2E-08

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Recreational	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	0	Pb-210	4.4E-01	8.1E-11	4.3E-11	0.0E+00	1.2E-09	1.4E-09
EU5	Recreational	CT-SB	0	Ra-226	4.4E-01	1.8E-07	5.1E-11	0.0E+00	3.9E-10	1.8E-07
EU5	Recreational	CT-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	0	Th-228	4.7E-02	5.3E-09	1.8E-11	0.0E+00	5.5E-12	5.3E-09
EU5	Recreational	CT-SB	0	Th-230	8.5E-01	7.1E-10	1.1E-10	0.0E+00	9.6E-11	9.1E-10
EU5	Recreational	CT-SB	0	Th-232	4.0E-02	6.9E-09	2.1E-11	0.0E+00	3.0E-11	7.0E-09
EU5	Recreational	CT-SB	0	U-234	8.3E-01	1.0E-11	8.4E-11	0.0E+00	7.4E-11	1.7E-10
EU5	Recreational	CT-SB	0	U-235	1.0E-01	2.8E-09	9.5E-12	0.0E+00	9.5E-12	2.8E-09
EU5	Recreational	CT-SB	0	U-238	7.6E-01	3.2E-09	6.6E-11	0.0E+00	8.6E-11	3.3E-09
										2.0E-07
EU5	Recreational	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	1000	Pb-210	4.4E-01	1.8E-24	9.4E-25	0.0E+00	2.7E-23	3.0E-23
EU5	Recreational	CT-SB	1000	Ra-226	4.4E-01	1.1E-07	6.0E-11	0.0E+00	1.0E-09	1.2E-07
EU5	Recreational	CT-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	1000	Th-228	4.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	1000	Th-230	8.5E-01	1.2E-07	1.6E-10	0.0E+00	1.1E-09	1.2E-07
EU5	Recreational	CT-SB	1000	Th-232	4.0E-02	2.3E-08	6.4E-11	0.0E+00	7.3E-11	2.4E-08
EU5	Recreational	CT-SB	1000	U-234	8.3E-01	5.7E-10	7.9E-11	0.0E+00	7.4E-11	7.2E-10
EU5	Recreational	CT-SB	1000	U-235	1.0E-01	2.7E-09	1.1E-11	0.0E+00	1.0E-11	2.8E-09
EU5	Recreational	CT-SB	1000	U-238	7.6E-01	3.0E-09	6.2E-11	0.0E+00	8.0E-11	3.1E-09
										2.7E-07

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Construction	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SS	0	Pb-210	4.5E+01	4.2E-08	1.3E-07	0.0E+00	3.1E-06	3.3E-06
EU1	Construction	CT-SS	0	Ra-226	4.5E+01	8.3E-05	1.3E-07	0.0E+00	5.1E-07	8.4E-05
EU1	Construction	CT-SS	0	Ra-228	1.3E-01	1.5E-07	1.2E-09	0.0E+00	3.6E-09	1.5E-07
EU1	Construction	CT-SS	0	Th-228	2.4E-01	3.3E-07	6.9E-09	0.0E+00	1.7E-09	3.4E-07
EU1	Construction	CT-SS	0	Th-230	7.1E-01	4.1E-10	2.3E-09	0.0E+00	1.7E-09	4.4E-09
EU1	Construction	CT-SS	0	Th-232	1.6E-01	1.1E-08	7.4E-10	0.0E+00	6.9E-10	1.2E-08
EU1	Construction	CT-SS	0	U-234	4.0E+00	2.2E-10	1.1E-08	0.0E+00	7.7E-09	1.9E-08
EU1	Construction	CT-SS	0	U-235	1.9E-01	2.2E-08	4.5E-10	0.0E+00	3.6E-10	2.3E-08
EU1	Construction	CT-SS	0	U-238	1.6E+01	2.9E-07	3.6E-08	0.0E+00	3.8E-08	3.7E-07
										8.8E-05
EU1	Construction	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SS	1000	Pb-210	4.5E+01	9.2E-22	2.9E-21	0.0E+00	6.7E-20	7.1E-20
EU1	Construction	CT-SS	1000	Ra-226	4.5E+01	5.3E-05	1.7E-07	0.0E+00	2.3E-06	5.5E-05
EU1	Construction	CT-SS	1000	Ra-228	1.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SS	1000	Th-228	2.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SS	1000	Th-230	7.1E-01	4.4E-07	3.7E-09	0.0E+00	2.0E-08	4.7E-07
EU1	Construction	CT-SS	1000	Th-232	1.6E-01	4.1E-07	6.7E-09	0.0E+00	6.1E-09	4.2E-07
EU1	Construction	CT-SS	1000	U-234	4.0E+00	1.2E-08	1.0E-08	0.0E+00	7.8E-09	3.0E-08
EU1	Construction	CT-SS	1000	U-235	1.9E-01	2.2E-08	5.2E-10	0.0E+00	4.0E-10	2.3E-08
EU1	Construction	CT-SS	1000	U-238	1.6E+01	2.7E-07	3.4E-08	0.0E+00	3.5E-08	3.4E-07
										5.6E-05

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Construction	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU2	Construction	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Construction	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Construction	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Construction	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	Ra-228	8.2E-02	9.6E-08	7.7E-10	0.0E+00	2.3E-09	1.0E-07
EU4	Construction	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	U-235	7.6E-02	9.0E-09	1.8E-10	0.0E+00	1.5E-10	9.3E-09
EU4	Construction	CT-SS	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.1E-07
EU4	Construction	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Ra-228	8.2E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	U-235	7.6E-02	8.9E-09	2.1E-10	0.0E+00	1.6E-10	9.2E-09
EU4	Construction	CT-SS	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										9.2E-09

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Construction	CT-SS	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	0	Pb-210	9.6E-02	8.8E-11	2.8E-10	0.0E+00	6.5E-09	6.8E-09
EU5	Construction	CT-SS	0	Ra-226	9.6E-02	1.7E-07	2.7E-10	0.0E+00	1.1E-09	1.8E-07
EU5	Construction	CT-SS	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	0	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	0	Th-230	7.6E-02	4.4E-11	2.5E-10	0.0E+00	1.8E-10	4.8E-10
EU5	Construction	CT-SS	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	0	U-234	1.9E-01	1.0E-11	5.1E-10	0.0E+00	3.6E-10	8.7E-10
EU5	Construction	CT-SS	0	U-235	5.9E-02	7.0E-09	1.4E-10	0.0E+00	1.2E-10	7.3E-09
EU5	Construction	CT-SS	0	U-238	1.5E-01	2.7E-09	3.3E-10	0.0E+00	3.5E-10	3.4E-09
										1.9E-07
EU5	Construction	CT-SS	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	1000	Pb-210	9.6E-02	1.9E-24	6.2E-24	0.0E+00	1.4E-22	1.5E-22
EU5	Construction	CT-SS	1000	Ra-226	9.6E-02	1.1E-07	3.5E-10	0.0E+00	4.8E-09	1.2E-07
EU5	Construction	CT-SS	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	1000	Th-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	1000	Th-230	7.6E-02	4.8E-08	3.9E-10	0.0E+00	2.2E-09	5.0E-08
EU5	Construction	CT-SS	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	1000	U-234	1.9E-01	5.7E-10	4.8E-10	0.0E+00	3.6E-10	1.4E-09
EU5	Construction	CT-SS	1000	U-235	5.9E-02	6.9E-09	1.7E-10	0.0E+00	1.3E-10	7.2E-09
EU5	Construction	CT-SS	1000	U-238	1.5E-01	2.5E-09	3.1E-10	0.0E+00	3.3E-10	3.2E-09
										1.8E-07

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Construction	CT-SB	0	Ac-227	1.1E-01	3.3E-08	2.2E-09	0.0E+00	1.4E-09	3.7E-08
EU1	Construction	CT-SB	0	Pa-231	1.1E-01	3.7E-09	8.2E-10	0.0E+00	5.0E-10	5.1E-09
EU1	Construction	CT-SB	0	Pb-210	3.2E+01	2.9E-08	9.4E-08	0.0E+00	2.1E-06	2.3E-06
EU1	Construction	CT-SB	0	Ra-226	3.2E+01	5.8E-05	8.8E-08	0.0E+00	3.6E-07	5.8E-05
EU1	Construction	CT-SB	0	Ra-228	4.4E-01	5.2E-07	4.1E-09	0.0E+00	1.2E-08	5.4E-07
EU1	Construction	CT-SB	0	Th-228	4.9E-01	6.8E-07	1.4E-08	0.0E+00	3.4E-09	7.0E-07
EU1	Construction	CT-SB	0	Th-230	1.9E+00	1.1E-09	6.2E-09	0.0E+00	4.4E-09	1.2E-08
EU1	Construction	CT-SB	0	Th-232	4.1E-01	2.8E-08	1.9E-09	0.0E+00	1.8E-09	3.1E-08
EU1	Construction	CT-SB	0	U-234	1.0E+01	5.8E-10	2.8E-08	0.0E+00	2.0E-08	4.9E-08
EU1	Construction	CT-SB	0	U-235	5.5E-01	6.4E-08	1.3E-09	0.0E+00	1.1E-09	6.7E-08
EU1	Construction	CT-SB	0	U-238	3.4E+01	6.4E-07	7.8E-08	0.0E+00	8.2E-08	8.0E-07
										6.3E-05
EU1	Construction	CT-SB	1000	Ac-227	1.1E-01	4.6E-22	3.0E-23	0.0E+00	1.9E-23	5.1E-22
EU1	Construction	CT-SB	1000	Pa-231	1.1E-01	3.4E-08	2.7E-09	0.0E+00	1.7E-09	3.8E-08
EU1	Construction	CT-SB	1000	Pb-210	3.2E+01	6.4E-22	2.1E-21	0.0E+00	4.7E-20	5.0E-20
EU1	Construction	CT-SB	1000	Ra-226	3.2E+01	3.7E-05	1.2E-07	0.0E+00	1.6E-06	3.8E-05
EU1	Construction	CT-SB	1000	Ra-228	4.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SB	1000	Th-228	4.9E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SB	1000	Th-230	1.9E+00	1.2E-06	9.6E-09	0.0E+00	5.3E-08	1.2E-06
EU1	Construction	CT-SB	1000	Th-232	4.1E-01	1.1E-06	1.7E-08	0.0E+00	1.6E-08	1.1E-06
EU1	Construction	CT-SB	1000	U-234	1.0E+01	3.2E-08	2.7E-08	0.0E+00	2.0E-08	7.9E-08
EU1	Construction	CT-SB	1000	U-235	5.5E-01	6.4E-08	1.5E-09	0.0E+00	1.2E-09	6.6E-08
EU1	Construction	CT-SB	1000	U-238	3.4E+01	5.9E-07	7.3E-08	0.0E+00	7.7E-08	7.4E-07
										4.2E-05

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Construction	CT-SB	0	Ac-227	2.4E-01	7.5E-08	4.9E-09	0.0E+00	3.1E-09	8.2E-08
EU2	Construction	CT-SB	0	Pa-231	2.4E-01	8.4E-09	1.8E-09	0.0E+00	1.1E-09	1.1E-08
EU2	Construction	CT-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	0	Th-228	4.3E-02	6.1E-08	1.3E-09	0.0E+00	3.0E-10	6.2E-08
EU2	Construction	CT-SB	0	Th-230	8.0E-04	4.6E-13	2.6E-12	0.0E+00	1.9E-12	5.0E-12
EU2	Construction	CT-SB	0	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	0	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	0	U-238	3.2E-01	6.0E-09	7.3E-10	0.0E+00	7.7E-10	7.5E-09
										1.6E-07
EU2	Construction	CT-SB	1000	Ac-227	2.4E-01	1.0E-21	6.7E-23	0.0E+00	4.2E-23	1.1E-21
EU2	Construction	CT-SB	1000	Pa-231	2.4E-01	7.5E-08	6.1E-09	0.0E+00	3.8E-09	8.5E-08
EU2	Construction	CT-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	Th-228	4.3E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	Th-230	8.0E-04	5.0E-10	4.1E-12	0.0E+00	2.3E-11	5.3E-10
EU2	Construction	CT-SB	1000	Th-232	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	U-238	3.2E-01	5.6E-09	6.9E-10	0.0E+00	7.2E-10	7.0E-09
										9.3E-08

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Construction	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	Th-228	1.2E-01	1.7E-07	3.5E-09	0.0E+00	8.4E-10	1.7E-07
EU3	Construction	CT-SB	0	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	Th-232	6.4E-02	4.3E-09	3.0E-10	0.0E+00	2.8E-10	4.9E-09
EU3	Construction	CT-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	U-235	4.8E-02	5.7E-09	1.2E-10	0.0E+00	9.4E-11	5.9E-09
EU3	Construction	CT-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.8E-07
EU3	Construction	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Th-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Th-230	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Th-232	6.4E-02	1.7E-07	2.7E-09	0.0E+00	2.5E-09	1.7E-07
EU3	Construction	CT-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	U-235	4.8E-02	5.6E-09	1.4E-10	0.0E+00	1.0E-10	5.9E-09
EU3	Construction	CT-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.8E-07

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Construction	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	0	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	0	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	0	Ra-228	1.2E-01	1.4E-07	1.1E-09	0.0E+00	3.3E-09	1.4E-07
EU4	Construction	CT-SB	0	Th-228	1.4E-01	2.0E-07	4.1E-09	0.0E+00	1.0E-09	2.0E-07
EU4	Construction	CT-SB	0	Th-230	7.9E-03	4.5E-12	2.6E-11	0.0E+00	1.9E-11	4.9E-11
EU4	Construction	CT-SB	0	Th-232	1.3E-01	9.0E-09	6.3E-10	0.0E+00	5.8E-10	1.0E-08
EU4	Construction	CT-SB	0	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	0	U-235	8.0E-02	9.4E-09	1.9E-10	0.0E+00	1.5E-10	9.7E-09
EU4	Construction	CT-SB	0	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.7E-07
EU4	Construction	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	Pb-210	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	Ra-226	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	Ra-228	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	Th-228	1.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	Th-230	7.9E-03	4.9E-09	4.1E-11	0.0E+00	2.3E-10	5.2E-09
EU4	Construction	CT-SB	1000	Th-232	1.3E-01	3.5E-07	5.7E-09	0.0E+00	5.2E-09	3.6E-07
EU4	Construction	CT-SB	1000	U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	U-235	8.0E-02	9.3E-09	2.2E-10	0.0E+00	1.7E-10	9.7E-09
EU4	Construction	CT-SB	1000	U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.7E-07

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-2
Risk Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Carcinogenic Risk Estimate (lifetime^{-1}) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Construction	CT-SB	0	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	0	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	0	Pb-210	4.4E-01	4.1E-10	1.3E-09	0.0E+00	3.0E-08	3.1E-08
EU5	Construction	CT-SB	0	Ra-226	4.4E-01	8.0E-07	1.2E-09	0.0E+00	5.0E-09	8.1E-07
EU5	Construction	CT-SB	0	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	0	Th-228	4.7E-02	6.6E-08	1.4E-09	0.0E+00	3.3E-10	6.8E-08
EU5	Construction	CT-SB	0	Th-230	8.5E-01	4.9E-10	2.8E-09	0.0E+00	2.0E-09	5.3E-09
EU5	Construction	CT-SB	0	Th-232	4.0E-02	2.7E-09	1.9E-10	0.0E+00	1.8E-10	3.1E-09
EU5	Construction	CT-SB	0	U-234	8.3E-01	4.6E-11	2.2E-09	0.0E+00	1.6E-09	3.9E-09
EU5	Construction	CT-SB	0	U-235	1.0E-01	1.2E-08	2.5E-10	0.0E+00	2.0E-10	1.3E-08
EU5	Construction	CT-SB	0	U-238	7.6E-01	1.4E-08	1.7E-09	0.0E+00	1.8E-09	1.8E-08
										9.5E-07
EU5	Construction	CT-SB	1000	Ac-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	1000	Pa-231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	1000	Pb-210	4.4E-01	8.9E-24	2.8E-23	0.0E+00	6.5E-22	6.9E-22
EU5	Construction	CT-SB	1000	Ra-226	4.4E-01	5.1E-07	1.6E-09	0.0E+00	2.2E-08	5.3E-07
EU5	Construction	CT-SB	1000	Ra-228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	1000	Th-228	4.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	1000	Th-230	8.5E-01	5.3E-07	4.4E-09	0.0E+00	2.4E-08	5.6E-07
EU5	Construction	CT-SB	1000	Th-232	4.0E-02	1.0E-07	1.7E-09	0.0E+00	1.6E-09	1.1E-07
EU5	Construction	CT-SB	1000	U-234	8.3E-01	2.5E-09	2.1E-09	0.0E+00	1.6E-09	6.2E-09
EU5	Construction	CT-SB	1000	U-235	1.0E-01	1.2E-08	2.9E-10	0.0E+00	2.2E-10	1.3E-08
EU5	Construction	CT-SB	1000	U-238	7.6E-01	1.3E-08	1.6E-09	0.0E+00	1.7E-09	1.7E-08
										1.2E-06

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Adult	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Resident Adult	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Adult	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	Ra-228	8.21E-02	1.9E-01	7.0E-05	1.0E-01	3.3E-03	3.0E-01
EU4	Resident Adult	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	0	U-235	7.59E-02	1.9E-02	1.4E-04	1.2E-03	5.4E-04	2.1E-02
EU4	Resident Adult	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.2E-01
EU4	Resident Adult	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Ra-228	8.21E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SS	1000	U-235	7.59E-02	1.9E-02	3.0E-04	6.0E-03	1.5E-03	2.6E-02
EU4	Resident Adult	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.6E-02

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Adult	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	0	Pb-210	9.56E-02	1.9E-04	3.2E-05	1.6E-01	1.8E-02	1.8E-01
EU5	Resident Adult	RME-SS	0	Ra-226	9.56E-02	3.4E-01	1.2E-05	1.2E-01	3.7E-03	4.7E-01
EU5	Resident Adult	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	0	Th-230	7.65E-02	9.0E-05	3.6E-04	1.0E-03	1.1E-03	2.6E-03
EU5	Resident Adult	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	0	U-234	1.87E-01	2.5E-05	3.6E-04	3.1E-03	1.4E-03	4.9E-03
EU5	Resident Adult	RME-SS	0	U-235	5.94E-02	1.5E-02	1.1E-04	9.3E-04	4.3E-04	1.6E-02
EU5	Resident Adult	RME-SS	0	U-238	1.45E-01	7.1E-03	2.5E-04	2.3E-03	1.0E-03	1.1E-02
										6.8E-01
EU5	Resident Adult	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	1000	Pb-210	9.56E-02	4.2E-18	7.0E-19	3.5E-15	4.0E-16	3.9E-15
EU5	Resident Adult	RME-SS	1000	Ra-226	9.56E-02	2.2E-01	2.8E-05	1.8E-01	1.4E-02	4.1E-01
EU5	Resident Adult	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	1000	Th-230	7.65E-02	9.5E-02	3.7E-04	7.6E-02	7.0E-03	1.8E-01
EU5	Resident Adult	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SS	1000	U-234	1.87E-01	1.1E-03	3.4E-04	3.8E-03	1.4E-03	6.6E-03
EU5	Resident Adult	RME-SS	1000	U-235	5.94E-02	1.4E-02	2.3E-04	4.7E-03	1.2E-03	2.1E-02
EU5	Resident Adult	RME-SS	1000	U-238	1.45E-01	6.7E-03	2.3E-04	2.1E-03	9.8E-04	1.0E-02
										6.3E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Adult	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	Th-228	1.20E-01	3.3E-01	5.0E-04	1.9E-03	2.2E-03	3.3E-01
EU3	Resident Adult	RME-SB	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	Th-232	6.41E-02	8.5E-03	1.5E-03	8.8E-03	4.8E-03	2.4E-02
EU3	Resident Adult	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	0	U-235	4.82E-02	1.2E-02	8.7E-05	7.5E-04	3.5E-04	1.3E-02
EU3	Resident Adult	RME-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.7E-01
EU3	Resident Adult	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Th-228	1.20E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	Th-232	6.41E-02	3.3E-01	1.8E-03	9.0E-02	8.4E-03	4.3E-01
EU3	Resident Adult	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	RME-SB	1000	U-235	4.82E-02	1.2E-02	1.9E-04	3.8E-03	9.5E-04	1.7E-02
EU3	Resident Adult	RME-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										4.4E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Adult	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	0	Ra-228	1.18E-01	2.7E-01	1.0E-04	1.5E-01	4.7E-03	4.3E-01
EU4	Resident Adult	RME-SB	0	Th-228	1.41E-01	3.9E-01	6.0E-04	2.2E-03	2.6E-03	4.0E-01
EU4	Resident Adult	RME-SB	0	Th-230	7.90E-03	9.3E-06	3.8E-05	1.0E-04	1.2E-04	2.7E-04
EU4	Resident Adult	RME-SB	0	Th-232	1.34E-01	1.8E-02	3.2E-03	1.8E-02	1.0E-02	5.0E-02
EU4	Resident Adult	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	0	U-235	7.96E-02	2.0E-02	1.4E-04	1.2E-03	5.7E-04	2.2E-02
EU4	Resident Adult	RME-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										8.9E-01
EU4	Resident Adult	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	Ra-228	1.18E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	Th-228	1.41E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	Th-230	7.90E-03	9.8E-03	3.8E-05	7.9E-03	7.2E-04	1.8E-02
EU4	Resident Adult	RME-SB	1000	Th-232	1.34E-01	6.8E-01	3.8E-03	1.9E-01	1.8E-02	8.9E-01
EU4	Resident Adult	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	RME-SB	1000	U-235	7.96E-02	1.9E-02	3.1E-04	6.3E-03	1.6E-03	2.8E-02
EU4	Resident Adult	RME-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										9.4E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Adult	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	0	Pb-210	4.39E-01	8.9E-04	1.5E-04	7.3E-01	8.4E-02	8.2E-01
EU5	Resident Adult	RME-SB	0	Ra-226	4.39E-01	1.6E+00	5.7E-05	5.6E-01	1.7E-02	2.2E+00
EU5	Resident Adult	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	0	Th-228	4.73E-02	1.3E-01	2.0E-04	7.5E-04	8.6E-04	1.3E-01
EU5	Resident Adult	RME-SB	0	Th-230	8.48E-01	1.0E-03	4.0E-03	1.1E-02	1.2E-02	2.9E-02
EU5	Resident Adult	RME-SB	0	Th-232	4.01E-02	5.3E-03	9.6E-04	5.5E-03	3.0E-03	1.5E-02
EU5	Resident Adult	RME-SB	0	U-234	8.27E-01	1.1E-04	1.6E-03	1.4E-02	6.3E-03	2.2E-02
EU5	Resident Adult	RME-SB	0	U-235	1.04E-01	2.6E-02	1.9E-04	1.6E-03	7.4E-04	2.8E-02
EU5	Resident Adult	RME-SB	0	U-238	7.62E-01	3.7E-02	1.3E-03	1.2E-02	5.5E-03	5.6E-02
										3.3E+00
EU5	Resident Adult	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	1000	Pb-210	4.39E-01	1.9E-17	3.2E-18	1.6E-14	1.8E-15	1.8E-14
EU5	Resident Adult	RME-SB	1000	Ra-226	4.39E-01	1.0E+00	1.3E-04	8.2E-01	6.4E-02	1.9E+00
EU5	Resident Adult	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	1000	Th-228	4.73E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	RME-SB	1000	Th-230	8.48E-01	1.0E+00	4.0E-03	8.5E-01	7.7E-02	2.0E+00
EU5	Resident Adult	RME-SB	1000	Th-232	4.01E-02	2.0E-01	1.1E-03	5.6E-02	5.2E-03	2.7E-01
EU5	Resident Adult	RME-SB	1000	U-234	8.27E-01	5.0E-03	1.5E-03	1.7E-02	6.2E-03	2.9E-02
EU5	Resident Adult	RME-SB	1000	U-235	1.04E-01	2.5E-02	4.0E-04	8.2E-03	2.1E-03	3.6E-02
EU5	Resident Adult	RME-SB	1000	U-238	7.62E-01	3.5E-02	1.2E-03	1.1E-02	5.2E-03	5.2E-02
										4.3E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Child	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Resident Child	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Child	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	Ra-228	8.21E-02	2.9E-01	6.0E-05	2.3E-02	8.5E-03	3.2E-01
EU4	Resident Child	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	0	U-235	7.59E-02	2.8E-02	1.2E-04	2.6E-04	1.4E-03	3.0E-02
EU4	Resident Child	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.5E-01
EU4	Resident Child	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Ra-228	8.21E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SS	1000	U-235	7.59E-02	2.8E-02	2.6E-04	1.3E-03	3.9E-03	3.4E-02
EU4	Resident Child	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.4E-02

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Child	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	0	Pb-210	9.56E-02	2.9E-04	2.8E-05	3.5E-02	4.8E-02	8.3E-02
EU5	Resident Child	RME-SS	0	Ra-226	9.56E-02	5.2E-01	1.1E-05	2.7E-02	9.6E-03	5.6E-01
EU5	Resident Child	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	0	Th-230	7.65E-02	1.4E-04	3.1E-04	2.2E-04	2.9E-03	3.6E-03
EU5	Resident Child	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	0	U-234	1.87E-01	3.8E-05	3.1E-04	6.8E-04	3.7E-03	4.7E-03
EU5	Resident Child	RME-SS	0	U-235	5.94E-02	2.2E-02	9.2E-05	2.0E-04	1.1E-03	2.4E-02
EU5	Resident Child	RME-SS	0	U-238	1.45E-01	1.1E-02	2.2E-04	5.0E-04	2.7E-03	1.4E-02
										6.9E-01
EU5	Resident Child	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	1000	Pb-210	9.56E-02	6.4E-18	6.0E-19	7.7E-16	1.1E-15	1.8E-15
EU5	Resident Child	RME-SS	1000	Ra-226	9.56E-02	3.3E-01	2.4E-05	3.9E-02	3.7E-02	4.1E-01
EU5	Resident Child	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	1000	Th-230	7.65E-02	1.4E-01	3.2E-04	1.7E-02	1.8E-02	1.8E-01
EU5	Resident Child	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SS	1000	U-234	1.87E-01	1.7E-03	3.0E-04	8.2E-04	3.7E-03	6.5E-03
EU5	Resident Child	RME-SS	1000	U-235	5.94E-02	2.2E-02	2.0E-04	1.0E-03	3.1E-03	2.6E-02
EU5	Resident Child	RME-SS	1000	U-238	1.45E-01	1.0E-02	2.0E-04	4.7E-04	2.6E-03	1.3E-02
										6.3E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Child	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	Th-228	1.20E-01	5.0E-01	4.4E-04	4.1E-04	5.7E-03	5.1E-01
EU3	Resident Child	RME-SB	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	Th-232	6.41E-02	1.3E-02	1.3E-03	1.9E-03	1.3E-02	2.9E-02
EU3	Resident Child	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	0	U-235	4.82E-02	1.8E-02	7.5E-05	1.6E-04	9.0E-04	1.9E-02
EU3	Resident Child	RME-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.5E-01
EU3	Resident Child	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Th-228	1.20E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	Th-232	6.41E-02	5.0E-01	1.6E-03	2.0E-02	2.2E-02	5.4E-01
EU3	Resident Child	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	RME-SB	1000	U-235	4.82E-02	1.8E-02	1.6E-04	8.3E-04	2.5E-03	2.1E-02
EU3	Resident Child	RME-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.6E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Child	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	0	Ra-228	1.18E-01	4.1E-01	8.6E-05	3.3E-02	1.2E-02	4.6E-01
EU4	Resident Child	RME-SB	0	Th-228	1.41E-01	5.9E-01	5.2E-04	4.9E-04	6.7E-03	6.0E-01
EU4	Resident Child	RME-SB	0	Th-230	7.90E-03	1.4E-05	3.2E-05	2.3E-05	3.0E-04	3.7E-04
EU4	Resident Child	RME-SB	0	Th-232	1.34E-01	2.7E-02	2.8E-03	4.0E-03	2.6E-02	6.0E-02
EU4	Resident Child	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	0	U-235	7.96E-02	3.0E-02	1.2E-04	2.7E-04	1.5E-03	3.2E-02
EU4	Resident Child	RME-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.1E+00
EU4	Resident Child	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	Ra-228	1.18E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	Th-228	1.41E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	Th-230	7.90E-03	1.5E-02	3.3E-05	1.7E-03	1.9E-03	1.8E-02
EU4	Resident Child	RME-SB	1000	Th-232	1.34E-01	1.0E+00	3.3E-03	4.1E-02	4.6E-02	1.1E+00
EU4	Resident Child	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	RME-SB	1000	U-235	7.96E-02	2.9E-02	2.7E-04	1.4E-03	4.1E-03	3.5E-02
EU4	Resident Child	RME-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.2E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Child	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	0	Pb-210	4.39E-01	1.3E-03	1.3E-04	1.6E-01	2.2E-01	3.8E-01
EU5	Resident Child	RME-SB	0	Ra-226	4.39E-01	2.4E+00	5.0E-05	1.2E-01	4.4E-02	2.6E+00
EU5	Resident Child	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	0	Th-228	4.73E-02	2.0E-01	1.7E-04	1.6E-04	2.2E-03	2.0E-01
EU5	Resident Child	RME-SB	0	Th-230	8.48E-01	1.5E-03	3.5E-03	2.4E-03	3.3E-02	4.0E-02
EU5	Resident Child	RME-SB	0	Th-232	4.01E-02	8.1E-03	8.3E-04	1.2E-03	7.9E-03	1.8E-02
EU5	Resident Child	RME-SB	0	U-234	8.27E-01	1.7E-04	1.4E-03	3.0E-03	1.6E-02	2.1E-02
EU5	Resident Child	RME-SB	0	U-235	1.04E-01	3.9E-02	1.6E-04	3.5E-04	1.9E-03	4.1E-02
EU5	Resident Child	RME-SB	0	U-238	7.62E-01	5.7E-02	1.1E-03	2.6E-03	1.4E-02	7.5E-02
										3.3E+00
EU5	Resident Child	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	1000	Pb-210	4.39E-01	2.9E-17	2.8E-18	3.5E-15	4.8E-15	8.4E-15
EU5	Resident Child	RME-SB	1000	Ra-226	4.39E-01	1.5E+00	1.1E-04	1.8E-01	1.7E-01	1.9E+00
EU5	Resident Child	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	1000	Th-228	4.73E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	RME-SB	1000	Th-230	8.48E-01	1.6E+00	3.5E-03	1.9E-01	2.0E-01	2.0E+00
EU5	Resident Child	RME-SB	1000	Th-232	4.01E-02	3.1E-01	9.9E-04	1.2E-02	1.4E-02	3.4E-01
EU5	Resident Child	RME-SB	1000	U-234	8.27E-01	7.5E-03	1.3E-03	3.6E-03	1.6E-02	2.9E-02
EU5	Resident Child	RME-SB	1000	U-235	1.04E-01	3.8E-02	3.5E-04	1.8E-03	5.4E-03	4.6E-02
EU5	Resident Child	RME-SB	1000	U-238	7.62E-01	5.3E-02	1.1E-03	2.5E-03	1.3E-02	7.0E-02
										4.3E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Industrial	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SS	0	Pb-210	4.55E+01	2.9E-02	6.5E-03	0.0E+00	2.7E+00	2.8E+00
EU1	Industrial	RME-SS	0	Ra-226	4.55E+01	5.2E+01	2.6E-03	0.0E+00	5.5E-01	5.3E+01
EU1	Industrial	RME-SS	0	Ra-228	1.26E-01	9.3E-02	4.6E-05	0.0E+00	1.6E-03	9.5E-02
EU1	Industrial	RME-SS	0	Th-228	2.36E-01	2.1E-01	4.3E-04	0.0E+00	1.3E-03	2.1E-01
EU1	Industrial	RME-SS	0	Th-230	7.10E-01	2.7E-04	1.5E-03	0.0E+00	3.2E-03	5.0E-03
EU1	Industrial	RME-SS	0	Th-232	1.58E-01	6.7E-03	1.6E-03	0.0E+00	3.7E-03	1.2E-02
EU1	Industrial	RME-SS	0	U-234	4.04E+00	1.7E-04	3.3E-03	0.0E+00	9.5E-03	1.3E-02
EU1	Industrial	RME-SS	0	U-235	1.86E-01	1.5E-02	1.4E-04	0.0E+00	4.1E-04	1.5E-02
EU1	Industrial	RME-SS	0	U-238	1.58E+01	2.5E-01	1.2E-02	0.0E+00	3.5E-02	2.9E-01
										5.6E+01
EU1	Industrial	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SS	1000	Pb-210	4.55E+01	6.4E-16	1.4E-16	0.0E+00	6.0E-14	6.0E-14
EU1	Industrial	RME-SS	1000	Ra-226	4.55E+01	3.3E+01	5.8E-03	0.0E+00	2.1E+00	3.5E+01
EU1	Industrial	RME-SS	1000	Ra-228	1.26E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SS	1000	Th-228	2.36E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SS	1000	Th-230	7.10E-01	2.8E-01	1.5E-03	0.0E+00	2.0E-02	3.0E-01
EU1	Industrial	RME-SS	1000	Th-232	1.58E-01	2.6E-01	1.9E-03	0.0E+00	6.4E-03	2.6E-01
EU1	Industrial	RME-SS	1000	U-234	4.04E+00	7.7E-03	3.2E-03	0.0E+00	9.5E-03	2.0E-02
EU1	Industrial	RME-SS	1000	U-235	1.86E-01	1.4E-02	3.1E-04	0.0E+00	1.1E-03	1.6E-02
EU1	Industrial	RME-SS	1000	U-238	1.58E+01	2.3E-01	1.1E-02	0.0E+00	3.3E-02	2.7E-01
										3.6E+01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Industrial	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU2	Industrial	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Industrial	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Industrial	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Industrial	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	Ra-228	8.21E-02	6.0E-02	3.0E-05	0.0E+00	1.0E-03	6.2E-02
EU4	Industrial	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	0	U-235	7.59E-02	5.9E-03	5.9E-05	0.0E+00	1.7E-04	6.2E-03
EU4	Industrial	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										6.8E-02
EU4	Industrial	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Ra-228	8.21E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SS	1000	U-235	7.59E-02	5.9E-03	1.3E-04	0.0E+00	4.7E-04	6.5E-03
EU4	Industrial	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										6.5E-03

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Industrial	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	0	Pb-210	9.56E-02	6.1E-05	1.4E-05	0.0E+00	5.7E-03	5.8E-03
EU5	Industrial	RME-SS	0	Ra-226	9.56E-02	1.1E-01	5.4E-06	0.0E+00	1.1E-03	1.1E-01
EU5	Industrial	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	0	Th-230	7.65E-02	2.9E-05	1.6E-04	0.0E+00	3.5E-04	5.4E-04
EU5	Industrial	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	0	U-234	1.87E-01	7.9E-06	1.6E-04	0.0E+00	4.4E-04	6.0E-04
EU5	Industrial	RME-SS	0	U-235	5.94E-02	4.6E-03	4.6E-05	0.0E+00	1.3E-04	4.8E-03
EU5	Industrial	RME-SS	0	U-238	1.45E-01	2.3E-03	1.1E-04	0.0E+00	3.3E-04	2.7E-03
										1.2E-01
EU5	Industrial	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	1000	Pb-210	9.56E-02	1.3E-18	3.0E-19	0.0E+00	1.3E-16	1.3E-16
EU5	Industrial	RME-SS	1000	Ra-226	9.56E-02	6.9E-02	1.2E-05	0.0E+00	4.4E-03	7.4E-02
EU5	Industrial	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	1000	Th-230	7.65E-02	3.0E-02	1.6E-04	0.0E+00	2.2E-03	3.2E-02
EU5	Industrial	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SS	1000	U-234	1.87E-01	3.6E-04	1.5E-04	0.0E+00	4.4E-04	9.4E-04
EU5	Industrial	RME-SS	1000	U-235	5.94E-02	4.6E-03	1.0E-04	0.0E+00	3.6E-04	5.1E-03
EU5	Industrial	RME-SS	1000	U-238	1.45E-01	2.1E-03	1.0E-04	0.0E+00	3.1E-04	2.5E-03
										1.1E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Industrial	RME-SB	0	Ac-227	1E-01	2.2E-02	4.4E-03	0.0E+00	1.3E-02	3.9E-02
EU1	Industrial	RME-SB	0	Pa-231	1.07E-01	2.4E-03	9.3E-04	0.0E+00	9.6E-03	1.3E-02
EU1	Industrial	RME-SB	0	Pb-210	3.17E+01	2.0E-02	4.6E-03	0.0E+00	1.9E+00	1.9E+00
EU1	Industrial	RME-SB	0	Ra-226	3.17E+01	3.6E+01	1.8E-03	0.0E+00	3.8E-01	3.7E+01
EU1	Industrial	RME-SB	0	Ra-228	4.42E-01	3.3E-01	1.6E-04	0.0E+00	5.5E-03	3.3E-01
EU1	Industrial	RME-SB	0	Th-228	4.85E-01	4.2E-01	8.8E-04	0.0E+00	2.7E-03	4.3E-01
EU1	Industrial	RME-SB	0	Th-230	1.86E+00	7.0E-04	3.8E-03	0.0E+00	8.5E-03	1.3E-02
EU1	Industrial	RME-SB	0	Th-232	4.11E-01	1.7E-02	4.2E-03	0.0E+00	9.7E-03	3.1E-02
EU1	Industrial	RME-SB	0	U-234	1.05E+01	4.4E-04	8.7E-03	0.0E+00	2.5E-02	3.4E-02
EU1	Industrial	RME-SB	0	U-235	5.45E-01	4.3E-02	4.2E-04	0.0E+00	1.2E-03	4.4E-02
EU1	Industrial	RME-SB	0	U-238	3.41E+01	5.3E-01	2.5E-02	0.0E+00	7.7E-02	6.3E-01
										4.0E+01
EU1	Industrial	RME-SB	1000	Ac-227	1E-01	3.0E-16	6.1E-17	0.0E+00	1.8E-16	5.4E-16
EU1	Industrial	RME-SB	1000	Pa-231	1.07E-01	2.2E-02	4.9E-03	0.0E+00	2.1E-02	4.7E-02
EU1	Industrial	RME-SB	1000	Pb-210	3.17E+01	4.5E-16	1.0E-16	0.0E+00	4.2E-14	4.2E-14
EU1	Industrial	RME-SB	1000	Ra-226	3.17E+01	2.3E+01	4.0E-03	0.0E+00	1.4E+00	2.4E+01
EU1	Industrial	RME-SB	1000	Ra-228	4.42E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SB	1000	Th-228	4.85E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	RME-SB	1000	Th-230	1.86E+00	7.3E-01	3.8E-03	0.0E+00	5.3E-02	7.9E-01
EU1	Industrial	RME-SB	1000	Th-232	4.11E-01	6.7E-01	5.0E-03	0.0E+00	1.7E-02	6.9E-01
EU1	Industrial	RME-SB	1000	U-234	1.05E+01	2.0E-02	8.3E-03	0.0E+00	2.5E-02	5.3E-02
EU1	Industrial	RME-SB	1000	U-235	5.45E-01	4.2E-02	9.1E-04	0.0E+00	3.3E-03	4.6E-02
EU1	Industrial	RME-SB	1000	U-238	3.41E+01	5.0E-01	2.4E-02	0.0E+00	7.2E-02	5.9E-01
										2.7E+01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Industrial	RME-SB	0	Ac-227	2E-01	4.9E-02	9.9E-03	0.0E+00	2.9E-02	8.7E-02
EU2	Industrial	RME-SB	0	Pa-231	2.39E-01	5.5E-03	2.1E-03	0.0E+00	2.2E-02	2.9E-02
EU2	Industrial	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	0	Th-228	4.31E-02	3.8E-02	7.8E-05	0.0E+00	2.4E-04	3.8E-02
EU2	Industrial	RME-SB	0	Th-230	8.00E-04	3.0E-07	1.6E-06	0.0E+00	3.7E-06	5.6E-06
EU2	Industrial	RME-SB	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	0	U-238	3E-01	5.0E-03	2.4E-04	0.0E+00	7.2E-04	5.9E-03
										1.6E-01
EU2	Industrial	RME-SB	1000	Ac-227	2E-01	6.7E-16	1.4E-16	0.0E+00	4.0E-16	1.2E-15
EU2	Industrial	RME-SB	1000	Pa-231	2.39E-01	4.9E-02	1.1E-02	0.0E+00	4.6E-02	1.1E-01
EU2	Industrial	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	Th-228	4.31E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	Th-230	8.00E-04	3.1E-04	1.6E-06	0.0E+00	2.3E-05	3.4E-04
EU2	Industrial	RME-SB	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	RME-SB	1000	U-238	3E-01	4.7E-03	2.2E-04	0.0E+00	6.7E-04	5.5E-03
										1.1E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Industrial	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	Th-228	1.20E-01	1.0E-01	2.2E-04	0.0E+00	6.8E-04	1.1E-01
EU3	Industrial	RME-SB	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	Th-232	6.41E-02	2.7E-03	6.6E-04	0.0E+00	1.5E-03	4.9E-03
EU3	Industrial	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	0	U-235	4.82E-02	3.8E-03	3.7E-05	0.0E+00	1.1E-04	3.9E-03
EU3	Industrial	RME-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.1E-01
EU3	Industrial	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Th-228	1.20E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	Th-232	6.41E-02	1.0E-01	7.9E-04	0.0E+00	2.6E-03	1.1E-01
EU3	Industrial	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	RME-SB	1000	U-235	4.82E-02	3.7E-03	8.1E-05	0.0E+00	3.0E-04	4.1E-03
EU3	Industrial	RME-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.1E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Industrial	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	0	Ra-228	1.18E-01	8.7E-02	4.3E-05	0.0E+00	1.5E-03	8.8E-02
EU4	Industrial	RME-SB	0	Th-228	1.41E-01	1.2E-01	2.6E-04	0.0E+00	8.0E-04	1.2E-01
EU4	Industrial	RME-SB	0	Th-230	7.90E-03	3.0E-06	1.6E-05	0.0E+00	3.6E-05	5.5E-05
EU4	Industrial	RME-SB	0	Th-232	1.34E-01	5.7E-03	1.4E-03	0.0E+00	3.2E-03	1.0E-02
EU4	Industrial	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	0	U-235	7.96E-02	6.2E-03	6.2E-05	0.0E+00	1.8E-04	6.5E-03
EU4	Industrial	RME-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.3E-01
EU4	Industrial	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	Ra-228	1.18E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	Th-228	1.41E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	Th-230	7.90E-03	3.1E-03	1.6E-05	0.0E+00	2.2E-04	3.3E-03
EU4	Industrial	RME-SB	1000	Th-232	1.34E-01	2.2E-01	1.6E-03	0.0E+00	5.5E-03	2.2E-01
EU4	Industrial	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	RME-SB	1000	U-235	7.96E-02	6.2E-03	1.3E-04	0.0E+00	4.9E-04	6.8E-03
EU4	Industrial	RME-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.3E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Industrial	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	0	Pb-210	4.39E-01	2.8E-04	6.3E-05	0.0E+00	2.6E-02	2.7E-02
EU5	Industrial	RME-SB	0	Ra-226	4.39E-01	5.0E-01	2.5E-05	0.0E+00	5.3E-03	5.1E-01
EU5	Industrial	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	0	Th-228	4.73E-02	4.1E-02	8.6E-05	0.0E+00	2.7E-04	4.2E-02
EU5	Industrial	RME-SB	0	Th-230	8.48E-01	3.2E-04	1.7E-03	0.0E+00	3.9E-03	5.9E-03
EU5	Industrial	RME-SB	0	Th-232	4.01E-02	1.7E-03	4.1E-04	0.0E+00	9.4E-04	3.0E-03
EU5	Industrial	RME-SB	0	U-234	8.27E-01	3.5E-05	6.9E-04	0.0E+00	2.0E-03	2.7E-03
EU5	Industrial	RME-SB	0	U-235	1.04E-01	8.1E-03	8.0E-05	0.0E+00	2.3E-04	8.4E-03
EU5	Industrial	RME-SB	0	U-238	7.62E-01	1.2E-02	5.6E-04	0.0E+00	1.7E-03	1.4E-02
										6.1E-01
EU5	Industrial	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	1000	Pb-210	4.39E-01	6.2E-18	1.4E-18	0.0E+00	5.8E-16	5.8E-16
EU5	Industrial	RME-SB	1000	Ra-226	4.39E-01	3.2E-01	5.6E-05	0.0E+00	2.0E-02	3.4E-01
EU5	Industrial	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	1000	Th-228	4.73E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	RME-SB	1000	Th-230	8.48E-01	3.3E-01	1.7E-03	0.0E+00	2.4E-02	3.6E-01
EU5	Industrial	RME-SB	1000	Th-232	4.01E-02	6.5E-02	4.9E-04	0.0E+00	1.6E-03	6.7E-02
EU5	Industrial	RME-SB	1000	U-234	8.27E-01	1.6E-03	6.5E-04	0.0E+00	1.9E-03	4.2E-03
EU5	Industrial	RME-SB	1000	U-235	1.04E-01	8.0E-03	1.7E-04	0.0E+00	6.4E-04	8.9E-03
EU5	Industrial	RME-SB	1000	U-238	7.62E-01	1.1E-02	5.3E-04	0.0E+00	1.6E-03	1.3E-02
										7.9E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Recreational	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SS	0	Pb-210	4.55E+01	3.2E-03	8.9E-04	0.0E+00	1.4E-01	1.5E-01
EU1	Recreational	RME-SS	0	Ra-226	4.55E+01	5.8E+00	3.5E-04	0.0E+00	2.9E-02	5.8E+00
EU1	Recreational	RME-SS	0	Ra-228	1.26E-01	1.0E-02	6.3E-06	0.0E+00	8.2E-05	1.0E-02
EU1	Recreational	RME-SS	0	Th-228	2.36E-01	2.3E-02	5.8E-05	0.0E+00	7.0E-05	2.3E-02
EU1	Recreational	RME-SS	0	Th-230	7.10E-01	2.9E-05	2.0E-04	0.0E+00	1.7E-04	4.0E-04
EU1	Recreational	RME-SS	0	Th-232	1.58E-01	7.4E-04	2.2E-04	0.0E+00	2.0E-04	1.2E-03
EU1	Recreational	RME-SS	0	U-234	4.04E+00	1.9E-05	4.5E-04	0.0E+00	5.0E-04	9.7E-04
EU1	Recreational	RME-SS	0	U-235	1.86E-01	1.6E-03	1.9E-05	0.0E+00	2.2E-05	1.6E-03
EU1	Recreational	RME-SS	0	U-238	1.58E+01	2.7E-02	1.6E-03	0.0E+00	1.9E-03	3.1E-02
										6.0E+00
EU1	Recreational	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SS	1000	Pb-210	4.55E+01	7.1E-17	1.9E-17	0.0E+00	3.1E-15	3.2E-15
EU1	Recreational	RME-SS	1000	Ra-226	4.55E+01	3.7E+00	7.8E-04	0.0E+00	1.1E-01	3.8E+00
EU1	Recreational	RME-SS	1000	Ra-228	1.26E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SS	1000	Th-228	2.36E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SS	1000	Th-230	7.10E-01	3.1E-02	2.0E-04	0.0E+00	1.1E-03	3.2E-02
EU1	Recreational	RME-SS	1000	Th-232	1.58E-01	2.8E-02	2.6E-04	0.0E+00	3.4E-04	2.9E-02
EU1	Recreational	RME-SS	1000	U-234	4.04E+00	8.5E-04	4.3E-04	0.0E+00	5.0E-04	1.8E-03
EU1	Recreational	RME-SS	1000	U-235	1.86E-01	1.6E-03	4.2E-05	0.0E+00	6.0E-05	1.7E-03
EU1	Recreational	RME-SS	1000	U-238	1.58E+01	2.5E-02	1.5E-03	0.0E+00	1.7E-03	2.9E-02
										3.9E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Recreational	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU2	Recreational	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Recreational	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Recreational	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Recreational	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	Ra-228	8.21E-02	6.7E-03	4.1E-06	0.0E+00	5.3E-05	6.7E-03
EU4	Recreational	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	0	U-235	7.59E-02	6.6E-04	8.0E-06	0.0E+00	8.9E-06	6.7E-04
EU4	Recreational	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										7.4E-03
EU4	Recreational	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Ra-228	8.21E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SS	1000	U-235	7.59E-02	6.5E-04	1.7E-05	0.0E+00	2.4E-05	6.9E-04
EU4	Recreational	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										6.9E-04

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Recreational	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	0	Pb-210	9.56E-02	6.8E-06	1.9E-06	0.0E+00	3.0E-04	3.1E-04
EU5	Recreational	RME-SS	0	Ra-226	9.56E-02	1.2E-02	7.3E-07	0.0E+00	6.0E-05	1.2E-02
EU5	Recreational	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	0	Th-230	7.65E-02	3.2E-06	2.1E-05	0.0E+00	1.8E-05	4.3E-05
EU5	Recreational	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	0	U-234	1.87E-01	8.7E-07	2.1E-05	0.0E+00	2.3E-05	4.5E-05
EU5	Recreational	RME-SS	0	U-235	5.94E-02	5.1E-04	6.2E-06	0.0E+00	7.0E-06	5.3E-04
EU5	Recreational	RME-SS	0	U-238	1.45E-01	2.5E-04	1.5E-05	0.0E+00	1.7E-05	2.8E-04
										1.3E-02
EU5	Recreational	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	1000	Pb-210	9.56E-02	1.5E-19	4.1E-20	0.0E+00	6.6E-18	6.8E-18
EU5	Recreational	RME-SS	1000	Ra-226	9.56E-02	7.7E-03	1.6E-06	0.0E+00	2.3E-04	7.9E-03
EU5	Recreational	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	1000	Th-230	7.65E-02	3.3E-03	2.1E-05	0.0E+00	1.1E-04	3.5E-03
EU5	Recreational	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SS	1000	U-234	1.87E-01	3.9E-05	2.0E-05	0.0E+00	2.3E-05	8.3E-05
EU5	Recreational	RME-SS	1000	U-235	5.94E-02	5.1E-04	1.4E-05	0.0E+00	1.9E-05	5.4E-04
EU5	Recreational	RME-SS	1000	U-238	1.45E-01	2.3E-04	1.4E-05	0.0E+00	1.6E-05	2.6E-04
										1.2E-02

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Recreational	RME-SB	0	Ac-227	1E-01	2.4E-03	6.0E-04	0.0E+00	6.8E-04	3.7E-03
EU1	Recreational	RME-SB	0	Pa-231	1.07E-01	2.7E-04	1.3E-04	0.0E+00	5.1E-04	9.0E-04
EU1	Recreational	RME-SB	0	Pb-210	3.17E+01	2.2E-03	6.2E-04	0.0E+00	9.9E-02	1.0E-01
EU1	Recreational	RME-SB	0	Ra-226	3.17E+01	4.0E+00	2.4E-04	0.0E+00	2.0E-02	4.0E+00
EU1	Recreational	RME-SB	0	Ra-228	4.42E-01	3.6E-02	2.2E-05	0.0E+00	2.9E-04	3.6E-02
EU1	Recreational	RME-SB	0	Th-228	4.85E-01	4.7E-02	1.2E-04	0.0E+00	1.4E-04	4.7E-02
EU1	Recreational	RME-SB	0	Th-230	1.86E+00	7.7E-05	5.2E-04	0.0E+00	4.5E-04	1.0E-03
EU1	Recreational	RME-SB	0	Th-232	4.11E-01	1.9E-03	5.8E-04	0.0E+00	5.1E-04	3.0E-03
EU1	Recreational	RME-SB	0	U-234	1.05E+01	4.9E-05	1.2E-03	0.0E+00	1.3E-03	2.5E-03
EU1	Recreational	RME-SB	0	U-235	5.45E-01	4.7E-03	5.7E-05	0.0E+00	6.4E-05	4.8E-03
EU1	Recreational	RME-SB	0	U-238	3.41E+01	5.9E-02	3.4E-03	0.0E+00	4.0E-03	6.6E-02
										4.3E+00
EU1	Recreational	RME-SB	1000	Ac-227	1E-01	3.3E-17	8.3E-18	0.0E+00	9.3E-18	5.0E-17
EU1	Recreational	RME-SB	1000	Pa-231	1.07E-01	2.4E-03	6.6E-04	0.0E+00	1.1E-03	4.2E-03
EU1	Recreational	RME-SB	1000	Pb-210	3.17E+01	4.9E-17	1.4E-17	0.0E+00	2.2E-15	2.2E-15
EU1	Recreational	RME-SB	1000	Ra-226	3.17E+01	2.5E+00	5.5E-04	0.0E+00	7.6E-02	2.6E+00
EU1	Recreational	RME-SB	1000	Ra-228	4.42E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SB	1000	Th-228	4.85E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	RME-SB	1000	Th-230	1.86E+00	8.1E-02	5.2E-04	0.0E+00	2.8E-03	8.4E-02
EU1	Recreational	RME-SB	1000	Th-232	4.11E-01	7.4E-02	6.8E-04	0.0E+00	8.8E-04	7.5E-02
EU1	Recreational	RME-SB	1000	U-234	1.05E+01	2.2E-03	1.1E-03	0.0E+00	1.3E-03	4.6E-03
EU1	Recreational	RME-SB	1000	U-235	5.45E-01	4.7E-03	1.2E-04	0.0E+00	1.8E-04	5.0E-03
EU1	Recreational	RME-SB	1000	U-238	3.41E+01	5.5E-02	3.2E-03	0.0E+00	3.8E-03	6.2E-02
										2.9E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Recreational	RME-SB	0	Ac-227	2E-01	5.4E-03	1.3E-03	0.0E+00	1.5E-03	8.2E-03
EU2	Recreational	RME-SB	0	Pa-231	2.39E-01	6.1E-04	2.8E-04	0.0E+00	1.1E-03	2.0E-03
EU2	Recreational	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	0	Th-228	4.31E-02	4.2E-03	1.1E-05	0.0E+00	1.3E-05	4.2E-03
EU2	Recreational	RME-SB	0	Th-230	8.00E-04	3.3E-08	2.2E-07	0.0E+00	1.9E-07	4.5E-07
EU2	Recreational	RME-SB	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	0	U-238	3E-01	5.5E-04	3.2E-05	0.0E+00	3.8E-05	6.2E-04
										1.5E-02
EU2	Recreational	RME-SB	1000	Ac-227	2E-01	7.4E-17	1.8E-17	0.0E+00	2.1E-17	1.1E-16
EU2	Recreational	RME-SB	1000	Pa-231	2.39E-01	5.4E-03	1.5E-03	0.0E+00	2.4E-03	9.3E-03
EU2	Recreational	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	Th-228	4.31E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	Th-230	8.00E-04	3.5E-05	2.2E-07	0.0E+00	1.2E-06	3.6E-05
EU2	Recreational	RME-SB	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	RME-SB	1000	U-238	3E-01	5.1E-04	3.0E-05	0.0E+00	3.5E-05	5.8E-04
										9.9E-03

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Recreational	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	Th-228	1.20E-01	1.2E-02	3.0E-05	0.0E+00	3.5E-05	1.2E-02
EU3	Recreational	RME-SB	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	Th-232	6.41E-02	3.0E-04	9.0E-05	0.0E+00	7.9E-05	4.7E-04
EU3	Recreational	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	0	U-235	4.82E-02	4.2E-04	5.1E-06	0.0E+00	5.6E-06	4.3E-04
EU3	Recreational	RME-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.3E-02
EU3	Recreational	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Th-228	1.20E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	Th-232	6.41E-02	1.1E-02	1.1E-04	0.0E+00	1.4E-04	1.2E-02
EU3	Recreational	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	RME-SB	1000	U-235	4.82E-02	4.1E-04	1.1E-05	0.0E+00	1.6E-05	4.4E-04
EU3	Recreational	RME-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.2E-02

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Recreational	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	0	Ra-228	1.18E-01	9.6E-03	5.8E-06	0.0E+00	7.6E-05	9.7E-03
EU4	Recreational	RME-SB	0	Th-228	1.41E-01	1.4E-02	3.5E-05	0.0E+00	4.2E-05	1.4E-02
EU4	Recreational	RME-SB	0	Th-230	7.90E-03	3.3E-07	2.2E-06	0.0E+00	1.9E-06	4.4E-06
EU4	Recreational	RME-SB	0	Th-232	1.34E-01	6.3E-04	1.9E-04	0.0E+00	1.7E-04	9.8E-04
EU4	Recreational	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	0	U-235	7.96E-02	6.9E-04	8.4E-06	0.0E+00	9.3E-06	7.1E-04
EU4	Recreational	RME-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.5E-02
EU4	Recreational	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	Ra-228	1.18E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	Th-228	1.41E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	Th-230	7.90E-03	3.4E-04	2.2E-06	0.0E+00	1.2E-05	3.6E-04
EU4	Recreational	RME-SB	1000	Th-232	1.34E-01	2.4E-02	2.2E-04	0.0E+00	2.9E-04	2.5E-02
EU4	Recreational	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	RME-SB	1000	U-235	7.96E-02	6.8E-04	1.8E-05	0.0E+00	2.6E-05	7.3E-04
EU4	Recreational	RME-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.6E-02

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Recreational	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	0	Pb-210	4.39E-01	3.1E-05	8.6E-06	0.0E+00	1.4E-03	1.4E-03
EU5	Recreational	RME-SB	0	Ra-226	4.39E-01	5.6E-02	3.4E-06	0.0E+00	2.8E-04	5.6E-02
EU5	Recreational	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	0	Th-228	4.73E-02	4.6E-03	1.2E-05	0.0E+00	1.4E-05	4.6E-03
EU5	Recreational	RME-SB	0	Th-230	8.48E-01	3.5E-05	2.4E-04	0.0E+00	2.0E-04	4.7E-04
EU5	Recreational	RME-SB	0	Th-232	4.01E-02	1.9E-04	5.6E-05	0.0E+00	5.0E-05	2.9E-04
EU5	Recreational	RME-SB	0	U-234	8.27E-01	3.9E-06	9.3E-05	0.0E+00	1.0E-04	2.0E-04
EU5	Recreational	RME-SB	0	U-235	1.04E-01	9.0E-04	1.1E-05	0.0E+00	1.2E-05	9.2E-04
EU5	Recreational	RME-SB	0	U-238	7.62E-01	1.3E-03	7.7E-05	0.0E+00	9.0E-05	1.5E-03
										6.5E-02
EU5	Recreational	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	1000	Pb-210	4.39E-01	6.8E-19	1.9E-19	0.0E+00	3.0E-17	3.1E-17
EU5	Recreational	RME-SB	1000	Ra-226	4.39E-01	3.5E-02	7.6E-06	0.0E+00	1.1E-03	3.6E-02
EU5	Recreational	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	1000	Th-228	4.73E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	RME-SB	1000	Th-230	8.48E-01	3.7E-02	2.4E-04	0.0E+00	1.3E-03	3.8E-02
EU5	Recreational	RME-SB	1000	Th-232	4.01E-02	7.2E-03	6.7E-05	0.0E+00	8.6E-05	7.3E-03
EU5	Recreational	RME-SB	1000	U-234	8.27E-01	1.7E-04	8.9E-05	0.0E+00	1.0E-04	3.7E-04
EU5	Recreational	RME-SB	1000	U-235	1.04E-01	8.9E-04	2.4E-05	0.0E+00	3.4E-05	9.5E-04
EU5	Recreational	RME-SB	1000	U-238	7.62E-01	1.2E-03	7.2E-05	0.0E+00	8.4E-05	1.4E-03
										8.5E-02

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Construction	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SS	0	Pb-210	4.55E+01	6.1E-02	1.0E-01	0.0E+00	1.3E+01	1.3E+01
EU1	Construction	RME-SS	0	Ra-226	4.55E+01	1.1E+02	4.0E-02	0.0E+00	2.6E+00	1.1E+02
EU1	Construction	RME-SS	0	Ra-228	1.26E-01	2.0E-01	7.1E-04	0.0E+00	7.5E-03	2.0E-01
EU1	Construction	RME-SS	0	Th-228	2.36E-01	4.3E-01	6.6E-03	0.0E+00	6.4E-03	4.5E-01
EU1	Construction	RME-SS	0	Th-230	7.10E-01	5.6E-04	2.3E-02	0.0E+00	1.6E-02	3.9E-02
EU1	Construction	RME-SS	0	Th-232	1.58E-01	1.4E-02	2.5E-02	0.0E+00	1.8E-02	5.7E-02
EU1	Construction	RME-SS	0	U-234	4.04E+00	3.6E-04	5.2E-02	0.0E+00	4.6E-02	9.8E-02
EU1	Construction	RME-SS	0	U-235	1.86E-01	3.1E-02	2.2E-03	0.0E+00	2.0E-03	3.5E-02
EU1	Construction	RME-SS	0	U-238	1.58E+01	5.2E-01	1.8E-01	0.0E+00	1.7E-01	8.7E-01
										1.3E+02
EU1	Construction	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SS	1000	Pb-210	4.55E+01	1.3E-15	2.2E-15	0.0E+00	2.9E-13	2.9E-13
EU1	Construction	RME-SS	1000	Ra-226	4.55E+01	6.9E+01	8.9E-02	0.0E+00	9.9E+00	7.9E+01
EU1	Construction	RME-SS	1000	Ra-228	1.26E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SS	1000	Th-228	2.36E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SS	1000	Th-230	7.10E-01	5.9E-01	2.3E-02	0.0E+00	9.6E-02	7.0E-01
EU1	Construction	RME-SS	1000	Th-232	1.58E-01	5.4E-01	3.0E-02	0.0E+00	3.1E-02	6.0E-01
EU1	Construction	RME-SS	1000	U-234	4.04E+00	1.6E-02	4.9E-02	0.0E+00	4.5E-02	1.1E-01
EU1	Construction	RME-SS	1000	U-235	1.86E-01	3.0E-02	4.8E-03	0.0E+00	5.5E-03	4.0E-02
EU1	Construction	RME-SS	1000	U-238	1.58E+01	4.8E-01	1.7E-01	0.0E+00	1.6E-01	8.1E-01
										8.2E+01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Construction	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU2	Construction	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Construction	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Construction	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Construction	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	Ra-228	8.21E-02	1.3E-01	4.6E-04	0.0E+00	4.9E-03	1.3E-01
EU4	Construction	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	0	U-235	7.59E-02	1.2E-02	9.1E-04	0.0E+00	8.1E-04	1.4E-02
EU4	Construction	RME-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.5E-01
EU4	Construction	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Ra-228	8.21E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SS	1000	U-235	7.59E-02	1.2E-02	2.0E-03	0.0E+00	2.2E-03	1.7E-02
EU4	Construction	RME-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.7E-02

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Construction	RME-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	0	Pb-210	9.56E-02	1.3E-04	2.1E-04	0.0E+00	2.7E-02	2.8E-02
EU5	Construction	RME-SS	0	Ra-226	9.56E-02	2.3E-01	8.3E-05	0.0E+00	5.5E-03	2.4E-01
EU5	Construction	RME-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	0	Th-230	7.65E-02	6.0E-05	2.4E-03	0.0E+00	1.7E-03	4.2E-03
EU5	Construction	RME-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	0	U-234	1.87E-01	1.7E-05	2.4E-03	0.0E+00	2.1E-03	4.5E-03
EU5	Construction	RME-SS	0	U-235	5.94E-02	9.8E-03	7.1E-04	0.0E+00	6.3E-04	1.1E-02
EU5	Construction	RME-SS	0	U-238	1.45E-01	4.8E-03	1.7E-03	0.0E+00	1.6E-03	8.0E-03
										2.9E-01
EU5	Construction	RME-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	1000	Pb-210	9.56E-02	2.8E-18	4.7E-18	0.0E+00	6.0E-16	6.1E-16
EU5	Construction	RME-SS	1000	Ra-226	9.56E-02	1.5E-01	1.9E-04	0.0E+00	2.1E-02	1.7E-01
EU5	Construction	RME-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	1000	Th-230	7.65E-02	6.3E-02	2.4E-03	0.0E+00	1.0E-02	7.6E-02
EU5	Construction	RME-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SS	1000	U-234	1.87E-01	7.5E-04	2.3E-03	0.0E+00	2.1E-03	5.1E-03
EU5	Construction	RME-SS	1000	U-235	5.94E-02	9.7E-03	1.5E-03	0.0E+00	1.7E-03	1.3E-02
EU5	Construction	RME-SS	1000	U-238	1.45E-01	4.4E-03	1.6E-03	0.0E+00	1.5E-03	7.5E-03
										2.7E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SS = reasonable maximum exposure - surface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Construction	RME-SB	0	Ac-227	1E-01	4.5E-02	6.9E-02	0.0E+00	6.2E-02	1.8E-01
EU1	Construction	RME-SB	0	Pa-231	1.07E-01	5.1E-03	1.4E-02	0.0E+00	4.6E-02	6.6E-02
EU1	Construction	RME-SB	0	Pb-210	3.17E+01	4.3E-02	7.0E-02	0.0E+00	9.1E+00	9.2E+00
EU1	Construction	RME-SB	0	Ra-226	3.17E+01	7.6E+01	2.8E-02	0.0E+00	1.8E+00	7.8E+01
EU1	Construction	RME-SB	0	Ra-228	4.42E-01	6.8E-01	2.5E-03	0.0E+00	2.6E-02	7.1E-01
EU1	Construction	RME-SB	0	Th-228	4.85E-01	8.9E-01	1.4E-02	0.0E+00	1.3E-02	9.2E-01
EU1	Construction	RME-SB	0	Th-230	1.86E+00	1.5E-03	5.9E-02	0.0E+00	4.1E-02	1.0E-01
EU1	Construction	RME-SB	0	Th-232	4.11E-01	3.6E-02	6.6E-02	0.0E+00	4.6E-02	1.5E-01
EU1	Construction	RME-SB	0	U-234	1.05E+01	9.3E-04	1.3E-01	0.0E+00	1.2E-01	2.5E-01
EU1	Construction	RME-SB	0	U-235	5.45E-01	9.0E-02	6.5E-03	0.0E+00	5.8E-03	1.0E-01
EU1	Construction	RME-SB	0	U-238	3.41E+01	1.1E+00	3.9E-01	0.0E+00	3.7E-01	1.9E+00
										9.2E+01
EU1	Construction	RME-SB	1000	Ac-227	1E-01	6.2E-16	9.4E-16	0.0E+00	8.5E-16	2.4E-15
EU1	Construction	RME-SB	1000	Pa-231	1.07E-01	4.6E-02	7.5E-02	0.0E+00	9.8E-02	2.2E-01
EU1	Construction	RME-SB	1000	Pb-210	3.17E+01	9.4E-16	1.5E-15	0.0E+00	2.0E-13	2.0E-13
EU1	Construction	RME-SB	1000	Ra-226	3.17E+01	4.8E+01	6.2E-02	0.0E+00	6.9E+00	5.5E+01
EU1	Construction	RME-SB	1000	Ra-228	4.42E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SB	1000	Th-228	4.85E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	RME-SB	1000	Th-230	1.86E+00	1.5E+00	5.9E-02	0.0E+00	2.5E-01	1.8E+00
EU1	Construction	RME-SB	1000	Th-232	4.11E-01	1.4E+00	7.8E-02	0.0E+00	8.0E-02	1.6E+00
EU1	Construction	RME-SB	1000	U-234	1.05E+01	4.2E-02	1.3E-01	0.0E+00	1.2E-01	2.9E-01
EU1	Construction	RME-SB	1000	U-235	5.45E-01	8.9E-02	1.4E-02	0.0E+00	1.6E-02	1.2E-01
EU1	Construction	RME-SB	1000	U-238	3.41E+01	1.0E+00	3.7E-01	0.0E+00	3.4E-01	1.8E+00
										6.1E+01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Construction	RME-SB	0	Ac-227	2E-01	1.0E-01	1.5E-01	0.0E+00	1.4E-01	3.9E-01
EU2	Construction	RME-SB	0	Pa-231	2.39E-01	1.2E-02	3.2E-02	0.0E+00	1.0E-01	1.5E-01
EU2	Construction	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	0	Th-228	4.31E-02	7.9E-02	1.2E-03	0.0E+00	1.2E-03	8.2E-02
EU2	Construction	RME-SB	0	Th-230	8.00E-04	6.3E-07	2.5E-05	0.0E+00	1.8E-05	4.4E-05
EU2	Construction	RME-SB	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	0	U-238	3E-01	1.0E-02	3.7E-03	0.0E+00	3.4E-03	1.8E-02
										6.4E-01
EU2	Construction	RME-SB	1000	Ac-227	2E-01	1.4E-15	2.1E-15	0.0E+00	1.9E-15	5.4E-15
EU2	Construction	RME-SB	1000	Pa-231	2.39E-01	1.0E-01	1.7E-01	0.0E+00	2.2E-01	4.9E-01
EU2	Construction	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	Th-228	4.31E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	Th-230	8.00E-04	6.6E-04	2.5E-05	0.0E+00	1.1E-04	7.9E-04
EU2	Construction	RME-SB	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	RME-SB	1000	U-238	3E-01	9.8E-03	3.4E-03	0.0E+00	3.2E-03	1.6E-02
										5.1E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Construction	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	Th-228	1.20E-01	2.2E-01	3.4E-03	0.0E+00	3.2E-03	2.3E-01
EU3	Construction	RME-SB	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	Th-232	6.41E-02	5.7E-03	1.0E-02	0.0E+00	7.2E-03	2.3E-02
EU3	Construction	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	0	U-235	4.82E-02	7.9E-03	5.8E-04	0.0E+00	5.1E-04	9.0E-03
EU3	Construction	RME-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.6E-01
EU3	Construction	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Th-228	1.20E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	Th-232	6.41E-02	2.2E-01	1.2E-02	0.0E+00	1.2E-02	2.4E-01
EU3	Construction	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	RME-SB	1000	U-235	4.82E-02	7.8E-03	1.3E-03	0.0E+00	1.4E-03	1.1E-02
EU3	Construction	RME-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.5E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Construction	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	0	Ra-228	1.18E-01	1.8E-01	6.7E-04	0.0E+00	7.0E-03	1.9E-01
EU4	Construction	RME-SB	0	Th-228	1.41E-01	2.6E-01	4.0E-03	0.0E+00	3.8E-03	2.7E-01
EU4	Construction	RME-SB	0	Th-230	7.90E-03	6.2E-06	2.5E-04	0.0E+00	1.7E-04	4.3E-04
EU4	Construction	RME-SB	0	Th-232	1.34E-01	1.2E-02	2.1E-02	0.0E+00	1.5E-02	4.8E-02
EU4	Construction	RME-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	0	U-235	7.96E-02	1.3E-02	9.5E-04	0.0E+00	8.5E-04	1.5E-02
EU4	Construction	RME-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.2E-01
EU4	Construction	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	Ra-228	1.18E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	Th-228	1.41E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	Th-230	7.90E-03	6.5E-03	2.5E-04	0.0E+00	1.1E-03	7.8E-03
EU4	Construction	RME-SB	1000	Th-232	1.34E-01	4.6E-01	2.5E-02	0.0E+00	2.6E-02	5.1E-01
EU4	Construction	RME-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	RME-SB	1000	U-235	7.96E-02	1.3E-02	2.1E-03	0.0E+00	2.3E-03	1.7E-02
EU4	Construction	RME-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.3E-01

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-3
Dose Calculation Details for the Reasonable Maximum Exposure Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Construction	RME-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	0	Pb-210	4.39E-01	5.9E-04	9.8E-04	0.0E+00	1.3E-01	1.3E-01
EU5	Construction	RME-SB	0	Ra-226	4.39E-01	1.1E+00	3.8E-04	0.0E+00	2.5E-02	1.1E+00
EU5	Construction	RME-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	0	Th-228	4.73E-02	8.7E-02	1.3E-03	0.0E+00	1.3E-03	9.0E-02
EU5	Construction	RME-SB	0	Th-230	8.48E-01	6.7E-04	2.7E-02	0.0E+00	1.9E-02	4.6E-02
EU5	Construction	RME-SB	0	Th-232	4.01E-02	3.6E-03	6.4E-03	0.0E+00	4.5E-03	1.4E-02
EU5	Construction	RME-SB	0	U-234	8.27E-01	7.3E-05	1.1E-02	0.0E+00	9.3E-03	2.0E-02
EU5	Construction	RME-SB	0	U-235	1.04E-01	1.7E-02	1.2E-03	0.0E+00	1.1E-03	1.9E-02
EU5	Construction	RME-SB	0	U-238	7.62E-01	2.5E-02	8.7E-03	0.0E+00	8.2E-03	4.2E-02
										1.4E+00
EU5	Construction	RME-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	1000	Pb-210	4.39E-01	1.3E-17	2.1E-17	0.0E+00	2.8E-15	2.8E-15
EU5	Construction	RME-SB	1000	Ra-226	4.39E-01	6.7E-01	8.6E-04	0.0E+00	9.6E-02	7.7E-01
EU5	Construction	RME-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	1000	Th-228	4.73E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	RME-SB	1000	Th-230	8.48E-01	7.0E-01	2.7E-02	0.0E+00	1.1E-01	8.4E-01
EU5	Construction	RME-SB	1000	Th-232	4.01E-02	1.4E-01	7.6E-03	0.0E+00	7.8E-03	1.5E-01
EU5	Construction	RME-SB	1000	U-234	8.27E-01	3.3E-03	1.0E-02	0.0E+00	9.3E-03	2.3E-02
EU5	Construction	RME-SB	1000	U-235	1.04E-01	1.7E-02	2.7E-03	0.0E+00	3.1E-03	2.3E-02
EU5	Construction	RME-SB	1000	U-238	7.62E-01	2.3E-02	8.2E-03	0.0E+00	7.7E-03	3.9E-02
										1.8E+00

COCP = constituent of potential concern
EPC = exposure point concentration
RME-SB = reasonable maximum exposure - subsurface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Adult	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Resident Adult	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Adult	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	Ra-228	8.21E-02	1.9E-01	4.6E-05	2.8E-02	1.6E-03	2.2E-01
EU4	Resident Adult	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	0	U-235	7.59E-02	1.9E-02	9.0E-05	3.1E-04	2.7E-04	1.9E-02
EU4	Resident Adult	CT-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.4E-01
EU4	Resident Adult	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Ra-228	8.21E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SS	1000	U-235	7.59E-02	1.9E-02	2.0E-04	1.6E-03	7.5E-04	2.1E-02
EU4	Resident Adult	CT-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.1E-02

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Adult	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	0	Pb-210	9.56E-02	1.9E-04	2.1E-05	4.2E-02	9.2E-03	5.1E-02
EU5	Resident Adult	CT-SS	0	Ra-226	9.56E-02	3.4E-01	8.3E-06	3.2E-02	1.8E-03	3.8E-01
EU5	Resident Adult	CT-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	0	Th-230	7.65E-02	9.0E-05	2.4E-04	2.6E-04	5.6E-04	1.2E-03
EU5	Resident Adult	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	0	U-234	1.87E-01	2.5E-05	2.4E-04	8.1E-04	7.1E-04	1.8E-03
EU5	Resident Adult	CT-SS	0	U-235	5.94E-02	1.5E-02	7.0E-05	2.4E-04	2.1E-04	1.5E-02
EU5	Resident Adult	CT-SS	0	U-238	1.45E-01	7.1E-03	1.7E-04	6.0E-04	5.2E-04	8.4E-03
										4.6E-01
EU5	Resident Adult	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	1000	Pb-210	9.56E-02	4.2E-18	4.6E-19	9.2E-16	2.0E-16	1.1E-15
EU5	Resident Adult	CT-SS	1000	Ra-226	9.56E-02	2.2E-01	1.9E-05	4.7E-02	7.0E-03	2.7E-01
EU5	Resident Adult	CT-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	1000	Th-230	7.65E-02	9.5E-02	2.4E-04	2.0E-02	3.5E-03	1.2E-01
EU5	Resident Adult	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SS	1000	U-234	1.87E-01	1.1E-03	2.3E-04	9.9E-04	7.1E-04	3.0E-03
EU5	Resident Adult	CT-SS	1000	U-235	5.94E-02	1.4E-02	1.5E-04	1.2E-03	5.9E-04	1.6E-02
EU5	Resident Adult	CT-SS	1000	U-238	1.45E-01	6.7E-03	1.6E-04	5.6E-04	4.9E-04	7.9E-03
										4.2E-01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Adult	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	Th-228	1.20E-01	3.3E-01	3.3E-04	5.0E-04	1.1E-03	3.3E-01
EU3	Resident Adult	CT-SB	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	Th-232	6.41E-02	8.5E-03	1.0E-03	2.3E-03	2.4E-03	1.4E-02
EU3	Resident Adult	CT-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	0	U-235	4.82E-02	1.2E-02	5.7E-05	2.0E-04	1.7E-04	1.2E-02
EU3	Resident Adult	CT-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.6E-01
EU3	Resident Adult	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Th-228	1.20E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	Th-232	6.41E-02	3.3E-01	1.2E-03	2.4E-02	4.2E-03	3.6E-01
EU3	Resident Adult	CT-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Adult	CT-SB	1000	U-235	4.82E-02	1.2E-02	1.2E-04	1.0E-03	4.8E-04	1.3E-02
EU3	Resident Adult	CT-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.7E-01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Adult	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	0	Ra-228	1.18E-01	2.7E-01	6.6E-05	4.0E-02	2.3E-03	3.2E-01
EU4	Resident Adult	CT-SB	0	Th-228	1.41E-01	3.9E-01	3.9E-04	5.9E-04	1.3E-03	3.9E-01
EU4	Resident Adult	CT-SB	0	Th-230	7.90E-03	9.3E-06	2.5E-05	2.7E-05	5.8E-05	1.2E-04
EU4	Resident Adult	CT-SB	0	Th-232	1.34E-01	1.8E-02	2.1E-03	4.9E-03	5.1E-03	3.0E-02
EU4	Resident Adult	CT-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	0	U-235	7.96E-02	2.0E-02	9.4E-05	3.3E-04	2.9E-04	2.0E-02
EU4	Resident Adult	CT-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										7.6E-01
EU4	Resident Adult	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	Ra-228	1.18E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	Th-228	1.41E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	Th-230	7.90E-03	9.8E-03	2.5E-05	2.1E-03	3.6E-04	1.2E-02
EU4	Resident Adult	CT-SB	1000	Th-232	1.34E-01	6.8E-01	2.5E-03	5.0E-02	8.8E-03	7.5E-01
EU4	Resident Adult	CT-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Adult	CT-SB	1000	U-235	7.96E-02	1.9E-02	2.0E-04	1.7E-03	7.9E-04	2.2E-02
EU4	Resident Adult	CT-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										7.8E-01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Adult	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	0	Pb-210	4E-01	8.9E-04	9.7E-05	1.9E-01	4.2E-02	2.4E-01
EU5	Resident Adult	CT-SB	0	Ra-226	4.39E-01	1.6E+00	3.8E-05	1.5E-01	8.5E-03	1.7E+00
EU5	Resident Adult	CT-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	0	Th-228	4.73E-02	1.3E-01	1.3E-04	2.0E-04	4.3E-04	1.3E-01
EU5	Resident Adult	CT-SB	0	Th-230	8.48E-01	1.0E-03	2.7E-03	2.9E-03	6.2E-03	1.3E-02
EU5	Resident Adult	CT-SB	0	Th-232	4.01E-02	5.3E-03	6.3E-04	1.5E-03	1.5E-03	8.9E-03
EU5	Resident Adult	CT-SB	0	U-234	8.27E-01	1.1E-04	1.1E-03	3.6E-03	3.1E-03	7.9E-03
EU5	Resident Adult	CT-SB	0	U-235	1.04E-01	2.6E-02	1.2E-04	4.3E-04	3.7E-04	2.7E-02
EU5	Resident Adult	CT-SB	0	U-238	7.62E-01	3.7E-02	8.7E-04	3.2E-03	2.7E-03	4.4E-02
										2.2E+00
EU5	Resident Adult	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	1000	Pb-210	4E-01	1.9E-17	2.1E-18	4.2E-15	9.2E-16	5.2E-15
EU5	Resident Adult	CT-SB	1000	Ra-226	4.39E-01	1.0E+00	8.5E-05	2.2E-01	3.2E-02	1.3E+00
EU5	Resident Adult	CT-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	1000	Th-228	4.73E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Adult	CT-SB	1000	Th-230	8.48E-01	1.0E+00	2.7E-03	2.2E-01	3.9E-02	1.3E+00
EU5	Resident Adult	CT-SB	1000	Th-232	4.01E-02	2.0E-01	7.5E-04	1.5E-02	2.6E-03	2.2E-01
EU5	Resident Adult	CT-SB	1000	U-234	8.27E-01	5.0E-03	1.0E-03	4.4E-03	3.1E-03	1.3E-02
EU5	Resident Adult	CT-SB	1000	U-235	1.04E-01	2.5E-02	2.7E-04	2.2E-03	1.0E-03	2.9E-02
EU5	Resident Adult	CT-SB	1000	U-238	7.62E-01	3.5E-02	8.1E-04	3.0E-03	2.6E-03	4.1E-02
										2.9E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Child	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Resident Child	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Child	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	Ra-228	8.21E-02	2.9E-01	4.0E-05	6.0E-03	4.3E-03	3.0E-01
EU4	Resident Child	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	0	U-235	7.59E-02	2.8E-02	7.8E-05	6.7E-05	7.1E-04	2.9E-02
EU4	Resident Child	CT-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.3E-01
EU4	Resident Child	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Ra-228	8.21E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SS	1000	U-235	7.59E-02	2.8E-02	1.7E-04	3.4E-04	2.0E-03	3.0E-02
EU4	Resident Child	CT-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.0E-02

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Child	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	0	Pb-210	9.56E-02	2.9E-04	1.8E-05	9.1E-03	2.4E-02	3.3E-02
EU5	Resident Child	CT-SS	0	Ra-226	9.56E-02	5.2E-01	7.2E-06	6.9E-03	4.8E-03	5.3E-01
EU5	Resident Child	CT-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	0	Th-230	7.65E-02	1.4E-04	2.1E-04	5.7E-05	1.5E-03	1.9E-03
EU5	Resident Child	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	0	U-234	1.87E-01	3.8E-05	2.1E-04	1.8E-04	1.9E-03	2.3E-03
EU5	Resident Child	CT-SS	0	U-235	5.94E-02	2.2E-02	6.1E-05	5.3E-05	5.6E-04	2.3E-02
EU5	Resident Child	CT-SS	0	U-238	1.45E-01	1.1E-02	1.4E-04	1.3E-04	1.4E-03	1.2E-02
										6.1E-01
EU5	Resident Child	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	1000	Pb-210	9.56E-02	6.4E-18	4.0E-19	2.0E-16	5.3E-16	7.3E-16
EU5	Resident Child	CT-SS	1000	Ra-226	9.56E-02	3.3E-01	1.6E-05	1.0E-02	1.8E-02	3.6E-01
EU5	Resident Child	CT-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	1000	Th-230	7.65E-02	1.4E-01	2.1E-04	4.3E-03	9.1E-03	1.6E-01
EU5	Resident Child	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SS	1000	U-234	1.87E-01	1.7E-03	2.0E-04	2.1E-04	1.8E-03	4.0E-03
EU5	Resident Child	CT-SS	1000	U-235	5.94E-02	2.2E-02	1.3E-04	2.7E-04	1.5E-03	2.4E-02
EU5	Resident Child	CT-SS	1000	U-238	1.45E-01	1.0E-02	1.3E-04	1.2E-04	1.3E-03	1.2E-02
										5.6E-01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Resident Child	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	Th-228	1.20E-01	5.0E-01	2.9E-04	1.1E-04	2.8E-03	5.0E-01
EU3	Resident Child	CT-SB	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	Th-232	6.41E-02	1.3E-02	8.8E-04	5.0E-04	6.3E-03	2.1E-02
EU3	Resident Child	CT-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	0	U-235	4.82E-02	1.8E-02	5.0E-05	4.3E-05	4.5E-04	1.9E-02
EU3	Resident Child	CT-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.4E-01
EU3	Resident Child	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Th-228	1.20E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	Th-232	6.41E-02	5.0E-01	1.0E-03	5.1E-03	1.1E-02	5.1E-01
EU3	Resident Child	CT-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Resident Child	CT-SB	1000	U-235	4.82E-02	1.8E-02	1.1E-04	2.2E-04	1.2E-03	1.9E-02
EU3	Resident Child	CT-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.3E-01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Resident Child	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	0	Ra-228	1.18E-01	4.1E-01	5.7E-05	8.5E-03	6.1E-03	4.3E-01
EU4	Resident Child	CT-SB	0	Th-228	1.41E-01	5.9E-01	3.4E-04	1.3E-04	3.4E-03	5.9E-01
EU4	Resident Child	CT-SB	0	Th-230	7.90E-03	1.4E-05	2.2E-05	5.9E-06	1.5E-04	1.9E-04
EU4	Resident Child	CT-SB	0	Th-232	1.34E-01	2.7E-02	1.8E-03	1.0E-03	1.3E-02	4.3E-02
EU4	Resident Child	CT-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	0	U-235	7.96E-02	3.0E-02	8.2E-05	7.1E-05	7.4E-04	3.1E-02
EU4	Resident Child	CT-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.1E+00
EU4	Resident Child	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	Ra-228	1.18E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	Th-228	1.41E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	Th-230	7.90E-03	1.5E-02	2.2E-05	4.5E-04	9.4E-04	1.6E-02
EU4	Resident Child	CT-SB	1000	Th-232	1.34E-01	1.0E+00	2.2E-03	1.1E-02	2.3E-02	1.1E+00
EU4	Resident Child	CT-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Resident Child	CT-SB	1000	U-235	7.96E-02	2.9E-02	1.8E-04	3.6E-04	2.1E-03	3.2E-02
EU4	Resident Child	CT-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.1E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Resident Child	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	0	Pb-210	4E-01	1.3E-03	8.4E-05	4.2E-02	1.1E-01	1.5E-01
EU5	Resident Child	CT-SB	0	Ra-226	4.39E-01	2.4E+00	3.3E-05	3.2E-02	2.2E-02	2.4E+00
EU5	Resident Child	CT-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	0	Th-228	4.73E-02	2.0E-01	1.1E-04	4.3E-05	1.1E-03	2.0E-01
EU5	Resident Child	CT-SB	0	Th-230	8.48E-01	1.5E-03	2.3E-03	6.3E-04	1.6E-02	2.1E-02
EU5	Resident Child	CT-SB	0	Th-232	4.01E-02	8.1E-03	5.5E-04	3.1E-04	4.0E-03	1.3E-02
EU5	Resident Child	CT-SB	0	U-234	8.27E-01	1.7E-04	9.1E-04	7.8E-04	8.2E-03	1.0E-02
EU5	Resident Child	CT-SB	0	U-235	1.04E-01	3.9E-02	1.1E-04	9.2E-05	9.7E-04	4.0E-02
EU5	Resident Child	CT-SB	0	U-238	7.62E-01	5.7E-02	7.5E-04	6.8E-04	7.2E-03	6.5E-02
										2.9E+00
EU5	Resident Child	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	1000	Pb-210	4E-01	2.9E-17	1.8E-18	9.1E-16	2.4E-15	3.4E-15
EU5	Resident Child	CT-SB	1000	Ra-226	4.39E-01	1.5E+00	7.4E-05	4.7E-02	8.4E-02	1.7E+00
EU5	Resident Child	CT-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	1000	Th-228	4.73E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Resident Child	CT-SB	1000	Th-230	8.48E-01	1.6E+00	2.3E-03	4.8E-02	1.0E-01	1.7E+00
EU5	Resident Child	CT-SB	1000	Th-232	4.01E-02	3.1E-01	6.5E-04	3.2E-03	6.8E-03	3.2E-01
EU5	Resident Child	CT-SB	1000	U-234	8.27E-01	7.5E-03	8.7E-04	9.4E-04	8.2E-03	1.7E-02
EU5	Resident Child	CT-SB	1000	U-235	1.04E-01	3.8E-02	2.3E-04	4.7E-04	2.7E-03	4.2E-02
EU5	Resident Child	CT-SB	1000	U-238	7.62E-01	5.3E-02	7.0E-04	6.4E-04	6.7E-03	6.1E-02
										3.8E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Industrial	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SS	0	Pb-210	4.55E+01	2.9E-02	6.5E-03	0.0E+00	1.4E+00	1.4E+00
EU1	Industrial	CT-SS	0	Ra-226	4.55E+01	5.2E+01	2.6E-03	0.0E+00	2.7E-01	5.2E+01
EU1	Industrial	CT-SS	0	Ra-228	1.26E-01	9.3E-02	4.6E-05	0.0E+00	7.8E-04	9.4E-02
EU1	Industrial	CT-SS	0	Th-228	2.36E-01	2.1E-01	4.3E-04	0.0E+00	6.7E-04	2.1E-01
EU1	Industrial	CT-SS	0	Th-230	7.10E-01	2.7E-04	1.5E-03	0.0E+00	1.6E-03	3.3E-03
EU1	Industrial	CT-SS	0	Th-232	1.58E-01	6.7E-03	1.6E-03	0.0E+00	1.9E-03	1.0E-02
EU1	Industrial	CT-SS	0	U-234	4.04E+00	1.7E-04	3.3E-03	0.0E+00	4.8E-03	8.3E-03
EU1	Industrial	CT-SS	0	U-235	1.86E-01	1.5E-02	1.4E-04	0.0E+00	2.1E-04	1.5E-02
EU1	Industrial	CT-SS	0	U-238	1.58E+01	2.5E-01	1.2E-02	0.0E+00	1.8E-02	2.7E-01
										5.4E+01
EU1	Industrial	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SS	1000	Pb-210	4.55E+01	6.4E-16	1.4E-16	0.0E+00	3.0E-14	3.1E-14
EU1	Industrial	CT-SS	1000	Ra-226	4.55E+01	3.3E+01	5.8E-03	0.0E+00	1.0E+00	3.4E+01
EU1	Industrial	CT-SS	1000	Ra-228	1.26E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SS	1000	Th-228	2.36E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SS	1000	Th-230	7.10E-01	2.8E-01	1.5E-03	0.0E+00	1.0E-02	2.9E-01
EU1	Industrial	CT-SS	1000	Th-232	1.58E-01	2.6E-01	1.9E-03	0.0E+00	3.2E-03	2.6E-01
EU1	Industrial	CT-SS	1000	U-234	4.04E+00	7.7E-03	3.2E-03	0.0E+00	4.7E-03	1.6E-02
EU1	Industrial	CT-SS	1000	U-235	1.86E-01	1.4E-02	3.1E-04	0.0E+00	5.7E-04	1.5E-02
EU1	Industrial	CT-SS	1000	U-238	1.58E+01	2.3E-01	1.1E-02	0.0E+00	1.7E-02	2.6E-01
										3.5E+01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Industrial	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU2	Industrial	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Industrial	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Industrial	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Industrial	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	Ra-228	8.21E-02	6.0E-02	3.0E-05	0.0E+00	5.1E-04	6.1E-02
EU4	Industrial	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	0	U-235	7.59E-02	5.9E-03	5.9E-05	0.0E+00	8.5E-05	6.1E-03
EU4	Industrial	CT-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										6.7E-02
EU4	Industrial	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Ra-228	8.21E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SS	1000	U-235	7.59E-02	5.9E-03	1.3E-04	0.0E+00	2.3E-04	6.2E-03
EU4	Industrial	CT-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										6.2E-03

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Industrial	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	0	Pb-210	9.56E-02	6.1E-05	1.4E-05	0.0E+00	2.9E-03	2.9E-03
EU5	Industrial	CT-SS	0	Ra-226	9.56E-02	1.1E-01	5.4E-06	0.0E+00	5.7E-04	1.1E-01
EU5	Industrial	CT-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	0	Th-230	7.65E-02	2.9E-05	1.6E-04	0.0E+00	1.7E-04	3.6E-04
EU5	Industrial	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	0	U-234	1.87E-01	7.9E-06	1.6E-04	0.0E+00	2.2E-04	3.8E-04
EU5	Industrial	CT-SS	0	U-235	5.94E-02	4.6E-03	4.6E-05	0.0E+00	6.6E-05	4.8E-03
EU5	Industrial	CT-SS	0	U-238	1.45E-01	2.3E-03	1.1E-04	0.0E+00	1.6E-04	2.5E-03
										1.2E-01
EU5	Industrial	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	1000	Pb-210	9.56E-02	1.3E-18	3.0E-19	0.0E+00	6.3E-17	6.4E-17
EU5	Industrial	CT-SS	1000	Ra-226	9.56E-02	6.9E-02	1.2E-05	0.0E+00	2.2E-03	7.2E-02
EU5	Industrial	CT-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	1000	Th-230	7.65E-02	3.0E-02	1.6E-04	0.0E+00	1.1E-03	3.1E-02
EU5	Industrial	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SS	1000	U-234	1.87E-01	3.6E-04	1.5E-04	0.0E+00	2.2E-04	7.2E-04
EU5	Industrial	CT-SS	1000	U-235	5.94E-02	4.6E-03	1.0E-04	0.0E+00	1.8E-04	4.9E-03
EU5	Industrial	CT-SS	1000	U-238	1.45E-01	2.1E-03	1.0E-04	0.0E+00	1.5E-04	2.4E-03
										1.1E-01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Industrial	CT-SB	0	Ac-227	1E-01	2.2E-02	4.4E-03	0.0E+00	6.5E-03	3.3E-02
EU1	Industrial	CT-SB	0	Pa-231	1.07E-01	2.4E-03	9.3E-04	0.0E+00	4.8E-03	8.2E-03
EU1	Industrial	CT-SB	0	Pb-210	3E+01	2.0E-02	4.6E-03	0.0E+00	9.5E-01	9.7E-01
EU1	Industrial	CT-SB	0	Ra-226	3.17E+01	3.6E+01	1.8E-03	0.0E+00	1.9E-01	3.6E+01
EU1	Industrial	CT-SB	0	Ra-228	4.42E-01	3.3E-01	1.6E-04	0.0E+00	2.7E-03	3.3E-01
EU1	Industrial	CT-SB	0	Th-228	4.85E-01	4.2E-01	8.8E-04	0.0E+00	1.4E-03	4.3E-01
EU1	Industrial	CT-SB	0	Th-230	1.86E+00	7.0E-04	3.8E-03	0.0E+00	4.3E-03	8.8E-03
EU1	Industrial	CT-SB	0	Th-232	4.11E-01	1.7E-02	4.2E-03	0.0E+00	4.8E-03	2.6E-02
EU1	Industrial	CT-SB	0	U-234	1.05E+01	4.4E-04	8.7E-03	0.0E+00	1.2E-02	2.2E-02
EU1	Industrial	CT-SB	0	U-235	5.45E-01	4.3E-02	4.2E-04	0.0E+00	6.1E-04	4.4E-02
EU1	Industrial	CT-SB	0	U-238	3.41E+01	5.3E-01	2.5E-02	0.0E+00	3.8E-02	5.9E-01
										3.9E+01
EU1	Industrial	CT-SB	1000	Ac-227	1E-01	3.0E-16	6.1E-17	0.0E+00	8.9E-17	4.5E-16
EU1	Industrial	CT-SB	1000	Pa-231	1.07E-01	2.2E-02	4.9E-03	0.0E+00	1.0E-02	3.7E-02
EU1	Industrial	CT-SB	1000	Pb-210	3E+01	4.5E-16	1.0E-16	0.0E+00	2.1E-14	2.1E-14
EU1	Industrial	CT-SB	1000	Ra-226	3.17E+01	2.3E+01	4.0E-03	0.0E+00	7.2E-01	2.4E+01
EU1	Industrial	CT-SB	1000	Ra-228	4.42E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SB	1000	Th-228	4.85E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Industrial	CT-SB	1000	Th-230	1.86E+00	7.3E-01	3.8E-03	0.0E+00	2.6E-02	7.6E-01
EU1	Industrial	CT-SB	1000	Th-232	4.11E-01	6.7E-01	5.0E-03	0.0E+00	8.4E-03	6.8E-01
EU1	Industrial	CT-SB	1000	U-234	1.05E+01	2.0E-02	8.3E-03	0.0E+00	1.2E-02	4.1E-02
EU1	Industrial	CT-SB	1000	U-235	5.45E-01	4.2E-02	9.1E-04	0.0E+00	1.7E-03	4.5E-02
EU1	Industrial	CT-SB	1000	U-238	3.41E+01	5.0E-01	2.4E-02	0.0E+00	3.6E-02	5.6E-01
										2.6E+01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Industrial	CT-SB	0	Ac-227	2E-01	4.9E-02	9.9E-03	0.0E+00	1.4E-02	7.3E-02
EU2	Industrial	CT-SB	0	Pa-231	2.39E-01	5.5E-03	2.1E-03	0.0E+00	1.1E-02	1.8E-02
EU2	Industrial	CT-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	0	Ra-228	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	0	Th-228	4.31E-02	3.8E-02	7.8E-05	0.0E+00	1.2E-04	3.8E-02
EU2	Industrial	CT-SB	0	Th-230	8.00E-04	3.0E-07	1.6E-06	0.0E+00	1.8E-06	3.8E-06
EU2	Industrial	CT-SB	0	Th-232	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	0	U-238	3E-01	5.0E-03	2.4E-04	0.0E+00	3.6E-04	5.6E-03
										1.3E-01
EU2	Industrial	CT-SB	1000	Ac-227	2E-01	6.7E-16	1.4E-16	0.0E+00	2.0E-16	1.0E-15
EU2	Industrial	CT-SB	1000	Pa-231	2.39E-01	4.9E-02	1.1E-02	0.0E+00	2.3E-02	8.3E-02
EU2	Industrial	CT-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	Ra-228	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	Th-228	4.31E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	Th-230	8.00E-04	3.1E-04	1.6E-06	0.0E+00	1.1E-05	3.3E-04
EU2	Industrial	CT-SB	1000	Th-232	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Industrial	CT-SB	1000	U-238	3E-01	4.7E-03	2.2E-04	0.0E+00	3.4E-04	5.2E-03
										8.8E-02

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Industrial	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	Th-228	1.20E-01	1.0E-01	2.2E-04	0.0E+00	3.4E-04	1.1E-01
EU3	Industrial	CT-SB	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	Th-232	6.41E-02	2.7E-03	6.6E-04	0.0E+00	7.5E-04	4.1E-03
EU3	Industrial	CT-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	0	U-235	4.82E-02	3.8E-03	3.7E-05	0.0E+00	5.4E-05	3.9E-03
EU3	Industrial	CT-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.1E-01
EU3	Industrial	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Th-228	1.20E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	Th-232	6.41E-02	1.0E-01	7.9E-04	0.0E+00	1.3E-03	1.1E-01
EU3	Industrial	CT-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Industrial	CT-SB	1000	U-235	4.82E-02	3.7E-03	8.1E-05	0.0E+00	1.5E-04	4.0E-03
EU3	Industrial	CT-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.1E-01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Industrial	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	0	Ra-228	1.18E-01	8.7E-02	4.3E-05	0.0E+00	7.3E-04	8.7E-02
EU4	Industrial	CT-SB	0	Th-228	1.41E-01	1.2E-01	2.6E-04	0.0E+00	4.0E-04	1.2E-01
EU4	Industrial	CT-SB	0	Th-230	7.90E-03	3.0E-06	1.6E-05	0.0E+00	1.8E-05	3.7E-05
EU4	Industrial	CT-SB	0	Th-232	1.34E-01	5.7E-03	1.4E-03	0.0E+00	1.6E-03	8.6E-03
EU4	Industrial	CT-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	0	U-235	7.96E-02	6.2E-03	6.2E-05	0.0E+00	8.9E-05	6.4E-03
EU4	Industrial	CT-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.3E-01
EU4	Industrial	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	Ra-228	1.18E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	Th-228	1.41E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	Th-230	7.90E-03	3.1E-03	1.6E-05	0.0E+00	1.1E-04	3.2E-03
EU4	Industrial	CT-SB	1000	Th-232	1.34E-01	2.2E-01	1.6E-03	0.0E+00	2.7E-03	2.2E-01
EU4	Industrial	CT-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Industrial	CT-SB	1000	U-235	7.96E-02	6.2E-03	1.3E-04	0.0E+00	2.4E-04	6.5E-03
EU4	Industrial	CT-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.3E-01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Industrial	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	0	Pb-210	4E-01	2.8E-04	6.3E-05	0.0E+00	1.3E-02	1.3E-02
EU5	Industrial	CT-SB	0	Ra-226	4.39E-01	5.0E-01	2.5E-05	0.0E+00	2.6E-03	5.0E-01
EU5	Industrial	CT-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	0	Th-228	4.73E-02	4.1E-02	8.6E-05	0.0E+00	1.3E-04	4.2E-02
EU5	Industrial	CT-SB	0	Th-230	8.48E-01	3.2E-04	1.7E-03	0.0E+00	1.9E-03	4.0E-03
EU5	Industrial	CT-SB	0	Th-232	4.01E-02	1.7E-03	4.1E-04	0.0E+00	4.7E-04	2.6E-03
EU5	Industrial	CT-SB	0	U-234	8.27E-01	3.5E-05	6.9E-04	0.0E+00	9.8E-04	1.7E-03
EU5	Industrial	CT-SB	0	U-235	1.04E-01	8.1E-03	8.0E-05	0.0E+00	1.2E-04	8.3E-03
EU5	Industrial	CT-SB	0	U-238	7.62E-01	1.2E-02	5.6E-04	0.0E+00	8.5E-04	1.3E-02
										5.9E-01
EU5	Industrial	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	1000	Pb-210	4E-01	6.2E-18	1.4E-18	0.0E+00	2.9E-16	3.0E-16
EU5	Industrial	CT-SB	1000	Ra-226	4.39E-01	3.2E-01	5.6E-05	0.0E+00	1.0E-02	3.3E-01
EU5	Industrial	CT-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	1000	Th-228	4.73E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Industrial	CT-SB	1000	Th-230	8.48E-01	3.3E-01	1.7E-03	0.0E+00	1.2E-02	3.5E-01
EU5	Industrial	CT-SB	1000	Th-232	4.01E-02	6.5E-02	4.9E-04	0.0E+00	8.2E-04	6.6E-02
EU5	Industrial	CT-SB	1000	U-234	8.27E-01	1.6E-03	6.5E-04	0.0E+00	9.7E-04	3.2E-03
EU5	Industrial	CT-SB	1000	U-235	1.04E-01	8.0E-03	1.7E-04	0.0E+00	3.2E-04	8.5E-03
EU5	Industrial	CT-SB	1000	U-238	7.62E-01	1.1E-02	5.3E-04	0.0E+00	8.0E-04	1.2E-02
										7.7E-01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Recreational	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SS	0	Pb-210	4.55E+01	1.5E-03	4.2E-04	0.0E+00	3.4E-02	3.6E-02
EU1	Recreational	CT-SS	0	Ra-226	4.55E+01	2.7E+00	1.7E-04	0.0E+00	6.8E-03	2.7E+00
EU1	Recreational	CT-SS	0	Ra-228	1.26E-01	4.9E-03	3.0E-06	0.0E+00	1.9E-05	4.9E-03
EU1	Recreational	CT-SS	0	Th-228	2.36E-01	1.1E-02	2.8E-05	0.0E+00	1.7E-05	1.1E-02
EU1	Recreational	CT-SS	0	Th-230	7.10E-01	1.4E-05	9.4E-05	0.0E+00	4.1E-05	1.5E-04
EU1	Recreational	CT-SS	0	Th-232	1.58E-01	3.5E-04	1.1E-04	0.0E+00	4.6E-05	5.0E-04
EU1	Recreational	CT-SS	0	U-234	4.04E+00	9.0E-06	2.2E-04	0.0E+00	1.2E-04	3.4E-04
EU1	Recreational	CT-SS	0	U-235	1.86E-01	7.6E-04	9.3E-06	0.0E+00	5.2E-06	7.8E-04
EU1	Recreational	CT-SS	0	U-238	1.58E+01	1.3E-02	7.5E-04	0.0E+00	4.4E-04	1.4E-02
										2.8E+00
EU1	Recreational	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SS	1000	Pb-210	4.55E+01	3.4E-17	9.2E-18	0.0E+00	7.4E-16	7.9E-16
EU1	Recreational	CT-SS	1000	Ra-226	4.55E+01	1.7E+00	3.7E-04	0.0E+00	2.6E-02	1.8E+00
EU1	Recreational	CT-SS	1000	Ra-228	1.26E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SS	1000	Th-228	2.36E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SS	1000	Th-230	7.10E-01	1.5E-02	9.4E-05	0.0E+00	2.5E-04	1.5E-02
EU1	Recreational	CT-SS	1000	Th-232	1.58E-01	1.3E-02	1.3E-04	0.0E+00	8.0E-05	1.4E-02
EU1	Recreational	CT-SS	1000	U-234	4.04E+00	4.0E-04	2.1E-04	0.0E+00	1.2E-04	7.3E-04
EU1	Recreational	CT-SS	1000	U-235	1.86E-01	7.5E-04	2.0E-05	0.0E+00	1.4E-05	7.9E-04
EU1	Recreational	CT-SS	1000	U-238	1.58E+01	1.2E-02	7.1E-04	0.0E+00	4.1E-04	1.3E-02
										1.8E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Recreational	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU2	Recreational	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Recreational	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Recreational	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Recreational	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	Ra-228	8.21E-02	3.2E-03	1.9E-06	0.0E+00	1.3E-05	3.2E-03
EU4	Recreational	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	0	U-235	7.59E-02	3.1E-04	3.8E-06	0.0E+00	2.1E-06	3.2E-04
EU4	Recreational	CT-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.5E-03
EU4	Recreational	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Ra-228	8.21E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SS	1000	U-235	7.59E-02	3.1E-04	8.2E-06	0.0E+00	5.8E-06	3.2E-04
EU4	Recreational	CT-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										3.2E-04

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Recreational	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	0	Pb-210	9.56E-02	3.2E-06	8.8E-07	0.0E+00	7.1E-05	7.5E-05
EU5	Recreational	CT-SS	0	Ra-226	9.56E-02	5.7E-03	3.5E-07	0.0E+00	1.4E-05	5.8E-03
EU5	Recreational	CT-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	0	Th-230	7.65E-02	1.5E-06	1.0E-05	0.0E+00	4.4E-06	1.6E-05
EU5	Recreational	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	0	U-234	1.87E-01	4.2E-07	1.0E-05	0.0E+00	5.5E-06	1.6E-05
EU5	Recreational	CT-SS	0	U-235	5.94E-02	2.4E-04	3.0E-06	0.0E+00	1.7E-06	2.5E-04
EU5	Recreational	CT-SS	0	U-238	1.45E-01	1.2E-04	7.0E-06	0.0E+00	4.1E-06	1.3E-04
										6.2E-03
EU5	Recreational	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	1000	Pb-210	9.56E-02	7.1E-20	1.9E-20	0.0E+00	1.6E-18	1.7E-18
EU5	Recreational	CT-SS	1000	Ra-226	9.56E-02	3.6E-03	7.8E-07	0.0E+00	5.4E-05	3.7E-03
EU5	Recreational	CT-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	1000	Th-230	7.65E-02	1.6E-03	1.0E-05	0.0E+00	2.7E-05	1.6E-03
EU5	Recreational	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SS	1000	U-234	1.87E-01	1.9E-05	9.5E-06	0.0E+00	5.5E-06	3.4E-05
EU5	Recreational	CT-SS	1000	U-235	5.94E-02	2.4E-04	6.4E-06	0.0E+00	4.6E-06	2.5E-04
EU5	Recreational	CT-SS	1000	U-238	1.45E-01	1.1E-04	6.5E-06	0.0E+00	3.8E-06	1.2E-04
										5.7E-03

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Recreational	CT-SB	0	Ac-227	1E-01	1.1E-03	2.9E-04	0.0E+00	1.6E-04	1.6E-03
EU1	Recreational	CT-SB	0	Pa-231	1.07E-01	1.3E-04	6.0E-05	0.0E+00	1.2E-04	3.1E-04
EU1	Recreational	CT-SB	0	Pb-210	3E+01	1.1E-03	2.9E-04	0.0E+00	2.4E-02	2.5E-02
EU1	Recreational	CT-SB	0	Ra-226	3.17E+01	1.9E+00	1.2E-04	0.0E+00	4.8E-03	1.9E+00
EU1	Recreational	CT-SB	0	Ra-228	4.42E-01	1.7E-02	1.0E-05	0.0E+00	6.8E-05	1.7E-02
EU1	Recreational	CT-SB	0	Th-228	4.85E-01	2.2E-02	5.7E-05	0.0E+00	3.4E-05	2.2E-02
EU1	Recreational	CT-SB	0	Th-230	1.86E+00	3.7E-05	2.5E-04	0.0E+00	1.1E-04	3.9E-04
EU1	Recreational	CT-SB	0	Th-232	4.11E-01	9.1E-04	2.7E-04	0.0E+00	1.2E-04	1.3E-03
EU1	Recreational	CT-SB	0	U-234	1.05E+01	2.3E-05	5.6E-04	0.0E+00	3.1E-04	8.9E-04
EU1	Recreational	CT-SB	0	U-235	5.45E-01	2.2E-03	2.7E-05	0.0E+00	1.5E-05	2.3E-03
EU1	Recreational	CT-SB	0	U-238	3.41E+01	2.8E-02	1.6E-03	0.0E+00	9.6E-04	3.0E-02
										2.0E+00
EU1	Recreational	CT-SB	1000	Ac-227	1E-01	1.6E-17	3.9E-18	0.0E+00	2.2E-18	2.2E-17
EU1	Recreational	CT-SB	1000	Pa-231	1.07E-01	1.2E-03	3.1E-04	0.0E+00	2.6E-04	1.7E-03
EU1	Recreational	CT-SB	1000	Pb-210	3E+01	2.3E-17	6.4E-18	0.0E+00	5.2E-16	5.5E-16
EU1	Recreational	CT-SB	1000	Ra-226	3.17E+01	1.2E+00	2.6E-04	0.0E+00	1.8E-02	1.2E+00
EU1	Recreational	CT-SB	1000	Ra-228	4.42E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SB	1000	Th-228	4.85E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Recreational	CT-SB	1000	Th-230	1.86E+00	3.8E-02	2.5E-04	0.0E+00	6.6E-04	3.9E-02
EU1	Recreational	CT-SB	1000	Th-232	4.11E-01	3.5E-02	3.2E-04	0.0E+00	2.1E-04	3.6E-02
EU1	Recreational	CT-SB	1000	U-234	1.05E+01	1.0E-03	5.3E-04	0.0E+00	3.1E-04	1.9E-03
EU1	Recreational	CT-SB	1000	U-235	5.45E-01	2.2E-03	5.9E-05	0.0E+00	4.2E-05	2.3E-03
EU1	Recreational	CT-SB	1000	U-238	3.41E+01	2.6E-02	1.5E-03	0.0E+00	9.0E-04	2.9E-02
										1.3E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Recreational	CT-SB	0	Ac-227	2E-01	2.5E-03	6.4E-04	0.0E+00	3.6E-04	3.5E-03
EU2	Recreational	CT-SB	0	Pa-231	2.39E-01	2.9E-04	1.3E-04	0.0E+00	2.7E-04	6.9E-04
EU2	Recreational	CT-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	0	Ra-228	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	0	Th-228	4.31E-02	2.0E-03	5.1E-06	0.0E+00	3.0E-06	2.0E-03
EU2	Recreational	CT-SB	0	Th-230	8.00E-04	1.6E-08	1.1E-07	0.0E+00	4.6E-08	1.7E-07
EU2	Recreational	CT-SB	0	Th-232	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	0	U-238	3E-01	2.6E-04	1.5E-05	0.0E+00	9.0E-06	2.9E-04
										6.5E-03
EU2	Recreational	CT-SB	1000	Ac-227	2E-01	3.5E-17	8.8E-18	0.0E+00	5.0E-18	4.9E-17
EU2	Recreational	CT-SB	1000	Pa-231	2.39E-01	2.6E-03	7.0E-04	0.0E+00	5.7E-04	3.9E-03
EU2	Recreational	CT-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	Ra-228	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	Th-228	4.31E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	Th-230	8.00E-04	1.6E-05	1.1E-07	0.0E+00	2.8E-07	1.7E-05
EU2	Recreational	CT-SB	1000	Th-232	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Recreational	CT-SB	1000	U-238	3E-01	2.4E-04	1.4E-05	0.0E+00	8.4E-06	2.7E-04
										4.1E-03

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Recreational	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	Th-228	1.20E-01	5.5E-03	1.4E-05	0.0E+00	8.4E-06	5.5E-03
EU3	Recreational	CT-SB	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	Th-232	6.41E-02	1.4E-04	4.3E-05	0.0E+00	1.9E-05	2.0E-04
EU3	Recreational	CT-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	0	U-235	4.82E-02	2.0E-04	2.4E-06	0.0E+00	1.3E-06	2.0E-04
EU3	Recreational	CT-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.9E-03
EU3	Recreational	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Th-228	1.20E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	Th-232	6.41E-02	5.5E-03	5.1E-05	0.0E+00	3.3E-05	5.5E-03
EU3	Recreational	CT-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Recreational	CT-SB	1000	U-235	4.82E-02	2.0E-04	5.2E-06	0.0E+00	3.7E-06	2.0E-04
EU3	Recreational	CT-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.7E-03

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Recreational	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	0	Ra-228	1.18E-01	4.6E-03	2.8E-06	0.0E+00	1.8E-05	4.6E-03
EU4	Recreational	CT-SB	0	Th-228	1.41E-01	6.5E-03	1.7E-05	0.0E+00	1.0E-05	6.5E-03
EU4	Recreational	CT-SB	0	Th-230	7.90E-03	1.6E-07	1.0E-06	0.0E+00	4.5E-07	1.6E-06
EU4	Recreational	CT-SB	0	Th-232	1.34E-01	3.0E-04	8.9E-05	0.0E+00	3.9E-05	4.3E-04
EU4	Recreational	CT-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	0	U-235	7.96E-02	3.3E-04	4.0E-06	0.0E+00	2.2E-06	3.3E-04
EU4	Recreational	CT-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.2E-02
EU4	Recreational	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	Ra-228	1.18E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	Th-228	1.41E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	Th-230	7.90E-03	1.6E-04	1.0E-06	0.0E+00	2.8E-06	1.7E-04
EU4	Recreational	CT-SB	1000	Th-232	1.34E-01	1.1E-02	1.1E-04	0.0E+00	6.8E-05	1.2E-02
EU4	Recreational	CT-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Recreational	CT-SB	1000	U-235	7.96E-02	3.2E-04	8.6E-06	0.0E+00	6.1E-06	3.4E-04
EU4	Recreational	CT-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.2E-02

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Recreational	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	0	Pb-210	4E-01	1.5E-05	4.1E-06	0.0E+00	3.3E-04	3.5E-04
EU5	Recreational	CT-SB	0	Ra-226	4.39E-01	2.6E-02	1.6E-06	0.0E+00	6.6E-05	2.6E-02
EU5	Recreational	CT-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	0	Th-228	4.73E-02	2.2E-03	5.5E-06	0.0E+00	3.3E-06	2.2E-03
EU5	Recreational	CT-SB	0	Th-230	8.48E-01	1.7E-05	1.1E-04	0.0E+00	4.8E-05	1.8E-04
EU5	Recreational	CT-SB	0	Th-232	4.01E-02	8.9E-05	2.7E-05	0.0E+00	1.2E-05	1.3E-04
EU5	Recreational	CT-SB	0	U-234	8.27E-01	1.8E-06	4.4E-05	0.0E+00	2.4E-05	7.0E-05
EU5	Recreational	CT-SB	0	U-235	1.04E-01	4.3E-04	5.2E-06	0.0E+00	2.9E-06	4.4E-04
EU5	Recreational	CT-SB	0	U-238	7.62E-01	6.2E-04	3.6E-05	0.0E+00	2.1E-05	6.8E-04
										3.0E-02
EU5	Recreational	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	1000	Pb-210	4E-01	3.2E-19	8.9E-20	0.0E+00	7.2E-18	7.6E-18
EU5	Recreational	CT-SB	1000	Ra-226	4.39E-01	1.7E-02	3.6E-06	0.0E+00	2.5E-04	1.7E-02
EU5	Recreational	CT-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	1000	Th-228	4.73E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Recreational	CT-SB	1000	Th-230	8.48E-01	1.7E-02	1.1E-04	0.0E+00	3.0E-04	1.8E-02
EU5	Recreational	CT-SB	1000	Th-232	4.01E-02	3.4E-03	3.2E-05	0.0E+00	2.0E-05	3.5E-03
EU5	Recreational	CT-SB	1000	U-234	8.27E-01	8.3E-05	4.2E-05	0.0E+00	2.4E-05	1.5E-04
EU5	Recreational	CT-SB	1000	U-235	1.04E-01	4.2E-04	1.1E-05	0.0E+00	8.0E-06	4.4E-04
EU5	Recreational	CT-SB	1000	U-238	7.62E-01	5.8E-04	3.4E-05	0.0E+00	2.0E-05	6.4E-04
										4.0E-02

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Construction	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SS	0	Pb-210	4.55E+01	6.1E-02	1.0E-01	0.0E+00	6.5E+00	6.7E+00
EU1	Construction	CT-SS	0	Ra-226	4.55E+01	1.1E+02	4.0E-02	0.0E+00	1.3E+00	1.1E+02
EU1	Construction	CT-SS	0	Ra-228	1.26E-01	2.0E-01	7.1E-04	0.0E+00	3.7E-03	2.0E-01
EU1	Construction	CT-SS	0	Th-228	2.36E-01	4.3E-01	6.6E-03	0.0E+00	3.2E-03	4.4E-01
EU1	Construction	CT-SS	0	Th-230	7.10E-01	5.6E-04	2.3E-02	0.0E+00	7.8E-03	3.1E-02
EU1	Construction	CT-SS	0	Th-232	1.58E-01	1.4E-02	2.5E-02	0.0E+00	8.9E-03	4.8E-02
EU1	Construction	CT-SS	0	U-234	4.04E+00	3.6E-04	5.2E-02	0.0E+00	2.3E-02	7.5E-02
EU1	Construction	CT-SS	0	U-235	1.86E-01	3.1E-02	2.2E-03	0.0E+00	9.9E-04	3.4E-02
EU1	Construction	CT-SS	0	U-238	1.58E+01	5.2E-01	1.8E-01	0.0E+00	8.5E-02	7.8E-01
										1.2E+02
EU1	Construction	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SS	1000	Pb-210	4.55E+01	1.3E-15	2.2E-15	0.0E+00	1.4E-13	1.5E-13
EU1	Construction	CT-SS	1000	Ra-226	4.55E+01	6.9E+01	8.9E-02	0.0E+00	5.0E+00	7.4E+01
EU1	Construction	CT-SS	1000	Ra-228	1.26E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SS	1000	Th-228	2.36E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SS	1000	Th-230	7.10E-01	5.9E-01	2.3E-02	0.0E+00	4.8E-02	6.6E-01
EU1	Construction	CT-SS	1000	Th-232	1.58E-01	5.4E-01	3.0E-02	0.0E+00	1.5E-02	5.8E-01
EU1	Construction	CT-SS	1000	U-234	4.04E+00	1.6E-02	4.9E-02	0.0E+00	2.3E-02	8.8E-02
EU1	Construction	CT-SS	1000	U-235	1.86E-01	3.0E-02	4.8E-03	0.0E+00	2.7E-03	3.8E-02
EU1	Construction	CT-SS	1000	U-238	1.58E+01	4.8E-01	1.7E-01	0.0E+00	7.9E-02	7.3E-01
										7.7E+01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Construction	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU2	Construction	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Construction	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00
EU3	Construction	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Th-230	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										0.0E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Construction	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	Ra-228	8.21E-02	1.3E-01	4.6E-04	0.0E+00	2.4E-03	1.3E-01
EU4	Construction	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	0	U-235	7.59E-02	1.2E-02	9.1E-04	0.0E+00	4.1E-04	1.4E-02
EU4	Construction	CT-SS	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.4E-01
EU4	Construction	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Ra-228	8.21E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SS	1000	U-235	7.59E-02	1.2E-02	2.0E-03	0.0E+00	1.1E-03	1.5E-02
EU4	Construction	CT-SS	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										1.5E-02

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC Net EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Construction	CT-SS	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	0	Pb-210	9.56E-02	1.3E-04	2.1E-04	0.0E+00	1.4E-02	1.4E-02
EU5	Construction	CT-SS	0	Ra-226	9.56E-02	2.3E-01	8.3E-05	0.0E+00	2.8E-03	2.3E-01
EU5	Construction	CT-SS	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	0	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	0	Th-230	7.65E-02	6.0E-05	2.4E-03	0.0E+00	8.4E-04	3.3E-03
EU5	Construction	CT-SS	0	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	0	U-234	1.87E-01	1.7E-05	2.4E-03	0.0E+00	1.1E-03	3.5E-03
EU5	Construction	CT-SS	0	U-235	5.94E-02	9.8E-03	7.1E-04	0.0E+00	3.2E-04	1.1E-02
EU5	Construction	CT-SS	0	U-238	1.45E-01	4.8E-03	1.7E-03	0.0E+00	7.8E-04	7.2E-03
										2.7E-01
EU5	Construction	CT-SS	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	1000	Pb-210	9.56E-02	2.8E-18	4.7E-18	0.0E+00	3.0E-16	3.1E-16
EU5	Construction	CT-SS	1000	Ra-226	9.56E-02	1.5E-01	1.9E-04	0.0E+00	1.0E-02	1.6E-01
EU5	Construction	CT-SS	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	1000	Th-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	1000	Th-230	7.65E-02	6.3E-02	2.4E-03	0.0E+00	5.2E-03	7.1E-02
EU5	Construction	CT-SS	1000	Th-232	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SS	1000	U-234	1.87E-01	7.5E-04	2.3E-03	0.0E+00	1.1E-03	4.1E-03
EU5	Construction	CT-SS	1000	U-235	5.94E-02	9.7E-03	1.5E-03	0.0E+00	8.7E-04	1.2E-02
EU5	Construction	CT-SS	1000	U-238	1.45E-01	4.4E-03	1.6E-03	0.0E+00	7.3E-04	6.7E-03
										2.5E-01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SS = central tendency - surface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU1	Construction	CT-SB	0	Ac-227	1E-01	4.5E-02	6.9E-02	0.0E+00	3.1E-02	1.4E-01
EU1	Construction	CT-SB	0	Pa-231	1.07E-01	5.1E-03	1.4E-02	0.0E+00	2.3E-02	4.3E-02
EU1	Construction	CT-SB	0	Pb-210	3E+01	4.3E-02	7.0E-02	0.0E+00	4.5E+00	4.6E+00
EU1	Construction	CT-SB	0	Ra-226	3.17E+01	7.6E+01	2.8E-02	0.0E+00	9.1E-01	7.7E+01
EU1	Construction	CT-SB	0	Ra-228	4.42E-01	6.8E-01	2.5E-03	0.0E+00	1.3E-02	7.0E-01
EU1	Construction	CT-SB	0	Th-228	4.85E-01	8.9E-01	1.4E-02	0.0E+00	6.6E-03	9.1E-01
EU1	Construction	CT-SB	0	Th-230	1.86E+00	1.5E-03	5.9E-02	0.0E+00	2.0E-02	8.1E-02
EU1	Construction	CT-SB	0	Th-232	4.11E-01	3.6E-02	6.6E-02	0.0E+00	2.3E-02	1.3E-01
EU1	Construction	CT-SB	0	U-234	1.05E+01	9.3E-04	1.3E-01	0.0E+00	5.9E-02	1.9E-01
EU1	Construction	CT-SB	0	U-235	5.45E-01	9.0E-02	6.5E-03	0.0E+00	2.9E-03	9.9E-02
EU1	Construction	CT-SB	0	U-238	3.41E+01	1.1E+00	3.9E-01	0.0E+00	1.8E-01	1.7E+00
										8.6E+01
EU1	Construction	CT-SB	1000	Ac-227	1E-01	6.2E-16	9.4E-16	0.0E+00	4.3E-16	2.0E-15
EU1	Construction	CT-SB	1000	Pa-231	1.07E-01	4.6E-02	7.5E-02	0.0E+00	4.9E-02	1.7E-01
EU1	Construction	CT-SB	1000	Pb-210	3E+01	9.4E-16	1.5E-15	0.0E+00	9.9E-14	1.0E-13
EU1	Construction	CT-SB	1000	Ra-226	3.17E+01	4.8E+01	6.2E-02	0.0E+00	3.5E+00	5.2E+01
EU1	Construction	CT-SB	1000	Ra-228	4.42E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SB	1000	Th-228	4.85E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU1	Construction	CT-SB	1000	Th-230	1.86E+00	1.5E+00	5.9E-02	0.0E+00	1.3E-01	1.7E+00
EU1	Construction	CT-SB	1000	Th-232	4.11E-01	1.4E+00	7.8E-02	0.0E+00	4.0E-02	1.5E+00
EU1	Construction	CT-SB	1000	U-234	1.05E+01	4.2E-02	1.3E-01	0.0E+00	5.9E-02	2.3E-01
EU1	Construction	CT-SB	1000	U-235	5.45E-01	8.9E-02	1.4E-02	0.0E+00	8.0E-03	1.1E-01
EU1	Construction	CT-SB	1000	U-238	3.41E+01	1.0E+00	3.7E-01	0.0E+00	1.7E-01	1.6E+00
										5.7E+01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU2	Construction	CT-SB	0	Ac-227	2E-01	1.0E-01	1.5E-01	0.0E+00	6.9E-02	3.2E-01
EU2	Construction	CT-SB	0	Pa-231	2.39E-01	1.2E-02	3.2E-02	0.0E+00	5.2E-02	9.5E-02
EU2	Construction	CT-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	0	Ra-228	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	0	Th-228	4.31E-02	7.9E-02	1.2E-03	0.0E+00	5.8E-04	8.1E-02
EU2	Construction	CT-SB	0	Th-230	8.00E-04	6.3E-07	2.5E-05	0.0E+00	8.8E-06	3.5E-05
EU2	Construction	CT-SB	0	Th-232	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	0	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	0	U-238	3E-01	1.0E-02	3.7E-03	0.0E+00	1.7E-03	1.6E-02
										5.2E-01
EU2	Construction	CT-SB	1000	Ac-227	2E-01	1.4E-15	2.1E-15	0.0E+00	9.5E-16	4.5E-15
EU2	Construction	CT-SB	1000	Pa-231	2.39E-01	1.0E-01	1.7E-01	0.0E+00	1.1E-01	3.8E-01
EU2	Construction	CT-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	Ra-228	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	Th-228	4.31E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	Th-230	8.00E-04	6.6E-04	2.5E-05	0.0E+00	5.4E-05	7.4E-04
EU2	Construction	CT-SB	1000	Th-232	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	U-235	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU2	Construction	CT-SB	1000	U-238	3E-01	9.8E-03	3.4E-03	0.0E+00	1.6E-03	1.5E-02
										4.0E-01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU3	Construction	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	Th-228	1.20E-01	2.2E-01	3.4E-03	0.0E+00	1.6E-03	2.2E-01
EU3	Construction	CT-SB	0	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	Th-232	6.41E-02	5.7E-03	1.0E-02	0.0E+00	3.6E-03	2.0E-02
EU3	Construction	CT-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	0	U-235	4.82E-02	7.9E-03	5.8E-04	0.0E+00	2.6E-04	8.8E-03
EU3	Construction	CT-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.5E-01
EU3	Construction	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Th-228	1.20E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Th-230	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	Th-232	6.41E-02	2.2E-01	1.2E-02	0.0E+00	6.2E-03	2.4E-01
EU3	Construction	CT-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU3	Construction	CT-SB	1000	U-235	4.82E-02	7.8E-03	1.3E-03	0.0E+00	7.1E-04	9.8E-03
EU3	Construction	CT-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										2.5E-01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU4	Construction	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	0	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	0	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	0	Ra-228	1.18E-01	1.8E-01	6.7E-04	0.0E+00	3.5E-03	1.9E-01
EU4	Construction	CT-SB	0	Th-228	1.41E-01	2.6E-01	4.0E-03	0.0E+00	1.9E-03	2.7E-01
EU4	Construction	CT-SB	0	Th-230	7.90E-03	6.2E-06	2.5E-04	0.0E+00	8.7E-05	3.4E-04
EU4	Construction	CT-SB	0	Th-232	1.34E-01	1.2E-02	2.1E-02	0.0E+00	7.5E-03	4.1E-02
EU4	Construction	CT-SB	0	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	0	U-235	7.96E-02	1.3E-02	9.5E-04	0.0E+00	4.2E-04	1.4E-02
EU4	Construction	CT-SB	0	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.1E-01
EU4	Construction	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	Pb-210	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	Ra-226	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	Ra-228	1.18E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	Th-228	1.41E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	Th-230	7.90E-03	6.5E-03	2.5E-04	0.0E+00	5.3E-04	7.3E-03
EU4	Construction	CT-SB	1000	Th-232	1.34E-01	4.6E-01	2.5E-02	0.0E+00	1.3E-02	5.0E-01
EU4	Construction	CT-SB	1000	U-234	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU4	Construction	CT-SB	1000	U-235	7.96E-02	1.3E-02	2.1E-03	0.0E+00	1.2E-03	1.6E-02
EU4	Construction	CT-SB	1000	U-238	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
										5.2E-01

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil

Table C2-4
Dose Calculation Details for the Central Tendancy Case

Exposure Unit	Exposure Scenario		Year	Analyte	COPC EPC (pCi/g)	Radiological Dose Estimate (mrem/yr) External Gamma	Dust Inhalation	Produce Ingestion	Soil Ingestion	Total
EU5	Construction	CT-SB	0	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	0	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	0	Pb-210	4E-01	5.9E-04	9.8E-04	0.0E+00	6.3E-02	6.4E-02
EU5	Construction	CT-SB	0	Ra-226	4.39E-01	1.1E+00	3.8E-04	0.0E+00	1.3E-02	1.1E+00
EU5	Construction	CT-SB	0	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	0	Th-228	4.73E-02	8.7E-02	1.3E-03	0.0E+00	6.4E-04	8.9E-02
EU5	Construction	CT-SB	0	Th-230	8.48E-01	6.7E-04	2.7E-02	0.0E+00	9.3E-03	3.7E-02
EU5	Construction	CT-SB	0	Th-232	4.01E-02	3.6E-03	6.4E-03	0.0E+00	2.3E-03	1.2E-02
EU5	Construction	CT-SB	0	U-234	8.27E-01	7.3E-05	1.1E-02	0.0E+00	4.7E-03	1.5E-02
EU5	Construction	CT-SB	0	U-235	1.04E-01	1.7E-02	1.2E-03	0.0E+00	5.5E-04	1.9E-02
EU5	Construction	CT-SB	0	U-238	7.62E-01	2.5E-02	8.7E-03	0.0E+00	4.1E-03	3.8E-02
										1.3E+00
EU5	Construction	CT-SB	1000	Ac-227	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	1000	Pa-231	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	1000	Pb-210	4E-01	1.3E-17	2.1E-17	0.0E+00	1.4E-15	1.4E-15
EU5	Construction	CT-SB	1000	Ra-226	4.39E-01	6.7E-01	8.6E-04	0.0E+00	4.8E-02	7.2E-01
EU5	Construction	CT-SB	1000	Ra-228	0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	1000	Th-228	4.73E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
EU5	Construction	CT-SB	1000	Th-230	8.48E-01	7.0E-01	2.7E-02	0.0E+00	5.7E-02	7.8E-01
EU5	Construction	CT-SB	1000	Th-232	4.01E-02	1.4E-01	7.6E-03	0.0E+00	3.9E-03	1.5E-01
EU5	Construction	CT-SB	1000	U-234	8.27E-01	3.3E-03	1.0E-02	0.0E+00	4.7E-03	1.8E-02
EU5	Construction	CT-SB	1000	U-235	1.04E-01	1.7E-02	2.7E-03	0.0E+00	1.5E-03	2.1E-02
EU5	Construction	CT-SB	1000	U-238	7.62E-01	2.3E-02	8.2E-03	0.0E+00	3.8E-03	3.5E-02
										1.7E+00

COCP = constituent of potential concern
EPC = exposure point concentration
CT-SB = central tendency - subsurface soil