TABLE OF CONTENTS

Section **Page**

TABLE OF CONTENTS i

LIST OF FIGURES ii

ACRONYMS AND ABBREVIATIONS iii

6.0 ENVIRONMENTAL INFORMATION 6-1
- 6.1 Wetlands And Surface Water 6-1
  - 6.1.1 Wetlands 6-1
  - 6.1.2 Surface Water 6-1
- 6.2 Threatened And Endangered Species 6-2
- 6.3 Cultural Resources Management 6-3
- 6.4 References For Chapter 6.0 6-4

LIST OF FIGURES

Figure No.	Title
6-1	Surface Water Features And Flood Boundaries
6-2	Surface Water Features

ACRONYMS AND ABBREVIATIONS

ER	Environmental Report
HAER	Historic American Engineering Record
NRC	United States Nuclear Regulatory Commission

6.0 ENVIRONMENTAL INFORMATION

Westinghouse performed an evaluation of potential environmental impacts associated with remaining decommissioning activities and license termination. As detailed further in the Hematite Environmental Report (ER) (Reference 6-1), this evaluation demonstrates that site decommissioning activities and license termination will not have a significant adverse impact on the environment. The ER was written to include the environmental information described in NUREG–1748, (Reference 6-2).

6.1 WETLANDS AND SURFACE WATER

Jurisdictional wetlands and surface water issues will be taken into consideration during decommissioning remediation operations and activities. Additional information regarding wetlands and surface water issues is provided in the ER.

6.1.1 WETLANDS

In preparation for the site remediation investigation, a wetland and surface water assessment was conducted in November 2003, to delineate and classify potential jurisdictional wetlands and surface water bodies at the Hematite Site. The single potential wetland identified on the site is located in a small depression south of the facility buildings, between the railroad berm and a gravel road that goes from the vicinity of the facility buildings south towards Joachim Creek (See Figure 6-1 and Figure 3-23 [Chapter 3]). This potential wetland is a small, isolated forested/scrub area confined to the south and southwest by the gravel road, and to the north by the railroad berm. There are no inputs or outputs to the area, and hydrology appears to be the result of precipitation which collects between the road and railroad.

6.1.2 SURFACE WATER

Five intermittent tributaries (North Lake Tributary, East Lake Tributary, Northeast Site Creek, Site Creek, and Lake Virginia/Site Creek Tributary) and one perennial stream (Joachim Creek) flow across or run adjacent to the site (see Figure 6-2). A lake and a pond (East Lake and Site Pond) are also on the property. These water resources, just as wetlands, are under the jurisdiction of the federal government and the State of Missouri.

The Site Creek/Pond and the Northeast Site Creek could potentially require remediation to remove contamination in sediment and nearby soil. The effect remediation activities may have on these surface water features are discussed in Section 8.5.

6.2 THREATENED AND ENDANGERED SPECIES

A letter dated December 10, 2004 from the U.S. Fish and Wildlife Service (Reference 6-3) states that "...no federally listed, proposed or candidate species or critical habitat occurs on or near the project site..." Observations made during pedestrian surveys of the central site tract indicate that it contains neither sensitive nor unique ecological resources, nor the types of habitat to support these resources. Additional information relative to threatened and endangered species is provided in the ER.

6.3 CULTURAL RESOURCES MANAGEMENT

Historic and cultural resources (including prehistoric or historic sites, buildings, districts, structures and objects) are protected under the National Historic Preservation Act (Reference 6-4), Executive Order 11593—Protection and Enhancement of the Cultural Environment, the Archaeological and Historic Preservation Act (Reference 6-5), and the Historic Sites Act (Reference 6-6). These regulations require federal agencies take into account the effects of their actions (including permitting and licensing activities) on potential historic or cultural resources, and if necessary, resolve potential impact issues with appropriate state and federal agencies.

The historical significance of the Hematite facility relates to the role the facility filled during the "Cold War" era. From 1956 to 1974 the Hematite facility supplied high-enriched nuclear fuel for the U.S. Navy nuclear submarine program and other reactor programs. The Hematite facility was also the first privately owned and operated uranium fuel production plant in the United States.

Plans for removal of facility buildings are discussed in Section 8.2. The United States Nuclear Regulatory Commission (NRC) approved removal of the above-grade portion of site buildings in 2006. The plan to remove these buildings would result in the permanent loss of these buildings from the historical record. Due to the potential historical significance and the proposed impacts to these buildings, the National Park Service and State Historic Preservation Officer required a Historic American Engineering Record (HAER) be compiled for each of the buildings at the facility.

The HAER process has been completed for the site, including photographic documentation of both the process equipment and buildings (HAER file No. MO-113, Reference 6-7). The National Park Service provided review and approval of the HAER (Reference 6-8). The completion of the HAER adequately documents the historical resources and satisfies the requirements of Section 106 of the National Historic Preservation Act. Additional information relative to cultural resources management is provided in the ER.

6.4 REFERENCES FOR CHAPTER 6.0

6-1 Westinghouse Electric Company Document No. DO-08-009, "Environmental Report."

6-2 U.S. Nuclear Regulatory Commission, NUREG-1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs," August 2003.

6-3 U. S. Department of the Interior, Fish and Wildlife Services, Letter from C. Scott (U.S. FWS) to A. Kouhestani (NRC), dated December 10, 2004.

6-4 Code of Federal Regulations, Title 16, Parts 470a-470w, "National Historic Preservation Act."

6-5 Code of Federal Regulations, Title 16, Parts 469-469c, "Archeological And Historic Preservation Act."

6-6 Code of Federal Regulations, Title 16, Parts 461-467, "Historic Sites Act."

6-7 Westinghouse Electric Company, HAER No. MO-113, "Historic American Engineering Record, Hematite Facility," 2003.

6-8 U.S. Department of the Interior, National Park Service, Letter from Rachel Franklin Weekley (Architectural Historian) to Dr. Steve J. Dasovitch (SCI Engineering, Inc.), dated December 17, 2008.

Figure 6-1

Surface Water Features And Flood Boundaries

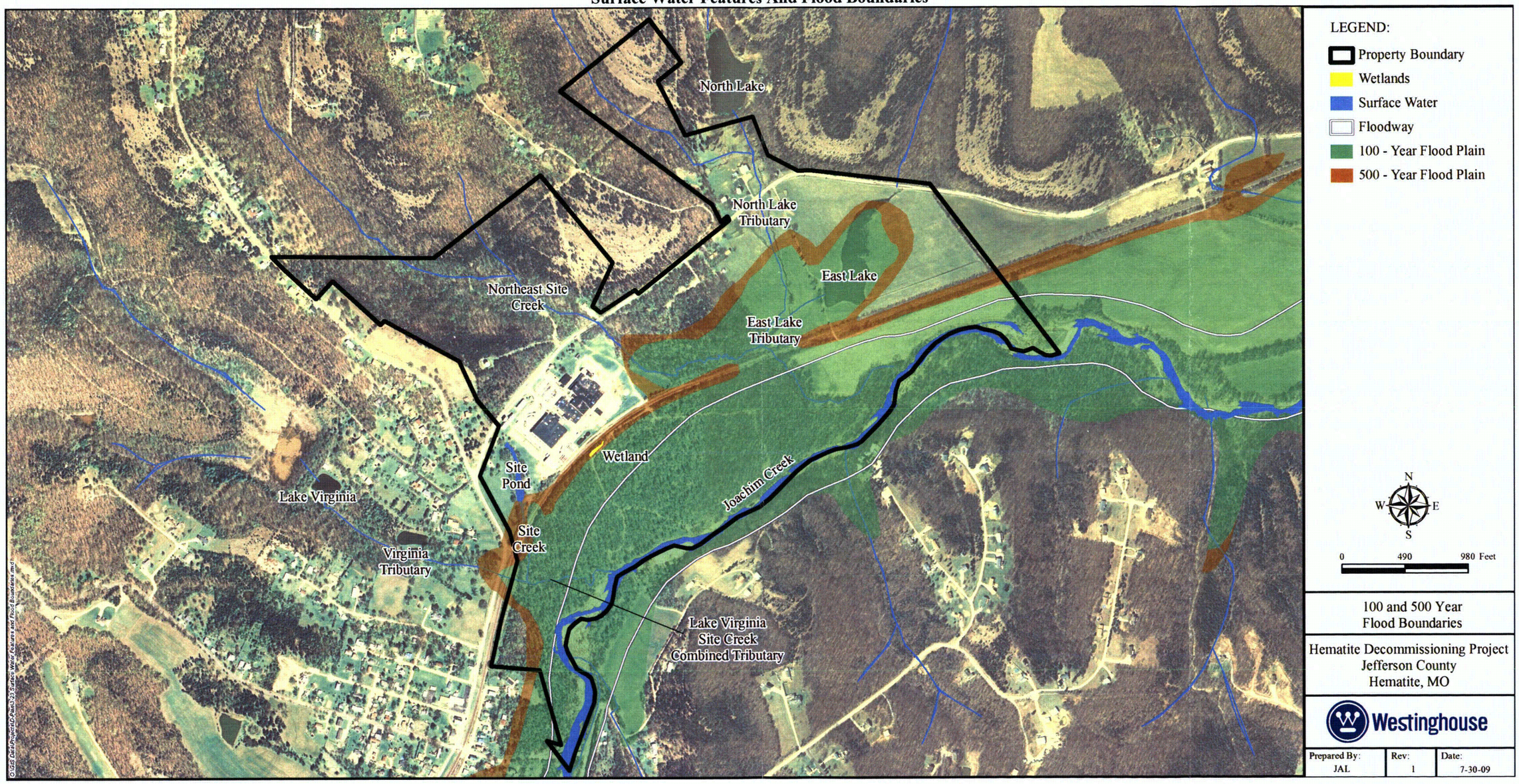

Figure 6-2

Surface Water Features

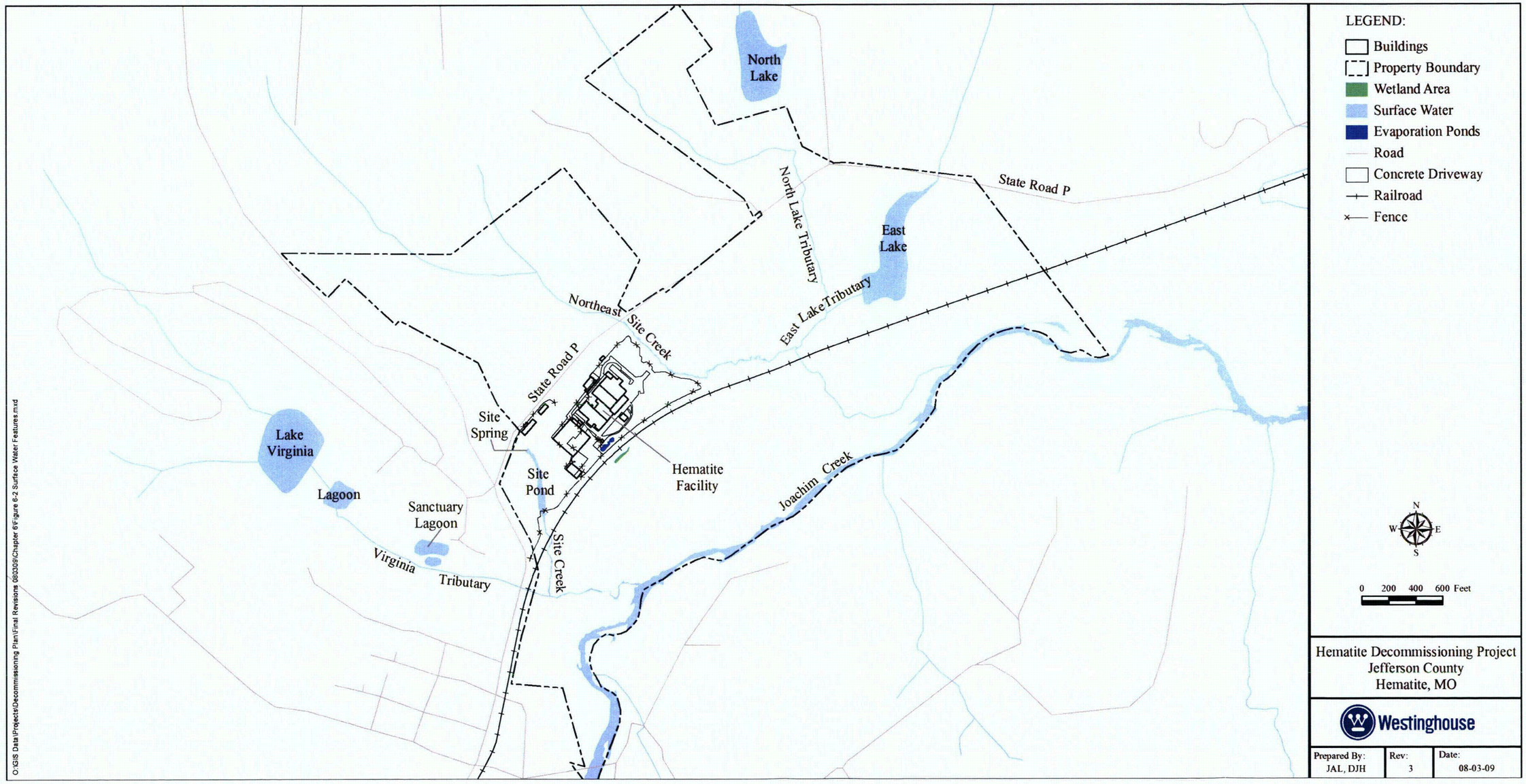

TABLE OF CONTENTS

Section **Page**

TABLE OF CONTENTS i

LIST OF TABLES ii

ACRONYMS AND ABBREVIATIONS iii

7.0 ALARA Analysis 7-1
- 7.1 Determination Of Benefits 7-3
  - 7.1.1 Collective Dose Averted 7-3
  - 7.1.2 Regulatory Cost Avoided 7-3
  - 7.1.3 Changes In Land Value 7-3
  - 7.1.4 Aesthetics 7-3
- 7.2 Description Of How Costs Were Estimated 7-4
- 7.3 ALARA Residual Radioactivity Levels – Soil 7-8
- 7.4 ALARA Residual Radioactivity Levels – Building Surfaces 7-10
  - 7.4.1 ALARA Analysis - Washing Building Surfaces 7-11
  - 7.4.2 ALARA Analysis - Scabbling Building Surfaces 7-13
- 7.5 Conclusion 7-15
- 7.6 References For Chapter 7.0 7-16

LIST OF TABLES

Table No.	Title
7-1	Possible Benefits And Costs Related To Decommissioning
7-2	ALARA Calculations – Soil
7-3	Remaining Building Geometry (Building 110, Building 230 And Building 231)
7-4	ALARA Cost Analysis Parameters For Building Surfaces
7-5	ALARA Calculations - Building Surfaces

ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
CFR	Code Of Federal Regulations
cm^2	square centimeters
DCGL	Derived Concentration Guideline Level
dpm	disintegration per minute
ft	foot
ft^2	square foot
HDP	Hematite Decommissioning Project
hr	hour
km	kilometer
m^2	square meters
m^3	cubic meters
mrem/yr	millirem per year
mSv	milliSieverts (1 mSv = 100 mrem)
NRC	Nuclear Regulatory Commission
pCi/g	picoCuries per gram
rem	Roentgen equivalent man
rem/yr	Roentgen equivalent man per year
TEDE	Total Effective Dose Equivalent
U	Uranium
WEC	Westinghouse Electric Company LLC
yr	year

7.0 ALARA ANALYSIS

This chapter provides the methods, results and conclusions of an As Low As Reasonably Achievable (ALARA) analysis for the soils and building surface criteria developed for use at the Hematite Decommissioning Project (HDP).

The ALARA criteria are provided in the Code of Federal Regulations (CFR), 10 CFR 20.1402 (Reference 7-1), which states:

> *"A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). Determination of the levels which are ALARA must take into account consideration of any detriments, such as deaths from transportation accidents, expected to potentially result from decontamination and waste disposal."*

In order to demonstrate the Hematite Site meets these requirements for site release, site-specific release criteria or derived concentration guideline levels (DCGLs) were developed using dose modeling, as described in Chapter 5. The established DCGLs, as described in Chapter 5, represent the radionuclide specific release criteria, that when met will ensure regulatory dose limits are satisfied.

Based on the HDP objective to remediate to unrestricted release criteria, and use appropriate dose modeling as described in Chapter 5 to relate concentration to dose, Section N.1.5, Appendix N of NUREG-1757, Volume 2 (Reference 7-2) is applicable:

> *"In certain circumstances, the results of an ALARA analysis are known on a generic basis and an analysis is not necessary. For residual radioactivity in soil at sites that may have unrestricted release, generic analyses show that shipping soil to a low-level waste disposal facility is unlikely to be cost effective for unrestricted release, largely because of the high costs of waste disposal. Therefore, shipping soil to a low-level waste disposal facility generally does not have to be evaluated for unrestricted release."*

As indicated by this statement, the results of an ALARA analysis for soils are "known on a generic basis and an analysis is not necessary." However, because Westinghouse Electric Company LLC (WEC) is committed to the ALARA philosophy, a simplified analysis has been performed to ensure compliance with ALARA principles.

NUREG-1757, Volume 2, Appendix N provides information outlining a simplified method to estimate when a proposed remediation guideline is cost effective. Possible benefits, as well as possible costs, are identified and compared. If the benefits from the remedial action are greater than the cost of the action, the remediation action is considered cost-effective and should be performed. Conversely, if the benefits are less than the cost, the level of residual radioactivity is considered to be ALARA, without taking additional remediation action. A list of possible benefits and costs to be considered in the analysis is provided in Table 7-1. The simplified ALARA analysis was conducted to demonstrate that the dose from residual radioactivity in soil is ALARA, satisfying the established dose criteria in 10 CFR 20, Subpart E (Reference 7-3).

A simplified ALARA analysis was also conducted for building surfaces. Based on the analysis results and WEC's commitment to ALARA, WEC will use typical good-practice construction efforts such as job-site cleanliness as part of the decommissioning process.

This analysis has been performed in accordance with Appendix N of NUREG-1757. However, at the time of preparation of this ALARA analysis the Nuclear Regulatory Commission (NRC) had withdrawn some sections of Appendix N, without providing interim guidance for replacement of the items removed. The withdrawal of portions of Appendix N was published in the "Federal Register Volume 72, No. 158, Page 46102" (Reference 7-4) on August 16, 2007. Specifically, the values for 'r', "monetary discount rate for dose averted" were withdrawn. Assumptions made to complete this analysis are noted in sections that follow.

The calculations shown in the following sections are based on conservative, low-end estimates of waste volume and cost per unit volume of waste. The results of calculations based on estimates of soil volume and typical unit volume costs, are summarized in Table 7-2.

7.1 DETERMINATION OF BENEFITS

7.1.1 COLLECTIVE DOSE AVERTED

As indicated above, remediation of site soils to levels that meet the unrestricted release criteria in 10 CFR 20, Subpart E, demonstrates those levels are ALARA. Therefore, calculation of collective dose averted is not required. However, collective dose costs are considered in the ALARA calculations below (Sections 7.3 and 7.4).

7.1.2 REGULATORY COST AVOIDED

Based on the Hematite Site objective to remediate to unrestricted release, costs which may be associated with restricted release (e.g., licensing fees, financial assurance costs, costs associated with public meetings or the community review committee, future liability costs, etc.) are avoided. Therefore, such costs are not taken into account in this analysis.

7.1.3 CHANGES IN LAND VALUE

Because of the relatively low land values in the Hematite vicinity and the small portion of the site assigned to industrial uses, the potential land value benefit is assumed to be small and was not considered.

7.1.4 AESTHETICS

Following removal of contaminated soil during remediation, the excavation will be refilled and contoured to the surroundings, including restoration of vegetation for erosion control. However, if a decision was made to remediate below the DCGL value, an increasing quantity of previously undisturbed land might be disrupted and removed. This additional remedial action would increase the overall environmental disturbance of the land, resulting in either no benefit, or an adverse aesthetics benefit.

7.2 DESCRIPTION OF HOW COSTS WERE ESTIMATED

Information regarding disposal costs, waste transportation and guidance in NUREG-1757, Volume 2, Appendix N was used to estimate total costs. The determination of costs does not include environmental impacts and loss of economic use of the site/facility, which need not be considered for the Hematite Site objective of remediation to unrestricted release criteria found in Code of Federal Regulations Title 10, Part 20. This level of remediation ensures the site will be available for any future proposed activity, thus preventing the loss of economic use. Additionally, land contours and vegetation will be restored following site remediation, for the purpose of erosion control. Because these costs are incurred regardless of the remediation method, they were excluded.

The calculations in the following sections are based on conservative, low-end estimates of waste volume and cost per unit volume of waste. Additional calculations for soil waste were performed using middle and high-end estimates of waste volume and a typical cost per unit volume, and are summarized in Table 7-2.

The total cost of a given decommissioning alternative is calculated using Equation N-3 of NUREG-1757, Volume 2, Appendix N:

$$Cost_T = Cost_R + Cost_{WD} + Cost_{Acc} + Cost_{TF} + Cost_{Wdose} + Cost_{Pdose} + Cost_{Other}$$

Where:

$Cost_T$ = Total cost;

$Cost_R$ = Monetary cost of the remediation action;

$Cost_{WD}$ = Monetary cost for transport and disposal of the waste generated;

$Cost_{Acc}$ = Monetary cost of worker accidents during the remediation action;

$Cost_{TF}$ = Monetary cost of traffic fatalities during transport of the waste;

$Cost_{Wdose}$ = Monetary cost of dose received by workers performing the remediation action and transporting waste to the disposal facility;

$Cost_{Pdose}$ = Monetary cost of the dose to the public from excavation, transport and disposal of the waste; and,

$Cost_{Other}$ = Other costs as appropriate for the particular situation.

The remediation cost ($Cost_R$) is the cost of the remediation action, including costs such as mobilization, demobilization, etc.

The costs for waste disposal were evaluated using the following formula, Equation N-4 from NUREG-1757, Volume 2, Appendix N:

$$Cost_{WD} = V_A * Cost_V$$

Where:

V_A = volume of waste produced in m^3; and

$Cost_V$ = cost of waste disposal per unit volume, including transportation, in dollars ($)/$m^3$.

The cost of non-radiological workplace accidents were evaluated using the following formula, Equation N-5 from NUREG-1757, Volume 2, Appendix N:

$$Cost_{Acc} = \$3{,}000{,}000 * F_W * T_A$$

Where:

F_W = workplace fatality rate in fatalities/hr;

= 4.2 E-8 /hr [NUREG 1757, Volume 2, Table N.2 (originally obtained from "NUREG 1496, Volume 2, Appendix B, Table A.1" [Reference 7-5]); and

T_A = worker-hours.

The cost of transportation risks from fatalities incurred during transportation were evaluated using Equation N-6 from NUREG-1757, Appendix N:

$$Cost_{TF} = \$3{,}000{,}000 * \left(\frac{V_A}{V_{Ship}}\right) * F_T * D_T$$

Where:

V_A = volume of waste produced in m^3;

V_{Ship} = volume of a rail shipment in m^3,

= 65 m^3 per rail car x 10 rail cars/shipment,

= 650 m^3 (Reference 7-6);

F_T = fatality rate per rail-kilometer traveled (fatalities/rail-km),

= 9.96 E-9 (8 yr average rail accident fatality rate, Reference 7-7); and,

D_T = distance traveled in km.

The cost of contaminated soil removal for unrestricted release does not include land restoration costs. The cost of remediation action ($Cost_R$), and the cost for transport and disposal of the waste generated by the action ($Cost_{WD}$), are combined into one value ($Cost_{R+WD}$) for this assessment. The $Cost_T$ is largely dependent on the volume of waste and disposal costs. Example calculations are provided below:

$Cost_{R+WD}$ = $Cost_R + Cost_{WD}$ = V_A x $Cost_{V(remediation + waste\ disposal)}$

= (Volume of waste produced) x
(cost of remediation, disposal and transportation per unit volume),

= 5,000 m^3 x \$1,100/m^3,

= \$5,500,000;

$Cost_{Acc}$ = Monetary value of a fatality equivalent to ($3,000,000/fatality) x (workplace fatality rate in fatalities/hour worked) x (worker time required for remediation in units of worker-hours),

= ($3,000,000/fatality) x (4.2E-8 fatalities/person-hr) x (5,000 m^3 x 1.62 person-hr/m^3),

= $1,021;

$Cost_{TF}$ = Monetary value of a fatality equivalent to ($3,000,000/person-rem) x (volume of waste produced/volume of a shipment) x (fatality rate per kilometer traveled) x (distance traveled),

= ($3,000,000/fatality) x (5,000m3/650m^3/shipment) x (9.96E-9 fatalities/km) x (4,571 km),

= $1,050;

$Cost_{Wdose}$ = This cost is not applicable. Based on dose modeling, the dose to an average construction worker is estimated to be 8 mrem/yr, at a soil concentration of 1,500 pCi/g Total Uranium. Therefore, $2,000 per person-rem x 0.008 rem/yr = $16/yr per construction worker. This dollar value is insignificant relative to the total cost of remediation, and need not be evaluated for the different alternatives;

$Cost_{Pdose}$ = This cost is not applicable. Dose to the public from excavation, transport and disposal of the waste is negligible; thus, the monetary cost of dose to the public is also negligible relative to the total cost of remediation;

$Cost_{Other}$ = This cost is not applicable. Land restoration costs are not included in this analysis; and,

$Cost_T$ = $5,502,072.

7.3 ALARA RESIDUAL RADIOACTIVITY LEVELS – SOIL

The purpose of this ALARA analysis is to demonstrate that the DCGLs established for soil remediation action in Chapter 5 are ALARA. The intent of the calculation below is to determine if additional soil remediation should be performed to further reduce dose below the 25 mrem/yr dose basis of the DCGLs. Therefore, only the cost associated with the additional remediation is used as input for these calculations.

The ALARA concentration of residual radioactivity (Conc) is that for which the benefit associated with additional remediation equals the cost of that remediation effort. Equation N-8 from NUREG-1757, Volume 2, Appendix N, can be applied as a ratio of soil concentrations to the $DCGL_W$.

$$\frac{Conc}{DCGL_W} = \frac{Cost_T}{\$2000 \times P_D \times 0.025 \times F \times A} \times \frac{r+\lambda}{1-e^{-(r+\lambda)N}}$$

Where:

Conc	=	Average concentration of residual radioactivity in the area being evaluated;
$DCGL_W$	=	Derived concentration guideline level equivalent to the average concentration of residual radioactivity per unit volume;
$Cost_T$	=	Total cost (see Table 7-2);
r	=	Monetary discount rate (0/yr for soil),
		Note: This variable was previously established at 0.03/yr for soil, but was removed from the equation through Federal Register Notice (72FR46102, August 16, 2007); therefore, for this analysis, the value has been conservatively set to 0 (i.e., no discounting for soils);
λ	=	Radiological decay constant for the radionuclide (1.55E-10/yr), assumed to be predominantly Uranium 238 (U-238). Note: The result is not impacted by the decay constant. When the decay constant for Uranium 234 (U-234) is used (2.82E-6/yr), the same result is obtained;
P_D	=	Population density (4E-4 person/m^2 for land);

F	=	Fraction of the residual radioactivity removed by the remediation action (0.8 - assuming 80 percent of the source term removed during remediation activities);
A	=	Area being evaluated (92,539 m^2 for impacted area);
N	=	Number of years over which the collective dose will be evaluated (1,000 yr for soil).

This calculation provides an estimate of the concentration at which a remediation action will be cost effective, prior to starting remediation. The ratio is in effect a cost-to-benefit ratio; therefore, a ratio greater than one (1) indicates the costs associated with additional remediation exceed the benefit to be realized by that remediation.

$$\frac{Conc}{DCGL_W} = \frac{\$5{,}502{,}072}{\$2{,}000 \times (4E-4) \times 0.025 \times 0.8 \times 92{,}539} \times \frac{0 + 1.55E-10}{1 - e^{-(0+1.55E-10)1000}}$$

$$\frac{Conc}{DCGL_W} = 3.72$$

Because this value is greater than one (1), the conclusion is that the soil DCGL is ALARA. Therefore, additional remediation action to achieve residual radioactivity concentrations in soil less then the DCGL values is not warranted.

The above calculation is considered to be a conservative estimate, based on use of conservative (low-range) estimates of waste volume (5,000 m^3) and cost per unit volume of waste (\$1,100/m^3). Table 7-2 provides the results of additional calculations using mid-range and high-range estimates for waste volume, and a typical cost per unit volume of waste.

Westinghouse also assumes that overburden and other excavated soils that are less than the soil DCGLs, will also meet the ALARA criterion since the cost to ship and dispose of them in a low-level waste disposal facility is not justified based on the above calculation. The waste disposal cost accounts for more than 99 percent of the total cost.

7.4 ALARA RESIDUAL RADIOACTIVITY LEVELS – BUILDING SURFACES

DCGLs were developed for buildings which will remain (Building 110, Building 230 and Building 231) following Hematite Site decommissioning and license termination, and are described in Chapter 5. These DCGLs were based on a Total Effective Dose Equivalent (TEDE) of 25 mrem/year to a member of the critical group, due solely to residual contamination on building and structural surfaces (building dimensions are shown in Table 7-3).

The purpose of this ALARA analysis is to demonstrate that the DCGLs established for building and structural remediation action are ALARA. The intent of the calculation below is to determine if additional building or structural remediation should be performed, to further reduce dose below the 25 mrem/yr dose basis of the DCGLs. Therefore, only the cost associated with the additional remediation is used as input for these calculations.

Chapter 5 describes the development of building and structure DCGLs based on three different scenarios and two different building geometries. The most conservative DCGLs were selected for use at the Hematite Site, and are summarized in Chapter 5. The pathway analysis associated with development of the DCGLs demonstrates most of the dose is from inhalation. The value for the contamination re-suspension rate used in development of the DCGLs was the median value from NUREG/CR 6755 (Reference 7-8).

As with the ALARA analysis for soils, the monetary cost (see section 7.2) of dose to the public ($Cost_{Pdose}$) and workers ($Cost_{Wdose}$) during the site remediation, as well as any other costs ($Cost_{Other}$), were assumed to be zero (0) for conservatism; there is minimal dose associated with the radionuclides of concern.

The ALARA concentration of residual radioactivity ('Conc'- average concentration of residual radioactivity in the area being evaluated) is that for which the benefit associated with additional remediation equals the cost of that remediation effort. Equation N-8 from NUREG 1757, Volume 2, Appendix N, can be applied as a ratio of building surface concentrations to the $DCGL_W$.

$$\frac{Conc}{DCGL_W} = \frac{Cost_T}{\$2{,}000 * P_D * 0.025 * F * A} \times \frac{r + \lambda}{1 - e^{-(r+\lambda)*N}}$$

As indicated in Section 7.3, this calculation provides an estimate of the concentration at which a remediation action will be cost effective, prior to starting remediation. Additionally, the calculation result can be applied as a correction factor, or DCGL adjustment, for ALARA purposes. The terms for this equation are further defined below, for each analysis performed.

Consistent with the examples in NUREG 1757, the two remedial actions evaluated for this ALARA analysis were washing building surfaces and scabbling building surfaces. Washing surfaces is assumed to remove all "removable activity"; 10 percent of building surface activity is assumed to be "removable activity" (see Chapter 5). Floor scabbling is assumed to remove 80 percent of the residual radioactivity.

Equation N-8 of NUREG 1757, Volume 2, Appendix N was used to calculate the benefits of additional remediation assuming a survey unit size of 100 m^2, and using the parameters in Table 7-4. The results of the ALARA analysis for each of the two remedial actions further described below.

7.4.1 ALARA ANALYSIS - WASHING BUILDING SURFACES

Washing building surfaces is assumed to be effective in removing any "removable contamination". The development basis for building surface DCGLs in Chapter 5 assumed "removable contamination" is approximately 10 percent of the total surface contamination (i.e., F = 0.1).

The values used for the remaining equation parameters are shown below:

Conc	=	Average concentration of residual radioactivity in the area being evaluated;
$DCGL_W$	=	Derived concentration guideline level equivalent to the average concentration of residual radioactivity per unit volume;
$Cost_T$	=	Total cost (see Table 7-5);
r	=	Monetary discount rate = 0.07/yr for buildings (Reference 7-9);
λ	=	Radiological decay constant for the radionuclide (1.55E-10/yr), assumed to be predominantly U-238. Note: The result is not impacted by the decay constant. When the decay constant for Uranium 234 (U-234) is used (2.82E-6/yr), the same result is obtained;
P_D	=	Population density (0.09 person/m^2 for buildings);
F	=	Fraction of the residual radioactivity removed by the remediation action (0.1 - assuming 10 percent of the source term removed during remediation activities);

A = Area being evaluated (100 m^2 survey unit); and,

N = Number of years over which the collective dose will be evaluated (70 yr for buildings).

As indicated in Section 7.3, Federal Register Volume 72, No. 158, Page 46102 documented removal of the monetary discount rate from the equation. However, NUREG/BR-0058, Revision 4, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," Section 4.3.5 (Reference 7-9) states:

> *"The 7 percent rate approximates the marginal pretax real rate of return on an average investment in the private sector, and is the appropriate discount rate whenever the main effect of a regulation is to displace or alter the use of capital in the private sector."*

Assuming a reasonable waste volume of 0.227 m^3 and disposal cost of \$1,100/m^3, calculations were performed for both a zero (0) and 0.07 monetary discount rate. The results below show that applying a zero (0) discount rate for building surfaces as a conservative assumption, as done for the soil ALARA calculations in Section 7.3, yields a value which is approximately 21 percent of the established DCGLs (see Table 7-5):

$$\frac{Conc}{DCGL_W} = \frac{\$656}{\$2{,}000 \times 0.09 \times 0.025 \times 0.10 \times 100} \times \frac{0 + 1.55E-10}{1 - e^{-(0+1.55E-10)70}} = 0.21$$

$$\frac{Conc}{DCGL_W} = \frac{\$656}{\$2{,}000 \times 0.09 \times 0.025 \times 0.10 \times 100} \times \frac{0.07 + 1.55E-10}{1 - e^{-(0.07+1.55E-10)70}} = 1.02$$

The guidance in NUREG/BR-0058 is directly applicable to this analysis, as it involves decision-making relative to "the use of capital in the private sector." As the results above indicate, application of a discount rate of 0.07 indicates the DCGLs are reasonable and ALARA. Based on the effort and practicality of performing surveys for residual contamination levels at 21 percent of the DCGL, and the costs to remediate to 21 percent of the DCGLs, use of a zero (0) discount rate is not considered reasonable or achievable; and, use of a zero (0) discount rate is considered to be overly conservative.

Table 7-5 provides the results of additional calculations using alternative estimates for waste volume, and a typical cost per unit volume of waste.

7.4.2 ALARA ANALYSIS - SCABBLING BUILDING SURFACES

The second and most common decontamination practice for structural decontamination, for which an ALARA analysis was performed, is surface scabbling or the mechanical removal of the structural surface. Scabbling is assumed to remove 80 percent of the residual surface contamination (F = 0.80).

The values used for the remaining equation parameters are shown below:

Conc	=	Average concentration of residual radioactivity in the area being evaluated;
$DCGL_W$	=	Derived concentration guideline level equivalent to the average concentration of residual radioactivity per unit volume;
$Cost_T$	=	Total cost (see Table 7-5);
r	=	Monetary discount rate = 0.07/yr for buildings (Reference 7-9);
λ	=	Radiological decay constant for the radionuclide (1.55E-10/yr), assumed to be predominantly U-238. Note: The result is not impacted by the decay constant. When the decay constant for Uranium 234 (U-234) is used (2.82E-6/yr), the same result is obtained;
P_D	=	Population density (0.09 person/m^2 for buildings);
F	=	Fraction of the residual radioactivity removed by the remediation action (0.80 - assuming 80 percent of the source term removed during remediation activities);
A	=	Area being evaluated (100 m^2 survey unit); and,
N	=	Number of years over which the collective dose will be evaluated (70 yr for buildings).

Using these values and the input parameters from Table 7-4, the estimated costs of remediation by surface scabbling are provided in Table 7-5, using both a zero (0) and 0.07 monetary rate as discussed in Section 7.4.1. The ALARA analysis for surface scabbling shows that when a monetary discount rate of 0.07 is applied, the DCGLs are ALARA.

$$\frac{Conc}{DCGL_W} = \frac{\$5{,}350}{\$2{,}000 \times 0.09 \times 0.025 \times 0.80 \times 100} \times \frac{0 + 1.55E-10}{1 - e^{-(0+1.55E-10)70}} = 0.21$$

$$\frac{Conc}{DCGL_W} = \frac{\$5{,}350}{\$2{,}000 \times 0.09 \times 0.025 \times 0.80 \times 100} \times \frac{0.07 + 1.55E-10}{1 - e^{-(0.07+1.55E-10)70}} = 1.05$$

Characterization results for Building 110, Building 230 and Building 231 are provided in the "Hematite Radiological Characterization Report" (Reference 7-10), and indicate most surface activity in these buildings is well below the most conservative DCGL (Uranium 234 (U-234), See Chapter 5 for DCGLs). However, further reduction of the DCGLs (i.e., using a zero (0) monetary discount rate) for ALARA purposes, is likely to result in additional remedial actions and associated costs, which are not considered in the above evaluations.

For example, a further reduction in DCGLs could require that sanitary wastewater or drain lines be excavated and disposed of as radioactive waste. The estimated cost for these remedial actions, assuming a line length of approximately 100 meters with a 1 meter excavation width, is $75,000. When this is factored into the ALARA equation, the results show that the currently established DCGLs continue to be ALARA, even with a zero (0) discount rate applied.

$$\frac{Conc}{DCGL_W} = \frac{\$75{,}000}{\$2{,}000 \times 0.09 \times 0.025 \times 1 \times 100} \times \frac{0 + 1.55E-10}{1 - e^{-(0+1.55E-10)70}} = 2.31$$

7.5 CONCLUSION

This ALARA analysis demonstrates that the dose from residual radioactivity, at the $DCGL_W$ values established for soil and building surfaces in Chapter 5 is ALARA. The Hematite Site approach (Section 7.2) of remediation to unrestricted release values provides net positive benefits with no consideration of costs associated with achieving those benefits.

An ALARA analysis was performed (Section 7.3) for soil remedial action, considering a range of waste volumes and disposal costs per unit volume, and the results indicate the DCGL values established for Hematite Site soils are ALARA; and, further remediation to levels less than those DCGL values is not justified.

An ALARA analysis was performed (Section 7.4) for building remedial action, considering a range of waste volumes and disposal costs per unit volume. The results indicate the DCGL values established for Hematite Site buildings which will remain following decommissioning (Building 110, Building 230 and Building 231) are ALARA, and that further remediation to levels less than those DCGL values is not justified.

7.6 REFERENCES FOR CHAPTER 7.0

7-1 Code of Federal Regulations, Title 10, Part 20.1402, "Standards for Protection Against Radiation – Radiological Criteria For Unrestricted Use," August 28, 2007.

7-2 U.S. Nuclear Regulatory Commission, NUREG-1757, "Consolidated Decommissioning Guidance, Characterization, Survey, and Determination of Radiological Criteria." Volume 2, Revision1, September 2006.

7-3 Code of Federal Regulations, Title 10, Part 20, Subpart E, "Standards for Protection Against Radiation – Radiological Criteria for License Termination."

7-4 Federal Register Volume 72, No. 158, Page 46102, "Consolidated Decommissioning Guidance; Notice of Revision to, Withdrawal of Portions of, and Process for Updating," August 16, 2007.

7-5 U.S. Nuclear Regulatory Commission, NUREG-1496, "Generic Environmental Impact Statement in Support of Rulemaking on Radiological Criteria for Decommissioning of NRC-Licensed Nuclear Facilities," Volume 2, July 1997.

7-6 Westinghouse Electric Company Document DO-05-001, "Environmental Report for Hematite Site Decommissioning," Revision 1, Section 4.2.2.a, "Normal Conditions of Transportation."

7-7 U. S. Department of Transportation, Federal Railroad Administration, Office of Safety Analysis, "Railroad Safety Statistics Annual Report," 1998 through 2005. *http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/Publications.aspx*.

7-8 U.S. Nuclear Regulatory Commission, NUREG/CR 6755, "Technical Basis for Calculating Radiation Doses for the Building Occupancy Scenario Using the Probabilistic RESRAD-BUILD 3.0 Code," 2002.

7-9 U.S. Nuclear Regulatory Commission, NUREG/BR-0058, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," Revision 4, September 2004.

7-10 Westinghouse Electric Company Document No. DO-08-003, "Hematite Radiological Characterization Report."

Table 7-1

Possible Benefits And Costs Related To Decommissioning

Possible Benefits	Possible Costs
• Collective Dose Averted • Regulatory Costs Avoided • Changes In Land Values • Aesthetics • Reduction In Public Opposition	• Remediation Costs • Additional Occupational/Public Dose • Occupational Non-radiological Risks • Transportation Direct Costs And Implied Risks • Environmental Impacts • Loss Of Economic Use Of Site/Facility

Table 7-2

ALARA Calculations – Soil

Estimated Waste Volume (m^3)	Estimated Waste Cost Per Unit Volume ($Cost_V$\$/m^3)	$Cost_{R+WD}$	$Cost_{Acc}$	$Cost_{TF}$	$Cost_T$	$\frac{Conc}{DCGL_W}$
5,000	$1,100	$5,500,000	$1,021	$1,051	$5,502,072	3.72
	$2,800	$14,000,000			$14,002,072	9.46
15,000	$1,100	$16,500,000	$3,062	$3,153	$16,506,215	11.15
	$2,800	$42,000,000			$42,006,215	28.37
30,000	$1,100	$33,000,000	$6,124	$6,307	$33,012,430	22.30
	$2,800	$84,000,000			$84,012,430	56.74

Note: The current soil volume estimate for the project is 801,500 cubic feet, or 22,695 cubic meters which is within the evaluated range.

Table 7-3

Remaining Building Geometry
(Building 110, Building 230 And Building 231)

Building	Length (ft)	Width (ft)	Height of Walls (ft)	Height at Peak (ft)	Floor Area (ft^2)	Floor Area (m^2)
110	60	50	12	NA	3,000	279
230	200	175	24	26	35,000	3,252
231	100	60	20	21	6,000	557
Total Floor Area					**44,000**	**4,088**

Note: Building dimensions obtained from Chapter 5

Table 7-4

ALARA Cost Analysis Parameters For Building Surfaces

Parameter	NUREG 1757 Volume 2 Equation	Description	Hematite Site Values
Dollars	N-1	Value in dollars per person-rem averted	* $2,000 /person-rem
P_D	N-2	Population density, people/m^2	* 0.09 person/m^2 for buildings
A	N-2	Area, m^2	100 m^2
F		Fraction of the residual activity removed by remediation	F = 0.1 for floor washing F = 0.8 for floor scabbling
Conc-Buildings	N-2	Average dpm/100cm^2 for each building survey unit (for each radionuclide)	Calculated value in ratio with $DCGL_w$
V_A	N-4	Volume of waste produced, m^3	13 m^3 (scabbling depth = 1/8 inch over 4,088 m^2) and 0.003m^3/m^2 of area scabbled (see Table 7-3 for area) or 0.318 m^3 per 100 m^2 area

Table 7-4 (continued)

ALARA Cost Analysis Parameters For Building Surfaces

Parameter	NUREG 1757 Volume 2 Equation	Description	Hematite Site Values
$Cost_V$	N-4	Waste disposal cost, $/m^3	low estimate = $1,100/m^3 high estimate= $2,800/m^3
$Cost_R$		Remediation Cost	$4/m^2 for floor washing (NUREG-1757, N.1.4) $50/m^2 for floor scabbling (NUREG-1757, N.1.4)
T_A	N-5	Worker time required for remediation, worker-hr	*1.62 person-hr/m^3 of waste, monitor, packaging and handling.
D_T	N-6	Distance traveled for waste transportation, km	Round trip: Festus, MO to Clive, UT = 2,840 miles = 4,571 km
V_{Ship}	N-6	Volume of rail shipment, m^3	65m^3/rail car *10 railcars/shipment = 650 m^3/shipment (Reference 7.7)
F_W	N-5	Workplace accident fatality rate, /hr	* 4.2 E-8 /hr

Table 7-4 (continued)

ALARA Cost Analysis Parameters For Building Surfaces

Parameter	NUREG 1757 Volume 2 Equation*	Description	Hematite Site Values
F_T	N-6	Transportation fatal accident rate, /km	9.96 E-9/km Rail Accident Fatality Rate 8-yr average (Reference 7-7)
r	N-2, N-8	Monetary discount rate	0.07 /yr for buildings [parameter removed per FR 72 46103]
N	N-2, N-8	Number of years of exposure	* 70 years for buildings

Note: * values from NUREG-1757, Volume 2, Table N.2 "Acceptable Parameter Values for Use in ALARA Analysis".

Table 7-5

ALARA Calculations - Building Surfaces

Estimated Waste Volume (m^3)	Estimated Waste Cost Per Unit Volume ($\$/m^3$)	$Cost_{WD}$	$Cost_R$	$Cost_{Acc}$	$Cost_{TF}$	$Cost_T$	No Discount, r=0 $\frac{Conc}{DCGL_W}$	Discount, r=0.07 $\frac{Conc}{DCGL_W}$
ALARA Analysis– Washing Building Surfaces								
0.227	**$1,100**	$250	400	$0.05	$0.05	$650	0.2063	1.02
0.227	**$2,800**	$636	400	$0.05	$0.05	$1,036	0.3288	1.62
1	**$1,100**	$1,100	400	$0.20	$0.21	$1,500	0.4763	2.35
1	**$2,800**	$2,800	400	$0.20	$0.21	$3,200	1.0160	5.02
ALARA Analysis – Scabbling Building Surfaces								
0.318	**$1,100**	$350	5000	$0.06	$0.07	$5,350	0.2123	1.05
0.318	**$2,800**	$890	5000	$0.06	$0.07	$5.891	0.2338	1.15
1	**$1,100**	$1,100	5000	$0.20	$0.21	$6,100	0.2421	1.20
1	**$2,800**	$2,800	5000	$0.20	$0.21	$7,800	0.3095	1.53