US Army Corps
of Engineers
Buffalo District

Final
Feasibility Study Addendum

Authorized under the Formerly Utilized Sites Remedial Action Program (FUSRAP)

Painesville Site
Painesville, Ohio

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Hazardous, Toxic, and Radiological Waste (HTRW)
Design District for Great Lakes and Ohio River Division

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ACRONYMS AND ABBREVIATIONS

Ac-227	Actinium-227
AEC	Atomic Energy Commission
ALARA	As low as reasonably achievable
ARAR	Applicable or relevant and appropriate requirement
bgs	Below ground surface
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COCs	Constituents of concern
DCGL	Derived Concentration Guideline Limit
DMC	Diamond Magnesium Company
DOE	Department of Energy
EE/CA	Engineering Evaluation/Cost Analysis
ERA	Ecological risk assessment
FS	Feasibility Study
FSA	Feasibility Study Addendum
FSSP	Final Status Survey Plan
FUSRAP	Formerly Utilized Sites Remedial Action Program
GSA	General Services Administration
HHRA	Human health risk assessment
ILCR	Incremental Lifetime Cancer Risk
km	Kilometers
LOSA	Lake Ontario Storage Area
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NRC	Nuclear Regulatory Commission
OAC	Ohio Administrative Code
Ohio EPA	Ohio Environmental Protection Agency
ORNL	Oak Ridge National Laboratory
Pa-231	Protactinium-231
Pb-210	Lead-210
PP	Proposed Plan
PRG	Preliminary Remediation Goal
Ra-226	Radium-226
Ra-228	Radium-228
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial Action Objective
RESRAD	Residual Radiation
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SOR	Sum of ratios

TBC	To be considered
TEDE	Total effective dose equivalent
Th-228	Thorium-228
Th-230	Thorium-230
Th-232	Thorium-232
U-234	Uranium-234
U-235	Uranium-235
U-238	Uranium-238
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency

1.0 INTRODUCTION

1.1 Background

The Painesville Formerly Utilized Sites Remedial Action Program (FUSRAP) Site is located at 720 Fairport-Nursery Road in Painesville, Ohio, approximately 35.4 kilometers (km) [22 miles (mi)] northeast of Cleveland. Figure 1 shows the site's proximity to the surrounding area. The site is currently owned by the Crompton Manufacturing Company, Inc. (formerly the Uniroyal Chemical Company). The Painesville FUSRAP Site is bounded on the north by the Norfolk and Southern Railroad, on the west by property owned by Crompton, on the south by Fairport Nursery Road, and on the east by Twin Rivers Technologies (formerly Lonza, Inc.). Active and inactive industrial properties immediately surround the Painesville Site. Figure 2 shows the Painesville FUSRAP Site and adjoining properties.

In the early 1940s, the Defense Plant Corporation financed construction of a magnesium production facility in Painesville, Ohio, on property acquired by the Federal Government. In support of the war effort and later government operations, the Diamond Magnesium Company (DMC) operated this facility from 1942 to 1953 for the General Services Administration (GSA). In 1963, the GSA sold the plant to the U.S. Rubber Company, which later became the Uniroyal Chemical Company, and is now Crompton. Figure 3 shows the former DMC site plan, and Figure 4 shows the layout of the Painesville Site as it appeared during Uniroyal operations.

There is no known history of processing or production of radioactive materials at the Painesville FUSRAP Site. The radioactivity present at the site resulted from the use of scrap ferrous metal to scrub chlorine gas released during the magnesium production process. The GSA sought such scrap metal from the Atomic Energy Commission (AEC) inventories at the Lake Ontario Storage Area (LOSA) in Niagara Falls, New York. By the early 1950s, LOSA had accumulated significant quantities of scrap metal, in part because metal drums were used to ship and store residues from the processing of pitchblende ores. When the pitchblende residues were consolidated into a storage facility at LOSA, the emptied drums were cleaned for reuse or scrapped. These drums, which contained observable residues of pitchblende ores, were part of the scrap shipped to the Painesville FUSRAP Site (ORNL 1991). The radionuclides associated with the pitchblende residues (primarily radium, thorium and uranium) and their naturally occurring decay products are considered FUSRAP related.

Because the constituents of concern (COCs) in the scrap metal were related to AEC activities, Oak Ridge National Laboratory (ORNL) conducted a preliminary and limited radiological survey in 1988 to determine whether the site met the current radiological guidelines. The findings from this survey indicated that residual radioactivity was present at the site above existing guidelines for unrestricted use (ORNL 1990, 1991). The principal radiological COCs were determined to be radium, thorium, uranium, and their naturally occurring decay products. Based on these initial surveys, the site was designated by the Department of Energy (DOE) as a FUSRAP site for further evaluation and remedial action, as appropriate (DOE 1992). The authorization for remedial action at the site only includes FUSRAP related constituents.

Management of FUSRAP was transferred from the DOE to the United States Army Corps of Engineers (USACE) in October 1997. USACE has completed a Site Characterization Report (USACE 1998a), an Engineering Evaluation/Cost Analysis (EE/CA) (USACE 1998b) to support a removal action at the site (USACE 1999), and a Remedial Investigation/Feasibility Study (RI/FS) of the site (USACE 2003). The RI/FS describes the nature and extent of FUSRAP constituents of concern (COCs) requiring remediation on the site, and develops and evaluates alternatives for addressing those contaminants.

1.2 Purpose and Scope of this Feasibility Study Addendum

This Feasibility Study Addendum (FSA) was prepared to document changes in the constituents of concern (COCs) listed in the May 2003 RI/FS Report, and to document changes in the remedial alternatives evaluated in the RI/FS Report. During preparation of the RI/FS Report, certain constituents were conservatively included in the list of COCs, which, after further review, are redundant to list, as they are decay products of long-lived radionuclides that will be addressed by the cleanup. Therefore, these constituents do not have to be listed as separate COCs, but can be considered with their parent COC. Reducing the list of COCs will not affect the level of cleanup at the site, but will simplify the confirmatory sampling after remediation is complete. The following sections describe which constituents will not be listed separately and explain the rationale behind the consolidation of COCs.

The secondary purpose of this FSA is to document a change in the remedial alternatives originally presented in the RI/FS Report. The RI/FS Report included four remedial alternatives: 1) No Action, 2) Capping in Place, 3) Excavation and Off-Site Disposal to a Subsistence Farmer Level, and 4) Excavation and Off-Site Disposal to an Industrial Worker Level. A subsequent evaluation of the reasonable future use of the site identified the future use as industrial, and the construction worker as the critical group upon which cleanup goals will be based. Only remedial alternatives that meet the construction worker cleanup scenario are required to be evaluated in the Feasibility Study and carried forward into the Proposed Plan, therefore, two different excavation and disposal alternatives (i.e., Alternatives 3 and 4) are not warranted. This FSA eliminates one of the excavation alternatives and documents the three alternatives that will be carried forward to the Proposed Plan: 1) No Action, 2) Capping in Place, and 3) Excavation and Off-Site Disposal to a Construction Worker Level.

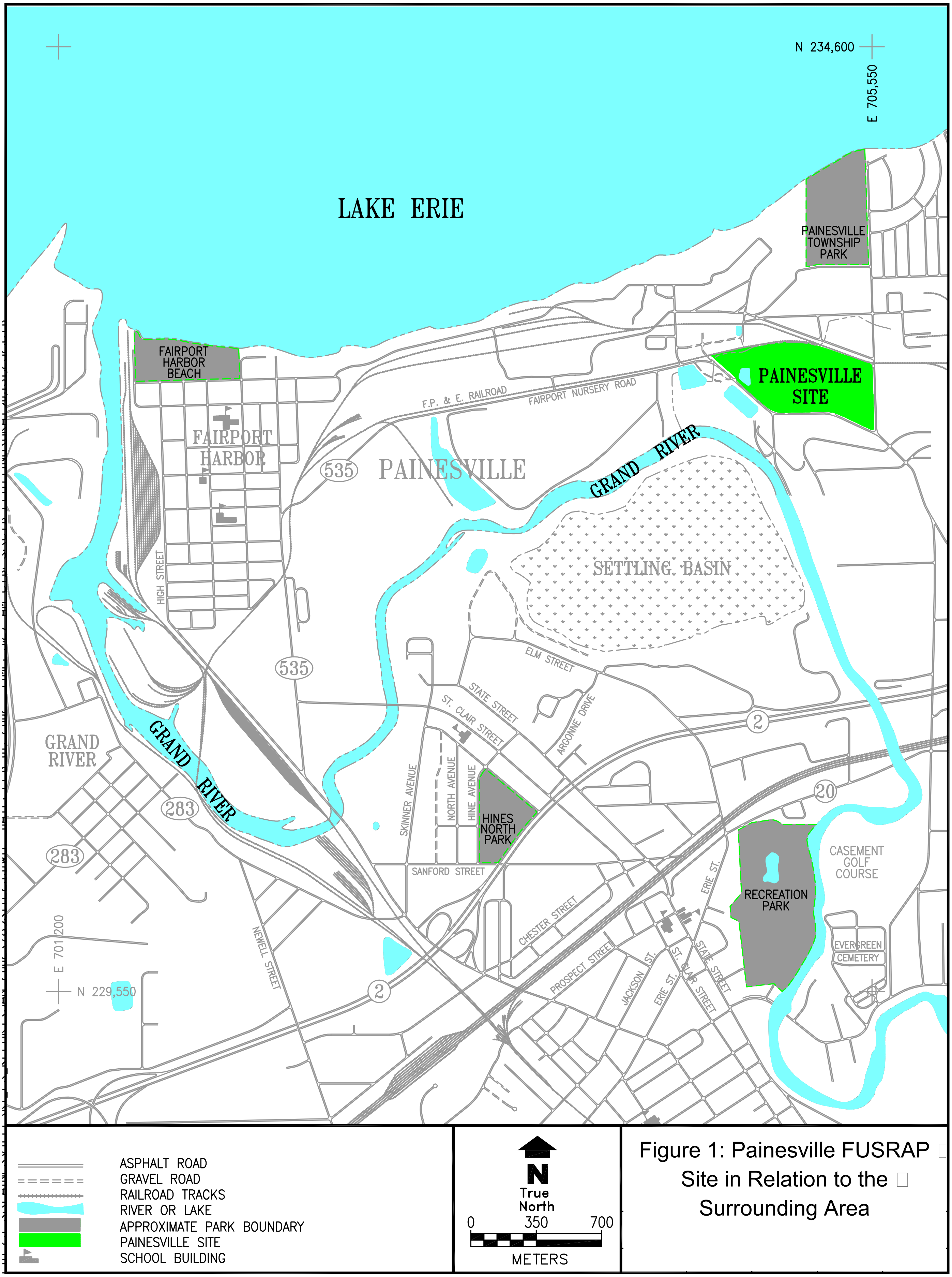
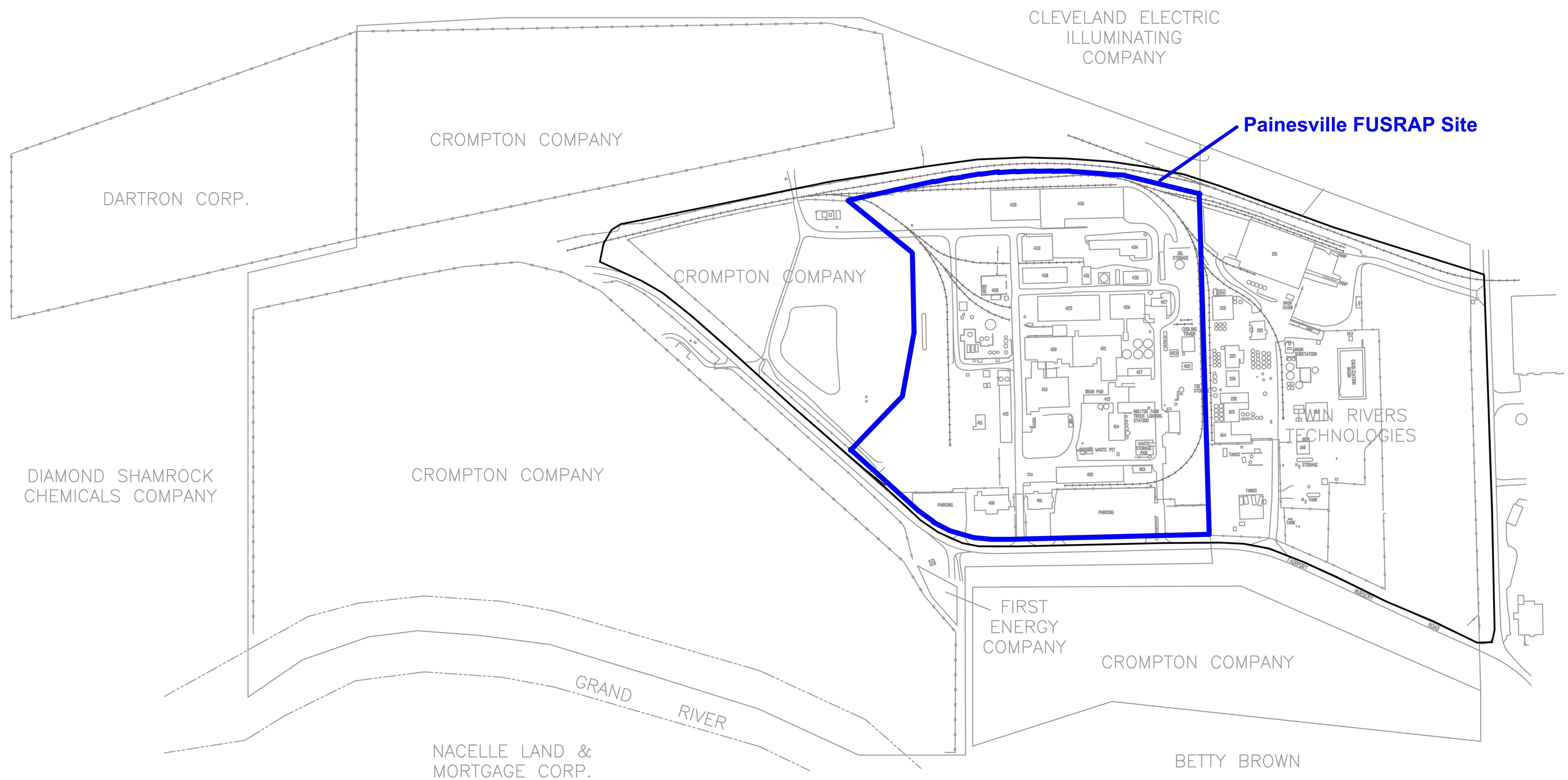


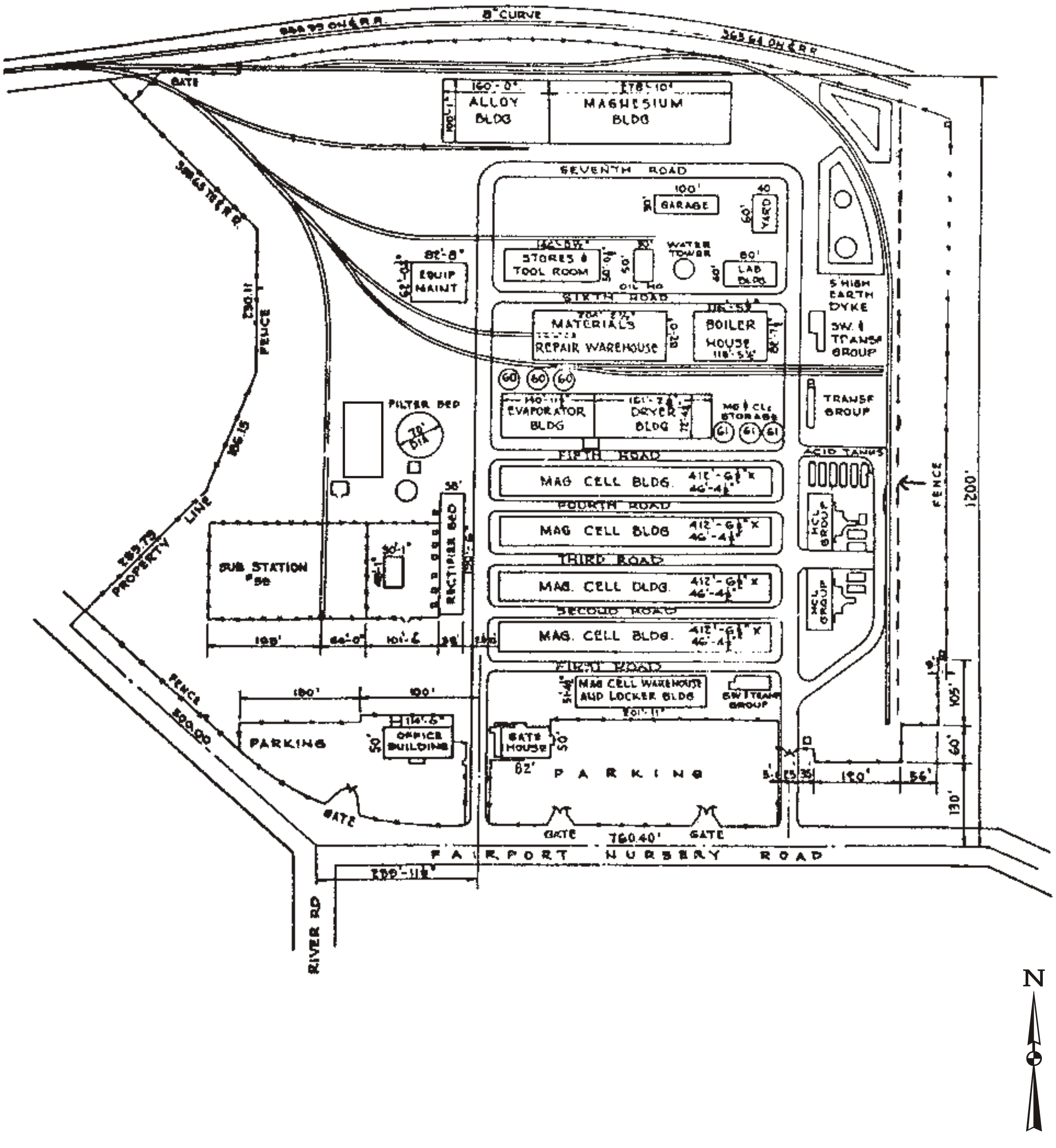
Figure 1: Painesville FUSRAP Site in Relation to the Surrounding Area



PAINESVILLE FUSRAP SITE
PROPERTY BOUNDARY
FENCE LINE
RAILROAD
RIVER BOUNDARY

N
True
North
200 0 200 400
FEET

Figure 2: Painesville FUSRAP Site and Adjoining Properties



Legend

100 0 100 200 300

SCALE IN FE

Figure 3: Former Diamond Magnesium Company Site Plan

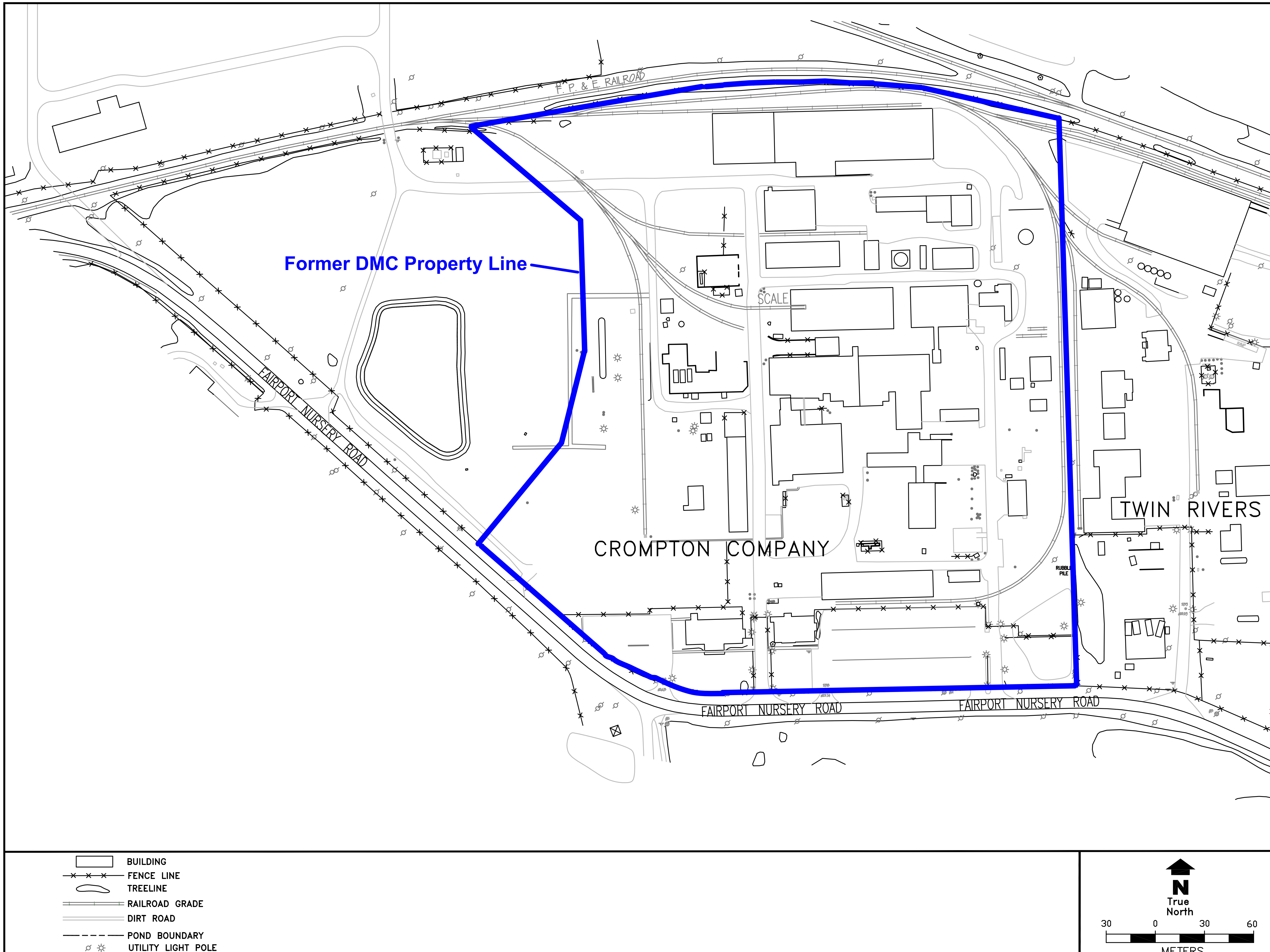


Figure 4: Painesville FUSRAP Site During Uniroyal/Lonza Operations

2.0 SUMMARY OF SITE RISKS

The Baseline Risk Assessment (BRA) portion of the RI (USACE 2003) provides a quantitative estimate of potential risks to human health and the environment from radiological constituents at the Painesville site. The purpose of the risk assessment was to determine the need for cleanup and provide a baseline to compare remedial alternatives. The human health risk assessment (HHRA) and the ecological risk assessment (ERA), which are the two components of the BRA, were conducted according to the methodology presented by the United States Environmental Protection Agency (USEPA) in the *Risk Assessment Guidance for Superfund* (RAGS) (EPA 1989) and other guidance documents. A brief summary of the radiological human health risks, as well as the ecological risks is provided herein.

The BRA only evaluated radiological constituents in soils, as the site characterization indicated that soil was the only media impacted by FUSRAP contaminants (USACE 2003). Each area of concern identified in the site characterization was evaluated as a separate unit. An industrial worker receptor was evaluated as the reasonably anticipated future land use, because the site was a former industrial facility, is currently zoned industrial, and is surrounded by active and inactive industrial properties. There was no information identified during the RI/FS that would lead to a conclusion that the reasonable future land use should be changed from the current use of industrial.

2.1 Human Health Risk Assessment

The HHRA for radiological constituents utilized the RESidual RADiation (RESRAD) computer code Version 6.2. RESRAD, following the RAGS methodology, calculates the total excess cancer risk (i.e., the risk of persons developing cancer as the result of exposure to site contaminants) from radiological constituents to a particular receptor, for all applicable exposure pathways. Input parameters are selected to model a hypothetical human user of the site, or receptor, such as an industrial worker. Risk estimates were calculated covering a 1,000-year period, to be consistent with the applicable or relevant and appropriate requirements (ARARs) identified in Section 3.0 of this document. The maximum risk over this period was then compared to the acceptable risk range specified in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (EPA 1990) of 10^{-6} to 10^{-4} (or one in 1,000,000 to one in 10,000). Constituents of concern (COCs) were conservatively identified as those individual radionuclides that contribute a single-pathway risk greater than 10^{-6}.

Risk for the industrial worker scenario was evaluated for exposure to surface soil (0-2 feet below ground surface (bgs)) through incidental soil ingestion, inhalation of dust, and direct external gamma exposure. Total excess cancer risk for the industrial worker receptor ranged from 1.4×10^{-4} for Area B, to 2.1×10^{-3} for the Rubble Pile. Because these risk values are above the acceptable risk range of

10^{-6} to 10^{-4}, action is required to ensure protection of human health and the environment for the anticipated future site use.

2.2 Ecological Risk Assessment

The screening ecological risk assessment showed that none of the organisms evaluated were at risk due to radionuclides regardless of habitat. When habitat considerations are added to the analysis, then the Painesville exposure units or habitat patches were found to have limited ecological attraction to wildlife because of small size and limited or no cover. In summary, most ecological resources at Painesville are rather limited, and there is no predicted risk from radionuclides. Addressing the risks to human health in soils will consequently reduce any potential risks to ecological receptors.

2.3 Constituents of Concern

In the Painesville RI, the following radiological constituents of concern were identified as presenting an incremental lifetime cancer risk (ILCR) greater than $1x10^{-6}$: actinium-227 (Ac-227), lead-210 (Pb-210), radium-226 (Ra-226), radium-228 (Ra-228), thorium-228 (Th-228), thorium-230 (Th-230), thorium-232 (Th-232), uranium-234 (U-234), uranium-235 (U-235), and uranium-238 (U-238). The incremental lifetime cancer risk is the excess cancer risk due only to exposure to the radionuclide, and is above and beyond any cancer risk that an unexposed individual may have. This cancer risk is averaged over a person's lifetime, and not just during the time of exposure to the radionuclide. As explained in Section 6 of the RI, the cancer risks were assessed for Painesville using RESRAD, consistent with procedures established in the RESRAD modeling manual (ANL 2001). The use of RESRAD is consistent with risk assessments performed using the USEPA *Risk Assessment Guidance for Superfund* (EPA 1989).

In the FS, a risk management decision may be made to only consider COCs that contribute the most to risk for cleanup goal development. This is being done to simplify the sum-of-the ratios (SOR) approach that will ultimately be used, along with the derived concentration guideline limits (DCGLs) in the final status survey plan (FSSP), that will guide remedial action and confirmatory sampling at Painesville. For this reason, some of the radionuclides will not be identified separately, but rather will be considered along with their parent isotope in the cleanup goal. In addition, other radionuclides will not be considered further if they are not risk drivers. Reducing the number of COCs should have no effect on the level of cleanup or total volume of soil remediated, but will help simplify the final sampling and analysis performed to confirm that cleanup is complete. This does not diminish the contribution of any radionuclides not included in the DCGL development, as they are progeny of the COC's and still included in the dose modeling.

A separate cleanup goal, DCGL, will not be developed for Ac-227, Pb-210, Ra-228, or Th-228. In addition, U-234, U235, and U238 will be combined into a single DCGL.

Because many of these radionuclides are present as decay products associated with a long lived (long half-life) “parent” radionuclide, the list of radiological COCs can be simplified by combining the decay products with their respective parent radionuclides where appropriate. Grouping decay series radionuclides in this manner simplifies the site survey and verification processes, without eliminating consideration of the health effects (dose or risk) associated with exposures to the decay products. Grouping simply means that the health effects impacts associated with decay products has been added to the overall parent group impact. For subsequent discussions the primary COC groups shown below will be used. Each of the groups with decay product COCs is shown with a “+D” designator, and the primary radionuclides associated with that group are listed next to the group designator.

- Thorium-232 +D – thorium-232, radium-228, thorium-228
- Thorium-230
- Radium-226 +D – radium-226, lead-210
- $Uranium_{total}$ – uranium-238, uranium-235, and uranium-234 (short lived decay products of uranium-238 and uranium-235 are also included)

For those groups that include decay products with half-lives greater than one year, but that are in secular equilibrium with a long lived parent (e.g., Th-232), the overall cleanup guideline for this group will be based on the most limiting radionuclide in the group. This will ensure that regardless of initial equilibrium conditions, the cleanup goal for the most limiting member of the group will not be exceeded. The limiting radionuclide refers to the radionuclide within the decay series that produces the highest dose to the receptor. For groups that include decay products with short half-lives, the RESRAD calculations automatically incorporate the risks and doses associated with the short-lived decay products.

Actinium-227 is a decay product of U-235, and is likely in secular equilibrium with U-235. In addition, a separate cleanup goal for Ac-227 does not need to be developed, because Ac-227 is not a risk driver. The Ohio Environmental Protection Agency (Ohio EPA) generally refers to an ILCR of 10^{-5} in developing cleanup goals. For the critical group, the industrial worker, Ac-227 does not exceed this risk level for any exposure unit. Furthermore, a review of the 1996 data indicated that Th-227 (the short lived daughter of Ac-227) was only observed in seven percent (7%) of positively listed results for Ac-227. Since Th-227 is a short-lived decay product of Ac-227, Th-227 should be detected in all samples containing Ac-227, especially since Th-227 is easier to detect than Ac-227. In addition, comparison of the samples containing both Ac-227 and Th-227 indicated poor correlation between the Ac-227 result and the Th-227 result, and spectrum interferences for Th-227. This would indicate the presence of Ac-227 at detectable levels may be attributable to unknown gamma interferences. For risk and dose assessment purposes, protactinium-231 (Pa-231), the parent of actinium-227, is also assumed to be present in equal activity with actinium-227.

However, Pa-231 had a frequency of detection of less than five percent (5%), which removed it from further consideration after the weight-of-evidence screening in the data evaluation step of the risk assessment. Finally, it is noted that the less significant risk drivers, such as Ac-227, are collocated with other radiological COCs contributing more significantly to risk. Therefore, addressing the most significant contributors to risk will also mitigate risks from other minor soil COCs.

Hereafter, references to COCs in the FSA, PP, ROD, and FSSP will pertain to the following AEC-related constituent groups: Th-232+D (Th-232, Ra-228, Th-228), Th-230, Ra-226+D (Ra-226, Pb-210), and total U (U-234, U-235, U-238).

3.0 REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) specify the requirements that remedial alternatives must fulfill to protect human health and the environment from contaminants. Essentially, they provide the basis for identifying and evaluating remedial alternatives. The RAOs for the Painesville site are intended to provide long-term protection of human health and the environment. In order to provide this protection, media-specific objectives that identify major contaminants and associated media-specific cleanup goals are developed.

Remedial Action Objectives are statements that set forth a general description of what the remedial action will accomplish. RAOs should specify contaminants and media of concern, potential exposure pathways, and remediation goals. The first step in developing RAOs is to establish preliminary remediation goals (PRGs). PRGs are a subset of RAOs that set forth a more specific statement of the desired endpoint concentrations or risk levels. PRGs are initially based on readily-available information, such as chemical-specific ARARs or other reliable information. PRGs should be modified, as necessary, as more information becomes available during the RI/FS. Final remediation goals will be determined when the remedy is selected.

3.1 Identification of Remedial Action Objectives

The results of the remedial investigation indicate that localized areas of soil at the Painesville site are contaminated with radium, uranium and thorium at concentrations that present risk to current and potential future land users. The RAOs for the site have been developed to specify the requirements that the remedial action alternatives must fulfill to protect human health and the environment from exposure to contaminants identified at the site. The RAOs for protecting human and ecological receptors will consider both the contaminant concentrations and the exposure routes since protectiveness may be achieved by reducing exposure as well as by reducing contaminant levels.

The RAOs for the Painesville site are as follows:

- To comply with applicable or relevant and appropriate requirements (ARARs).
- To ensure protection of human health and the environment by reducing exposure by external gamma, inhalation and ingestion to the FUSRAP COCs (Ra-226, Th-230, Th-232, and total U) in site soils.
- To remediate the site so that the following site wide area average Derived Concentration Guideline Levels (DCGLs) are not exceeded: Ra-226 = 9 pCi/g, Th-230 = 25 pCi/g, Th-232 = 6 pCi/g, and Total U = 482 pCi/g.

RAOs are applicable to all media that need to be addressed at the site. The 1996 field effort reported on in the 1998 Characterization Report (USACE, 1998a) found no evidence of AEC related contaminants in the sediments, surface water, or air of the Painesville site. These media are therefore not addressed in the proposed plan. Groundwater was evaluated in the 2003 RI/FS report and found to be currently unimpacted, and protected from migration of radionuclides by the nature and thickness of the soils at the site.

3.2 Applicable or Relevant and Appropriate Requirements

The identification and evaluation of ARARs is an integral part of the remedial process. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) specifies that remedial actions for cleanup of hazardous substances must comply with requirements or standards under Federal or more stringent state environmental laws that are applicable or relevant and appropriate to the hazardous substances at a site. Protection of human health and the environment is assured by complying with ARARs. The following sections discuss the ARARs for cleanup of the Painesville site.

3.2.1 Introduction to ARARs

Section 121(d)(1) of CERCLA sets requirements with respect to any hazardous substance, pollutant, or contaminant that will remain on-site. Remedial actions must upon completion achieve a level or standard of control which at least attains legally applicable or relevant and appropriate standards, requirements, criteria, or limitations (ARARs) promulgated under Federal environmental law or any more stringent State environmental or facility siting law.

Identifying ARARs involves determining whether a requirement is applicable, and if it is not applicable, then whether a requirement is relevant and appropriate. Individual ARARs for each site must be identified on a site-specific basis. Factors to assist in identifying ARARs include the physical circumstances of the site, contaminants present, and characteristics of the remedial action.

Applicable requirements are defined as those standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that are legally applicable to the hazardous substances, or pollutants or contaminants at the site. A law or regulation is applicable if the jurisdictional prerequisites of the law or regulation are satisfied.

Relevant and appropriate requirements are defined as those standards, requirements, criteria, or limitations promulgated under federal environmental or State environmental or facility siting laws that, while not applicable to a hazardous substance or pollutant or contaminant, are relevant and appropriate under the circumstances of the release or threatened release of the hazardous substance or pollutant or contaminant at the site.

State requirements are ARARs under CERCLA only if they are: (1) promulgated and of general applicability, (2) identified by the state in a timely manner, and (3) more stringent than federal standards.

Determining whether a rule is relevant and appropriate is a two-step process, which involves determining whether the rule is relevant, and, if so, whether it is appropriate. A requirement is relevant if it addresses problems or situations sufficiently similar to the circumstances of the release at the site. It is appropriate if it is well suited to the site.

CERCLA Section 121(e), 42 USC 9621(e), provides that no permit is required for the portion of any removal or remedial action conducted onsite. Although no permit is required, onsite actions must comply with substantive requirements that permits enforce, but not with related administrative and procedural requirements. That is, remedial actions conducted onsite do not require a permit but must be conducted in a manner consistent with permitted conditions as if a permit were required.

A third category of standards, requirements, criteria or limitations is the “To Be Considered” (TBC) category, which includes proposed rules and non-promulgated advisories or guidance issued by federal or state government that are not legally binding and do not have the status of potential ARARs. If no other standard is available for a situation to help determine the necessary level of cleanup for protection of health or the environment, a TBC may be included as guidance or justification for a standard used in the remediation, at the discretion of the lead agency.

The USACE has identified Title 10, Part 20, of the Code of Federal Regulations (10 CFR 20), and Chapter 3701:1-38, Rule Number 22, of the Ohio Administrative Code (OAC 3701:1-38-22) as ARARs for the Painesville FUSRAP Site.

3.2.2 Federal ARAR - 10 CFR 20, Subpart E

The Painesville Site is contaminated with radioactive material that is the residuals of ore processing at another site that occurred prior to 1978, when Congress provided the Nuclear Regulatory Commission (NRC) authority to regulate such materials. Generally, the regulations most relevant to ore processing sites with these types of residual materials are 40 CFR 192 and 10 CFR 40, Appendix A. However, these regulations are not relevant here because ore processing did not occur on the Painesville Site, but rather the residuals were inadvertently released on the site as a side effect of the storage and use in the magnesium production process of empty metal containers that had previously been used to transport the residuals. The radiological contamination at the site is from the containers, and not distributed from ore processing. Since the distribution of residuals is not similar to the distribution that would be expected at an ore processing facility, 40 CFR 192 and 10 CFR 40, Appendix A, are not relevant to the site.

10 CFR 20, Subpart E is applicable to Nuclear Regulatory Commission licensed facilities. The regulation establishes standards for the decommissioning of facilities licensed by the NRC to manage special nuclear, source, or byproduct

material. The decommissioning standards establish criteria for license termination with unrestricted use, license termination under restricted conditions and allow the submission of alternate criteria for license termination. Under the regulation, a facility is considered to be acceptable for unrestricted use if residual radioactivity exceeding background results in a total effective dose equivalent (TEDE) that does not exceed 25 millirem (mrem) per year to the average member of the critical group, including groundwater sources of drinking water, and must further reduce residual radioactivity to as low as reasonably achievable (ALARA) levels. The critical group is "the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances." A facility will be considered acceptable for restricted use if the levels of residual radioactivity are ALARA, there are legally enforceable land use controls that will assure the TEDE will not exceed 25 mrem per year and will not impose undue burdens on the local community, and if the land use controls fail the TEDE is ALARA but not more than 100 mrem per year. An alternative criterion is acceptable if it is protective of public health and the environment and the dose from all man-made sources combined, except medical, would be no more than 100 mrem per year. The alternative criterion also must include land use controls and achieve ALARA levels.

The Painesville Site does not have an NRC license. Therefore, 10 CFR 20 Subpart E rule is not applicable to the site. However, USACE has identified 10 CFR 20 Subpart E as an ARAR because it is both relevant to and appropriate for the site. The regulation addresses situations sufficiently similar to the circumstances of the release at the Painesville Site and its use is appropriate to the circumstances of the release. The ore processing residuals from the empty metal containers have caused localized occurrences of uranium or thorium in concentrations that exceed the regulated source material concentration limitation, so that a source material license could have been required for the site. If the site had been licensed for the possession or processing of source material, its decommissioning would be subject to the license decommissioning standards in 10 CFR 20, Subpart E. Additionally, the size and nature of the facilities, the media and the constituents of concern at the Painesville Site are generally the same or similar to those found at the sites subject to this regulation. Therefore, 10 CFR 20, Subpart E, is relevant and appropriate for the Painesville Site.

10 CFR 20, Subpart E, requires identification of the critical group when developing cleanup goals. The Painesville Site has been an industrial site since the early 1940s, and is currently zoned as industrial. The Painesville Site is surrounded by active and inactive industrial properties, including an active facility, Twin Rivers Technologies, immediately adjacent to the site. Soils at the site are poorly suited for agricultural purposes, as native soils are high in clay content, and a layer of miscellaneous fill exists over much of the site. Groundwater supplies at the site are low in quantity and of low quality for drinking purposes. Finally, the site property owner, Crompton, is conducting chemical cleanup activities at the site and adjacent properties, which include capping of

landfills and lagoons, restricting potential future residential development or construction on them. Therefore, the reasonable expected future site use of the Painesville Site is industrial.

The 2003 RI/FS Report developed cleanup goals based on an average industrial worker as the critical group. The industrial worker was assumed to spend the majority of time on-site indoors, with limited exposure to the FUSRAP materials in site soils. Since that time, all of the buildings on the site have been demolished, and any future industrial development or use will require construction of new facilities. Based on this, the critical group used to develop cleanup goals is being changed to a construction worker. The construction worker is assumed to spend his entire time on-site outdoors, with greater potential exposure to FUSRAP materials than the industrial worker, which results in more stringent cleanup goals. Additional information is presented in Section 3.3 and Appendix B.

3.2.3 State ARAR - OAC 3701:1-38-22

A state standard that is promulgated, is identified by the state in a timely manner and is more stringent than federal requirements may be applicable or relevant and appropriate. In addition, the state must consistently apply, or demonstrate the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state.

OAC 3701:1-38-22 is a regulation that was promulgated by the State of Ohio to establish standards for the decommissioning of facilities licensed by the state to manage special nuclear, source, or byproduct material. The State of Ohio has the authority to promulgate and enforce such regulations based on an agreement with the NRC that allows the State to regulate such materials in the State of Ohio and the NRC to discontinue such regulation.

OAC 3701:1-38-22 adopts the same required standard for license termination with unrestricted use as 10 CFR 20, Subpart E. A facility is considered to be acceptable for unrestricted use if residual radioactivity exceeding background results in a total effective dose equivalent (TEDE) that does not exceed 25 millirem (mrem) per year to the average member of the critical group, including groundwater sources of drinking water, and must further reduce residual radioactivity to as low as reasonably achievable (ALARA) levels. The critical group is defined in the same way as under 10 CFR 20, Subpart E. However, unlike 10 CFR 20, Subpart E, the regulation does not allow decommissioning with license termination for other than unrestricted use. Instead, if a site is decommissioned using alternate criteria, a decommissioning possession only license must be maintained on the site.

The Painesville Site is not licensed by the state. Therefore, OAC 3701:1-38-22 is not applicable. However, USACE has identified OAC 3701:1-38-22 as an ARAR because it is both relevant to and appropriate for the site, for the same reasons that 10 CFR 20, Subpart E, is relevant and appropriate. Because a construction worker has been identified as the average member of the critical group, and the cleanup goals have been developed to meet the criteria for unrestricted use for the construction worker, 10 CFR 20, Subpart E, and OAC 3701:1-38-22 are functionally equivalent for the Painesville Site.

3.3 Cleanup Goals

The Painesville site will be remediated and closed in a manner consistent with guidance contained in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (EPA 2000). MARSSIM requires that dose or risk-based standards be converted into equivalent activity concentration values, known as Derived Concentration Guideline Levels (DCGLs). MARSSIM assumes that two types of DCGLs will be applied to a site, a $DCGL_w$ and a $DCGL_{emc}$. The $DCGL_w$ represents a wide area average value that must be attained. The $DCGL_{emc}$ refers to elevated area or "hot spot" criteria. $DCGL_{emc}$ requirements ensure that no localized areas will remain that potentially pose unacceptable risks.

Based on the ARAR analysis, a TEDE goal of 25 mrem/yr was assumed for the site with a construction worker considered as the average member of the critical group. The site-specific RESRAD model described in Appendix B was used to back-calculate equivalent $DCGL_w$ requirements for each of the Painesville radiological COCs. A full list of the RESRAD parameters used to develop the construction worker DCGLs is given in Appendix A. The results from this calculation are contained in Table 1. The $DCGL_w$ requirements in Table 1 were derived assuming only one of the radionuclides is present above background levels. Since soils will potentially contain a mix of residual radionuclides once remediation is complete, a Sum of Ratios (SOR) calculation will be used to ensure that the total dose represented by the residual radionuclides is less than the 25 mrem/yr requirement.

The $DCGL_w$ requirements in Table 1 were used to develop the volume estimates for contaminated soils remaining at the Painesville site. In addition to the $DCGL_w$ requirements contained in Table 1, appropriate $DCGL_{emc}$ requirements will be derived for the Painesville site before remediation begins. A detailed Final Status Survey Plan (FSSP) will also be developed prior to the initiation of remediation at the Painesville site. The FSSP will contain the confirmation methodology that will be used to demonstrate compliance with $DCGL_w$ and $DCGL_{emc}$ requirements across the site once remediation is complete.

Table 1: COCs and Selected Soil Cleanup Goals for the Painesville Site

RECEPTOR	COC	BACKGROUND (pCi/g)	CLEANUP GOAL (pCi/g) [a,b]
Construction Worker	Ra-226[c]	1.42	9
	Th-230	2.56	25
	Th-232[d]	1.53	6
	Total U[e]	5.97[f]	482

[a] These cleanup goals represent activity levels above site background activity corresponding to 25 mrem/yr. These cleanup goals are equivalent to an incremental lifetime cancer risk of approximately 2E-05 for a construction worker.

[b] If a mixture of radionuclides is present, then the sum of ratios applies per MARSSIM. For example, using the unrestricted land use cleanup goals for soil, the following sum of ratios equation is obtained:

$$SOR = \frac{Ra-226}{9} + \frac{Th-230}{25} + \frac{Th-232}{6} + \frac{U-234 + U-235 + U-238}{482}$$

where SOR = sum of the ratios result
Ra-226 = net Ra-226 soil concentrations
Th-230 = net Th-230 soil concentrations
Th-232 = net Th-232 soil concentrations
U-234 = net U-234 soil concentrations
U-235 = net U-235 soil concentrations
U-238 = net U-238 soil concentrations
Net soil concentrations exclude background.

[c] Ra-226 criteria includes Pb-210 contribution to dose.
[d] Th-232 criteria includes Th-228 and Ra-228 contribution to dose.
[e] Concentration represents the total uranium guideline.
[f] Total uranium background is the sum of the background values for U-234, U-235 and U-238.

4.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

As mentioned in Section 1.2, the secondary purpose of this Feasibility Study Addendum is to revise the remedial alternatives that were developed in the May 2003 RI/FS Report. The RI/FS Report included four remedial alternatives: 1) No Action, 2) Capping in Place, 3) Excavation and Off-Site Disposal to a Subsistence Farmer Level, and 4) Excavation and Off-Site Disposal to an Industrial Worker Level. As discussed in Section 3.2.2 above, an evaluation of the reasonable future use of the Painesville Site has led to the identification of the construction worker as the Critical Group upon which cleanup goals will be based. Only remedial alternatives that meet the construction worker cleanup scenario are required to be evaluated in the Feasibility Study and carried forward into the Proposed Plan, therefore, two different excavation and disposal alternatives (i.e., Alternatives 3 and 4) are not warranted. Only three remedial alternatives will be carried forward into the Proposed Plan, which are presented below. The first two alternatives, no action and capping of soils in place, have not changed from the RI/FS Report. As discussed previously in Sections 3.2.2 and 3.3, the cleanup goals have been changed for the third alternative, excavation and off-site disposal, which changes the total volume of contaminated soil requiring cleanup, and hence, the cost of the alternative.

4.1 Alternative 1 - No Action

The no action alternative does not change from what was presented in the May 2003 RI/FS Report. Under the no action alternative, no additional remedial action would be taken at the Painesville Site. This alternative is included to provide a baseline for evaluation of other alternatives in accordance with the NCP and CERCLA requirements.

4.2 Alternative 2 - Capping of Contaminated Soils In Place

The capping alternative does not change from what was presented in the May 2003 RI/FS Report. This alternative combines the installation of an asphalt cap with land use controls and environmental monitoring. Impacted soils exceeding a construction worker SOR of 1 would be covered in-place by a one-foot thick asphalt cap. The cap would function as a barrier to reduce potential radiation exposure to site workers and the public. Land use controls would be required to ensure that the impacted material is not disturbed unless further remedial actions are taken. Inspections and maintenance of the cap and environmental monitoring would continue following implementation of the remedial action. The present worth cost of this alternative is $2,606,000.

4.3 Alternative 3 - Excavation and Off-Site Disposal

This alternative is similar to the original Alternative 3 in the May 2003 RI/FS Report, with the only change being that remediation is based on the construction worker DCGLs developed in Section 3.3 of this Feasibility Study Addendum rather than subsistence farmer DCGLs. This changes the volume of contaminated soil requiring excavation and disposal, and hence the estimated cost of the alternative, but everything else remains the same. The total volume of contaminated soil requiring excavation is approximately 4,000 cubic yards (cy), and the present worth cost of this alternative is $5,297,000.

This alternative involves the excavation of impacted soil exceeding a construction worker SOR of 1, off-site transportation, and disposal of the soil at a commercial facility licensed and/or permitted to accept radiological waste. Dust suppression and erosion control measures would be implemented as needed during the remedial action to protect the workers and minimize airborne migration of radionuclides. Site access restrictions and environmental monitoring would be maintained throughout the remedial action. Excavated areas would be backfilled with clean soil, graded and re-vegetated. Figure 5 illustrates the excavation boundaries for this alternative.

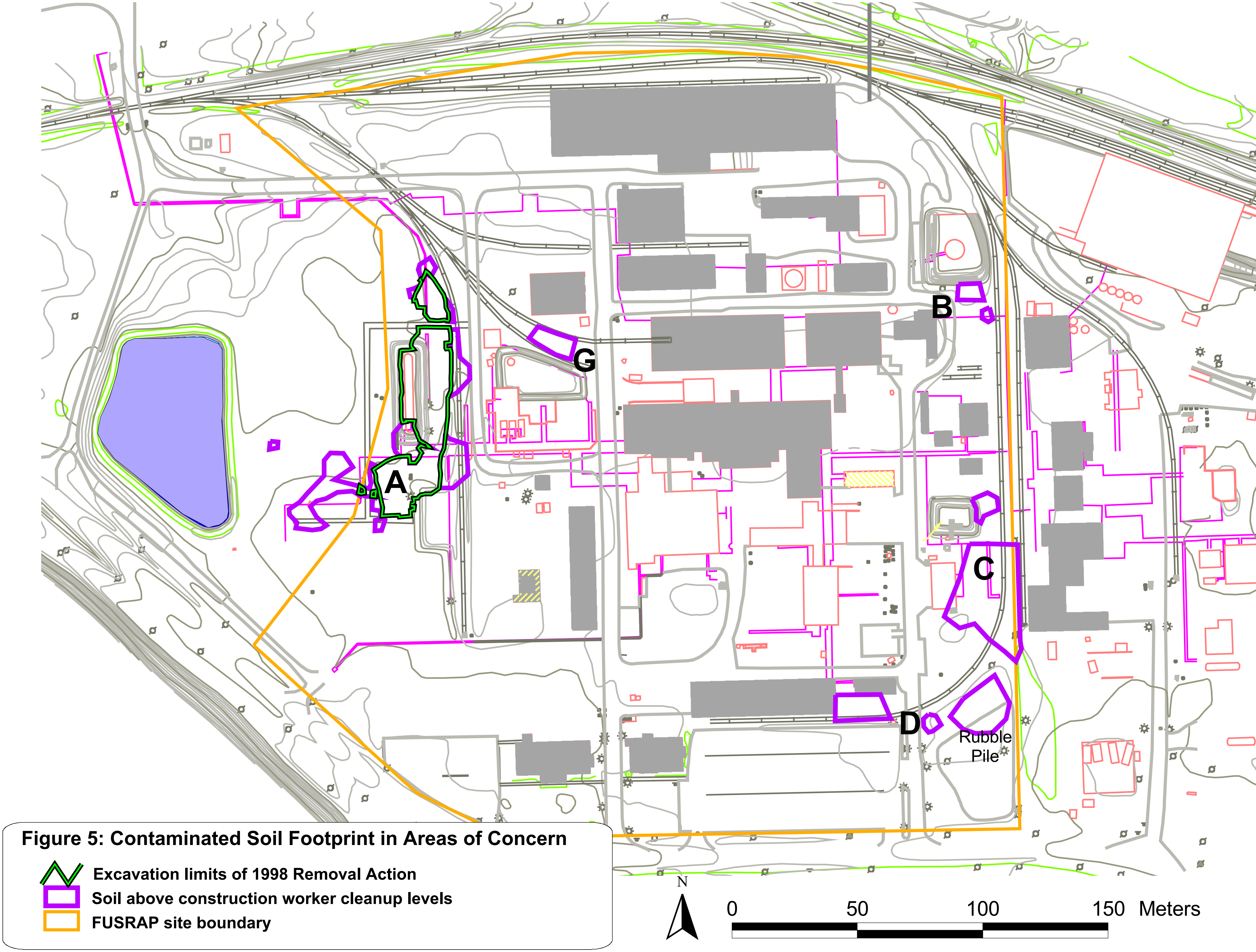


Figure 5: Contaminated Soil Footprint in Areas of Concern

5.0 REFERENCES

ANL 2001. *User's Manual for RESRAD Version 6*. Argonne National Laboratory Environmental Assessments Division, July 2001.

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ORNL 1990. *Preliminary Site Survey Report for the Uniroyal Chemical Company, Formerly the Painesville Company, 720 Fairport-Nursery Road, Painesville, Ohio (DMP001).* ORNL/TM-11119, March 1990.

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APPENDIX A: RESRAD INPUT PARAMETERS

PAINESVILLE FUSRAP SITE
RESRAD INPUT PARAMETERS USED TO DEVELOP CLEANUP GOALS

RESRAD Parameter	Units	RESRAD default value	Construction Worker value	Reference for non-RESRAD default parameter values	Rationale for non-RESRAD default parameter values
Area of contaminated zone	m^2	1.00E+04	1.00E+04		
Thickness of contaminated zone	m	2.00E+00	2.00E+00		
Length parallel to aquifer flow	m	1.00E+02	1.00E+02		
Time since placement of material	yr	0.00E+00	0.00E+00		
Cover depth	m	0.00E+00	0.00E+00		
Density of cover material	g/m^3	1.50E+00	NU	Contamination at surface with no cover	Site-specific assumption
Cover depth erosion rate	m/yr	1.00E-03	NU	Contamination at surface with no cover	Site-specific assumption
Density of contaminated zone	g/m^3	1.50E+00	1.80E+00	USACE 1998 Characterization Report (1)	Site-specific measurement
Contaminated zone erosion rate	m/yr	1.00E-03	6.00E-05	2% slope, no farming, RESRAD Data Handbook (2)	Construction worker assumption
Contaminated zone total porosity	unitless	4.00E-01	3.10E-01	USACE 1998 Characterization Report (1)	Site-specific measurement
Contaminated zone field capacity	unitless	2.00E-01	1.50E-01	USACE 1998 Characterization Report (1)	Site-specific measurement
Contaminated zone hydraulic conductivity	m/yr	1.00E+01	3.47E+00	USACE 1998 Characterization Report (1)	Site-specific measurement
Contaminated zone b parameter	unitless	5.30E+00	5.30E+00		
Humidity in air	g/m^3	8.00E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Average annual wind speed	m/sec	2.00E+00	2.00E+00		
Evapotranspiration coefficient	unitless	5.00E-01	5.00E-01		
Precipitation	m/yr	1.00E+00	1.00E+00		
Irrigation	m/yr	2.00E-01	2.00E-01		
Irrigation mode	unitless	Overhead	Overhead		
Runoff coefficient	unitless	2.00E-01	2.00E-01		
Watershed area for nearby stream or pond	m^2	1.00E+06	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Accuracy for water/soil computations	unitless	1.00E-03	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Saturated zone density	g/m^3	1.50E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Saturated zone total porosity	unitless	4.00E-01	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Saturated zone effective porosity	unitless	2.00E-01	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Saturated zone field capacity	unitless	2.00E-01	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Saturated zone hydraulic conductivity	m/yr	1.00E+02	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Saturated zone hydraulic gradient	unitless	2.00E-02	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Saturated zone b parameter	unitless	5.30E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Water table drop rate	m/yr	1.00E-03	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Well pump intake depth (m below water table)	m	1.00E+01	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Model: Nondispersion (ND) or	unitless	ND	NU	Goundwater not used for drinking or irrigation	Site-specific assumption

PAINESVILLE FUSRAP SITE
RESRAD INPUT PARAMETERS USED TO DEVELOP CLEANUP GOALS

RESRAD Parameter	Units	RESRAD default value	Construction Worker value	Reference for non-RESRAD default parameter values	Rationale for non-RESRAD default parameter values
Mass-Balance (MB)					
Well pumping rate	m^3/yr	2.50E+02	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Number of unsaturated zone strata	unitless	1.00E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Unsaturated zone thickness	m	4.00E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Unsaturated zone soil density	g/m^3	1.50E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Unsaturated zone total porosity	unitless	4.00E-01	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Unsaturated zone effective porosity	unitless	2.00E-01	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Unsaturated zone field capacity	unitless	2.00E-01	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Unsaturated zone b parameter	unitless	5.30E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Unsaturated zone hydraulic conductivity	m/yr	1.00E+01	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Distribution coefficient - actinium	cm^3/g	2.00E+01	2.40E+03	Value for clay soils, RESRAD Data Handbook (2)	Site-specific assumption
Distribution coefficient - protactinium	cm^3/g	5.00E+01	2.70E+03	Value for clay soils, RESRAD Data Handbook (2)	Site-specific assumption
Distribution coefficient - lead	cm^3/g	1.00E+02	5.50E+02	Value for clay soils, RESRAD Data Handbook (2)	Site-specific assumption
Distribution coefficient - radium	cm^3/g	7.00E+01	9.10E+03	Value for clay soils, RESRAD Data Handbook (2)	Site-specific assumption
Distribution coefficient - thorium	cm^3/g	6.00E+04	5.80E+03	Value for clay soils, RESRAD Data Handbook (2)	Site-specific assumption
Distribution coefficient - uranium	cm^3/g	5.00E+01	1.60E+03	Value for clay soils, RESRAD Data Handbook (2)	Site-specific assumption
Inhalation rate	m^3/yr	8.40E+03	7.30E+03	20 m^3/day, USEPA Standard Default (3)	Guidance for adult worker
Mass loading for inhalation	g/m^3	1.00E-04	6.00E-04	RESRAD Data Collection Handbook (2)	Guidance for construction worker
Exposure duration	yr	3.00E+01	1.00E+00	Single construction season	Construction worker assumption
Shielding factor, inhalation (indoor)	unitless	4.00E-01	4.00E-01		
Shielding factor, external gamma (indoor)	unitless	7.00E-01	4.00E-01	USEPA 2000 (4)	USEPA guidance
Fraction of time spent indoors	unitless	5.00E-01	0.00E+00	Receptor spends no time indoors	Construction worker assumption
Fraction of time spent outdoors (on site)	unitless	2.50E-01	2.28E-01	8 hours per day, 250 days per year	Construction worker assumption
Shape factor flag, external gamma	unitless	1.00E+00	1.00E+00		
Fruits, vegetables and grain consumption	kg/yr	1.60E+02	NU	No home-grown food consumed	Construction worker assumption
Leafy vegetable consumption	kg/yr	1.40E+01	NU	No home-grown food consumed	Construction worker assumption
Milk consumption	L/yr	9.20E+01	NU	No home-grown food consumed	Construction worker assumption
Meat and poultry consumption	kg/yr	6.30E+01	NU	No home-grown food consumed	Construction worker assumption
Fish consumption	kg/yr	5.40E+00	NU	No home-grown food consumed	Construction worker assumption
Other seafood consumption	kg/yr	9.00E-01	NU	No home-grown food consumed	Construction worker assumption
Soil ingestion rate	g/yr	3.65E+01	1.75E+02	480 mg/day, USEPA 1997 EFH, Table 4-16 (5)	Guidance for outdoor summer activities

PAINESVILLE FUSRAP SITE
RESRAD INPUT PARAMETERS USED TO DEVELOP CLEANUP GOALS

RESRAD Parameter	Units	RESRAD default value	Construction Worker value	Reference for non-RESRAD default parameter values	Rationale for non-RESRAD default parameter values
Drinking water intake	L/yr	5.10E+02	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Contamination fraction of drinking water	unitless	1.00E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Contamination fraction of household water	unitless	1.00E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Contamination fraction of livestock water	unitless	1.00E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Contamination fraction of irrigation water	unitless	1.00E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Contamination fraction of aquatic food	unitless	5.00E-01	NU	No home-grown food consumed	Construction worker assumption
Contamination fraction of plant food	unitless	-1.00E+00	NU	No home-grown food consumed	Construction worker assumption
Contamination fraction of meat	unitless	-1.00E+00	NU	No home-grown food consumed	Construction worker assumption
Contamination fraction of milk	unitless	-1.00E+00	NU	No home-grown food consumed	Construction worker assumption
Livestock fodder intake for meat	kg/day	6.80E+01	NU	No home-grown food consumed	Construction worker assumption
Livestock fodder intake for milk	kg/day	5.50E+01	NU	No home-grown food consumed	Construction worker assumption
Livestock water intake for meat	L/day	5.00E+01	NU	No home-grown food consumed	Construction worker assumption
Livestock water intake for milk	L/day	1.60E+02	NU	No home-grown food consumed	Construction worker assumption
Livestock soil intake	kg/day	5.00E-01	NU	No home-grown food consumed	Construction worker assumption
Mass loading for foliar deposition	g/m^3	1.00E-04	NU	No home-grown food consumed	Construction worker assumption
Depth of soil mixing layer	m	1.50E-01	1.50E-01		
Depth of roots	m	9.00E-01	NU	No home-grown food consumed	Construction worker assumption
Drinking water fraction from ground water	unitless	1.00E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Household water fraction from ground water	unitless	1.00E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Livestock water fraction from ground water	unitless	1.00E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Irrigation fraction from ground water	unitless	1.00E+00	NU	Goundwater not used for drinking or irrigation	Site-specific assumption
Wet weight crop yield for non-leafy	kg/m^2	7.00E-01	NU	No home-grown food consumed	Construction worker assumption
Wet weight crop yield for leafy	kg/m^2	1.50E+00	NU	No home-grown food consumed	Construction worker assumption
Wet weight crop yield for fodder	kg/m^2	1.10E+00	NU	No home-grown food consumed	Construction worker assumption
Growing season for non-leafy	years	1.70E-01	NU	No home-grown food consumed	Construction worker assumption
Growing season for leafy	years	2.50E-01	NU	No home-grown food consumed	Construction worker assumption
Growing season for fodder	years	8.00E-02	NU	No home-grown food consumed	Construction worker assumption
Translocation factor for non-leafy	unitless	1.00E-01	NU	No home-grown food consumed	Construction worker assumption
Translocation factor for leafy	unitless	1.00E+00	NU	No home-grown food consumed	Construction worker assumption
Translocation factor for fodder	unitless	1.00E+00	NU	No home-grown food consumed	Construction worker assumption
Dry foliar interception fraction for non-leafy	unitless	2.50E-01	NU	No home-grown food consumed	Construction worker assumption

PAINESVILLE FUSRAP SITE
RESRAD INPUT PARAMETERS USED TO DEVELOP CLEANUP GOALS

RESRAD Parameter	Units	RESRAD default value	Construction Worker value	Reference for non-RESRAD default parameter values	Rationale for non-RESRAD default parameter values
Dry foliar interception fraction for leafy	unitless	2.50E-01	NU	No home-grown food consumed	Construction worker assumption
Dry foliar interception fraction for fodder	unitless	2.50E-01	NU	No home-grown food consumed	Construction worker assumption
Wet foliar interception fraction for non-leafy	unitless	2.50E-01	NU	No home-grown food consumed	Construction worker assumption
Wet foliar interception fraction for leafy	unitless	2.50E-01	NU	No home-grown food consumed	Construction worker assumption
Wet foliar interception fraction for fodder	unitless	2.50E-01	NU	No home-grown food consumed	Construction worker assumption
Weathering removal constant for vegetation	unitless	2.00E+01	NU	No home-grown food consumed	Construction worker assumption
Storage time: fruits, non-leafy vegetables, and	days	1.40E+01	NU	No home-grown food consumed	Construction worker assumption
Storage time: leafy vegetables	days	1.00E+00	NU	No home-grown food consumed	Construction worker assumption
Storage time: milk	days	1.00E+00	NU	No home-grown food consumed	Construction worker assumption
Storage time: meat and poultry	days	2.00E+01	NU	No home-grown food consumed	Construction worker assumption
Storage time: fish	days	7.00E+00	NU	No home-grown food consumed	Construction worker assumption
Storage time: crustacea and mollusks	days	7.00E+00	NU	No home-grown food consumed	Construction worker assumption
Storage time: well water	days	1.00E+00	NU	No home-grown food consumed	Construction worker assumption
Storage time: surface water	days	1.00E+00	NU	No home-grown food consumed	Construction worker assumption
Storage time: livestock fodder	days	4.50E+01	NU	No home-grown food consumed	Construction worker assumption
Thickness of building foundation	m	1.50E-01	NU	Radon pathway turned off	Construction worker assumption
Bulk density of building foundation	g/cm^3	2.40E+00	NU	Radon pathway turned off	Construction worker assumption
Total porosity of the cover material	unitless	4.00E-01	NU	Radon pathway turned off	Construction worker assumption
Total porosity of the building foundation	unitless	1.00E-01	NU	Radon pathway turned off	Construction worker assumption
Volumetric water constant of the cover materia	unitless	5.00E-02	NU	Radon pathway turned off	Construction worker assumption
Volumetric water constant of the foundation	unitless	3.00E-02	NU	Radon pathway turned off	Construction worker assumption
Diffusion coef. for radon gas in cover material	m/sec	2.00E-06	NU	Radon pathway turned off	Construction worker assumption
Diffusion coef. for radon gas in foundation mat	m/sec	3.00E-07	NU	Radon pathway turned off	Construction worker assumption
Diffusion coef. for radon gas in contaminated z	m/sec	2.00E-06	NU	Radon pathway turned off	Construction worker assumption
Radon vertical dimension of mixing	m	2.00E+00	NU	Radon pathway turned off	Construction worker assumption
Average building air exchange rate	1/hour	5.00E-01	NU	Radon pathway turned off	Construction worker assumption
Height of the building (room)	m	2.50E+00	NU	Radon pathway turned off	Construction worker assumption
Building interior area factor	unitless	0.00E+00	NU	Radon pathway turned off	Construction worker assumption
Building depth below ground surface	m	-1.00E+00	NU	Radon pathway turned off	Construction worker assumption
Emanating power of Rn-222 gas	unitless	2.50E-01	NU	Radon pathway turned off	Construction worker assumption
Emanating power of Rn-220 gas	unitless	1.50E-01	NU	Radon pathway turned off	Construction worker assumption

PAINESVILLE FUSRAP SITE
RESRAD INPUT PARAMETERS USED TO DEVELOP CLEANUP GOALS

RESRAD Parameter	Units	RESRAD default value	Construction Worker value	Reference for non-RESRAD default parameter values	Rationale for non-RESRAD default parameter values
Pathway – external gamma	unitless	active	active		
Pathway – inhalation (w/o radon)	unitless	active	active		
Pathway – plant ingestion	unitless	active	inactive	No home-grown food consumed	Construction worker assumption
Pathway – meat ingestion	unitless	active	inactive	No home-grown food consumed	Construction worker assumption
Pathway – milk ingestion	unitless	active	inactive	No home-grown food consumed	Construction worker assumption
Pathway – aquatic foods	unitless	active	inactive	No home-grown food consumed	Construction worker assumption
Pathway – drinking water	unitless	active	inactive	Goundwater not used for drinking or irrigation	Site-specific assumption
Pathway – soil ingestion	unitless	active	active		
Pathway – radon	unitless	active	inactive	Receptor spends no time indoors	Construction worker assumption

NU Not Used

Notes (from section 6.3.2 of the RI/FS)
Geotechnical parameters such as distribution coefficients and hydraulic conductivity were measured during the 1996 characterization effort. All relevant parameters were considered for use in RESRAD. Whenever a range of values was available for a given parameter, the more conservative value was generally used. When measured values were not available or varied greatly, the RESRAD software default values were used. Several of the model inputs were based on EPA recommendations for the reasonable maximum exposure scenario. The preference was to use site-specific data first, use values recommended or otherwise employed by EPA second, and use RESRAD defaults last.

Full Citations

1) USACE 1998. *Characterization Report for the Painesville Site, Painesville, Ohio* (Final, Revision 1) May 1998.

2) Argonne National Laboratory (ANL). 1993. *Data Collection Handbook to Support Modeling the Impacts of radioactive materials in Soil*, Environmental Assessments Division, Chicago, IL, April.

3) US EPA 1991. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors, Interim Final*, OSWER Directive 9285.6-03, EPA, Office of Emergency and Remedial Response, Washington, DC.

4) US EPA 2000. *Soil Screening Guidance for Radionuclides: User's Guide.* Office of Emergency and Remedial Response and Office of Radiation and Indoor Air. Washington, DC. OSWER No. 9355.4-16A http://www.epa.gov/superfund/resources/radiation/radssg.htm#user

5) US EPA 1997. *Exposure Factors Handbook*, EPA/600/P-95/002F

APPENDIX B: DCGL DEVELOPMENT

APPENDIX B

DCGL DEVELOPMENT

B.1 DEVELOPMENT OF DERIVED CONCENTRATION GUIDELINE LIMITS

Derived concentration guideline limits (i.e., DCGLs) were developed for the Painesville FUSRAP Site with the RESRAD computer code (version 6.22). The radionuclides of concern included total U (U-234, U-235, and U-238), Th-232+D (Th-232, Ra-228, and Th-228), Ra-226+D (Ra-226 and Pb-210) and Th-230.

The construction worker scenario was chosen for the analysis. This scenario considered incidental soil ingestion, external gamma radiation, and inhalation. The exposure pathways considered in the analysis are summarized in Table B-1. The plant, meat, milk, and fish ingestion pathways along with ground water pathways were not used in the guideline calculations. It was assumed that the municipal water would be used for all purposes including drinking and irrigation. DCGL values were based on a 25 mrem/yr dose limit (Subpart E of 10 CFR 20). A comprehensive listing of parameter values used in the RESRAD code for the construction worker scenario is provided at the end of this appendix. These parameters were developed as part of discussions held between USACE and the Ohio Environmental Protection Agency (OEPA) as part of the CERCLA documentation process for the site and using the *RESRAD Users Manual (Yu et al. 2001).*

The $DCGL_w$ values for the Painesville site are based on an area of 10,000 m^2 and depth of 2 m. Figures B-1 through B-12 chart the residual radioactive soil guidelines for areas ranging from 1 m^2 to 10,000 m^2 for the radionuclides of concern (i.e., U-234 U-235, U-238, U-total, Th-228, Ra-228, Th-232, Th-232+D, Th-230, Pb-210, Ra-226, and Ra-226+D).

For deriving guidelines for the “+D” radionuclides listed above it is assumed that their progeny are in secular equilibrium. For example, derived guidelines for Th-232+D assume that its associated progeny Ra-228 and Th-228 are in secular equilibrium with Th-232. Therefore, a derived guideline value of 6.2 pCi/g for Th-232+D (Table B-3, construction worker scenario), means that the total dose estimated from the mixture (6.2 pCi/g of Th-232, 6.2 pCi/g of Ra-228 and 6.2 pCi/g of Th-228) is 25 mrem/yr.

The total uranium guideline assumes the uranium isotopes are present in their natural activity ratios, i.e.

$$DCGL_{U-Total}(t) = \frac{1}{\sum_i \frac{w_i}{DCGL_i(t)}}$$

where the activity weighting factors (w) are 1/2.046, 0.046/2.046, and 1/2.046 for U-234, U-235, and U-238 respectively. Note that the DCGLs for the individual nuclides reported in Table B-2 are evaluated at the time of each radionuclides’ peak dose.

However, to obtain the DCGL for the natural uranium mixture, the DCGLs in the equation above must be evaluated at the time when the total dose peaks. For example, the peak dose from the natural uranium mixture would occur at year 0. Thus the 0 year DCGLs for each uranium isotope are used to determine the limiting DCGL for total uranium at year 1000. If U-238 is measured as the indicator radionuclide, the U-238 concentration limits can be calculated by dividing the total uranium guideline by 2.046.

While DCGLs were derived for four different areas (1 m^2, 100 m^2, 2,000 m^2, and 10,000 m^2), it is expected that only the DCGLs corresponding to the 10,000 m^2 and 100 m^2 areas will be used for final status survey purposes. The 10,000 m^2 DCGLs will be used to demonstrate compliance over an entire survey unit ($DCGL_w$ testing), and the 100 m^2 DCGLs will be used to evaluate localized areas of elevated activity ($DCGL_{emc}$ testing). Selection of the 10,000 m^2 DCGLs provides the most appropriate comparison for testing average concentrations across an entire survey unit, and selection of the 100 m^2 DCGLs provides a conservative set of values for testing areas with localized elevated concentrations (i.e., “hot spots”).

A summary of the proposed $DCGL_w$ and $DCGL_{emc}$ values for the Painesville site is shown below.

Derived Concentration Guideline Levels for the Painesville Site*

Radionuclide	$DCGL_w$ (pCi/g)	$DCGL_{emc}$ (pCi/g)
	Survey Units	**100 m^2**
U-total	482	810
Ra-226+D	9	12
Th-230	25	34
Th-232+D	6	8

* Values rounded to units of one pCi/g.

Soil containing radioactivity at the DCGL level for a single radionuclide would result in a worst case annual dose to a construction worker worker of 25 mrem/yr. Since it is possible for more than one radionuclide to be present in soils, the DCGLs will be applied using a sum-of-ratios (SOR) approach. The residual concentration in soil for each radionuclide (after background subtraction) will be divided by its respective DCGL, and these ratios will be added together. As long as this sum-of-ratios is less than or equal to 1.0, the dose criterion of 25 mrem/yr will be met. The general SOR formula for use with the DCGLs for the Painesville site is shown below.

$$SOR_{DCGL} = \frac{Ra-226}{Ra-226\_DCGL} + \frac{Th-230}{Th-230\_DCGL} + \frac{Th-232}{Th-232\_DCGL} + \frac{U-tot}{(U-tot\_DCGL)}$$

Table B-1. RESRAD exposure pathways for the construction worker scenario

RESRAD Exposure Pathway	Active/Suppressed
External Gamma Radiation	Active
Inhalation of Particulates	Active
Ingestion of Plant Foods	Suppressed
Incidental Ingestion of Soil	Active
Ingestion of Meat Products	Suppressed
Ingestion of Milk	Suppressed
Ingestion of Fish/Crustacea	Suppressed
Ingestion of Water	Suppressed
Radon	Suppressed

Table B-2. Uranium DCGLs for areas of 1 - 10,000 m² based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

Radionuclide	Time of Peak Dose (yr)	Approximate Area (m^2)	Guidelines (pCi/g) Construction Worker
U-234	0	1	2981
U-235	1000	1	705
U-238	0	1	2252
U-Total	0	1	2468
U-234	1000	100	1441
U-235	1000	100	148
U-238	0	100	609
U-Total	0	100	810
U-234	1000	2,000	767
U-235	1000	2,000	112
U-238	0	2,000	422
U-Total	0	2,000	522
U-234	1000	10,000	696
U-235	1000	10,000	107
U-238	0	10,000	394
U-Total	0	10,000	482

Table B-3. Th-232 and its Progeny DCGLs for areas of 1 - 10,000 m^2 based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

Radionuclide	Time of Peak Dose (yr)	Approximate Area (m^2)	Guidelines (pCi/g)
			Construction Worker
Th-228	0	1	119
Ra-228	2.7	1	108
Th-232	72	1	50.6
Th-232+D	0	1	50.6
Th-228	0	100	15.9
Ra-228	2.7	100	14.2
Th-232	72	100	8.0
Th-232+D	0	100	8.0
Th-228	0	2,000	13.5
Ra-228	2.7	2,000	12.0
Th-232	72	2,000	6.5
Th-232+D	0	2,000	6.5
Th-228	0	10,000	13.0
Ra-228	2.7	10,000	11.6
Th-232	72	10,000	6.2
Th-232+D	0	10,000	6.2

Table B-4. Th-230, Ra-226 and its progeny DCGLs for areas of 1 - 10,000 m^2 based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

Radionuclide	Time of Peak Dose (yr)	Approximate Area (m^2)	Guidelines (pCi/g)
			Construction Worker
Th-230	1000	1	226
Pb-210	0	1	13000
Ra-226	0	1	97.6
Ra-226+D	0	1	96.9
Th-230	1000	100	33.7
Pb-210	0	100	780
Ra-226	3	100	12.3
Ra-226+D	0	100	12.1
Th-230	1000	2,000	25.5
Pb-210	0	2,000	86
Ra-226	65	2,000	9.8
Ra-226+D	0	2,000	9.4
Th-230	1000	10,000	24.6
Pb-210	0	10,000	85.9
Ra-226	65	10,000	9.5
Ra-226+D	0	10,000	9.0

Figure B-1. U-234 DCGLs for areas of 1 – 10,000 m^2 based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

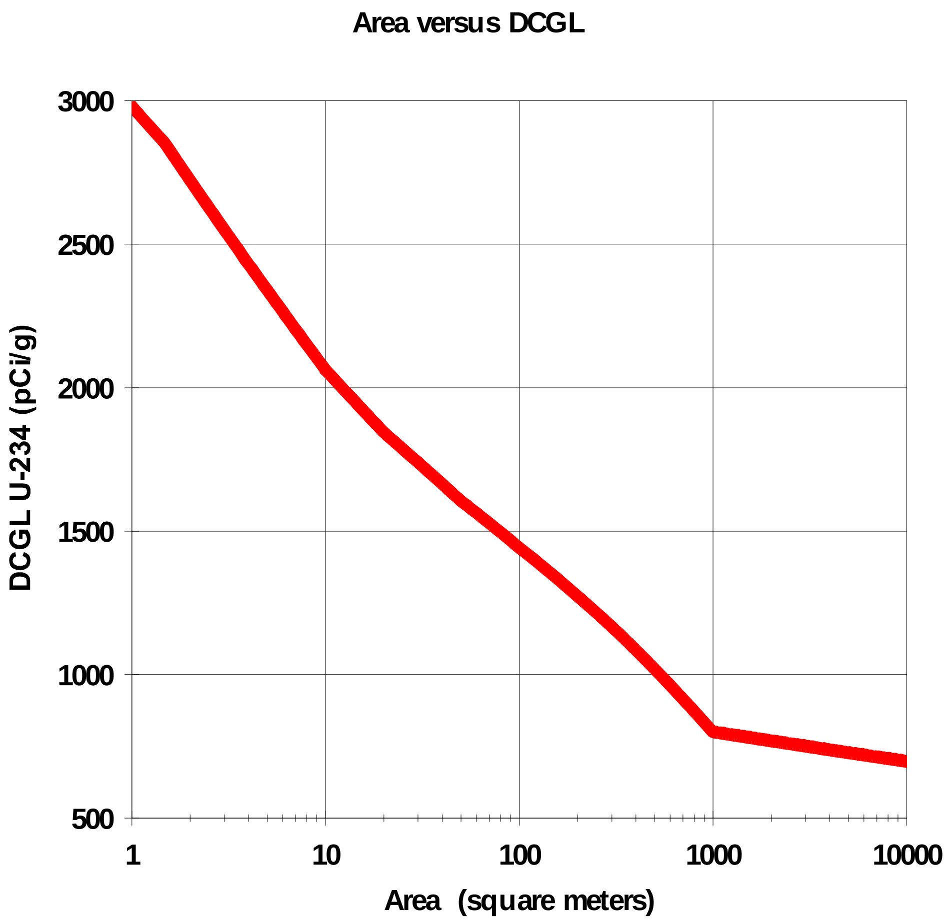


Figure B-2. U-235 DCGLs for areas of 1 – 10,000 m^2 based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

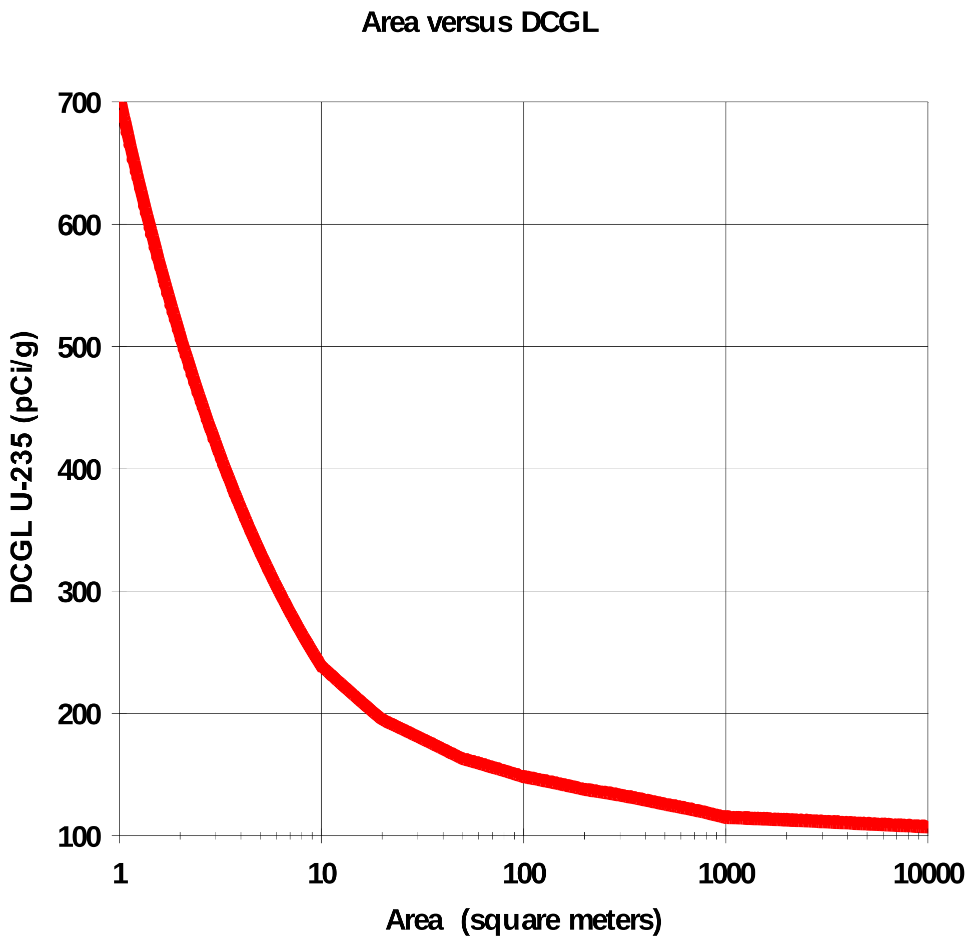


Figure B-3. U-238 DCGLs for areas of 1 – 10,000 m^2 based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

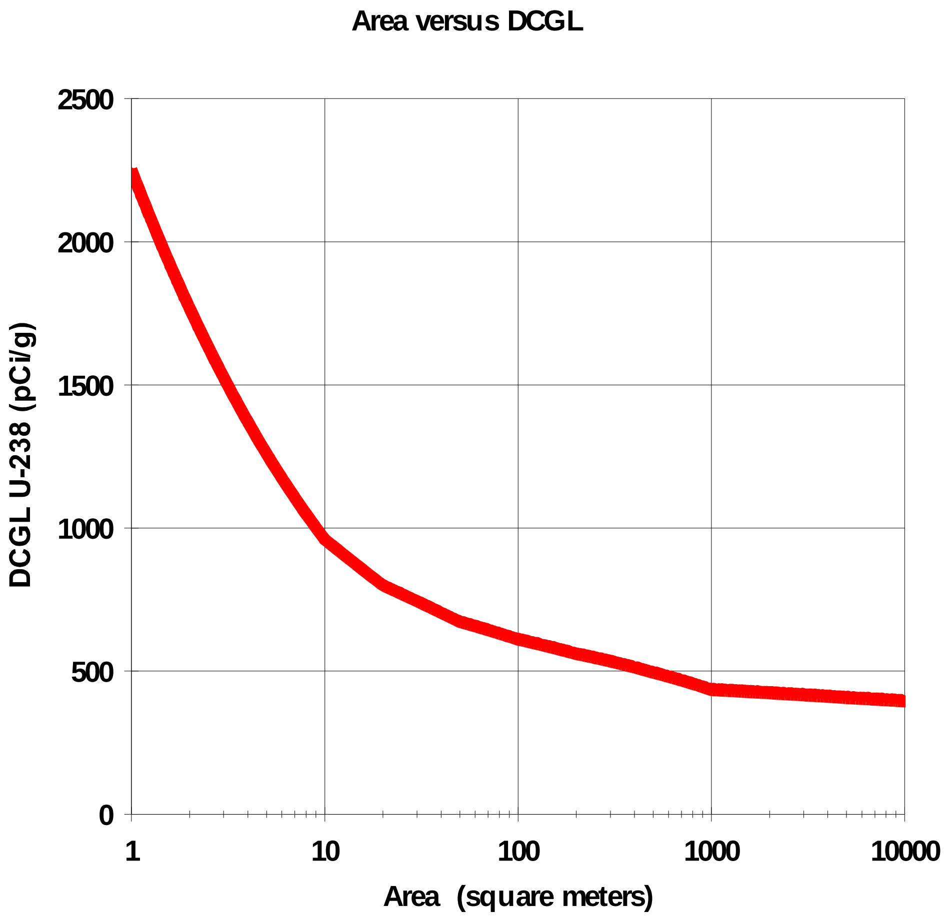


Figure B-4. Total uranium DCGLs for areas of 1 – 10,000 m^2 based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

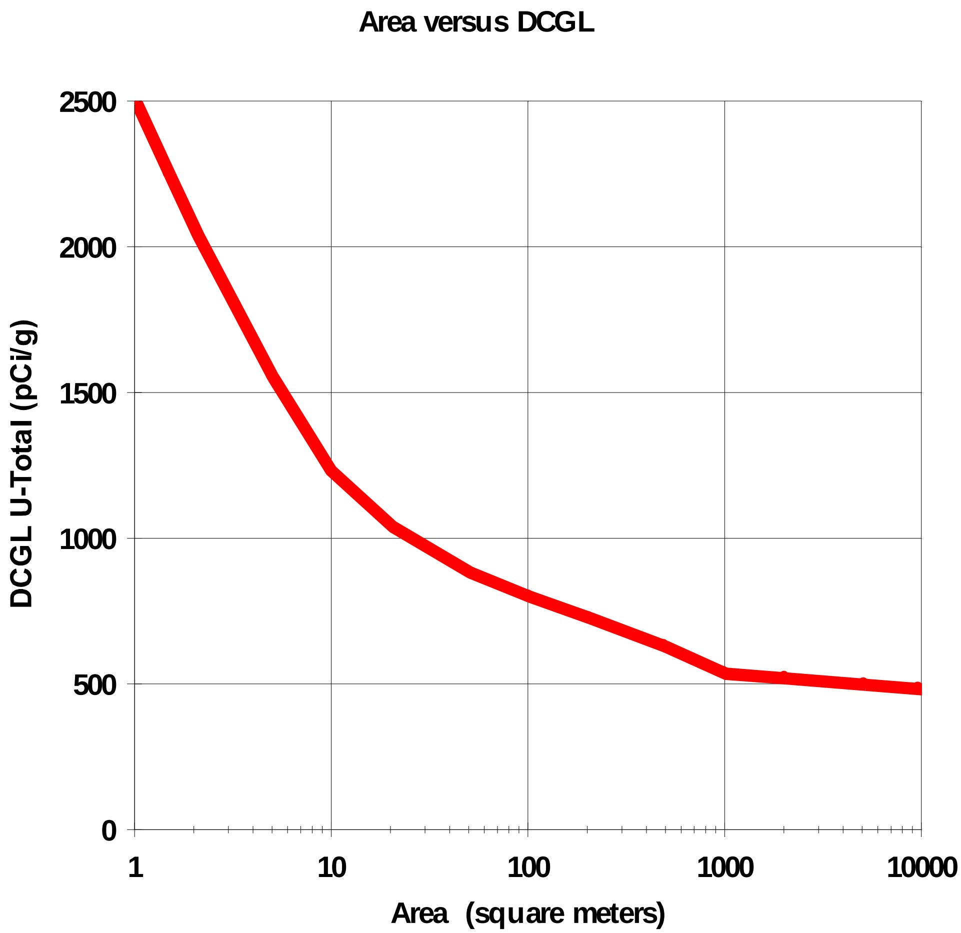


Figure B-5. Th-228 DCGLs for areas of 1 – 10,000 m² based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

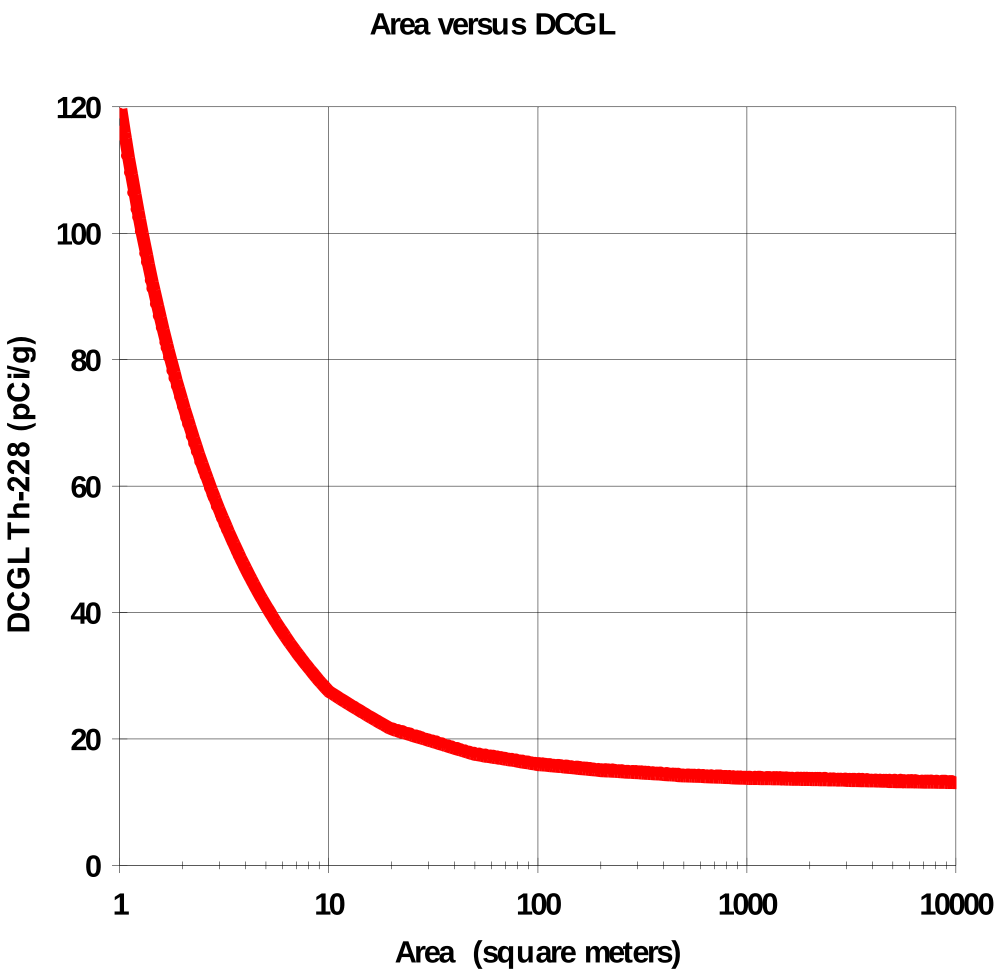


Figure B-6. Ra-228 DCGLs for areas of 1 – 10,000 m^2 based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

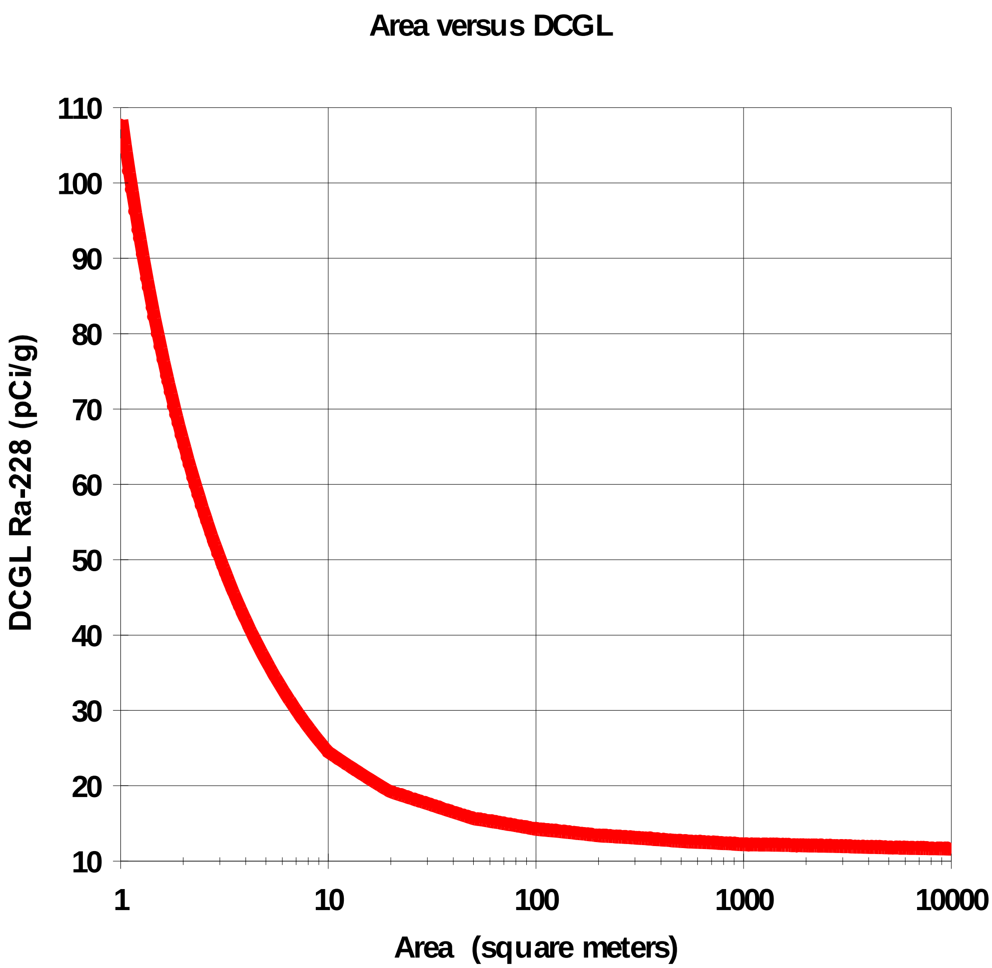


Figure B-7. Th-232 DCGLs for areas of 1 – 10,000 m^2 based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

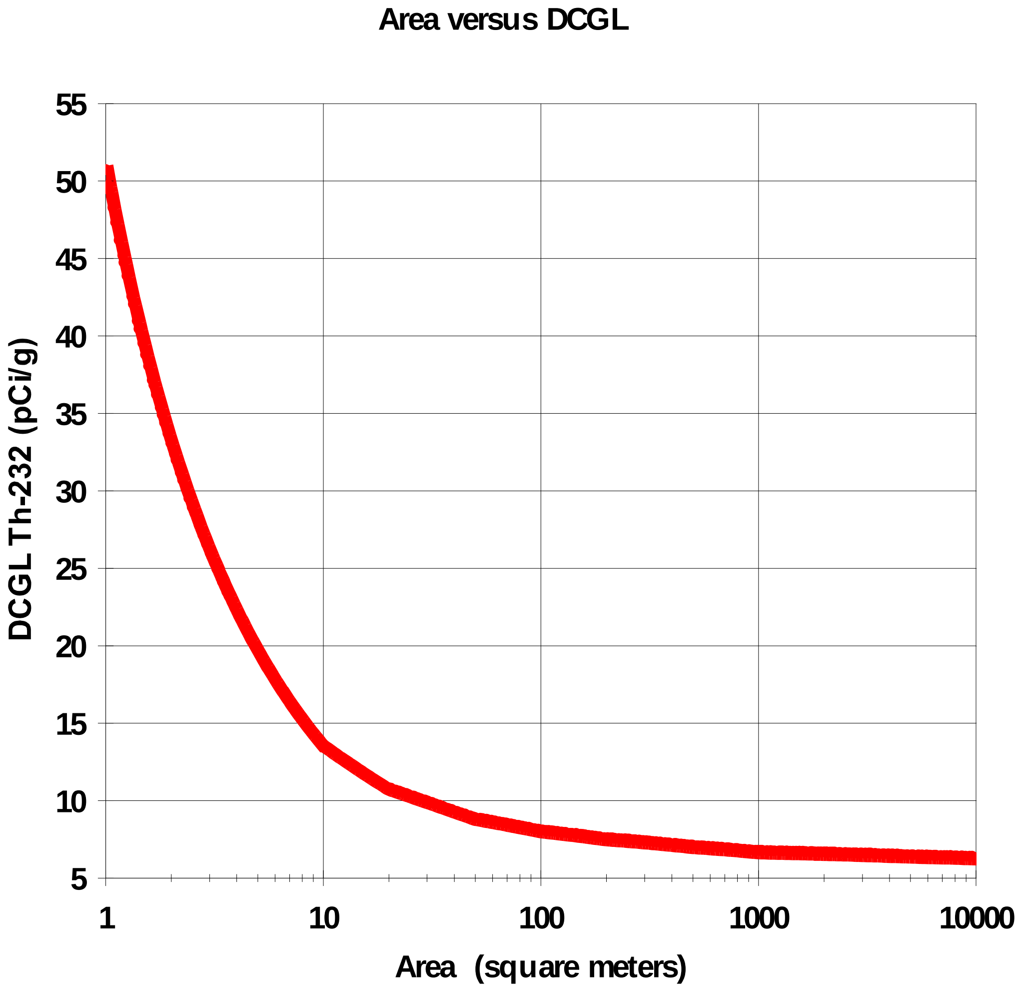


Figure B-8. Th-232+D DCGLs for areas of 1 – 10,000 m^2 based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

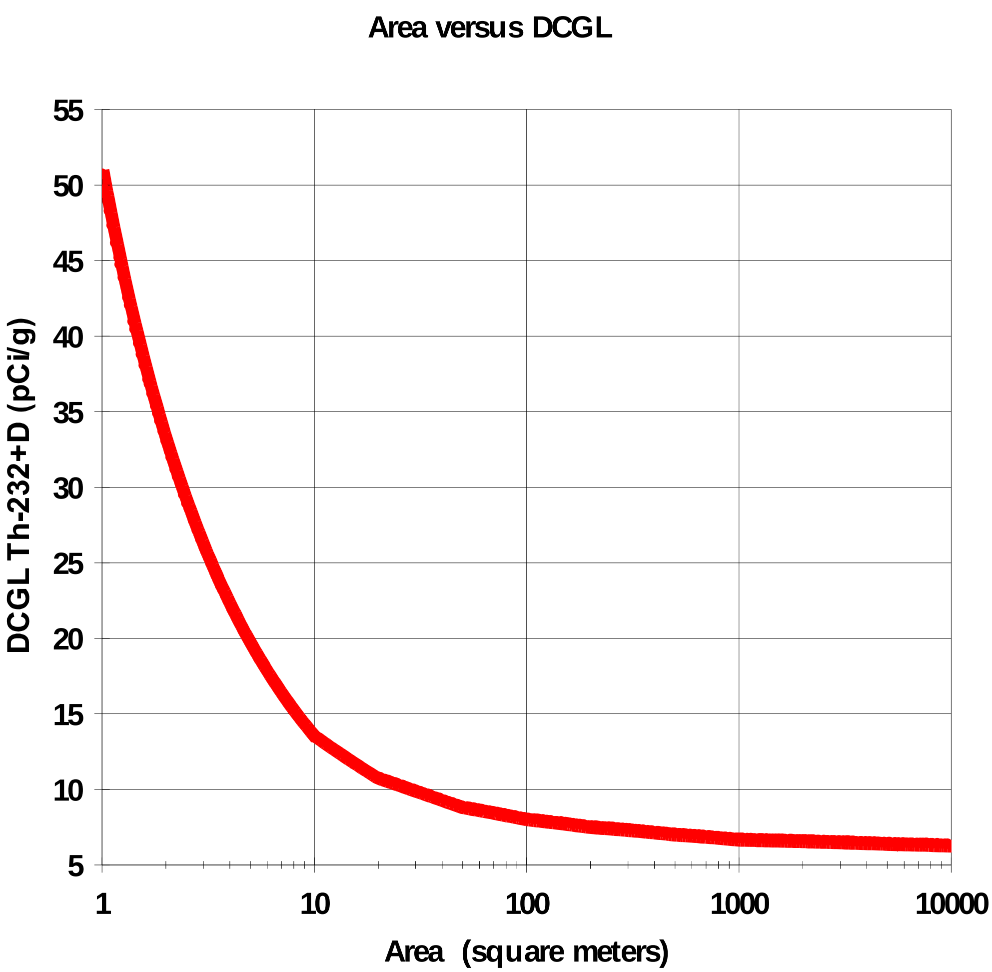


Figure B-9. Th-230 DCGLs for areas of 1 – 10,000 m^2 based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

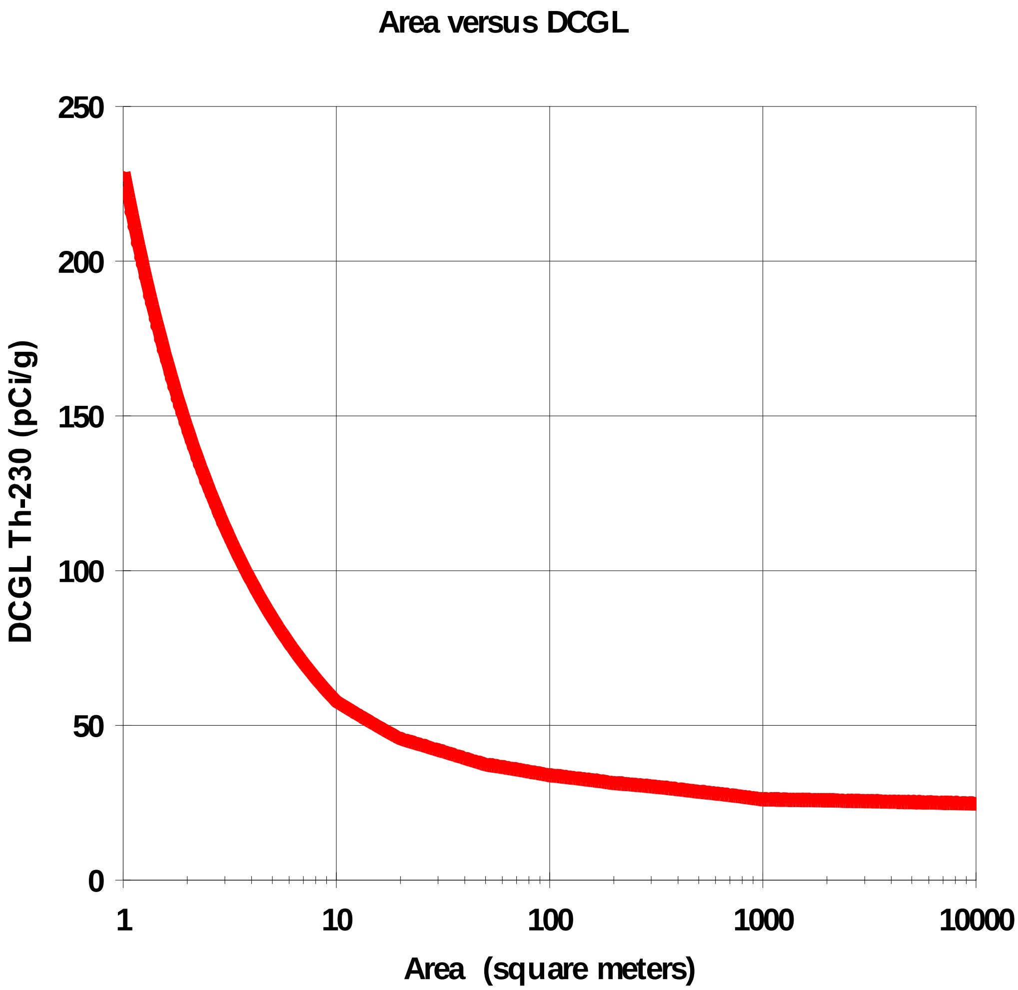


Figure B-10. Pb-210 DCGLs for areas of 1 – 10,000 m^2 based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

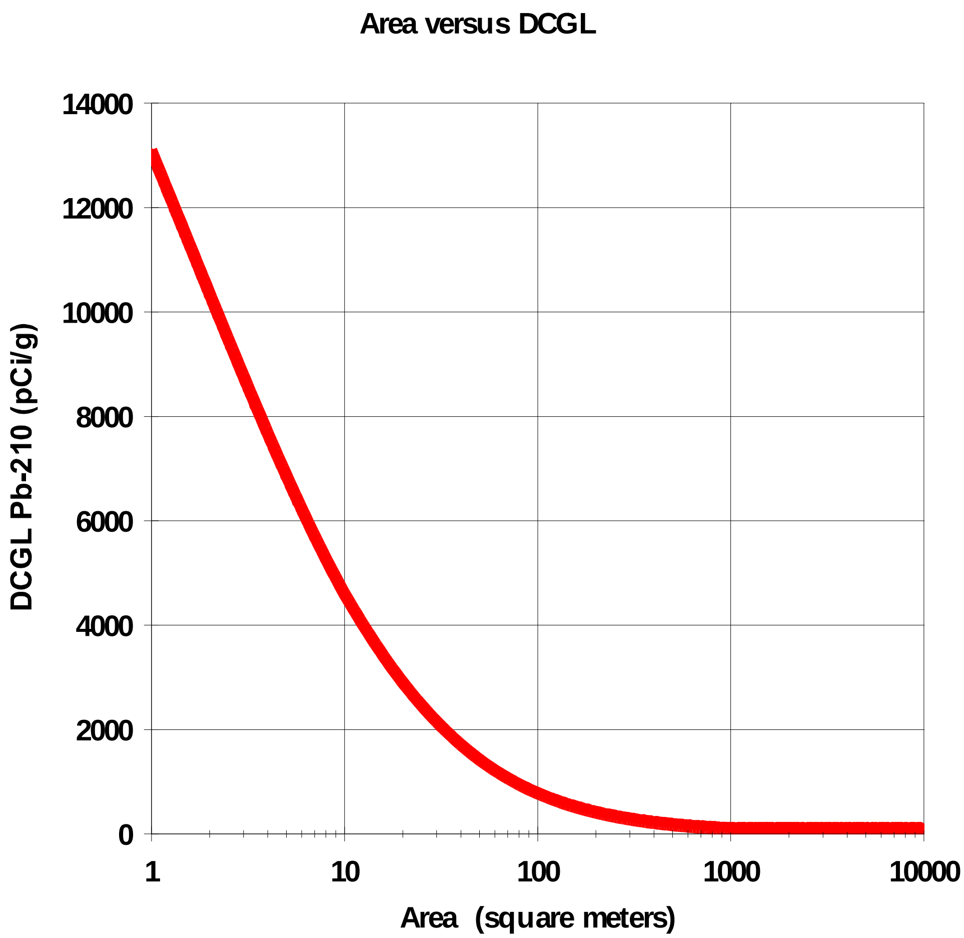


Figure B-11. Ra-226 DCGLs for areas of 1 – 10,000 m^2 based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).

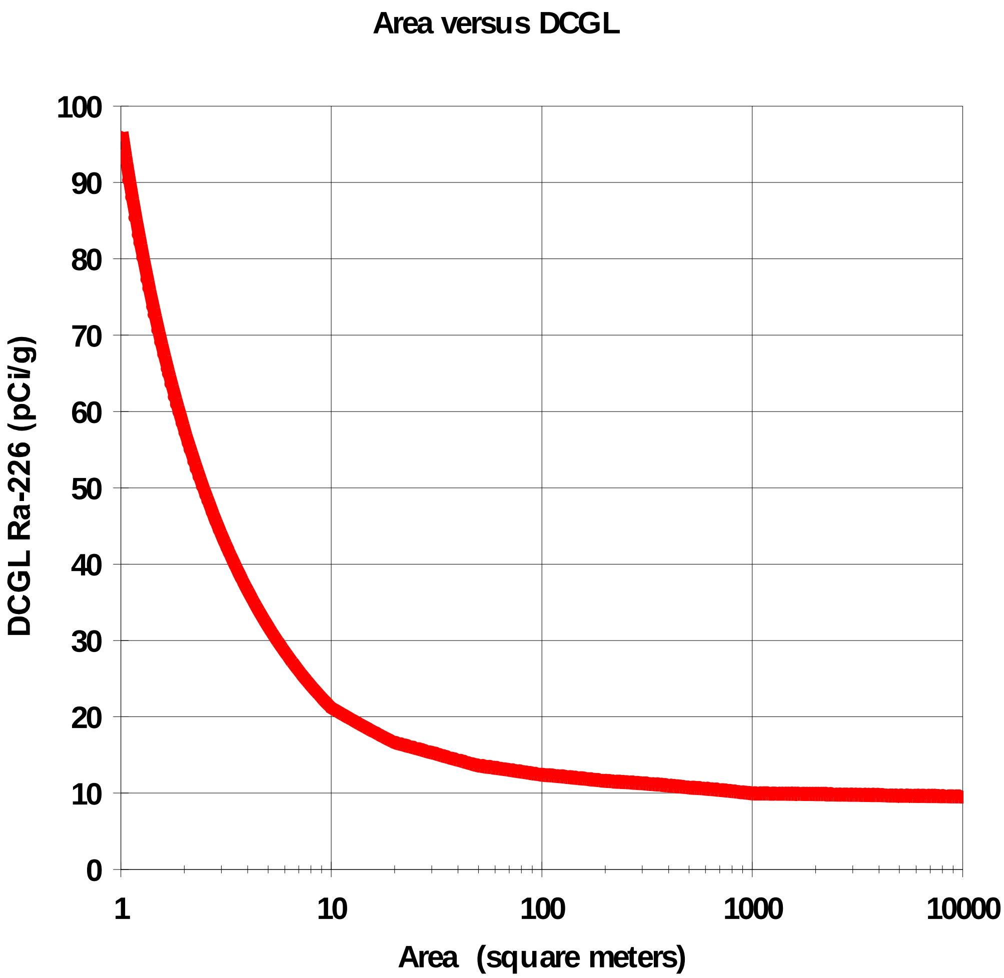
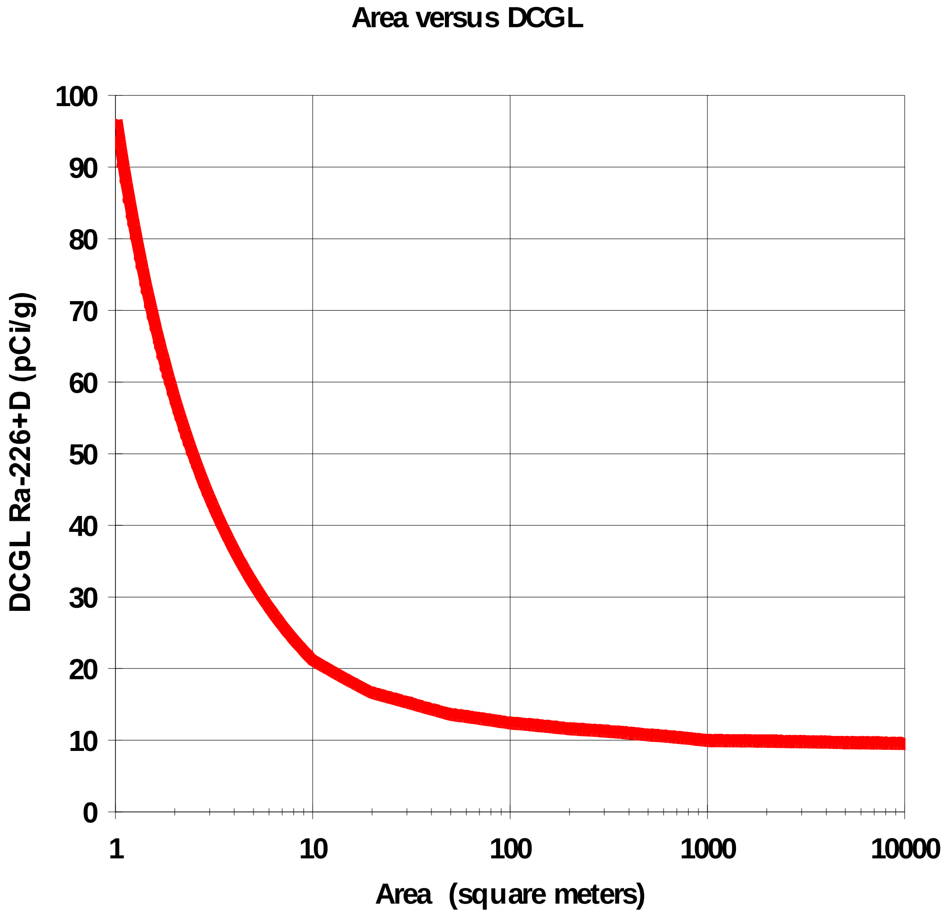


Figure B-12. Ra-226+D DCGLs for areas of 1 – 10,000 m^2 based on the construction worker scenario (external gamma, inhalation, soil ingestion), no plant, meat, milk, fish, water ingestion and no use of groundwater for irrigation or other purposes (25 mrem/yr dose limit).



B.2 REFERENCES
Construction Scenario Input:

B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.720E+00	6.720E+00	DCF2(1)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(2)
B-1	Pb-210+D	2.320E-02	2.320E-02	DCF2(3)
B-1	Ra-226+D	8.600E-03	8.600E-03	DCF2(4)
B-1	Ra-228+D	5.080E-03	5.080E-03	DCF2(5)
B-1	Th-228+D	3.450E-01	3.450E-01	DCF2(6)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(7)
B-1	Th-232	1.640E+00	1.640E+00	DCF2(8)
B-1	U-234	1.320E-01	1.320E-01	DCF2(9)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(10)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(11)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.480E-02	DCF3(1)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(2)
D-1	Pb-210+D	7.270E-03	7.270E-03	DCF3(3)
D-1	Ra-226+D	1.330E-03	1.330E-03	DCF3(4)
D-1	Ra-228+D	1.440E-03	1.440E-03	DCF3(5)
D-1	Th-228+D	8.080E-04	8.080E-04	DCF3(6)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(7)
D-1	Th-232	2.730E-03	2.730E-03	DCF3(8)
D-1	U-234	2.830E-04	2.830E-04	DCF3(9)
D-1	U-235+D	2.670E-04	2.670E-04	DCF3(10)
D-1	U-238+D	2.690E-04	2.690E-04	DCF3(11)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)

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 D-34 ³                                                          ³           ³           ³
 D-34 ³ Pa-231   , plant/soil concentration ratio, dimensionless    ³ 1.000E-02 ³ 1.000E-02 ³ RTF( 2,1)
 D-34 ³ Pa-231   , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)    ³ 5.000E-03 ³ 5.000E-03 ³ RTF( 2,2)
 D-34 ³ Pa-231   , milk/livestock-intake ratio, (pCi/L)/(pCi/d)     ³ 5.000E-06 ³ 5.000E-06 ³ RTF( 2,3)
 D-34 ³                                                          ³           ³           ³
 D-34 ³ Pb-210+D , plant/soil concentration ratio, dimensionless    ³ 1.000E-02 ³ 1.000E-02 ³ RTF( 3,1)
 D-34 ³ Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)    ³ 8.000E-04 ³ 8.000E-04 ³ RTF( 3,2)
 D-34 ³ Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)     ³ 3.000E-04 ³ 3.000E-04 ³ RTF( 3,3)
 D-34 ³                                                          ³           ³           ³
 D-34 ³ Ra-226+D , plant/soil concentration ratio, dimensionless    ³ 4.000E-02 ³ 4.000E-02 ³ RTF( 4,1)
 D-34 ³ Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)    ³ 1.000E-03 ³ 1.000E-03 ³ RTF( 4,2)
 D-34 ³ Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)     ³ 1.000E-03 ³ 1.000E-03 ³ RTF( 4,3)
 D-34 ³                                                          ³           ³           ³
 D-34 ³ Ra-228+D , plant/soil concentration ratio, dimensionless    ³ 4.000E-02 ³ 4.000E-02 ³ RTF( 5,1)
 D-34 ³ Ra-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)    ³ 1.000E-03 ³ 1.000E-03 ³ RTF( 5,2)
 D-34 ³ Ra-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)     ³ 1.000E-03 ³ 1.000E-03 ³ RTF( 5,3)
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 D-34 ³ Th-228+D , plant/soil concentration ratio, dimensionless    ³ 1.000E-03 ³ 1.000E-03 ³ RTF( 6,1)
 D-34 ³ Th-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)    ³ 1.000E-04 ³ 1.000E-04 ³ RTF( 6,2)
 D-34 ³ Th-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)     ³ 5.000E-06 ³ 5.000E-06 ³ RTF( 6,3)
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 D-34 ³ Th-230   , milk/livestock-intake ratio, (pCi/L)/(pCi/d)     ³ 5.000E-06 ³ 5.000E-06 ³ RTF( 7,3)
 D-34 ³                                                          ³           ³           ³
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D-34	Th-232 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(8,1)
D-34	Th-232 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(8,2)
D-34	Th-232 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(8,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(9,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(9,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(9,3)
D-34				
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(10,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(10,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(10,3)
D-34				
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(11,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(11,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(11,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(2,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(2,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(3,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(3,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(4,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(4,2)
D-5				
D-5	Ra-228+D , fish	5.000E+01	5.000E+01	BIOFAC(5,1)
D-5	Ra-228+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(5,2)
D-5				
D-5	Th-228+D , fish	1.000E+02	1.000E+02	BIOFAC(6,1)

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 D-5  ³ Th-228+D , crustacea and mollusks                       ³ 5.000E+02 ³ 5.000E+02 ³ BIOFAC( 6,2)
 D-5  ³                                                         ³           ³           ³
 D-5  ³ Th-230   , fish                                         ³ 1.000E+02 ³ 1.000E+02 ³ BIOFAC( 7,1)
 D-5  ³ Th-230   , crustacea and mollusks                       ³ 5.000E+02 ³ 5.000E+02 ³ BIOFAC( 7,2)
 D-5  ³                                                         ³           ³           ³
 D-5  ³ Th-232   , fish                                         ³ 1.000E+02 ³ 1.000E+02 ³ BIOFAC( 8,1)
 D-5  ³ Th-232   , crustacea and mollusks                       ³ 5.000E+02 ³ 5.000E+02 ³ BIOFAC( 8,2)
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 D-5  ³ U-234    , fish                                         ³ 1.000E+01 ³ 1.000E+01 ³ BIOFAC( 9,1)
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 D-5  ³                                                         ³           ³           ³
 D-5  ³ U-235+D  , fish                                         ³ 1.000E+01 ³ 1.000E+01 ³ BIOFAC(10,1)
 D-5  ³ U-235+D  , crustacea and mollusks                       ³ 6.000E+01 ³ 6.000E+01 ³ BIOFAC(10,2)
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 D-5  ³ U-238+D  , fish                                         ³ 1.000E+01 ³ 1.000E+01 ³ BIOFAC(11,1)
 D-5  ³ U-238+D  , crustacea and mollusks                       ³ 6.000E+01 ³ 6.000E+01 ³ BIOFAC(11,2)
 ÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
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                                                        Site-Specific Parameter Summary
0     ³                                              ³   User    ³           ³         Used by RESRAD         ³  Parameter
 Menu ³                     Parameter                ³   Input   ³  Default  ³ (If different from user input) ³    Name
 ÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 R011 ³ Area of contaminated zone (m**2)             ³ 1.000E+04 ³ 1.000E+04 ³              ---               ³ AREA
```

R011	Thickness of contaminated zone (m)	2.000E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	not used	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Pb-210	1.000E+00	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g): Ra-226	1.000E+00	0.000E+00	---	S1(4)
R012	Initial principal radionuclide (pCi/g): Ra-228	1.000E+00	0.000E+00	---	S1(5)
R012	Initial principal radionuclide (pCi/g): Th-228	1.000E+00	0.000E+00	---	S1(6)
R012	Initial principal radionuclide (pCi/g): Th-230	1.000E+00	0.000E+00	---	S1(7)
R012	Initial principal radionuclide (pCi/g): Th-232	1.000E+00	0.000E+00	---	S1(8)
R012	Initial principal radionuclide (pCi/g): U-234	1.000E+00	0.000E+00	---	S1(9)
R012	Initial principal radionuclide (pCi/g): U-235	1.000E+00	0.000E+00	---	S1(10)
R012	Initial principal radionuclide (pCi/g): U-238	1.000E+00	0.000E+00	---	S1(11)
R012	Concentration in groundwater (pCi/L): Pb-210	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(4)
R012	Concentration in groundwater (pCi/L): Ra-228	not used	0.000E+00	---	W1(5)
R012	Concentration in groundwater (pCi/L): Th-228	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): Th-230	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): Th-232	not used	0.000E+00	---	W1(8)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(9)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(10)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(11)

R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.800E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	6.000E-05	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	3.100E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	1.500E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	3.470E+00	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP

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0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ

R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Ac-227				
R016	Contaminated zone (cm**3/g)	2.400E+03	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	not used	2.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	not used	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	5.787E-05	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Pa-231				
R016	Contaminated zone (cm**3/g)	2.700E+03	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	5.144E-05	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for Pb-210				
R016	Contaminated zone (cm**3/g)	5.500E+02	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.525E-04	ALEACH(3)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)

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Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	9.100E+03	7.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.526E-05	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for Ra-228				
R016	Contaminated zone (cm**3/g)	9.100E+03	7.000E+01	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.526E-05	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R016	Distribution coefficients for Th-228				
R016	Contaminated zone (cm**3/g)	5.800E+03	6.000E+04	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU(6,1)
R016	Saturated zone (cm**3/g)	not used	6.000E+04	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.395E-05	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for Th-230				
R016	Contaminated zone (cm**3/g)	5.800E+03	6.000E+04	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU(7,1)
R016	Saturated zone (cm**3/g)	not used	6.000E+04	---	DCNUCS(7)

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 R016 ³   Leach rate (/yr)                                  ³ 0.000E+00 ³ 0.000E+00 ³           2.395E-05            ³ ALEACH( 7)
 R016 ³   Solubility constant                               ³ 0.000E+00 ³ 0.000E+00 ³           not used             ³ SOLUBK( 7)
      ³                                                     ³           ³           ³                                ³
 R016 ³ Distribution coefficients for Th-232                ³           ³           ³                                ³
 R016 ³   Contaminated zone (cm**3/g)                       ³ 5.800E+03 ³ 6.000E+04 ³              ---               ³ DCNUCC( 8)
 R016 ³   Unsaturated zone 1 (cm**3/g)                      ³ not used  ³ 6.000E+04 ³              ---               ³ DCNUCU( 8,1)
 R016 ³   Saturated zone (cm**3/g)                          ³ not used  ³ 6.000E+04 ³              ---               ³ DCNUCS( 8)
 R016 ³   Leach rate (/yr)                                  ³ 0.000E+00 ³ 0.000E+00 ³           2.395E-05            ³ ALEACH( 8)
 R016 ³   Solubility constant                               ³ 0.000E+00 ³ 0.000E+00 ³           not used             ³ SOLUBK( 8)
      ³                                                     ³           ³           ³                                ³
 R016 ³ Distribution coefficients for U-234                 ³           ³           ³                                ³
 R016 ³   Contaminated zone (cm**3/g)                       ³ 1.600E+03 ³ 5.000E+01 ³              ---               ³ DCNUCC( 9)
 R016 ³   Unsaturated zone 1 (cm**3/g)                      ³ not used  ³ 5.000E+01 ³              ---               ³ DCNUCU( 9,1)
 R016 ³   Saturated zone (cm**3/g)                          ³ not used  ³ 5.000E+01 ³              ---               ³ DCNUCS( 9)
 R016 ³   Leach rate (/yr)                                  ³ 0.000E+00 ³ 0.000E+00 ³           8.680E-05            ³ ALEACH( 9)
 R016 ³   Solubility constant                               ³ 0.000E+00 ³ 0.000E+00 ³           not used             ³ SOLUBK( 9)
      ³                                                     ³           ³           ³                                ³
 R016 ³ Distribution coefficients for U-235                 ³           ³           ³                                ³
 R016 ³   Contaminated zone (cm**3/g)                       ³ 1.600E+03 ³ 5.000E+01 ³              ---               ³ DCNUCC(10)
 R016 ³   Unsaturated zone 1 (cm**3/g)                      ³ not used  ³ 5.000E+01 ³              ---               ³ DCNUCU(10,1)
 R016 ³   Saturated zone (cm**3/g)                          ³ not used  ³ 5.000E+01 ³              ---               ³ DCNUCS(10)
 R016 ³   Leach rate (/yr)                                  ³ 0.000E+00 ³ 0.000E+00 ³           8.680E-05            ³ ALEACH(10)
 R016 ³   Solubility constant                               ³ 0.000E+00 ³ 0.000E+00 ³           not used             ³ SOLUBK(10)
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                                    Site-Specific Parameter Summary (continued)
0     ³                                                     ³   User    ³           ³         Used by RESRAD         ³  Parameter
 Menu ³                      Parameter                      ³   Input   ³  Default  ³ (If different from user input) ³    Name
 ÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 R016 ³ Distribution coefficients for U-238                 ³           ³           ³                                ³
 R016 ³   Contaminated zone (cm**3/g)                       ³ 1.600E+03 ³ 5.000E+01 ³              ---               ³ DCNUCC(11)
 R016 ³   Unsaturated zone 1 (cm**3/g)                      ³ not used  ³ 5.000E+01 ³              ---               ³ DCNUCU(11,1)
```

R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(11)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	8.680E-05	ALEACH(11)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(11)
R017	Inhalation rate (m**3/yr)	7.300E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	6.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	1.000E+00	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	4.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E-00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.280E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)

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 R017 ³   Ring  7                                    ³ not used  ³ 0.000E+00 ³              ---              ³ FRACA( 7)
 R017 ³   Ring  8                                    ³ not used  ³ 0.000E+00 ³              ---              ³ FRACA( 8)
 R017 ³   Ring  9                                    ³ not used  ³ 0.000E+00 ³              ---              ³ FRACA( 9)
 R017 ³   Ring 10                                    ³ not used  ³ 0.000E+00 ³              ---              ³ FRACA(10)
 R017 ³   Ring 11                                    ³ not used  ³ 0.000E+00 ³              ---              ³ FRACA(11)
 R017 ³   Ring 12                                    ³ not used  ³ 0.000E+00 ³              ---              ³ FRACA(12)
      ³                                              ³           ³           ³                               ³
 R018 ³ Fruits, vegetables and grain consumption (kg/yr) ³ not used  ³ 1.600E+02 ³              ---              ³ DIET(1)
 R018 ³ Leafy vegetable consumption (kg/yr)          ³ not used  ³ 1.400E+01 ³              ---              ³ DIET(2)
 R018 ³ Milk consumption (L/yr)                      ³ not used  ³ 9.200E+01 ³              ---              ³ DIET(3)
 R018 ³ Meat and poultry consumption (kg/yr)         ³ not used  ³ 6.300E+01 ³              ---              ³ DIET(4)
 R018 ³ Fish consumption (kg/yr)                     ³ not used  ³ 5.400E+00 ³              ---              ³ DIET(5)
 R018 ³ Other seafood consumption (kg/yr)            ³ not used  ³ 9.000E-01 ³              ---              ³ DIET(6)
 R018 ³ Soil ingestion rate (g/yr)                   ³ 1.752E+02 ³ 3.650E+01 ³              ---              ³ SOIL
 R018 ³ Drinking water intake (L/yr)                 ³ not used  ³ 5.100E+02 ³              ---              ³ DWI
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0     ³                                              ³   User    ³           ³         Used by RESRAD        ³  Parameter
 Menu ³                    Parameter                 ³   Input   ³  Default  ³ (If different from user input) ³    Name
 ÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄ
 R018 ³ Contamination fraction of drinking water     ³ not used  ³ 1.000E+00 ³              ---              ³ FDW
 R018 ³ Contamination fraction of household water    ³ not used  ³ 1.000E+00 ³              ---              ³ FHHW
 R018 ³ Contamination fraction of livestock water    ³ not used  ³ 1.000E+00 ³              ---              ³ FLW
 R018 ³ Contamination fraction of irrigation water   ³ not used  ³ 1.000E+00 ³              ---              ³ FIRW
 R018 ³ Contamination fraction of aquatic food       ³ not used  ³ 5.000E-01 ³              ---              ³ FR9
 R018 ³ Contamination fraction of plant food         ³ not used  ³-1         ³              ---              ³ FPLANT
 R018 ³ Contamination fraction of meat               ³ not used  ³-1         ³              ---              ³ FMEAT
 R018 ³ Contamination fraction of milk               ³ not used  ³-1         ³              ---              ³ FMILK
      ³                                              ³           ³           ³                               ³
 R019 ³ Livestock fodder intake for meat (kg/day)    ³ not used  ³ 6.800E+01 ³              ---              ³ LFI5
 R019 ³ Livestock fodder intake for milk (kg/day)    ³ not used  ³ 5.500E+01 ³              ---              ³ LFI6
```

R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC

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 C14  ³ C-14 evasion flux rate from soil (1/sec)         ³ not used  ³ 7.000E-07 ³              ---              ³ EVSN
 C14  ³ C-12 evasion flux rate from soil (1/sec)         ³ not used  ³ 1.000E-10 ³              ---              ³ REVSN
 C14  ³ Fraction of grain in beef cattle feed            ³ not used  ³ 8.000E-01 ³              ---              ³ AVFG4
 C14  ³ Fraction of grain in milk cow feed               ³ not used  ³ 2.000E-01 ³              ---              ³ AVFG5
 C14  ³ DCF correction factor for gaseous forms of C14   ³ not used  ³ 8.894E+01 ³              ---              ³ CO2F
      ³                                                  ³           ³           ³                               ³
 STOR ³ Storage times of contaminated foodstuffs (days): ³           ³           ³                               ³
1RESRAD, Version Beta     T« Limit = 0.5 year        06/21/2004  13:32  Page  10
 Summary : RESRAD Default Parameters                   File: painesville_con.RAD

                                    Site-Specific Parameter Summary (continued)
0     ³                                                  ³   User    ³           ³         Used by RESRAD        ³  Parameter
 Menu ³                    Parameter                     ³   Input   ³  Default  ³ (If different from user input) ³    Name
 ÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 STOR ³   Fruits, non-leafy vegetables, and grain        ³ 1.400E+01 ³ 1.400E+01 ³              ---              ³ STOR_T(1)
 STOR ³   Leafy vegetables                               ³ 1.000E+00 ³ 1.000E+00 ³              ---              ³ STOR_T(2)
 STOR ³   Milk                                           ³ 1.000E+00 ³ 1.000E+00 ³              ---              ³ STOR_T(3)
 STOR ³   Meat and poultry                               ³ 2.000E+01 ³ 2.000E+01 ³              ---              ³ STOR_T(4)
 STOR ³   Fish                                           ³ 7.000E+00 ³ 7.000E+00 ³              ---              ³ STOR_T(5)
 STOR ³   Crustacea and mollusks                         ³ 7.000E+00 ³ 7.000E+00 ³              ---              ³ STOR_T(6)
 STOR ³   Well water                                     ³ 1.000E+00 ³ 1.000E+00 ³              ---              ³ STOR_T(7)
 STOR ³   Surface water                                  ³ 1.000E+00 ³ 1.000E+00 ³              ---              ³ STOR_T(8)
 STOR ³   Livestock fodder                               ³ 4.500E+01 ³ 4.500E+01 ³              ---              ³ STOR_T(9)
      ³                                                  ³           ³           ³                               ³
 R021 ³ Thickness of building foundation (m)             ³ not used  ³ 1.500E-01 ³              ---              ³ FLOOR1
 R021 ³ Bulk density of building foundation (g/cm**3)    ³ not used  ³ 2.400E+00 ³              ---              ³ DENSFL
 R021 ³ Total porosity of the cover material             ³ not used  ³ 4.000E-01 ³              ---              ³ TPCV
 R021 ³ Total porosity of the building foundation        ³ not used  ³ 1.000E-01 ³              ---              ³ TPFL
 R021 ³ Volumetric water content of the cover material   ³ not used  ³ 5.000E-02 ³              ---              ³ PH2OCV
 R021 ³ Volumetric water content of the foundation       ³ not used  ³ 3.000E-02 ³              ---              ³ PH2OFL
 R021 ³ Diffusion coefficient for radon gas (m/sec):     ³           ³           ³                               ³
 R021 ³   in cover material                              ³ not used  ³ 2.000E-06 ³              ---              ³ DIFCV
 R021 ³   in foundation material                         ³ not used  ³ 3.000E-07 ³              ---              ³ DIFFL
```

R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX