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# PERFORMANCE OBJECTIVES FOR TANK FARM CLOSURE RISK ASSESSMENTS

Prepared for the U.S. Department of Energy  
Assistant Secretary for Environmental Management

**CH2MHILL**  
*Hanford Group, Inc.*

Richland, Washington

Contractor for the U.S. Department of Energy  
Office of River Protection under Contract DE-AC27-99RL14047

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FM Mann, AJ Knepp, and JW Badden  
CH2M HILL Hanford Group, Inc.

March 2003

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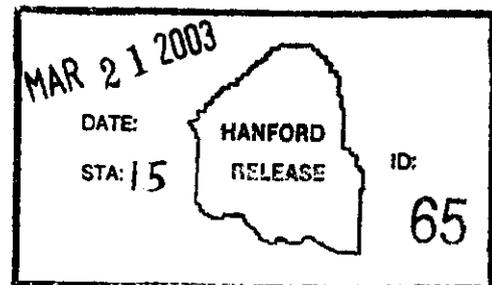
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**PERFORMANCE OBJECTIVES FOR  
TANK FARM CLOSURE RISK ASSESSMENTS**

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**March 2003**

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## LIST OF ACRONYMS

AEA	Atomic Energy Act
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
CDE	cumulative dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CoC	contaminant of concern
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
Ecology	Washington State Department of Ecology
EDE	effective dose equivalent
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
HFFACO	Hanford Federal Facility Agreement and Consent Order
HFSUWG	Hanford Future Site Uses Working Group
ILAW	immobilized low-activity waste
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission
PA	performance assessment
RCRA	Resource Conservation and Recovery Act
SAC	System Assessment Capability
TPA	Tri-Party Agreement
TWRS	Tank Waste Remediation System
TWINS	TWRS Information System
USC	United States code
WAC	Washington Administrative Code
WMA	Waste Management Areas

## 1.0 OVERVIEW

To be meaningful, results from a numeric risk assessment of the consequences of an action must be compared against the standards for such an action. That is, before one disposes of waste or closes a facility with waste, one must show that the disposal or closure action protects the public health and safety and the environment. These standards are called performance objectives.

Regulations requiring performing performance assessments, (whether federal ones like the Department of Energy [DOE] Order 435.1, *Radioactive Waste Management* and its implementing guides or Washington State ones like the regulations implementing the *Washington Administrative Code* [WAC] 173-340 “Model Toxics Control Act – Cleanup”), usually require that the determination of performance objectives be one of the first steps performed. These performance objectives not only set comparison level for the numeric results, but also define the media, pathways, exposure scenarios (receptors), spatial locations, and times that the performance assessment must consider. Thus, a performance objective consists of a compliance level, place(s) of compliance, and time(s) of compliance.

Performance objectives are not the levels that a regulatory agency will enforce in a permit or authorization. Those levels, often called enforcement levels, will be set in the permit or authorization. Rather, performance objectives are those levels against which the results of the numeric simulation will be compared to judge the success of the proposed cleanup or disposal actions. Additional comparison levels may be requested for information purposes, but are not officially part of the decision on the adequacy of the proposed action.

To emphasize that the performance objectives discussed in this document are not regulatory performance objectives, the three components of the performance objective will be renamed in this document as assessment standard, point(s) of assessment, and time(s) of assessment. However, whenever quotations are taken from other documents (e.g., regulations) the quotation will not be changed from the more standard terminology.

According to the *Hanford Federal Facility Agreement and Consent Order* (HFACCO 1989), a number of risk assessments will be required to analyze the environmental and human health impacts from retrieval and closure activities.

This document is based on the *Performance Objectives for the 2005 Immobilized Low-Activity Waste Performance Assessment* (ILAW PA) (Mann 2002). The performance objectives in this document will be used in future risk assessments for tank waste retrieval or tank closure activities. These risk assessments are described in the *Contents of Risk Assessments to Support the Retrieval and Closure of Tanks for the Washington State Department of Ecology* (Mann et al. 2003) and summarized in Table 1.1.

Requirements for ecological assessments are not yet presented in this document. As the requirements for such assessments are defined, this document will be revised to include the appropriate performance objectives.

**Table 1.1 Important Features of Risk Assessments**

Category	Purpose	Significant Feature
Post Retrieval Tank Risk Assessment	Determine whether additional retrieval of waste is necessary	Determine inventory of key contaminants in residual waste in tank and in any retrieval leaks. Perform numeric calculations of impacts of waste remaining (including impacts from other tanks and equipment in farm or WMA) assuming no impacts from tank fill.
Pre-Closure Tank Risk Assessment	Determine whether closure of tank can proceed using the methods proposed	Determine impacts from various options to close (including fill and barriers) a tank. Impacts will include impacts from other tanks and equipment in farm or WMA. Provide worker risk information for proposed closure options.
Tank Farm Feasibility Study	Determine actions that are needed to close a tank farm or WMA	Determine impacts from various options to close tank farm or WMA. Provide worker risk information for proposed closure options.
Tank Farm Closure Risk Assessment	Determine whether closure actions as implemented have been successful	Determine impacts from closed tank farm or WMA, once all closure activities (except possibly final surface barrier) are completed.

WMA Waste Management Areas

The initial step in identifying performance objectives is to note the requirements that could be applied to the proposed action. If that action is the disposal of radioactive mixed waste on the Hanford Site, a variety of requirements should be considered:

- DOE requirements,
- Nuclear Regulatory Commission (NRC) requirements,
- Environmental Protection Agency (EPA) requirements,
- State of Washington requirements,
- Programmatic requirements, and
- Public involvement.

Such an analysis leads that the performance assessment must evaluate the following:

- General Public
- Workers
- Inadvertent Intruders
- Groundwater
- Surface Water
- Air Resources.

In addition, there are restrictions on the waste itself if it is land disposed.

The performance objectives identified here are only for the long-term assessment of the public health and environmental impacts from the closure of tanks. Thus, for example, worker and public safety during the actual closure operation are not considered here. Although reviewed by others performing Hanford Site assessments, it must be emphasized that these performance objectives deal only with the tank closure activities and not with the performance objectives of other Hanford Site actions. The objectives are summarized in Table 1.2.

As described in the following sections,

2. Background
3. Regulations
4. Points of Assessment
5. Times of Assessment
6. Choice of Performance Objectives
7. Public Involvement

Performance objectives have been determined for both radioactive and chemical species.

**Table 1.2 Performance Objectives for Tank Closure <sup>a</sup>**  
**(Standards for Specific Contaminants are given in Appendix A)**

<b>Protection of General Public and Workers <sup>b, c, d</sup></b>	
All-pathways dose from only this facility	25 mrem in a year <sup>e</sup>
All-pathways dose including other Hanford Site sources	100 mrem in a year <sup>e</sup>
Chemical Carcinogens (Incremental Lifetime Cancer Risk)	$10^{-5}$ <sup>f</sup>
Non cancer-causing chemicals (hazard index)	1 <sup>f</sup>
<b>Protection of an Inadvertent Intruder <sup>e, g.</sup></b>	
Acute exposure	500 mrem
Continuous exposure	100 mrem in a year
<b>Protection of Groundwater Resources <sup>b, c, d, h, j</sup></b>	
Alpha emitters	
<sup>226</sup> Ra plus <sup>228</sup> Ra	5 pCi/ℓ
All others (excluding uranium)	15 pCi/ℓ
Beta and photon emitters	4 mrem in a year
<b>Protection of Surface Water Resources <sup>b, k</sup></b>	
Alpha emitters	
<sup>226</sup> Ra plus <sup>228</sup> Ra	0.3 pCi/ℓ <sup>m</sup>
All others (excluding uranium)	15 pCi/ℓ <sup>m</sup>
Beta and photon emitters	1 mrem in a year <sup>m</sup>
<b>Protection of Air Resource <sup>b, n</sup></b>	
Radon (flux through surface)	$20 \text{ pCi m}^{-2} \text{ s}^{-1}$
All other radionuclides	10 mrem in a year

<sup>a</sup> All doses are calculated as effective dose equivalents; values given are in addition to any existing amounts or background.

<sup>b</sup> Evaluated for 1,000 years, but calculated to the time of peak or 10,000 years, whichever is longer.

<sup>c</sup> Groundwater use starts at the time when groundwater contaminated by Hanford Site operations before the year 2000 is estimated to be potable.

<sup>d</sup> Evaluated at the point of maximal exposure, but no closer than the fence line of the waste management area in which the tank farm belongs. Also calculated at the edge of the 200 Area Core Zone and just before groundwater enters the Columbia River.

<sup>e</sup> Main driver is DOE Orders on *Radioactive Waste Management* (DOE O 435.1).

<sup>f</sup> Main driver is Washington State "Model Toxics Control Act -Cleanup" (WAC 173-340).

<sup>g</sup> Evaluated for 500 years, but calculated from 100 to 1,000 years.

<sup>h</sup> All concentrations are in water taken from a well.

<sup>j</sup> Main driver is *National Primary Drinking Water Regulations* (40 Code of Federal Regulations [CFR] 141).

<sup>k</sup> Evaluated at well at the edge of the Columbia River, no mixing with the river is assumed.

<sup>l</sup> Main driver is Washington State Model Toxics Control Act (WAC 173-340).

<sup>m</sup> Main driver is "Water Quality Standards for Surface Waters of the State of Washington" (WAC 173-201A).

<sup>n</sup> Main driver is *National Emission Standards for Hazardous Air Pollutants*, subparts H and Q (40 CFR 61).

## 2.0 BACKGROUND

### 2.1 GENERAL REQUIREMENTS

Before low-level radioactive waste may be disposed of, a performance assessment must be written and then approved by the DOE, (DOE O 435.1). Before hazardous chemical waste can be disposed at a newly constructed disposal unit, a risk assessment must be prepared as a component of the *Resource Conservation and Recovery Act of 1976* (RCRA) Part B Permit Application, and then approved by The Washington State Department of Ecology (Ecology) (as authorized by Environmental Protection Agency [EPA] as part of the RCRA delegation). Similarly, before a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) contaminated site is remediated, a remedial investigation/feasibility study (including a risk assessment) must be prepared and EPA must approve the action through a Record of Decision. The performance assessment is to determine whether “reasonable assurance” exists that the performance objectives of the disposal facility will be met.

The DOE requirements for waste disposal (DOE O 435.1), (Appendix B.1), as well as WAC 173-303, “Dangerous Waste Regulations”, the Washington State regulations implementing RCRA (WAC 173-303)(Appendices B.2 and B.3), and CERCLA (Appendix B.4) require:

- The protection of public health and safety; and
- The protection of the environment.

A first step in any risk assessment is to determine the appropriate performance objectives against which the results can be compared. Although quantitative limits are sometimes stated (for example, the all-pathways exposure limit is 25 mrem/year), usually there is a requirement that other associated (but usually unspecified) regulations must also be considered.

### 2.2 TANK CLOSURE

There are about 54 million gallons of high-level waste stored in underground tanks located in the central plateau area of the Hanford Site. The present plans are to retrieve the waste, separate the waste into streams, and then vitrify each stream. The high-level waste stream would contain relatively little volume, but it would contain the bulk of the radionuclides. The vitrified high-level waste will be stored onsite until it is shipped to a federally approved geological repository. The low-activity waste stream will contain most of the material, but relatively few radionuclides. The vitrified (or immobilized) low-activity waste is planned to be disposed of in near-surface underground trenches in the 200 East Area, which is part of Hanford’s central plateau.

The 149 single-shell tanks are grouped into 12 tank farms (A, AX, B, BX, BY, C, S, SX, T, TX, TY, and U) that have 4 (AX) to 18 (TX) tanks. These tank farms are then grouped into seven

waste management areas (WMA) for the purpose of groundwater protection (WMA A/AX, WMA B/BX/BY, WMA C, WMA S/SX, WMA T, WMA TX/TY, and WMA U).

It is expected that some wastes will remain in the tanks because to retrieve all the waste may not be technically or economically feasible. To close these tanks, the DOE order on radioactive waste management, (DOE O 435.1), requires that performance assessments analyzing radionuclides be created and approved by DOE headquarters in support of the Waste Incidental to Reprocessing determination, in support of the planning of the closure of a high-level waste facility, and in modification of the Hanford Site's Disposal Authorization Statement, DOE P 141.1, *Department of Energy Management of Cultural Resources*. Since the tanks are in the Part A portion of the Hanford Site-Wide Hazardous Waste Facility Permit, a risk assessment is also required as part of the modification of the Site's permit. The HFFACO lists a large number of risk assessments that will support tank closure (See Appendix D).

### **2.3 DESCRIPTION OF THE HANFORD SITE AND CENTRAL PLATEAU**

The Hanford Site is in the southern part of central Washington State. It is bounded on the north and east by the Columbia River. The main part of the western border is the Rattlesnake Ridge, while the southern border is the Yakima River and the City of Richland.

The central plateau is a raised area in the central part of the site, created by flood deposits left from the Lake Missoula glacier floods, the last of which occurred about 10,000 years ago. The groundwater, whose top is about 200 to 350 feet below the surface, mainly flows to the east. However, because of the large amounts of the liquid waste disposed to the soil (~400 billion gallons), groundwater flow has at times been redirected to the north. With the cessation of the vast bulk of the discharge, groundwater flow is reverting to its natural easterly direction.

The large discharges have contaminated the groundwater under large areas of the central plateau, with the groundwater plume extending to the Columbia River. The major contaminants in the plumes are  $^3\text{H}$ ,  $^{129}\text{I}$ ,  $^{99}\text{Tc}$ , U,  $\text{NO}_3$ , and  $\text{CCl}_4$ . The first contaminants have a multiple sources, while the last ( $\text{CCl}_4$ ) comes from discharges past from the Plutonium Finishing Plant.

### **2.4 CONTAMINANTS (RADIOISOTOPES AND CHEMICALS)**

Tank waste contains both radionuclides as well as hazardous chemicals. Thus, both sets of contaminants of concern (CoCs) must be considered.

Previous assessments have agreed on the important CoCs for the groundwater pathway. The *Hanford Immobilized Low-Activity Performance Assessment: 2001 Version* (Mann et al. 2001) found  $^{99}\text{Tc}$  and  $^{129}\text{I}$  as the main CoCs for the groundwater pathway, with chemicals being much less important. The *Field Investigation Report for Waste Management Area S-SX* (Knepp 2001) found  $^{99}\text{Tc}$ ,  $\text{NO}_3$ , and uranium as the key CoCs. The *Composite Analysis for the Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, (Kincaid et al. 1998) found  $^3\text{H}$ ,  $^{129}\text{I}$ , and  $^{99}\text{Tc}$  as the major CoCs. The *Performance Assessment for the Disposal of*

*Low-Level Waste in the 200 West Area Burial Grounds and the Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds* (Wood et al. 1995 and Wood et al. 1996) again found <sup>99</sup>Tc as the main CoC.

Performance objectives will, in general, be established for a class of contaminants (e.g., all contaminants, chemicals only, or radionuclides only) rather than for individual CoCs. In some cases, limits for key CoCs will be listed. The radionuclides listed in this document are those that were explicitly identified in the ILAW PA (Mann et al. 2001). The dangerous chemicals listed here are those most often detected in Hanford tank waste as documented in Table B.1 of the *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project* (Wiemers et al. 1998).

## **2.5 PATHWAYS AND MEDIA**

Various regulations mandate performance objectives covering various pathways and various media. The DOE order on radioactive waste management requires protection for the greatest number of contaminant pathways and is therefore used as the basis of this document.

The DOE order on radioactive waste management requires that all pathways be investigated. In addition, the performance assessment must address impacts to groundwater, surface water, and air resources. Finally, the DOE order requires that potential impacts on an inadvertent intruder be considered when establishing contaminant concentration limits for waste packages going to disposal (DOE O 435.1).

## **2.6 LAND USE**

In 1943, the U.S. Army Corps of Engineers created the Hanford Site from small farming areas along the Columbia River to locate facilities used to produce nuclear weapon materials for fighting World War II. Since then, the major activities on the Hanford Site have been controlled by the DOE and its predecessors, the U.S. Atomic Energy Commission (1945-1975), and the Energy and Research Development Administration (1975-1976). Current major programs at the Hanford Site are dedicated to waste management, environmental restoration, long-term stewardship, and research and development.

In 1992, DOE, EPA, and Ecology gathered a group of stakeholders to study potential future uses for the Hanford Site land. This Hanford Future Site Uses Working Group issued a summary, *The Future for Hanford: Uses and Cleanup, Summary of the Final Report of the Hanford Future Site Uses Working Group* (HFSUWG 0026618, 1992) and a detailed report, *The Future for Hanford: Uses and Cleanup, the Final Report of the Hanford Future Site Uses Working Group* (HFSUWG 0026619, 1992) of its findings. The *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement and Comprehensive Land-Use Plan* (DOE/EIS-0222F, 1999) is heavily based on the work of the HFSUWG. However, DOE's land use planning extends for only 50 years instead of the 100 years forecast by the working group.

The HFSUWG 0026618 (1992) stated:

*“The working group identified a single cleanup scenario for the Central Plateau. This scenario assumes that future uses of the surface, subsurface and groundwater in and immediately surrounding the 200 West and 200 East Areas would be exclusive. Surrounding the exclusive area would be a temporary surface and subsurface exclusive buffer zone composed of at least the rest of the Central Plateau. As the risks from the waste management activities decrease, it is expected that the buffer zone would shrink commensurately.”*

64 FR 61615, the “Record of Decision for the Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement” (DOE/EIS-0222F, 1999) identifies near-term land uses for the Hanford Site. The record of decision prescribes the use in the 200 Areas as exclusively industrial (primarily waste management) with much of the surrounding land having the use of preservation or conservation. Recently, the Hanford Reach National Monument was established along the river corridor as well in lands at the northern and western edges of the site (65 FR 37253, “Establishment of the Hanford Reach National Monument.”)

Most recently, DOE, EPA, and Ecology put forth a risk framework, Letter, “Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area” (Kline et al. 2002) delineating land use scenarios:

1. The Core Zone (200 Areas including B Pond (main pond), and S Ponds) will have an Industrial Scenario for the foreseeable future.
2. The Core Zone will be remediated and closed allowing for “other uses” consistent with an industrial scenario (environmental industries) that will maintain human presence in this area, which in turn will enhance the ability to maintain the institutional knowledge of wastes left in place for the future generations. Exposure scenarios used for this zone should include a reasonable maximum exposure to a worker/day user, to possible Native American users, and to intruders.
3. DOE will follow the required regulatory processes for groundwater remediation (including public participation) to establish the points of compliance and remedial action objectives. It is anticipated that groundwater contamination under the Core Zone will preclude beneficial use for the foreseeable future, which is at least the period of waste management and institutional controls (150 years). It is assumed that the tritium and iodine-129 plumes beyond the Control Zone Boundary will exceed the drinking water standards for the period of the next 150 to 300 years (less for the tritium plume). It is expected that other groundwater contaminants will remain below, or be restored to drinking water levels outside the Core Zone.
4. No drilling for water use or otherwise will be allowed in the Core Zone for the foreseeable future. An intruder scenario will be calculated in assessing the risk to human health and environment.
5. Waste sites outside the Core Zone but within the Central Plateau (200N, Gable Mountain Pond, B/C Crib Controlled Area) will be remediated and closed based on evaluation of multiple land use scenarios to optimize land use, institutional control cost, and long-term stewardship.

6. An industrial use scenario will set cleanup levels on the Central Plateau. Other scenarios (e.g. residential, recreational) may be used for comparison purposes to support decision making especially for:
  - The post-institutional control period (>150 years).
  - Sites near the Core Zone perimeter to analyze opportunities to “shrink the site”.
  - Early (precedent-setting) closure/remediation decisions.
7. This framework does not deal with the tank retrieval decision.

Table 2.1 summarizes this agreement.

**Table 2.1 Hanford Site Land Uses<sup>a,b</sup>**

Time (Y)	Core Zone (~200 Area)	Beyond Core Zone and Before River Corridor	National Monument and Columbia River
2000→2012	DOE cleanup activities	DOE cleanup activities	DOE cleanup activities
2012→2035	DOE cleanup activities	DOE cleanup activities	Recreational use
2035→2150	Restricted industrial use; no intruders and no groundwater use	Restricted Use, no groundwater use	Recreational use
2150→X <sup>c</sup>	Industrial use; data for informational use only	Multiple land use, data for informational use only	Recreational use
X <sup>c</sup> →	Industrial use; other uses for informational use only	Multiple land use	Recreational use

a Attachment of letter of Kline et al 2002

b Native American exposure scenarios will be evaluated at those locations where they have been defined.

c X is defined as the time that the groundwater contamination falls below the limits set in 40 CFR 61 (National Primary Drinking Water Standards) for a particular location due to contamination release before the year 2000 from Hanford Site facilities. Thus, it is likely that for locations beyond the core zone, X will be nearer to the present than for locations in the Core Zone. It is assumed (in the reference cited) that X is larger than 2150.

### 3.0 REGULATIONS AND OTHER PERFORMANCE ASSESSMENTS

#### 3.1 INTRODUCTION

Because both chemicals and radionuclides are considered, a large number of federal and state regulations are potentially applicable to the determination of protection of public health, safety and the environment. The CERCLA process (EPA/540/G-89/006, CERCLA Compliance with Other Laws Manual, Interim Final, 1988; EPA540/G-89/009, CERCLA Compliance with Other Laws Manual: Part II, *Clean Air Act*, and Other Environmental Statues and State Requirements, 1989) guided the process of identifying relevant regulations. Table 3.1 lists the regulations that were reviewed and that were judged potentially relevant to this proposed disposal action.

<b>Table 3.1. List of Relevant Regulations. (3 sheets)</b>	
<b>REGULATION</b>	<b>COMMENT</b>
<b>Federal Regulations</b>	
“Standards for Protection Against Radiation” (10 CFR 20, particularly Subparts C, D, and K)	Establishes standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the NRC.
“Licensing Requirements for Land Disposal of Radioactive Wastes” (10 CFR 61, particularly Subparts C and D)	Requirements of the Nuclear Regulatory Commission for the land disposal of low-level radioactive waste
“Occupational Radiation Protection” (10 CFR 835, particularly Subpart C)	Establishes radiation protection standards, limits, and programs for protecting individuals from ionizing radiation from the conduct of DOE activities
“Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste” (10 CFR 961)	
“National Environmental Policy Act Implementing Procedures” (10 CFR 1021)	
“National Primary and Secondary Ambient Air Quality Standards”(40 CFR 50)	Establishes air concentration standards that are protective of the public
“National Emission Standards for Hazardous Air Pollutants” (40 CFR 61, Particularly Subparts H and Q)	Establishes maximum exposure to public via air pathway
“National Primary Drinking Water Regulations” (40 CFR 141)	Sets drinking water standards
“National Secondary Drinking Water Standards” (40 CFR 143)	These regulations are not Federally enforceable, but are intended as guidelines for states. Washington State MTCA requires compliance with secondary standards for groundwater protection
“Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Wastes (40 CFR 191)	
“Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings” (40 CFR 192)	
“Criteria for the Certification and Re-certification of the Waste Isolation Pilot Plant’s Compliance with 40 CFR 191 Disposal Regulations” (40 CFR 194)	
“Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada” (40 CFR 197)	

<b>Table 3.1. List of Relevant Regulations. (3 sheets)</b>	
<b>REGULATION</b>	<b>COMMENT</b>
"Identification and Listing of Hazardous Waste" (40 CFR 261, particularly Subparts B and C)	Establishes which wastes are subject to RCRA
"Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" (40 CFR 264, particularly Subpart F)	Establishes groundwater protection
RCRA Landfills (40 CFR 264, Subpart N)	Establishes rules for landfills
Corrective Action for Solid Waste Management Units (40 CFR 264, Subpart 3- Proposed)	Identifies chemical-specific cleanup levels that are protective of groundwater
"Land Disposal Restrictions" (40 CFR 268, particularly Subpart D)	Prescribes treatment standards that must be met prior to land disposal of RCRA waste
"National Oil and Hazardous Substance Pollution contingency Plan", Superfund, Emergency Planning, and Community Right-to-Know Programs (40 CFR 300, particularly E)	Establishes methods and criteria for determining the appropriate extent of response by CERCLA and Clean Water Act
"Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution In Commerce, And Use Prohibitions" (40 CFR 761)	Regulates storage and disposal of polychlorinated biphenyls (PCBs)
<b>DOE Orders and Policies</b>	
<i>Radioactive Waste Management</i> (DOE O 435.1)	DOE order covering disposal of low-level waste, released July 9, 1999
<i>General Environmental Protection Program</i> (DOE 5400.1)	Lists executive orders, laws, and regulations which DOE actions must meet
<i>Radiation Protection of the Public and the Environment</i> (DOE 5400.5)	Provides exposure limits for general activities
<i>Department of Energy Radiological Health and Safety Policy</i> (DOE P 441.1)	Establishes basis of DOE's radiological control programs
<b>Washington State Regulations</b>	
WAC 173-200, "Water Quality Standards for Ground Waters of the State of Washington"	Sets standards for ground waters in the State of Washington
WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington"	Sets standards for surface waters in the State of Washington
WAC 173-303, "Dangerous Waste Regulations"	Implements RCRA in the State of Washington
WAC 173-304, "Minimal Functional Standards for Solid Waste Handling"	Sets requirements for landfills
WAC 173-340, "Model Toxics Control Act Cleanup Regulations"	Establishes the methods used to develop cleanup standards and their use in selection of a cleanup action. Primary and secondary drinking water standards and carcinogenicity ( $1 \times 10^{-6}$ risk), are the major criteria identified in the regulation as groundwater cleanup criteria
WAC 173-400, "General Regulations for Air Pollution Source"	Establish technically feasible and reasonably attainable standards to control emission or air contaminants
WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides"	Sets emission standards into air for radionuclides in the state of Washington
WAC 232-012, "Permanent Regulations"	
WAC 246-221, "Radiation Protection Standards"	Sets radiation protection standards for the state of Washington

<b>Table 3.1. List of Relevant Regulations. (3 sheets)</b>	
<b>REGULATION</b>	<b>COMMENT</b>
WAC 246-247, "Radiation Protection – Air emissions"	Sets radioactive air emissions standards
WAC 246-250, "Radioactive Waste – Licensing and Disposal"	Sets requirements for disposal of low-level radioactive wastes in the State of Washington
WAC 246-290 (310), "Standards for Public Water Supplies"	Defines requirements to protect consumers using public drinking water supplies
<b>Other</b>	
EPA Memorandum, "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination," OSWER 9200a, (1997)	Provides guidance on cleanup levels at CERCLA sites
Mostly superceded by:	
EPA Directive, <i>Radiation Risk Assessment at CERCLA, Q&amp;A</i> (OSWER 9200b, 1999)	
WDOH/320-015, "Hanford Guidance for Radiological Cleanup"	Provide interim regulatory guidance for Hanford Site Cleanup

Chemicals and radionuclides tend to be regulated separately. Ecology and EPA pursuant to RCRA and the Washington State Hazardous Waste Management Act (Revised Code of Washington [RCW] Chapter 70.105 regulates chemical waste management (including the management of the chemical components of radioactive mixed waste). Chemical waste activities at the Hanford Site are regulated under RCRA by virtue of Section 6001 of RCRA. EPA has delegated to the State of Washington much of the authority to implement the federal RCRA program. Ecology regulations (WAC 173-303, "Dangerous Waste Regulations are consistent with, and at least as stringent as, the EPA regulations (40 CFR 260-279) implementing RCRA.

An overarching document for chemical waste management is the *Hanford Federal Facility Agreement and Consent Order* (the Tri-Party Agreement or TPA) (Ecology et al. 1989). This agreement among DOE, EPA, and Ecology provides the means for compliance at the Hanford Site for satisfying the requirements of RCRA, CERCLA, and the *Washington State Hazardous Waste Management Act* (RCW 70.105). The TPA 1) defines cleanup commitments and sets due dates; 2) establishes responsibilities among the agencies; and 3) reflects the goal of achieving regulatory compliance and completing remediation activities with enforceable milestones.

DOE facilities used for the management, storage, treatment, and disposal of radioactive waste and radioactive mixed waste are planned, designed, constructed and operated under the authority of the *Atomic Energy Act of 1954* (AEA). DOE orders are issued under the authority of Section 161(i)(3) of AEA that permits DOE to govern activities authorized by the AEA to protect health and minimize danger to life and property.

Other regulations and general environmental acts were not included in Table 3.1 because:

- Requirements are for different environmental actions (for example, the disposal of uranium mill tailings, transuranic or high-level waste, which are covered by Title 10, *Code of Federal Regulations* [CFR], Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," [10 CFR 60]; Title 10, *CFR*, Part 961, "Standard

Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste,” [10 CFR 961]; Title 40, *CFR*, Part 191, “Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Wastes,” [40 CFR 191]; Title 40, *CFR*, Part 192, “Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings,” [40 CFR 192]; Title 10, *CFR*, Part 194, “Criteria for the Certification and Re-certification of the Waste Isolation Pilot Plant’s Compliance with 40 CFR 191 Disposal Regulations,” [40 CFR 194]; and Title 40, *CFR*, Part 197, “Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada,” [40 CFR 197]).

- Requirements dealing with general environmental concerns (e.g., the *National Environmental Policy Act* – NEPA, *National Historic Preservation Act of 1996*; *Archeological and Historic Preservation Act of 1996*; protection of cultural resources [DOE P 141.1]; Native American treaty rights [appendix A of DOE/EIS-0222F]; 59 FR 7629, “Executive Order 12898 of February 11, 1994: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations;” *Endangered Species Act of 1973* [ESA]; and WAC 232-012, “Permanent Regulations,” Department of Game Procedures) and such concerns are thought to be adequately addressed for the long-term by regulations presented here; or
- The regulations that were proposed, but that have since been withdrawn. Examples are the Radiation Site Cleanup Regulation (proposed 40 CFR 196) and Environmental Radiation Standards for Management and Disposal of Low-Level Waste (proposed 40 CFR 193) from the U.S. Environmental Protection Agency. Any future developments of such proposals will be followed.

The following sections of this chapter discuss how the regulations affect the various pathways and media investigated by the tank closure risk assessments.

- 3.2 Protection of the General Public
- 3.3 Protection for Workers
- 3.4 Protection of the Inadvertent Intruder
- 3.5 Protection of Ground Water Resources
- 3.6 Protection of Surface Water Resources
- 3.7 Protection of Air Resources
- 3.8 Land Disposal Restrictions

Quantitative limits from the regulations are contained in Appendix C tables.

## 3.2 PROTECTION OF THE GENERAL PUBLIC

### 3.2.1 Introduction

All regulations dealing with the disposal of or the clean up of waste have requirements for protecting the general public. Because of regulatory history, performance objectives for the protection of the general public from radionuclides and from chemicals have taken different paths. The performance objectives for protection from radionuclides have uniformly been expressed in terms of radiation dose. For chemicals, known or suspected carcinogens are the main concern, with the performance objectives being expressed in terms of incremental lifetime cancer risk. For non-carcinogens, the performance objectives are expressed in terms of hazard indices.

### 3.2.2 Radionuclides

Values of key performance objectives from various regulations and other documents for protecting the public are given in Table C.1.

**3.2.2.1 Atomic Energy Act.** Starting with the Atomic Energy Commission, rules implementing the AEA have been consistent. The philosophy was (and still is) to limit the total dose that a member of the public receives and then to limit exposures from specified actions to a fraction of this limit. Such an approach is based on international consensus and standards (that is, publications from the International Commission on Radiological Protection, e.g. *Recommendations of the International Commission on Radiological Protection, Annals of the ICRP*, Vol 1, No. 3 [ICRP 26] and *Limits for Intake by Workers, Annals of the ICRP*, Vols 2-8 [ICRP 30]).

Over the years, as dosimetry science has progressed, how dose has been expressed has evolved from dose to critical organs to cumulative dose equivalent (CDE) to the present use of effective dose equivalent (EDE). Presently, DOE (DOE O 435.1) and the NRC (Title 10, *Code of Federal Regulations*, Part 61, “Licensing Requirements for the Land Disposal of Radioactive Waste”)(10 CFR 61) use the same value for protecting the public from low-level waste disposal actions: 25 mrem/year EDE.

The Defense Nuclear Facilities Safety Board noted that a member of the public could receive exposures from several sources at a DOE site (Letter, “Recommendation 94-2, Safety Standards for Low-Level Waste” [Conway 1994]). Guidance from DOE-Headquarters (DOE P 441.1) is that protection of the general public from multiple sources should be based on *DOE Radiological Health and Safety Policy*, DOE Order 5400.5. This order sets a limit of 100 mrem in a year from all sources. In addition, the Order requires that if the dose is above 30 mrem in a year, then an additional analysis is required. For the Hanford Site, this is considered a fence surrounding the present Hanford Site 200 Areas. The *Composite Analysis for the Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site* (Kincaid et al. 1998) shows compliance with this requirement.

**3.2.2.2 Comprehensive Environmental Response, Compensation, and Liability Act.** The Environmental Protection Agency started from a different point in implementing CERCLA. Unlike the AEA, CERCLA covers both radionuclides and hazardous chemicals. Therefore, EPA developed an approach to handle both. For known or suspected carcinogens (which includes radionuclides), limits are expressed in terms of an excess upper bound lifetime cancer risk to an individual (Title 40, *Code of Federal Regulations*, Part 300.430, Subpart E, “National Oil and Hazardous Substance Pollution Contingency Plan: Hazardous Substance Response” [40 CFR 300.430]). In general, the EPA uses the approach of finding applicable or relevant and appropriate regulations (ARARs). The EPA **“has determined that the NRC decommissioning requirements (e.g., 25, 100 mrem/yr dose limits) under 10 CFR 20 Subpart E should generally not be used to establish cleanup levels under CERCLA, even when these regulations are ARARs”** (*Radiation Risk Assessment at CERCLA Sites: Q & A*, OSWER 9200b, 1999, emphasis in the original). For the cases where no ARARs are present or acceptable to the EPA, “Cleanup levels not based on an ARAR should be based on the carcinogenic risk range (generally  $10^{-4}$  to  $10^{-6}$  ...)” (OSWER 9200b, 1999). Under CERCLA, the administrator has extensive flexibility in balancing risk mitigation against other factors. The CERCLA guidance (OSWER 9200b, 1999) continues “EPA generally uses  $1 \times 10^{-4}$  in making risk management decisions. A specific risk estimate around  $10^{-4}$  may be considered acceptable if based on site-specific circumstances.” and “In general, dose assessment used as a method to assess risk is not recommended at CERCLA sites.” The “Hanford Guidance for Radiological Cleanup” (WDOH/320-015, 1997) from the Washington Department of Health follows the CERCLA approach. For CERCLA remedial actions at Hanford, the Tri-Parties have chosen 15 mrem/yr above background over a period of 1,000 years after final remediation for a maximally exposed individual to meet the CERCLA cumulative excess cancer risk range of  $10^{-4}$  to  $10^{-6}$ .

**3.2.2.3 Summary for Radionuclides.** For CERCLA sites, the performance objective for protecting the general public should be an increased individual lifetime cancer risk of  $10^{-4}$ . In its guidance for its order on Radioactive Waste Management, DOE has reaffirmed its intent to use 25 mrem/a year as the all-pathway objective, while acknowledging EPAs concern. It is recognized that the entire Hanford Site central plateau will be closed under CERCLA sometime in the future, but that currently, individual facilities are managed under the appropriate regulation. Thus, for non-CERCLA sites (for examples, those regulated under RCRA), the action-specific performance objective for protecting the general public should be 25 mrem/year, with performance objectives from all sources of 100 mrem/yr.

### 3.2.3 Chemicals

Although there are two main regulations, CERCLA and RCRA (as implemented by the State of Washington), which drive the protection of the general public, their goals and methods are similar. Both CERCLA (40 CFR 300.430) and the State of Washington (WAC 173-340-708) (See Table C.2) use incremented lifetime cancer risk (ILCR) as the risk measure. Both use an impact measure of  $10^{-6}$  increase in ILCR for single chemicals. The state of Washington uses a measure of  $10^{-5}$  for multiple chemicals, while CERCLA uses  $10^{-4}$  for multiple chemicals and radionuclides.

To handle non-carcinogenic chemicals, the hazard index is used. Based on EPA tables, contaminant concentrations are weighted and then summed. The requirements are that the sum be less than unity.

### **3.2.4 Allotment of Performance Standards**

In general, the regulations provide performance standards for a given action, rather than from all sources. However, in some cases (e.g., DOE order on environmental protection [DOE 5400.5] and federal regulations for workers [Title 10, *Code of Federal Regulations*, Part 835, "Occupational Radiation Protection]), limits are given for all sources. Because standards are provided for a given action, there is no need to allocate the standards among actions.

### **3.2.5 Summary**

Separate performance objectives are given for CERCLA and non-CERCLA sites. For CERCLA sites, the all-pathways performance objective is an increase of  $10^{-4}$  in lifetime cancer risk. For non-CERCLA sites (in particular, RCRA sites), the radiological performance objective is 25 mrem/year from the action, while the chemical objective is  $10^{-5}$  incremented lifetime cancer risk.

Since tanks are regulated AEA/RCRA facilities, the radiological performance objective is 25 mrem/year from the action, while the chemical objective is  $10^{-5}$  incremented lifetime cancer risk. In addition, the hazard index from non-carcinogenic chemicals must be less than 1.

## **3.3 PROTECTION FOR WORKERS**

For this performance assessment, as for others performed under DOE orders on radioactive waste management, worker health is not explicitly addressed. Rather, the more restrictive requirements for the general public are used. Protection for workers during construction and operations will be addressed in the safety analysis report that will be prepared for the Immobilized Waste Program. As seen from Table C.1 (Protection of General Public) and Table C.3 (Protection of Workers), Protection of workers is more restrictive.

## **3.4 PROTECTION OF THE INADVERTENT INTRUDER**

Just as in protecting the general public, regulations arising from the key laws are different. In general, DOE and NRC, in the regulation of radionuclides under the AEA, have assumed that there would be a period of institutional control after disposal. For clean up of sites, EPA also allows assumptions of periods of institutional control, such as for containment alternatives. RCRA assumes institutional control would last long enough for risk to remain unimportant.

Only sites under AEA jurisdiction have a separate protection level for inadvertent intrusion. The limits are shown in Table C.4. The exposure limits for protecting a hypothetical inadvertent intruder (DOE O 435.1, and 10 CFR 61) are consistent, since the Class C waste disposal limits are based on 500 mrem for a one-time (acute) exposure and 100 mrem/year for a continuous exposure.

### 3.5 PROTECTION OF GROUND WATER RESOURCES

#### 3.5.1 Introduction

The protection of ground water resources is the most complicated requirement to determine. The level of protection for groundwater is usually based on its intended use. However, predicting future groundwater use is highly subjective given the long periods involved in a performance assessment. The quantities being limited (decay rate and dose) differ in the various regulations. Moreover, different regulatory agencies approach the protection of groundwater resources using a variety of methods.

The guidance under the new DOE order on radioactive waste management (see Appendix B) is to use the site's groundwater protection management plan. However, the *Hanford Site Ground Water Protection Management Plan, Rev. 2*, (DOE/RL-89-12, 1995) focuses only on short-term activities and does not address the metrics to apply for the long-term protection of groundwater.

The state of Washington has determined that the highest beneficial use of groundwater is as a source of drinking water (WAC 173-200-030, "Water Quality Standards for Groundwaters of the State of Washington" and WAC 173-340-720). In the past most risk assessments at the Hanford Site have generalized the requirements from Title 40, *Code of Federal Regulations*, Part 141, the "National Primary Drinking Water Regulations" (40 CFR 141) for determining if the disposal action meets the groundwater protection requirement. The scenario used is based on a public drinking water system serving at least 25 people and located at the point of assessment of the disposal facility.

Table C.5 provides the performance standards for drinking water. Table C.6 provides the performance standards for the explicit protection of groundwater. Table C.7 provides a summary of regulatory levels sorted by contaminant.

#### 3.5.2 Radionuclides

For radionuclides, there is fair agreement among the regulations. The notable exception is the level of contaminant concentration in WAC 173-200-040. For this performance assessment, the Federal standards are used. This means that the current EPA regulation governing drinking water (40 CFR 141) is used to protect groundwater. The "Maximum Contaminant Level Goals" subpart F of 40 CFR 141 and Title 40, *Code of Federal Regulations*, Part 143, the "National Secondary Drinking Water Standards" (40 CFR 143) were not used because they are stated only

as goals. This follows the precedent set in the *Tank Waste Remediation System Environmental Impact Statement* (TWRSEIS) (DOE G 435.1), a joint publication of the Washington State Department of Ecology and DOE as well as earlier versions of the ILAW performance assessment (e.g., Mann et al. 2001).

The Title 40, *CFR*, Part 141, "National Primary Drinking Water Regulations" (40 *CFR* 141) treats radionuclides and chemicals separately. It groups beta and photon emitters into one category (having a limit of 4 mrem/yr), alpha emitters other than uranium and radium isotopes into a second category (having a limit of 15 pCi/l), and gives other contaminants individual limits (usually expressed in pCi/L or mg/L). It should be noted that after December 8, 2003, the limits for radionuclides will turn into goals.

Washington State regulations for drinking water, WAC 246-290-310, "Public Water Supplies: Maximum Contaminant Levels (MCLs)" are based on 10 *CFR* 141. It should be noted that radionuclides in Washington State drinking water are regulated by Ecology.

Washington State's requirements for beta emitters are based on a screening level previously used by the EPA. These screening levels were selected because the requirements are easily verified in the field. (The current EPA regulations are based on risk limitation). The current state screening level ensures that even for beta emitters emitting high-energy gamma radiation, the dose limit will be met. However, for low-energy beta emitters, the state screening level is conservative by a factor of about 100. This high degree of conservatism exists for radionuclides, such as <sup>99</sup>Tc, that are important in this performance assessment.

A final question is how to apply the standards chosen. The standards can be applied at a point in the groundwater or averaged over a height corresponding to the water intake elevations of drinking water systems. Given that groundwater is being protected as a source for drinking water, the latter approach will be used. This is appropriate since estimations of future groundwater contamination are built on numeric models that have a finite cell size. A study from Washington State University, *Evaluation of the Potential for Agricultural Development at the Hanford Site* (Evans et al. 2000), found that the average screened length for industrial wells was 4.6 meters (15 feet), for domestic wells was 6.17 meters (20 feet), and for irrigation and municipal wells significantly larger. For comparisons to the performance objectives, a screen length of 4.6 meters will be used, corresponding to the smallest width. These screen lengths are normally found at the bottom of the well, which Evans et al found to be about 40 meters (~130 feet) deep. However, as contamination near a facility is normally near the top of the groundwater, the well screen will be assumed to start at the top of the groundwater and extend downward.

### 3.5.3 Chemicals

Unlike radionuclides, where the contaminants are treated usually as groups (i.e., beta/gamma emitters and alpha emitters), each chemical is treated separately. For the inorganic chemicals, there is good agreement among the regulations, as seen from Table C.7. Different regulations treat different organic chemicals.

For the analyses covered by this document, the most restrictive regulation will be applied. To reduce the length of the tables, only those organic chemicals listed in Table A.1 will be included in the list of chemicals for which performance objectives are applied. The organic chemicals listed in Table A.1 are those most often detected in Hanford tank waste as documented in the *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project* (Wiemers et al. 1998).

#### **3.5.4 Allotment of Performance Standards**

Unlike the standards for protecting the public, which are usually stated for a given disposal or clean-up action, the standards for groundwater protection, cover all sources that cause the contamination. This is quite reasonable, especially at the Hanford Site, as many sources may have caused a contaminant plume in groundwater. However, such a commingling of sources is difficult to sort out.

The situation is even more complicated with the agreement by the Tri Parties (DOE, EPA, and Ecology) (Kline 2002). The agreement creates a new source (pre-existing Hanford conditions) that also must be considered.

Once the Systems Assessment Capability updates the results of the 1998 Composite Analysis (Kincaid et al. 1998), then it should be possible to sort out how much of the performance standard for each contaminant can be allocated to each source (including the pre-existing sources). Until that time, the full allotment of performance standards will be applied to tank farms, as there is no basis for any other split.

#### **3.5.5 Summary**

For the protection of groundwater, the Federal Drinking Water Standards will be used, except for those chemicals where Washington State or other Federal regulations are more restrictive.

### **3.6 PROTECTION OF SURFACE WATER RESOURCES**

#### **3.6.1 Introduction**

Federal (40 CFR 141) and State requirements (WAC 173-201A and WAC 173-340-730) for surface water protection are similar in scope and objectives. Both are directed at preventing degradation of surface water quality and preservation of highest priority water uses.

Relevant Regulations are presented in Table C.8.

### 3.6.2 Radionuclides

The Washington State regulation mandates a dose limit that is the lesser of the EPA drinking water standard and explicit limits for each radionuclide contained in the State regulation (WAC 173-201A). For the major radionuclides of interest, the explicit limits when converted to dose are greater than 1.3 mrem in a year. A 1.0 mrem (EDE) dose in a year (one quarter of the EPA drinking water standard) value is used because it meets the Washington State regulation while minimizing reporting requirements.

### 3.6.3 Chemicals

Performance goals for chemicals were chosen by selecting the more restrictive of the Federal and State groundwater regulations. All inorganic chemicals found in the regulations are included in Table A.3. However, for organic chemicals only those organic chemicals that have been detected frequently in tank waste are included in Table A.3.

## 3.7 PROTECTION OF AIR RESOURCES

Table C.9 contains the relevant regulations governing air emissions. Federal air emissions limits found in Parts H and Q of the "National Emissions Standards for Hazardous Air Pollutants" (40 CFR 61) are the same as those found in the DOE M 435.1, *Radioactive Waste Management Manual*. State standards vary, but the main Department of Health regulation uses the federal standard. Based on these standards, emissions (except radon) are limited to 10 mrem (EDE) in a year with radon emissions limited to 20 pCi/m<sup>2</sup>s.

## 3.8 CONCENTRATION AND RELEASE LIMITS

Besides requiring the protection of various resources, regulations under AEA and RCRA require the limiting of contaminant concentration and contaminant release rates. The requirements are shown in Table C.10.

The NRC Class C restrictions strictly do not apply to DOE, as DOE has the legal authority to disposal of greater than Class C wastes. However, as DOE does not yet have procedures to dispose of greater than Class C waste, the NRC Class C limits apply at Hanford.

For hazardous substances regulated under RCRA, maximum concentrations and maximum release rates are regulated. The release rates are not necessarily for conditions that the dangerous waste will actually experience, but rather are based on a standardized test. The test, Toxicity Characteristic Leaching Procedure (TCLP), is designed to mimic conditions from municipal landfills.

At present, the material properties of the residual waste are not known. It is expected that release waste tests on actual tank waste residuals will be performed.

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## 4.0 POINTS OF ASSESSMENT

### 4.1 Introduction

“Points of assessment” as used in this document are not regulatory points of compliance. Although they are based on regulation, the points of assessment defined in this document are only the locations at which estimated future impacts are compared against levels set in Chapter 3. The regulatory points of compliance will be defined in regulatory documents associated with the facility (e.g., permits, Records of Decisions, etc.).

Another nuance to understand in the use of computer models is that the spatial resolution of the models often is quite large. The spatial resolution may be a few meters (~10 feet) in the case of models dealing with the disposal facility to 375 meters (~ 1/5 mile) in the case of Hanford Site models. Therefore, even though the points of assessment may be precisely defined, as implemented in the computer models the points of assessment will cover a range of values.

The next section discusses the various options available, while the remaining sections describe the selection of points of assessment for each of the items to be protected.

### 4.2 Options

Although, in theory, there could be a large number of possible choices for the points of assessment, in reality there are only five:

- At the facility,
- The maximum point of impact at least 100 meters from the facility,
- The maximum point of impact at the fence line of the facility or beyond,
- The maximum point of impact at the edge of the 200 Area core zone or beyond, and
- The maximum point of impact along the Columbia or Yakima Rivers.

The 200 Area core zone (see Section 2.6) is a construct that has not yet been formalized. This core zone includes the present 200 East and 200 West Areas and the land in between them. It also includes nearby ponds (e.g. S Pond, B Ponds) created by massive discharge of dilute waste. The creation of the core zone recognizes the past use and impacts as well as the likely future use of this area.

### 4.3 Protection of the General Public, Workers, and Ground Water

Past work (e.g., Mann et al. 2001, *Field Investigation Report for Waste Management Area B-BY-BX*, Knepp 2002) has shown that the most important media (by far) for the protection of the general public is groundwater. As noted in Section 3.3, long-term protection of workers is to be met by applying the same standards as protecting the public. Thus, this section will deal with groundwater points of assessment.

Whereas the points of assessment for other items are fairly straight forward, the establishment of points of assessment for protecting the general public, workers, and groundwater is complicated. Not only do different regulations have slightly different rules, but given the complex past history of contamination at the Hanford Site, these points of assessment may be time dependent.

Regulations governing chemicals and radionuclides recognize the idea of a buffer area surrounding the facility. In the case of RCRA, *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities* (40 CFR 264.95) states “The point of compliance is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units.” As implemented by the State of Washington, the *Model Toxics Control Act – Cleanup* (WAC 173-340-72) uses a similar definition. The limits for a waste management area at the Hanford Site are usually taken to be the fence line surrounding the facility. In the case of the AEA (DOE M 435.1[IV.P92] (b)), “The point of compliance shall correspond to the point of highest projected dose or concentration beyond a 100 meter buffer zone surrounding the disposed waste.” As noted in DOE O 435.1-1, *Technical Basis for DOE M 435.1*, “The “point of compliance is consistent with regulatory positions included in Title 40, *Code of Federal Regulations*, Part 192.32, “Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings,” (40 CFR 192.32) and Title 40, *Code of Federal Regulations*, Part 264.95, “Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and disposal Facilities,” (40 CFR 264.95). The NRC regulation at 10 CFR 61.52(a) (8) states that a ‘buffer zone of land must be maintained between any buried waste and the disposal site boundary ...’”.

Given that fence lines are often about 100 meters away from the tanks and given the relatively poor spatial resolution of the computer models, the choice between the fence line and 100 meters from the facility is usually mute. Rather, the choice should be made on how best to model the facility and its surrounding area.

A more difficult requirement is the introduction of the future land use. Due to past actions, the groundwater underneath much of the 200 Area core zone and extending toward the Columbia River is currently contaminated above drinking water standards (see Figures 4.1 and 4.2, which were taken from the *Hanford Site Groundwater Monitoring for Fiscal Year 2001* [Hartman et al. 2002]).

As noted in Section 2.6, the three parties (DOE, EPA, and Ecology) have agreed that given this large area of contamination, it may be impracticable for future releases to meet standards at the waste management boundary. Rather they have adopted an approach involving time dependent points of compliance. As the groundwater is cleaned up, the point of compliance moves toward the waste management area.

For risk assessments, such an approach is difficult to implement, as there are an infinite number of points of assessments and a similar number of times of assessment. A nearly equivalent process is to define a limited set of points of assessment with each having a separate time of assessment based on predicted Hanford Site groundwater cleanup.

Figure 4-1. Location of groundwater concentrations of radionuclides above drinking water standards. (From Hartman 2002)

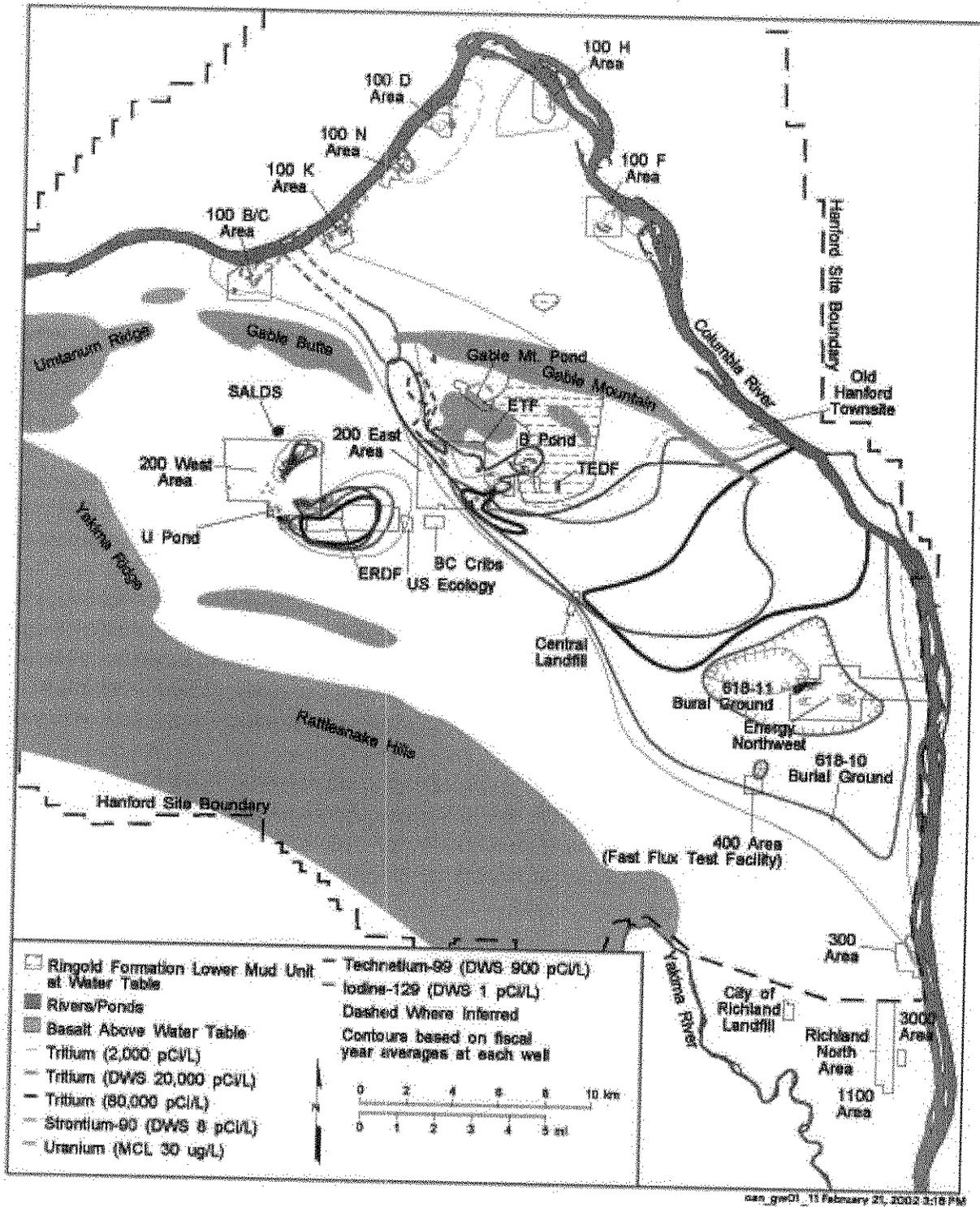
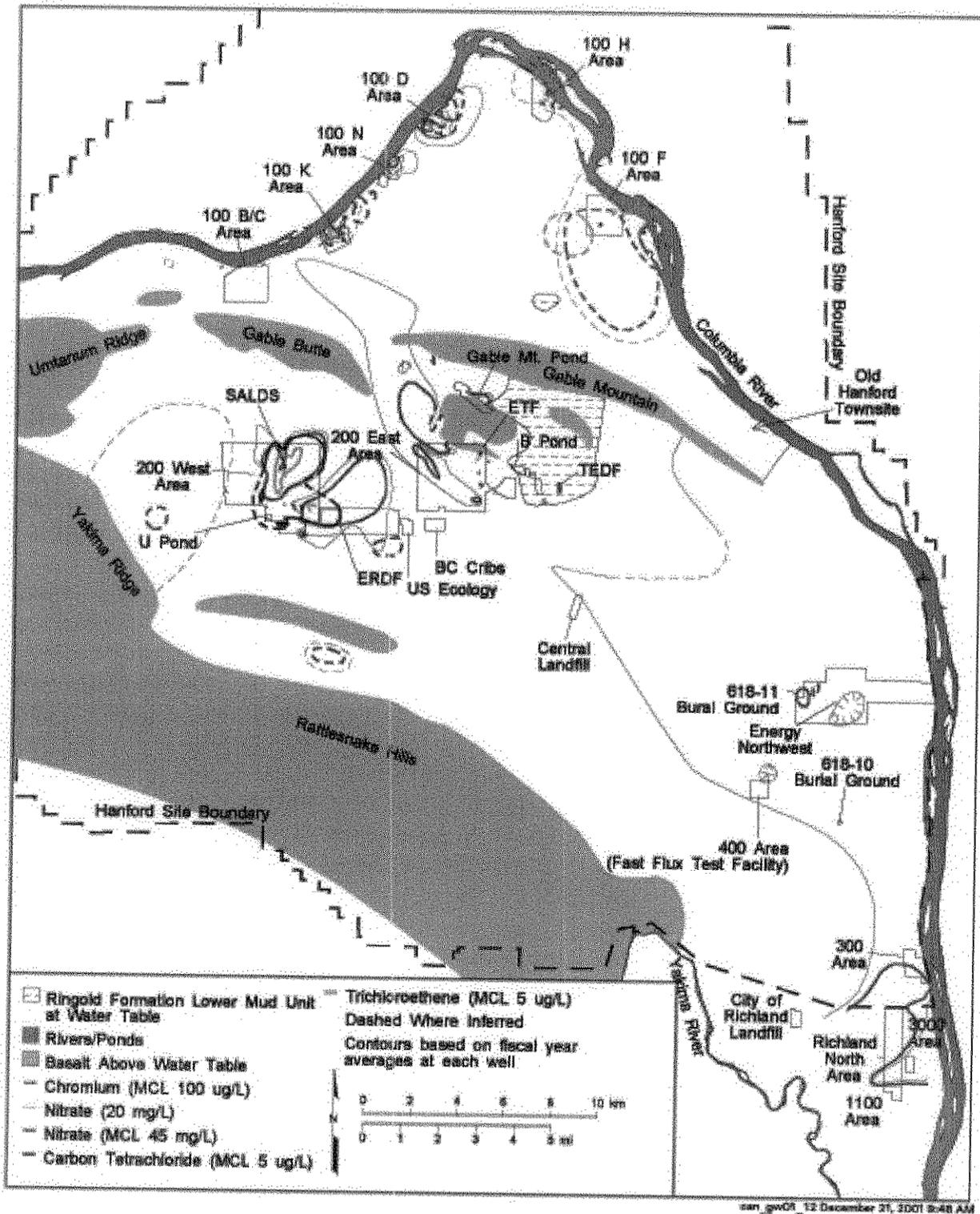


Figure 4-2. Location of groundwater concentrations of chemicals above drinking water standards. (From Hartman 2002)



The suggested points of assessment are

- Fence line of the facility (or 100 meters downgradient of the facility),
- Edge of 200 Area Core Zone, and
- Just before groundwater reaches the Columbia River.

Times of assessment for each of these points are discussed in Chapter 5. These times of assessment are currently based on *Composite Analysis for the Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site* (Kincaid et al. 1998), with updates expected from the System Assessment Capability. Such an approach allows for straightforward calculations and comparisons without biasing the comparisons.

For the tank closure risk assessments, the fence line point of the waste management area containing the tank(s) will be the main point of calculation. Based on previous work (Mann et al. 2001 and Knepp 2002), this point is expected have the largest impacts. The other points (Edge of 200 Area Core Zone and just before the Columbia River) will be used for information only, as it is expected that the groundwater dilution will reduce the impacts.

#### **4.4 PROTECTION OF THE INADVERTENT INTRUDER**

In order for an inadvertent intruder to be harmed by the disposal facility, the intruder must contact the facility. Thus, the point of assessment for the inadvertent intruder is the maximum point of impact at the facility itself.

#### **4.5 PROTECTION OF SURFACE WATER RESOURCES**

The only surface waters near the Hanford Site are the Columbia and Yakima Rivers. Because groundwater flows from the 200 Area to the Columbia River and not to the Yakima River, only the Columbia River will be considered. The Columbia River has an extremely large flow rate (typically 1,000 to 3,000 m<sup>3</sup>/s [*Hanford Site Environmental Report for Calendar year 1998*, Dirkes 1999]). However, the mixing factor for groundwater / Columbia River mixing is not well established for regulatory purposes. Therefore, conservatively, a unit-mixing factor will be used with the point of assessment being the groundwater just before it enters the Columbia River.

#### **4.6 PROTECTION OF AIR RESOURCES**

The point of assessment for protecting air resources is taken at the disposal facility. Either the regulations (e.g. 40 CFR 41.192) specify a maximum flux through the surface of the facility or the regulations (e.g., 40 CFR 61.92) specify a maximum dose. Either way, the maximum impact will be at the facility.

#### 4.7 SUMMARY

For tank closure risk assessments, the points of assessment will be

- At the facility for protection of the inadvertent intruder and air resources
- No nearer than the fence line of the waste management area downgradient from the disposal facility for the protection of the public, workers, and groundwater, and
- In the groundwater just before it enters the Columbia River for the protection of the surface waters.

Impacts to groundwater and the public will also be generated for points at the edge of the 200 Area Core Zone and just before the groundwater enters the Columbia River. However, these values are not believed to be restrictive.

## 5.0 TIMES OF ASSESSMENT

### 5.1 INTRODUCTION

“Times of assessment” as used in this document are not regulatory times of compliance. Although they are based on regulation, the times of assessment defined in this document are only the time periods over which estimated future impacts are compared against levels set in Chapter 3 at points specified in Chapter 4. The regulatory times of compliance will be defined in regulatory documents authorizing the facility (e.g., permits, Records of Decisions, etc.).

The next section discusses the various options available, while the remaining sections describe the selection of points of assessment for each of the items to be protected.

### 5.2 OPTIONS

Although, in theory, there could be a large number of possible choices for the points of assessment, in reality there are only seven defined by regulatory drivers:

- From the end of institutional control to 500 years,
- From the end of institutional control to 1,000 years,
- From the end of institutional control to 10,000 years,
- From the end of institutional control to time of maximum impact,
- From the time a resource can beneficially be used to 1,000 years,
- From the time a resource can beneficially be used to 10,000 years, and
- From the time a resource can beneficially be used to the time of maximum impact

Different regulations have different philosophies. The same regulation (e.g., DOE M 435.1) may have different philosophies for different items being protected.

It is the policy of DOE that the department will not release land until all resources are protected (DOE 5400.5). However, given the land use decisions outlined in Section 2.6, the separation of the end time of institutional control and the time at which resources can be beneficially used should be kept.

As noted in Section 2.6, DOE along with its regulators (EPA and Ecology) have determined that for at least the next 150 years, the 200 Area Core Zone will be under institutional control. During this time, access to the sites will be limited and controlled. Therefore, no significant impacts are expected.

In general, the times of assessment for hazardous materials are not explicitly defined in the regulations (see, for example, 40 CFR 264.96), but are rather given in the permit.

In general, DOE (DOE M 435.1 [IV.P] [2]) uses a maximum time of 1,000 years. Calculations may extend to 10,000 years, but only as part of sensitivity and uncertainty analyses. This is a

change from previous guidance (e.g. *Performance Assessment Task Team Progress Report* [Wood et al. 1994]) which had recommended 10,000 years. Appendix B.1.4 (DOE O 435.1-1) presents a more complete defense of DOE's choice of 1,000 years.

The Nuclear Regulatory Commission uses a longer time: 10,000 years (see, for example, the *Branch Technical Position on a Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities* [NRC-1573, 1997]). The use of 10,000 years as a time of assessment is consistent with that used in the other Hanford Site performance assessments: the *Performance Assessment of Grouted Double Shell Tank Waste Disposal at Hanford* (Kincaid et al. 1995), the *Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds* (Wood et al. 1995), and the *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds* (Wood et al. 1996).

The use of the time having maximum exposure has not normally been used as time of assessment in risk assessments, because such a time is quite sensitive to parameters chosen for the risk assessment. However, calculations out to this time are often performed for information.

### **5.3 PROTECTION OF THE GENERAL PUBLIC, WORKERS, AND GROUND WATER**

For the protection of the general public, workers, and groundwater, both a beginning time and an ending time must be considered. These will be considered independently in the following text.

#### **5.3.1 Beginning Period**

Noting that exposure is primarily through the use of groundwater, the beginning time will be set as the time that beneficial use of groundwater is possible. This is consistent with the guidance given by DOE, EPA, and Ecology as noted in Section 2.6. However, since this is a relatively new policy, details have not been formalized.

A path forward for the assessment points at the 200 Area Core Zone and near the Columbia River is easily suggested. In 1998, the *Composite Analysis for the Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site* (Kincaid et al. 1998) estimated groundwater impacts from 200 Area sources. (The composite analysis was approved by DOE/HQ in memorandum "Conditional acceptance of the Immobilized Low-Activity Tank Waste Disposal facility Performance Assessment and the Hanford Site 200 Plateau Composite Analysis" [Fiore 1999]). Because the composite analysis was performed under AEA, neither Ecology nor EPA formally commented on the analysis nor approved the report. The Composite Analysis shows that groundwater concentrations of beta/photon emitting radionuclides at the Columbia River will not fall below Federal Primary Drinking Water standards (40 CFR 141) until about 2030 (Private communication concerning the numeric results supporting the 1998 Composite Analysis, Bergeron 2002). Similarly, the analysis shows that groundwater cannot be beneficially used until ~2160 (Bergeron 2002) at the boundary of the 200 Area Core Zone.

Obviously, there are uncertainties with this approach. Because the Composite Analysis was not designed to perform explicitly these calculations, judgment must be applied on the choice of where along the Columbia River and where along the 200 Area Core Zone to apply the criteria of beneficial use. In addition, which criteria of beneficial use should be applied is uncertain. As noted in Section 3.5, various groundwater criteria could be applied. Finally, the analyses for the Composite Analysis were done in 1996 and 1997, a time period predating a vast increase in vadose zone and groundwater information and understanding.

It is highly likely that the flow paths of future releases will basically follow the current groundwater streams and those predicted in the composite analysis. Although changes are to be expected (e.g., from the cessation of discharging liquids into the vadose zone and hence into groundwater), it is likely that stream path predicted by the composite analysis will predict the times that groundwater could be beneficial.

The analysis above assumed that the Federal Primary Drinking Water Standards were the appropriate standard for beneficial use of groundwater. Washington State regulations (WAC 173-200-040 and WAC 173-340-720) do define the most beneficial use of groundwater that must be protected as a source of drinking water. However, rather than use 40 CFR 141, other criteria could be used (for example, the increase in cancer deaths under 40 CFR 300.430 or WAC 173-340). The Federal drinking water standards were chosen as the standards to be applied to drinking water in Section 3.6. The choice of action level and the choice of criteria to set the beginning of the assessment time should be consistent.

Although the composite analysis was issued in 1998, DOE M 435.1 (IV.R.3 [a]) requires that it must be maintained to reflect new information and understanding. Through the development of the System Assessment Capability (SAC) and its associated databases, a new composite analysis is expected to be issued in 2004-2005. Results from a revised SAC could be available as soon as the end of calendar year 2003.

However, the approach of using the composite analysis cannot be applied for the point of assessment near the facility. The grid size (375 meters) is too large to provide meaningful results so near the facility (~100 meters) and the analysis was not implemented to perform calculations so near facilities. Thus, each facility must establish their own approach.

There is significant amount of groundwater contamination presently around tank farms. The vast majority of this contamination results from planned past practice liquid discharges, although some has come from unplanned tank leaks and release. It is unlikely that the groundwaters near tank farms will be of beneficial use before 2150. Therefore, this time is tentatively taken as the beginning time for the period of assessment for tank closure risk assessments.

### **5.3.2 Ending Period**

DOE M 435.1 makes clear DOE's intention to use 1,000 years as the time of assessment. However, as much of the waste disposed of at the Hanford Site is derived from high-level waste, the NRC has indicated that DOE must protect the public and the environment consistent with

NRC standards (External letter, "Classification of Hanford Low-Activity Tank Waste Fraction," Paperiello 1997). Thus, the more conservative time of assessment (10,000 years) should be used to provide information. This is especially true for the Hanford Site, where vadose zone travel times for even the most mobile contaminants disposed of under engineered conditions are predicted to be many thousands of years.

#### **5.4 PROTECTION OF THE INADVERTENT INTRUDER**

The time period for analyzing the inadvertent intruder is usually taken from the end of institutional control out to 500 or 1,000 years. The end time is usually unimportant as the decay of key radionuclides normally overcomes the ingrowths of any other radionuclides (usually actinides).

The inadvertent intrusion time of assessment differs slightly between regulations. Current DOE guidance (Letter, "Critical Assumptions for Department of Energy Low-Level Disposal Facility Assessments," Alm 1997) is that active institutional control shall occur for at least 100 years, but notes that longer times can be used if justified. DOE intends to control the Hanford Site 200 Areas as long as necessary to protect the public, *Draft Hanford Remediation Action Environmental Impact Statement and Comprehensive Land Use Plan* (DOE/EIS 0222D, 1996). As noted in Section 2.6, the period of control will be at least 150 years from the present.

A second consideration is that the Nuclear Regulatory Commission allows a delay in the start of the time of assessment for protecting inadvertent intruders if the waste is placed in an engineered facility that is well marked. The philosophy being that such a facility would be remembered and that the warning signs would deter intruders. For NRC Class C level waste, the 500 years is normally used because of the restrictions placed on the disposal of such waste (10 CFR 61). The Hanford Site grout performance assessment (Kincaid et al. 1995) used the 500-year assessment time based on the assumption that passive barriers and markers would be present. The performance assessments for the disposal of solid radioactive waste on the Hanford Site (Wood et al. 1995 and Wood et al. 1996) also have used an assessment time of 500 years.

Following the precedent of the other Hanford Site performance assessments, the 500-year assessment time was used in this assessment because passive barriers and markers are planned for this proposed disposal action. Therefore, protection of an inadvertent intruder shall be considered met if the exposure limits are met at 500 years after closure. Calculations will be run from 100 years to 1,000 years after the time of disposal to obtain the doses as a function of time.

#### **5.5 PROTECTION OF SURFACE WATER RESOURCES**

The time period of assessment for surface waters is based on the discussion of protecting groundwater just before it enters the Columbia River. Therefore, the time period of assessment will be the time of site closure (~2030 years) to 1,000 years. However, results will be presented out to 10,000 years.

## **5.6 PROTECTION OF AIR RESOURCES**

Because of decay of the radionuclides, the earliest times are usually the most important. Again, based on Section 2.6 the end of institutional control (150 years) from the present will be used as the start of the assessment period. The end will be taken to be 1,000 years, following DOE policy.

## **5.7 Summary**

For tank farm closure risk assessments, the times of assessment will be:

- For the protection of the general public, workers, groundwater, and air resources: 2150 to 3030.
- For the protection of surface waters: 2030 to 3030.
- For the protection of the inadvertent intruder: 2530 to 3030.

However, explicit calculations for the protection of the general public, workers, groundwater, and surface waters will extend to 10,000 years. Results will also be provided to show the time of peak impact for these items. Results for the inadvertent intruder will be provided starting 100 years after closure.

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## 6.0 PUBLIC INVOLVEMENT

It is important that Hanford stakeholders have the opportunity to affect the performance objectives used in the tank closure risk assessments. Public comments were requested on the documents (*Overview of the Performance Objectives and Scenarios of TWRS Low-Level Waste Disposal Program*, Mann 1994; *Performance Objectives of the Tank Waste Remediation Systems Low-Level Waste Disposal Program*, Mann 1995; *Performance Objectives for the Hanford Site ILAW Program*, Mann 1999; and *Performance Objectives for the Hanford Immobilized Low-Activity Waste Performance Assessment*, Mann 2002) on which this document is based. Only minor comments have been received.

Comments on this version of the document should be sent to:

Frederick M. Mann  
CH2M Hill Hanford Group  
Mail Stop E6-17  
Post Office Box 1500  
Richland, Washington 99352

Since calculations for tank closure have already started, to be effective the comments should be sent as soon as possible.

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## 7.0 REFERENCES

- 10 CFR 20, "Standards for Protection against Radiation," *Code of Federal Regulations*, as amended.
- Subpart C, "Occupational Dose Limits," Sections 1201 through 1208.
  - Subpart D, "Radiation Dose Limits for Individual Members of the Public."
  - Subpart K, "Waste Disposal," Sections 2001 through 2007.
- 10 CFR 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," *Code of Federal Regulations*, as amended.
- 10 CFR 61, "Licensing Requirements for the Land Disposal of Radioactive Waste," *Code of Federal Regulations*, as amended.
- Subpart C, "Performance Objectives," Sections 40 through 44.
  - Subpart D, "Technical Requirements for Land Disposal Facilities," Sections 50 through 59.
- 10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.
- Subpart C, "Standards for Internal and External Exposure," Sections 202 through 209.
- 10 CFR 961, "Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste," *Code of Federal Regulations*, as amended.
- 10 CFR 1021, "National Environmental Policy Act Implementing Procedures," *Code of Federal Regulations*, as amended. (Found in Appendix B, page B-1).
- 40 CFR 50, "National Primary and Secondary Ambient Air Quality Standards," *Code of Federal Regulations*, as amended. Sections 4 through 12
- 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, as amended, Section 92,
- Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities, Section 92.
  - Subpart Q, "National Emission Standards for Radon Emissions from Department of Energy Facilities," Section 192.
- 40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.
- Subpart B, "Maximum Contaminant Levels and Maximum Residual Disinfectant Level Goals," Sections 11 through 16.
  - Subpart F, "Maximum Contaminant Level Goals," Sections 50 to 55.
  - Subpart G, "National Revised Primary Drinking Water Regulations: Maximum Contaminant Levels and Maximum Residual Disinfectant Levels," Part 60 to 66.

40 CFR 143, "National Secondary Drinking Water Standards," *Code of Federal Regulations*, as amended.

- "Secondary maximum contaminant levels," Section 3.

40 CFR 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Wastes," *Code of Federal Regulations*, as amended.

40 CFR 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," *Code of Federal Regulations*, as amended.

- Subpart D, "Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended," Sections 30 to 34.

40 CFR 194, "Criteria for the Certification and Re-certification of the Waste Isolation Pilot Plant's Compliance with 40 CFR 191 Disposal Regulations," *Code of Federal Regulations*, as amended.

40 CFR 197, "Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada," *Code of Federal Regulations*, as amended.

40 CFR 261, "Identification and Listing of Hazardous Waste," *Code of Federal Regulations*, as amended.

- Subpart B, "Criteria for Identifying the Characteristics of Hazardous Waste and for Listing Hazardous Waste," Sections 10 and 11.
- Subpart C, "Characteristics of Hazardous Waste," Sections 20 through 24.

40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

- Subpart F, "Release from Solid Waste Management Units," Sections 90 to 101.
- Subpart N, "Landfills," Sections 300 to 317.
- Subpart 3, "Corrective Action for Solid Waste Management Units".

40 CFR 268, "Land Disposal Restrictions," *Code of Federal Regulations*, as amended.

- Subpart D, "Treatment Standards", Sections 40 through 48.

40 CFR 300, "National Oil and Hazardous Substance Pollution Contingency Plan," *Code of Federal Regulations*, as amended.

- Subpart E, "Hazardous Substance Response", Sections 400 through 440.

40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," *Code of Federal Regulations*, as amended.

59 FR 7629, 1994, "Executive Order 12898 of February 11, 1994: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," *Federal Register*, Vol. 59, page 7629, (February 16).

64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement," *Federal Register*, Vol. 64, page 61615, (November 12).

65 FR 37253, 2000, "Establishment of the Hanford Reach National Monument," *Federal Register*, Vol. 65, pp. 37253-37257 (June 13).

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*Archeological and Historic Preservation Act of 1996*, 16 USC 461, et seq

*Atomic Energy Act of 1954 (AEA)*, 42 USC 2011, et seq.

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Beube, R., 1996, "Draft Recommendations on Prospective Assessments for Long-Term Management of Low-Level Radioactive Waste," (memorandum to distribution, September 5), U.S. Department of Energy, Washington, D.C. (Found in Appendix B, page B-7)

*Clean Air Act*, 42 USC 7401, et seq.

*Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)*, 42 USC 9601, et. seq.

Conway, J., 1994, "Recommendation 94-2, Safety Standards for Low-Level Waste", (letter to H. O'Leary, September 8), Defense Nuclear Facility Safety Board.

DE-AC27-01RV14136, 2002, Contract between Bechtel National, Inc, Inc. and the U.S. Department of Energy regarding Waste Treatment Plant, Modification No. A020. (Found in Appendix C, page C-23).

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- DOE 5400.5, 1993, *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, D.C.
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APPENDIX A

Contaminant-Specific Performance Objectives

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**Table A-1 Most Often Detected Organic Chemicals in Tank Waste**  
**Organic Chemical with greater than 100 analytical detects in tank waste or greater than 20**  
**analytical detects in TWRS Information System (TWINS) Solid/Liquid Hits. Taken from**  
**Table B.1 of Wiemers 1998.**

CAS#	Constituent	CAS#	Constituent
56-23-5	Carbon tetrachloride	108-67-8	1,3,5-Trimethylbenzene
64-17-5	Ethyl alcohol	108-87-2	Methylcyclohexane
64-18-6	Formic acid	108-88-3	Toluene
67-56-1	Methyl alcohol	108-94-1	Cyclohexanone
67-63-0	2-Propyl alcohol	109-66-0	n-Pentane
67-64-1	2-Propanone (Acetone)	109-74-0	n-Butyronitrile
67-66-3	Chloroform	109-99-9	Tetrahydrofuran
71-23-8	n-Propyl alcohol	110-43-0	2-Heptanone
71-36-3	n-Butyl alcohol	110-54-3	n-Hexane
71-43-2	Benzene	110-59-8	Pentanenitrile
71-50-1	Acetate	110-82-7	Cyclohexane
71-55-6	1,1,1-Trichloroethane	110-86-1	Pyridine
74-87-3	Chloromethane	111-13-7	2-Octanone
74-98-6	n-Propane	111-65-9	n-Octane
75-05-8	Acetonitrile	111-84-2	n-Nonane
75-07-0	Acetaldehyde	112-40-3	n-Dodecane
75-09-2	Dichloromethane (Methylene Chloride)	115-07-1	Propene
75-19-4	Cyclopropane	115-11-7	2-Methylpropene
75-35-4	1,1-Dichloroethene	117-81-7	Bis(2-ethylhexyl) phthalate
75-65-0	2-Methyl-2-propanol	123-72-8	n-Butyl aldehyde
75-69-4	Trichlorofluoromethane	124-18-5	n-Decane
75-71-8	Dichlorodifluoromethane	126-73-8	Tributyl phosphate
76-13-1	1,2,2-Trichlorotrifluoroethane	127-18-4	1,1,2,2-Tetrachloroethene
78-93-3	2-Butanone	142-82-5	n-Heptane
79-00-5	1,1,2-Trichloroethane	144-62-7	Oxalic Acid
79-01-6	1,1,2-Trichloroethylene	541-05-9	Cyclotrisiloxane, hexamethyl-
95-47-6	o-Xylene	556-67-2	Ocatamethylcyclotetrasiloxane
95-63-6	1,2,4-Trimethylbenzene	591-78-6	2-Hexanone
100-41-4	Ethyl Benzene	611-14-3	2-Ethyltoluene
100-42-5	Styrene	628-73-9	n-Hexanenitrile
104-76-7	2-Ethyl-1-hexanol	629-08-3	n-Heptanenitrile
106-35-4	3-Heptanone	629-50-5	n-Tridecane
106-46-7	1,4-Dichlorobenzene	629-59-4	n-Tetradecane
106-97-8	Butane	629-62-9	n-Pentadecane
107-12-0	Propionitrile	1066-40-6	Trimethylsilanol
107-46-0	Hexamethyldisiloxane	1120-21-4	n-Undecane
107-83-5	Pentane, 2-methyl-	1330-20-7	Xylene
107-87-9	2-Pentanone	1825-61-2	Methoxytrimethylsilane
108-10-1	4-Methyl-2-pentanone	3622-84-2	Benzenesulfonamide, N-butyl-

**Table A-2 Performance Standards of Specific Chemicals for Groundwater Protection**  
Standards are provided only for those organics most often found in tank waste (see Table A.1)

<b>Radionuclides</b>			
H-3	20,000 pCi/l	Sr-90	8 pCi/l
Ra-226	3pCi/l	Ra-226 and Ra-228	5 pCi/l
<b>Inorganic Chemicals</b>			
Antimony	0.006 mg/l	Arsenic	0.00005 mg/l
Barium	1.0 mg/l	Beryllium	0.004 mg/l
Cadmium	0.005 mg/l	Chloride	250. mg/l
Chromium	0.05 mg/l	Cyanide	0.2 mg/l
Fluoride	2.0 mg/l	Iron	0.3 mg/l
Lead	0.05 mg/l	Manganese	0.05 mg/l
Mercury	0.002 mg/l	Nickel	0.1 mg/l
Nitrate (as N)	10. mg/l	Nitrite (as N)	10. mg/l
Nitrate + Nitrite (as N)	10. mg/l	Selenium	0.01 mg/l
Silver	0.05 mg/l	Sulfate (as SO <sub>4</sub> )	250. mg/l
Thalium	0.002 mg/l	Zinc	5.0 mg/l
<b>Organic Chemicals</b>			
Benzene	0.001 mg/l	Bis(2-ethylhexyl)phthalate	0.006 mg/l
Carbon tetrachloride	0.0003 mg/l	Chloroform	0.007 mg/l
1,4-Dichlorobenzene	0.004 mg/l	Cis-1,2-Dichloroethylene	0.07 mg/l
Dichloromethane	0.005 mg/l	Ethyl benzene	0.7 mg/l
Toluene	1.0 mg/l	1,1,1-Trichloroethane	0.2 mg/l
1,1,2-Trichloroethane	0.005 mg/l	Xylenes (total)	10. mg/l
o-Xylene	0.7 mg/l		

**Table A-3 Performance Standards of Specific Chemicals for Surface Water Protection**  
 Values that are the same as drinking water standards are not repeated.

Ammonia	4.0 mg/l	Arsenic	0.19 mg/l
Cadmium (a)	0.00082 mg/l	Chloride	230. mg/l
Copper (a)	0.0087 mg/l	Chromium	0.011 mg/l
Cyanide	0.0052 mg/l	Lead (a)	0.00178 mg/l
Mercury	0.000012 mg/l	Nickel (a)	0.120 mg/l
Selenium	0.005 mg/l	Zinc (a)	0.080 mg/l

a based on Columbia River at Pasco having a mean hardness of 73 mg/l (DOE 1988)

**Table A-4 Performance Standards of Specific Chemicals for Air Resources Protection**

	Limits for Average Maximum		
	Sulfur oxides	0.50 ppm for 3 hours	0.14 ppm for 24 hours
Carbon Monoxide		35 ppm for 1 hour	9 ppm for 8 hours
Ozone		0.12 ppm for 1 hour	0.08 ppm for 8 hours
Nitrogen Dioxide			0.053 ppm
Lead			1.5 $\mu\text{g}/\text{m}^3$

**Table A-5 Performance Standards of Specific Chemicals for Land Disposal (2 sheets)**  
Standards are provided only for those organics most often find in tank waste (see Table A.1)

<b>Radionuclides</b>			
<b>Radionuclide</b>	<b>Concentration limit</b>	<b>Radionuclide</b>	<b>Concentration limit</b>
C-14	8. Ci/m <sup>3</sup>	C-14 (activated metal)	80. Ci/m <sup>3</sup>
Ni-59 (activated metal)	220. Ci/m <sup>3</sup>	Ni-63	700. Ci/m <sup>3</sup>
Ni-63 (activated metal)	7000 Ci/m <sup>3</sup>	Sr-90	7000. Ci/m <sup>3</sup>
Nb-94 (activated metal)	0.2 Ci/m <sup>3</sup>	Tc-99	3. Ci/m <sup>3</sup>
I-129	0.08 Ci/m <sup>3</sup>	Cs-137	4600. Ci/m <sup>3</sup>
Alpha emitters (with half-lives greater than 5 years)			100 nCi/g
Pu – 241	3500 nCi/g	Cm-242	20000 nCi/g
<b>Inorganic Chemicals</b>			
<b>Chemical</b>	<b>TCLP Limit</b>	<b>Chemical</b>	<b>TCLP Limit</b>
Antimony	1.15 mg/l	Arsenic	5.0 mg/l
Barium	21. mg/l	Cadmium	0.11 mg/l
Chromium (total)	0.60 mg/l	Lead	0.75 mg/l
Mercury	0.025 mg/l	Nickel	11.0 mg/l
Selenium	1.0 mg/l	Silver	0.14 mg/l
Thallium	0.20 mg/l	Vanadium	1.6 mg/l
Zinc	4.3 mg/l		
<b>Chemical</b>	<b>Concentration</b>	<b>Chemical</b>	<b>Concentration</b>
Cyanide (total)	590 mg/kg	Cyanide (amenable)	30 mg/kg
<b>Organic Chemicals</b>			
<b>CAS #</b>	<b>Constituent</b>	<b>TCLP Limit</b>	
56-23-5	Carbon tetrachloride	0.5 mg/l	
67-56-1	Methanol	0.75 mg/l	
67-66-3	Chloroform	6.0 mg/l	
71-43-2	Benzene	0.5 mg/l	
75-35-4	1,1-Dichloroethylene	0.7 mg/l	
78-93-3	Methyl ethyl ketone	200. mg/l	
79-01-6	Trichloroethylene	0.5 mg/l	
106-46-7	1,4-Dichlorobenzene	7.5 mg/l	
108-94-1	Cyclohexanone	0.75 mg/l	
110-86-1	Pyridine	5. mg/l	
127-18-4	1,1,2,2-Tetrachloroethene	0.7 mg/l	
<b>CAS #</b>	<b>Constituent</b>	<b>Concentration limit</b>	
56-23-5	Carbon tetrachloride	6 mg/kg	
67-64-1	Acetone	160 mg/kg	
67-66-3	Chloroform	6 mg/kg	
71-36-3	n-Butyl alcohol	2.6 mg/kg	
71-43-2	Benzene	10 mg/kg	
71-55-6	1,1,1-Trichloroethane	6 mg/kg	
74-87-3	Chloromethane/Methyl chloride	30 mg/kg	
75-09-2	Methylene chloride	30 mg/kg	
75-35-4	1,1-Dichloroethylene	6 mg/kg	
75-69-4	Trichlorofluoromethane	30 mg/kg	
75-71-8	Dichlorodifluoromethane	7.2 mg/kg	
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	30 mg/kg	
78-93-3	Methyl ethyl ketone	36 mg/kg	
79-00-5	1,1,2-Trichloroethane	6 mg/kg	
79-01-6	Trichloroethylene	6 mg/kg	
100-41-4	Ethyl benzene	10 mg/kg	

**Table A-5 Performance Standards of Specific Chemicals for Land Disposal (2 sheets)**  
Standards are provided only for those organics most often find in tank waste (see Table A.1)

<b>CAS #</b>	<b>Constituent</b>	<b>Concentration limit</b>
106-46-7	p-Dichlorobenzene	6 mg/kg
106-93-4	1,2-Dibromoethane/Ethylene dibromide	15 mg/kg
108-10-1	Methyl isobutyl ketone	33 mg/kg
108-88-3	Toluene	10 mg/kg
110-86-1	Pyridine	16 mg/kg
1330-20-7	Xylenes-mixed isomers (sum of o-, m-, and p-xylene concentrations)	30 mg/kg

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APPENDIX B

**Key Regulations**

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**B.1 DOE Order on Radioactive Waste Management (DOE O 435.1)**

**B.1.1 DOE Order 435.1 (*Radioactive Waste Management*) (DOE 1999a)**

DOE Order 435.1 is the DOE order on radioactive waste management that is currently effective. DOE Order 435.1 requires:

- (4a) “DOE radioactive waste management activities shall be systematically planned, documented, executed, and evaluated.”
- (4b). “Radioactive waste shall be managed to
  - (1) Protect the public from exposure to radiation from radioactive materials. Requirements for public protection are in DOE O 5400.5, *Radiation Protection of the Public and the Environment*.
  - (2) Protect the environment. Requirements for environmental protection are in DOE O 5400.1, *General Environmental Protection Program*, and DOE O 5400.5, *Radiation Protection of the Public and the Environment*.
  - (3) Protect the work force. Requirements for radiation protection of workers are in 10 CFR 835; requirements for industry safety are in DOE O 440.1, *Worker Protection Management for DOE Federal and Contractor Employees*.
  - (4) Comply with applicable Federal, state, and local laws and regulations. These activities shall also comply with applicable Executive Orders and other DOE directives.”
- (4c) “All radioactive waste shall be managed in accordance with the requirements in DOE M 435.1, *Radioactive Waste Management Manual*.”

**B.1.2 *Radioactive Waste Management Manual* (DOE M 435.1)**

The document that implements DOE Order 435.1 is DOE M 435.1, *Radioactive Waste Management Manual*. This manual requires (Chapter I, 1D) the following regulations and DOE directives for all DOE radioactive waste management facilities, operations, and activities.

- (1D) “**Analysis of Environmental Impacts.** Radioactive waste management facilities, operations, and activities shall meet the requirements of 10 CFR 1021, *National Environmental Policy Act Implementing Procedures*; and DOE O 451.1A, *National Environmental Policy Act Compliance Program*.”
- (1E10) “**Mixed Waste.** Radioactive waste that contains a hazardous waste component is also subject to the *Resource Conservation and Recovery Act* (RCRA) as amended.” Note hazardous waste is termed “dangerous waste” in Washington State requirements.

- (1E13) **“Radiation Protection.** Radioactive waste management facilities, operations, and activities shall meet the requirements of 10 CFR 835, *Occupational Radiation Protection*, and DOE O 5400.5, *Radiation Protection of the Public and the Environment.*”
- (1E18) **“Site Evaluation And Facility Design.** New radioactive waste management facilities, operations, and activities shall be sited and designed in accordance with DOE O 420.1, *Facility Safety*, and DOE O 430.1, *Life Cycle Asset Management.*”
- (1E21) **“Worker Protection.** Radioactive waste management facilities, operations, and activities shall meet the requirements of DOE O 440.1, *Worker Protection Management for DOE Federal and Contractor Employees.*”

Section P of Chapter IV of the DOE *Radioactive Waste Management Manual* has additional requirements for low-level waste disposal facilities.

- (1) **“Performance Objectives.** Low-level waste disposal facilities shall be sited, designed, operated, maintained, and closed so that reasonable assurance exists that the following performance objectives will be met for waste disposed of after September 26, 1988:
- (a) Dose to representative members of the public shall not exceed 25 mrem (0.25 mSv) in a year total effective dose equivalent from all exposure pathways, excluding the dose from radon and its progeny in air.
  - (b) Dose to representative members of the public via the air pathway shall not exceed 10 mrem (0.10 mSv) in a year total effective dose equivalent, excluding the dose from radon and its progeny.
  - (c) Release of radon shall be less than an average flux of 20 pCi/m<sup>2</sup>/s (0.74 Bq/m<sup>2</sup>/s) at the surface of the disposal facility. Alternatively, a limit of 0.5 pCi/l (0.185 Bq/l) of air may be applied.
- (2) **Performance Assessment.** A site-specific radiological performance assessment shall be prepared and maintained for DOE low-level waste disposal facilities which received waste after September 26, 1988. The performance assessment shall include calculations of potential dose to representative future members of the public and potential releases from the facility to provide reasonable expectation that the performance objectives identified in this Chapter will not be exceeded over a period of 1,000 years after facility closure.
- (a) Analyses performed to demonstrate compliance with the performance objectives in this chapter, and to establish limits on performance measures for inadvertent intruders in this chapter shall be based on reasonable activities in the critical group of exposed individuals. Unless otherwise specified, the assumption of average living habits and exposure conditions in representative critical groups of individuals projected to receive the highest dose is appropriate. ...

- (b) The point of compliance shall correspond to the point of highest projected dose or concentration beyond a 100 meter buffer zone surrounding the disposed waste. A larger or smaller buffer zone may be used provided adequate justification is provided.
- (c) Performance assessments shall address reasonably foreseeable natural processes that might disrupt barriers against release and transport of radioactive materials.
- (d) Performance assessments shall use DOE-approved dose coefficients (dose conversion factors) for internal and external exposure of reference adults.
- (e) The performance assessment shall include an estimate of the maximum projected dose, flux, or concentration and the time of the maximum, in the sensitivity/uncertainty analysis.
- (f) Performance assessments shall include a demonstration that projected releases of the radionuclides to the environment shall be maintained as low as reasonably achievable (ALARA).
- (g) For the purpose of establishing limits on radionuclides that may be disposed near-surface, the performance assessment shall include an assessment of impacts to water resources.
- (h) For purposes of establishing limits on concentration of radionuclides that may be disposed of near-surface, the performance assessment shall include an assessment of impacts calculated for a hypothetical person assumed to inadvertently intrude into the low-level waste disposal facility. For intruder analyses, institutional controls shall be assumed to be effective in deterring intrusion for at least 100 years following closure. The intruder analyses shall use performance measures of 100 mrem (1 mSv) in a year total effective dose equivalent for chronic exposure and 500 mrem (5 mSv) total effective dose equivalent for acute exposure.”

### **B.1.3 Implementation Guide for DOE M 435.1 (DOE G 435.1)**

The Department of Energy has also issued an implementation guide DOE G 435.1 on how the *Radioactive Waste Management Manual* is to be used.

Section IV.P(1) provides guidance on the performance objectives.

- (1) The use of the phrase ‘representative members of the public’ is “to indicate that overly conservative assumptions such as age, sex, or assumed activities of persons, are not made.”
- (2) The air-pathway objective (10 mrem in a year) “is for all sources on the DOE site, not just the disposal facility.”
- (3) Sources of radon include the “constituent of waste at the time of disposal or produced by radioactive decay following disposal.”
  - “In most cases, the ground surface emanation limit for radon of 20 pCi/m<sup>2</sup>/s should be used. However, in cases where the disposed waste radiologically resembles uranium or thorium mill tailings, the limit on air concentration may be warranted. The radon dose can also be calculated as

part of the total air dose, in which case, radon does not need to be addressed separately.”

Section IV.P.(2) provides guidance on the performance assessment. “Detailed guidance on conducting performance assessments has been developed and is contained in *Format and Content Guide for U.S. Department of Energy Low-Level Disposal Facility Performance Assessments and Composite Analyses*” (DOE G 435.1-1). Guidance explicitly in the implementation guide includes:

- (1) The compliance time period is 1,000 years after the disposal facility has been closed. “This time was selected to encompass rates of processes likely to govern migration of radiochemical species most likely to contribute to calculated dose. Longer times of assessments are not to be used to assess compliance because of the inherent large uncertainties in extrapolating calculations over long time frames.”
- (2) “Performance assessment analyses should be based on reasonable activities of the portion of the exposed population likely to receive the highest dose (i.e., the critical group). The performance assessment analyses should not be based on “worst case” assumptions. Rather, the analyses should be based on scenarios that represent reasonable actions of a typical group of individuals performing activities that are consistent with regional social customs, work, and housing practices, and expected regional environmental conditions at the time of the exposure scenario.”
- (3) “The concept of a buffer zone is inherent in defining a low-level waste disposal facility. The disposal facility is comprised of a number of disposal units.” “Setting the extent of the buffer zone at 100 meters is somewhat arbitrary, but 100 meters is considered to be sufficient, but not unreasonably large, for the stated purposes.” “In certain cases, e.g. if the disposal facility is located adjacent to the current DOE site boundary, it may be more appropriate to use a smaller buffer zone. In other cases, e.g., where the disposal facility is located far from the DOE site boundary, and the site’s land use planning does not envision relinquishing control of the site, a larger buffer zone could be considered.”
- (4) Natural processes “might disrupt the intended performance of the disposal facility, but such consideration should be limited to those processes which are foreseeable.” Examples of such natural processes are corrosion which “will, in time, breach most containers; environmental conditions, will, in time, consume the capacity of chemical buffers, and burrowing animals and root intrusion will eventually breach disposal facility caps.” “Other processes or events, although not regularly occurring, are, nonetheless, reasonably foreseeable. Such events would include severe weather such as flooding (e.g., 100 year flood, probable maximum flood), and seismic events. Other processes, such as climate change, are considered to be too speculative for consideration in the performance assessment.”

- (5) Dose calculations are “for adults (i.e., Reference Man). The actual dose to a particular individual from a given exposure to radioactive material is dependent on a number of characteristics, including age and sex. However, doses are not to be predicted for specific individuals or classes of persons. Rather, the calculations are to represent potential exposures to hypothetical future members of the public.”
- (6) “Performance assessments should include ALARA assessment that focus on alternatives for low-level waste disposal. The alternatives considered might consider the use of different disposal unit covers, waste forms, containers, or other alternatives (e.g. concrete vaults versus earthen trenches) consistent with the situation being addressed. The rigor of the ALARA assessment and its analysis of alternatives should be commensurate with the magnitude of the risk and decisions to be made.”
- (7) “The hierarchy for establishing water resource protection performance measures is:
- First, the DOE LLW disposal facility must comply with any applicable State or local law, regulation, or legally applicable requirements for water resource protection.
  - Second, the DOE LLW disposal facility should comply with any formal agreement applicable to water resource protection that is made with appropriate State or local officials.
  - Third, if neither the above conditions apply, the site should select assumptions for use in the performance assessment based on criteria established in the site groundwater protection management program and any formal land-use plans.
  - If none of the above conditions apply, the site should identify a performance measure for protection of water resources that is consistent with the use of water as a drinking water source. Examples of this type of performance measure would be the assumption of the concentration limits in 40 CFR 141 or a dose limit of 4 mrem per year above background from the ingestion of water.”
- (8) “Although DOE is committed to retaining control of land containing residual radioactive material, such as disposed low-level waste, it is nonetheless appropriate to consider the impacts of potential inadvertent intrusion. Intrusion can be considered either as an accident scenario which could occur during lapses of institutional control or as a hypothetical situation assumed simply to provide a basis for establishing control over the concentration of radioactive material acceptable in a near-surface disposal facility.”

“Institutional control should be assumed to be effective in preventing intrusion for 100 years following disposal facility closure. Longer periods may be assumed with justification (e.g. land-use planning, passive controls).”

“Development of intruder scenarios should be based on the following assumptions

- Intruders could carry out activities for no more than about a year before discovery.
- An intruder performs reasonable activities consistent with regional social customs and well drilling, excavation, and construction practices, and the regional environmental conditions projected for the time that intrusion is assumed to occur.
- Intrusion events involve random contact with waste.
- An intruder will take reasonable, investigative actions upon discovery of unusual materials.
- Intrusion events that contact waste should normally be assumed to be limited to drilling or simple extraction scenarios involving use of relatively unsophisticated tools and commonplace machinery.
- Doses calculated for an intruder will depend on waste disposal facility design and operating practices, and may be reduced by practices such as disposal below depths normally associated with common construction activities, use of intruder barriers or durable waste forms or containers, or distributed disposal of higher activity waste.”

“The inadvertent intruder assessment should, at a minimum, include consideration of an acute construction scenario, an acute well drilling scenario, and a chronic agricultural scenario.”

#### **B.1.4 Technical Basis for DOE M 435.1**

Further information is given in the *Technical Basis for DOE M 435.1* (DOE O 435.1-1). In particular, the sections on the performance objectives and performance assessment given justification for the approach taken and the values used.

- 1) The requirement of an all-pathways effective dose equivalent “is consistent with established radiation protection practice that allocates a fraction of the 100 mrem/yr public dose to a particular practice or activity. It is also consistent with the regulatory practice of the NRC to require all-pathways assessments, and this is consistent with the NRC low-level waste disposal facility licensing regulations at 10 CFR 61.”
- 2) The requirement on groundwater protection “provides defense in depth to the all pathways performance objective.” “Guidance developed for this requirement describes a tiered structure for its application. The guidance is based on a recognition that at the current time, there are no applicable Federal regulations. Therefore, the emphasis is to be consistent with the site’s groundwater protection management program. Also, the role of future use commitments between DOE and other authorities in the management of water resources may provide a sound basis for making decisions.”

- 3) The time period for compliance (1,000 years after closure) “was selected after consideration of the times used in other regulations (e.g. 10 CFR 191, 40 CFR 192), and recognition of the uncertainties and hypothetical nature of long-term projections.” “based on the study, *Comparison of Low-Level Waste Disposal Programs of DOE and Selected International Countries* (DOE/LLW-236) (DOE G 435.1-1) two countries (Canada and Sweden) have established a time of compliance of 10,000 years. The other two countries (France and the United Kingdom) have not specified a time of compliance. Similarly, to date, DOE, NRC, and EPA have not specified a time of compliance for low-level waste disposal facility performance assessments. A team composed of primarily of DOE contractor performance assessment staff evaluated the options for a time of compliance. In its progress report, *Performance Assessment Task Team Progress Report* (DOE/LLW-157, Rev. 1) (Wood et al. 1994), the team recommended a time of compliance of 10,000 years. This time was consistent with the time specified on 10 CFR 191 for high-level and transuranic waste disposal, and was considered to be conservative in that no longer times had been seriously proposed. This time or longer times had been used in DOE disposal facility performance assessments conducted up to that time. Subsequently, EPA asked agency reviewers for their opinions on the use of 10,000, 1,000, or some other time frame as the time of compliance for low-level waste disposal facility performance assessments. DOE responded that its position was that 1000 years was an appropriate time.”
- 4) The “point of compliance is consistent with regulatory positions included in 40 CFR 192.32 and 40 CFR 264.95. The NRC regulation at 10 CFR 61.52(a)(8) states that a ‘buffer zone of land must be maintained between any buried waste and the disposal site boundary ...’ In NUREG-1200, section 4.3.6 (NRC-1200) it is recommended that this buffer be at least 30 m wide. The Performance Assessment Task Team recommended a point of compliance of 100 meters in the *Performance Assessments Task Team Progress Report* (DOE/LLW-157, Rev. 1). [Wood 1994] In the *Draft Recommendations on Prospective Assessments for Long-Term Management of Low-Level Radioactive Waste* (memorandum, R. Beube, dated September 5, 1996) (DOE O 435.1-1), the DOE Office of Environment recommended that the point of compliance should be at the point of public access. Therefore the point of compliance would be the site boundary. The Office of Environment recommendations further acknowledged that it may be prudent to use a closer point of assessment if there is uncertainty about the future location of the site boundary. 40 CFR 192.32 permits the establishment of alternative concentration limits that are as low as reasonable and meet the standards of 40 CFR 264.94(a) at all points at a greater distance than 500 meters from the edge of the disposal area and/or outside the site boundary.”
- 5) “The rationale for using standard adult dose conversion factors comes from the fact that in a performance assessment one is calculating a postulated dose to a hypothetical future person assumed to be engaged in a set of ‘normal’ activities

over a period of years. Consequently, performing calculations as if real people of known age were being impacted by releases from the facility is not reasonable.”

- 6) “in addition to calculations over the time of compliance (1000 years), performance assessments also are to present calculations of maxima relative to each of the performance objectives. The results of these calculations are part of the sensitivity and uncertainty analysis which would support a conclusion that the model is providing a reasonable projection. These longer calculations address the need to ensure that there are no unexpected significant increases shortly after the time of compliance and provide a mechanism for understanding the model performance and significance of modelling parameters. The calculation of maxima does present the possibility that there may be results that exceed the performance objectives. The significance of these results must be handled with caution and judgement. The further out in time that the maxima occurs, the less significant is the relationship to the performance objective.”

“This requirement represents a DOE policy decision; it derives in part from IAEA Fundamental Principles of Radioactive Waste Management.”

- 7) “The use of the ALARA concept in long-term assessments is a best management practice that contributes defense-in-depth to the possible exposures from a disposal facility. Application of the ALARA principle for managing current operational exposures has practical and measurable merit in that real doses are being avoided or reduced. This concept is extended here by addressing projected releases of materials well into the future which may result in doses.”
- 8) “The concept of protection of inadvertent intrusion is consistent with national and international practice (NRCP, ICRP, IAEA). The NRC included the protection of inadvertent intruders as one of the performance objectives in 10 CFR 61. Other international and national organizations have and continue to include the protection of inadvertent intruders as one of the elements of radiation protection.”

“Since the intent of the Department is to control the use of the land where low-level waste is disposed until the land can be released, inadvertent intruder calculations provide defense-in-depth by limiting the concentration of waste that can be disposed of in the near surface. With each performance assessment evaluating and developing limits for near-surface disposal, DOE is more cost-effective in managing waste and is consistent with the philosophy of using performance based requirements.”

## **B.2. Washington State Dangerous Waste Regulations (WAC 173-303)**

### **B.2.1 Introduction**

Washington Administrative Code (WAC) 173-303 “implements chapter 70.105 RCW, the Hazardous Waste Management Act of 1976 as amended, and implements in part chapters 70.105A, 70.105D, and 15.54 RCW, and subtitle C of Public Law 94-580, the Resource Conservation and Recovery Act, ...” (Section 010). Section 10 also states “The purposes of this regulation are to ... (4) establish the siting, design, operation, closure, post-closure, financial, and monitoring requirements for dangerous and extremely hazardous waste transfer, treatment, storage, and disposal facilities; ...; (6) establish and administer a program for permitting dangerous and extremely dangerous waste management facilities; ...”.

Dangerous and extremely hazardous wastes are defined in Sections 70 through 100 of the regulation. In general, Hanford tank wastes are considered dangerous or extremely hazardous wastes. As noted in Section 70(2)(a), “once a material has been determined to be a dangerous waste, then any solid waste generated from the recycling, treatment, storage, or disposal of that dangerous waste is a dangerous waste unless and until ...” a specific action agreed to be the state has occurred.

By section 160(2), “A container or inner liner is “empty” when: (a) All wastes in it have been taken out that can be removed using practices commonly employed to remove materials from that type of container or inner liner (e.g., pouring, pumping, aspirating, etc.) and, no more than one inch of waste remains at the bottom of the container or inner, or ... if the container’s total capacity is greater than one hundred ten gallons, the volume of waste remaining in the container or inner liner is no more than 0.3 percent of the container’s total capacity.” For 100 series tanks, which have a diameter of 75 feet, then the tank would be empty if the tank had less than 367 cubic feet. For 200 series tanks, which have a diameter of 20 feet, the corresponding volume is 27 cubic feet. The Tri-Party Agreement requires (see Milestone M-45-00) are 360 and 30 cubic feet.

### **B.2.2 Closure and Postclosure**

Section 610 (Closure and Postclosure) requires (2) as a closure performance standard that “the owner or operator must close the facility in a manner that:

- (a) (i) Minimizes the need for further maintenance;
  - (ii) Controls, minimizes, or eliminates the extent necessary to protect human health and the environment, post-closure escape of dangerous waste, dangerous constituents, leachate, contaminated run-off, or dangerous waste decomposition products to the ground, surface water, ground water, or the atmosphere; and
  - (iii) returns the land to the appearance and use of surrounding land areas to the degree possible given the nature of the previous dangerous waste activity.
- (b) Where the closure requirements of this sections, or of ... [various WAC 173-303 sections] or 40 CFR 264.1102 (incorporated by reference at WAC 173-303-695) call for the removal or

decontamination of dangerous wastes, wastes residuals, or equipment, bases, liners, soils, or other materials containing or contaminated with dangerous wastes or waste residue, then such removal or decontamination must assure that the levels of dangerous waste or dangerous waste constituents or residuals do not exceed:

- (i) For soils, ground water, surface, and air, the numeric cleanup levels calculated using residual residential exposure assumptions according to the Model Toxic Control Act Regulations, Chapter 173-340 WAC as now or hereafter amended. Primarily, these will be numeric cleanups calculated according to MTCA Method B, although MTCA Method A may be used as appropriate, see WAC 173-340-700 through 173-340-760, excluding WAC 173-340-745; and
- (ii) For all structures, equipment, bases, and liners, etc., clean closure standards will be set by the department on a case-by-case basis in accordance with the closure performance standards of WAC 173-303-610(2)(a)(ii) and in a manner that minimizes or eliminates post-closure escape of dangerous waste constituents.

Section 610(3) provides the requirements of the closure plan. Section 610(4) provides schedule requirements. Section 610(5) provides general requirements for the disposal or decontamination of equipment, structures, and soils, while (6) deals with the certificate of closure. Section 610(7)(a) states postclosure care “must continue for thirty years’ after closure. Section 610(7)(b) allows the Department of Ecology to shorten or lengthen that time.

Section 640(4) provides requirements for containment and detection of releases from tanks. Section 630 (8)(a) requires “At closure of a tank system, the owner or operator must remove or decontaminate all waste residues, contaminated containment system components (liners, etc.), contaminated soils, and structures and equipment contaminated with waste, and manage them as dangerous waste, unless WAC 173-303-070(2)(a) applies. The closure plan, closure activities, cost estimates for closure, and financial responsibility for tank systems must meet all requirements specified in WAC 173-303-610 and WAC-173-303-620.” Section 630(8)(b) goes on to state “If the owner or operator demonstrates that not all contaminated soils can be practically removed or decontaminated as required in (a) of this subsection, then the owner or operator must close the tank system and perform post-closure care in accordance with the closure and post-closure care requirements that apply to landfills (see WAC 173-303-665(6))). In addition, for purposes of closure, post-closure, and financial responsibility, such a tank system is then considered to be a landfill, and the owner or operator must meet all of the requirements for landfills specified in WAC 173-303-610 and 173-303-620.” Section 630(8)(c) requires compliance with 640(8)(a) and (b) for tanks that do not have secondary containment.

Section 645 governs the releases from regulated facilities. Subsection 3 describes the ground water protection standard in general terms. Subsection 4 authorizes the Department of Ecology to specify the contaminants of concern in the permit. Subsection 5 provides concentration limits. The subsection states “The concentration of a dangerous constituent (i) must not exceed the background level of that constituent in the ground water at the time that limit is specified in the permit; or (ii) for any of the constituents listed in Table 1 of this subsection, must not exceed the respective value given in that table if the background level of the constituent is below the value given in Table 1; or (iii) must not exceed an alternate limit established by the department under (b) of this subsection.” Table 1 is reproduced as Table C.6. Subsection (b) states “The

Department will establish an alternate concentration limit for a dangerous constituent if it finds that the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the alternate concentration limit is not exceeded.”

Subsection (6) defines the point of compliance with “The department will specify in the facility permit the point of compliance at which the ground water protection standard of subsection (3) of this section, applies and at which monitoring must be conducted. The point of compliance is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units. Alternatively, the point of compliance may be any closer points identified by the department at the time the permit is issued, considering the risks of the facility, the wastes and constituents managed there, the potential for waste constituents to have already migrated past the alternate compliance point, and the potential threats to the ground and surface waters. Subsection (7) defines the time of compliance as “the compliance period during which the ground water protection of subsection (3) of this section applies.” Subsections (8) through (11) provide general ground water monitoring requirements. In particular, Subsection (11) describes the requirements for a corrective action program. Section 646 further describes “corrective actions”.

### **B.2.3 Air Emissions**

Section 692 (Air emission standards for tanks, surface impoundments, and containers) applies the requirements of 40 CFR Part 264 CC to tanks, surface impoundments, or containers.

### **B.2.4 Hanford Site Requirements**

Section 700 (Requirements for the Washington State extremely hazardous waste management at Hanford) sets no performance objectives, but rather deals with administrative matters.

### **B.3 Model Toxics Control Act (70.105D RCW)**

Washington Administrative Code (WAC) 173-340 is “promulgated under the Model Toxic Controls Act. It establishes administrative processes and standards to identify, investigate, and clean up facilities where hazardous substances have come to be located. ... This chapter is primarily intended to address releases of hazardous substances caused by past activities although its provisions may be applied to potential and ongoing releases of hazardous substances from current activities (Section 100) ... If hazardous substances remain at a facility after actions have been completed under other applicable laws or regulations, this chapter may be applied to protect human health or the environment” (Section 110). Relevant hazardous substances are defined or designated under 70.105 RCW or section 101 (14) of the federal cleanup law, 42 U.S.C., Sec. 9601 (14) and includes radioactive isotopes and hazardous chemicals.

Part VII – Cleanup Standards are defined as ARARs under CERCLA actions.

Part VII of WAC 173-340 establishes cleanup standards that “consist of the following: 1) cleanup levels for hazardous substances present at the site, 2) the location where these cleanup levels must be met (point of compliance), and 3) other regulatory requirements that apply to the site because of the type of action and / or location of the site (applicable state and federal laws)”. “The cleanup level is the concentration of a hazardous substance in soil, water, air, or sediment that is determined to be protective of human health and the environment under specific exposure conditions.”

Three methods are defined under this section for establishing cleanup levels. Method A “may be used to establish cleanup levels at sites that have few hazardous substances and that meet one of the following criteria:

- a) Sites undergoing a routine cleanup action as defined in WAC 173-340-200, or
- b) Sites where numerical standards are available for all indicator hazardous substances in the media for which the Method A cleanup level is being used.”

This method provides a tabular list of concentrations for the different media (groundwater, soil, surface water, and air).

Method B (Universal Method) “applies to all media at all sites.” Under Method B, “cleanup levels shall be at least as stringent as all of the following:

- a) Concentrations of individual hazardous substances established under applicable state and federal laws,
- b) Concentrations that are estimated to result in no adverse effects on the protection and propagation of aquatic life, and no significant adverse effects of terrestrial ecological receptors using the procedures specified in WAC 173-340-7490 through 173-340-7494,
- c) For hazardous substances for which sufficiently protective health-based criteria or standards have not been established under applicable state and federal laws, those concentrations which protect human health as determined by the following methods:
  - 1) Concentrations that are estimated to result in no acute or chronic toxic effects on human health as determined using hazard quotient of 1 and the procedures specified in WAC 173-340-720 through 173-340-760

- 2) For known or suspected carcinogens, concentrations for which the upper bound on the estimated excess cancer risk is less than or equal to one in one million as determined the procedures specified in WAC 173-340-720 through 173-340-769
- 3) Concentrations that eliminate or minimize the potential for food chain contamination as necessary to protect human health.”

Method C (Conditional Method) cleanup levels represent concentrations that are protective of human health and the environment for specified site uses and conditions. ... Each medium must be evaluated separately using the criteria applicable to that medium.” Under Method C, cleanup levels for individual hazardous substances are established using applicable state and federal laws and the risk factor equations and other requirements specified in this Chapter. Under Method B, “cleanup levels shall be at least as stringent as all of the following:

- a) Concentrations of individual hazardous substances established under applicable state and federal laws,
- b) Concentrations that are estimated to result in no adverse effects on the protection and propagation of aquatic life, and no significant adverse effects of terrestrial ecological receptors using the procedures specified in WAC 173-340-7490 through 173-340-7494,
- c) For hazardous substances for which sufficiently protective health-based criteria or standards have not been established under applicable state and federal laws, those concentrations which protect human health as determined by the following methods:
  - 1) Concentrations that are estimated to result in no significant adverse acute or chronic toxic effects on human health as estimated using a hazard quotient of 1 and the procedures specified in WAC 173-340-720 through 173-340-760
  - 2) For known or suspected carcinogens, concentrations for which the upper bound on the estimated excess cancer risk is less than or equal to one in one hundred thousand as determined using the procedures specified in WAC 173-340-720 through 173-340-760
  - 3) Concentrations that eliminate or minimize the potential for food chain contamination as necessary to protect human health.”

The department may establish more stringent cleanup levels “when based on site specific evaluation the department determines such levels are necessary to protect human health and the environment. ... Concentrations of individual hazardous substances ... , including those based on applicable state and federal laws, shall be adjusted downward to take into account exposure to multiple hazardous substances and/or exposures resulting from more than one pathway of exposure. These adjustments need to be made only if, without these adjustments, the hazard index would exceed one (1) or the total excess cancer risk would exceed one in one hundred thousand ( $1 \times 10^{-5}$ ).”

Section 708 “defines the risk assessment framework that shall be used to establish cleanup levels and remediation levels using a quantitative risk assessment ... Cleanup and remediation levels shall be based on estimates of current and future resource uses and reasonable maximum exposures expected to occur under both current and potential future site use conditions. ... WAC 173-340-720 through 173-340-760 define the reasonable maximum exposures for groundwater, surface water, soil and air. ... Land uses other than residential and industrial shall not be used a basis for a reasonable maximum exposure scenario for the purposes of establishing a cleanup

level. Estimated doses of individual hazardous substances resulting from more than one pathway of exposure are assumed to be additive.

Section 708 prescribes reference doses, carcinogenic potency factors, bioconcentration factors and exposure parameters to be used in human health risk assessments. "For the purposes of establishing cleanup level and remediation levels, a reference dose/reference concentration established by the U.S. Environmental Protection Agency and available through the IRIS data base shall be used "(if available). Other U.S. EPA databases are referenced if the IRIS database does not include the hazardous substance. "For the purposes of establishing cleanup levels and remediation levels for hazardous substances, ... a carcinogenic potency factor established by the U.S. Environmental Protection Agency and available through IRIS shall be used." Other U.S. EPA databases are referenced if the IRIS database does not include the hazardous substance. "For the purposes of establishing cleanup levels and remediation levels for a hazardous substance under WAC 173-340-730 (Surface water cleanup standards) a bioconcentration factor established by the U.S. EPA and used to establish the ambient water quality criterion for that substance under section 304 of the Clean Water Act shall be used." "... the department has defined in WAC 173-340-720 through 173-340-760 the default values for exposure parameters to be used when establishing cleanup levels and remediation levels ..." Exceptions for these default values are explicitly defined in WAC 173-340-708 and 173-340-720 through 173-340-760. "Probabilistic risk assessment methods may be used only under this chapter on an informational basis for evaluating alternative remedies. Such methods shall not be used to replace cleanup standards and remediation levels derived using deterministic methods."

Cleanup standards are established under WAC 173-340-720 through 173-340-760 for groundwater, surface water, unrestricted land use soil, industrial properties soil, air, and sediment cleanup. The procedures for determining cleanup levels are described for Methods A, B, and C. Points of compliance are established for the groundwater and surface water standards. Method B and Method C equations for estimating both carcinogenic and noncarcinogenetic limits on allowable concentrations are also provided for selected media.

"WAC 173-340-7490 through 173-340-7494 define the goals and procedures the department will use for:

- a) Determining whether a release of hazardous substances to the soil may pose a threat to the terrestrial environment;
- b) Characterizing existing or potential threats to terrestrial plants or animals exposed to hazardous substances in soil; and,
- c) Establishing site-specific cleanup standards to the protection of terrestrial plants and animals.

No further evaluation is required if the site meets any of the following criteria: 1) "all soil contaminated with hazardous substances is or will be located below the point of compliance ... (an institutional control is not required if the contamination is at least fifteen feet below ground surface)", 2) "all soil contaminated with hazardous substances is or will be covered by buildings, paved roads, pavement, or other physical barriers that will prevent plants or wildlife from being exposed to the soil contaminations ...", 3) "where site conditions are related or connected to undeveloped land in the following manner: ..." such that there is limited undeveloped land, or the contamination includes specific hazardous substances, or 4) "the concentrations of hazardous substances do not exceed background levels as defined in WAC 173-340-709."

**B.4 Comprehensive Environmental Response, Compensation, and Liability Act**  
(42 USC 601 et seq.)

**(Subchapter 1, section 9621, Cleanup Standards)**

**(a):**

The President shall select appropriate remedial actions determined to be necessary to be carried out under section 9604 of this title or secured under section 9606 of this title which are in accordance with this section and, to the extent practicable, the national contingency plan, and which provide for cost-effective response.

**(d)(1)**

Remedial actions selected under this section or otherwise required or agreed to by the President under this chapter shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further release at a minimum which assures protection of human health and the environment. Such remedial actions shall be relevant and appropriate under the circumstances presented by the release or threatened release of such substance, pollutant, or contaminant.

**(d)(2)(A):**

With respect to any hazardous substance, pollutant or contaminant that will remain onsite, if -

- (i) any standard, requirement, criteria, or limitation under any Federal environmental law, including, but not limited to, the Toxic Substances Control Act (15U.S.C. 2601 et seq.), the Safe Drinking Water Act (42 U.S.C. 300f et seq.), the Clean Air Act (42 U.S.C. 7401 et seq.), the Clean Water Act (33 U.S.C. 1251 et seq.), the Marine Protection, Research and Sanctuaries Act (16 U.S.C. 1431 et seq., 1447 et seq., 33 U.S.C. 1401 et seq., 2801 et seq.), or the Solid Waste Disposal Act (42 U.S.C. 6901 et seq.); or
- (ii) any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation, including each such State standard, requirement, criteria, or limitation contained in a program approved, authorized or delegated by the Administrator under a statute cited in subparagraph (A), and that has been identified to the President by the State in a timely manner,

is legally applicable to the hazardous substance or pollutant or contaminant concerned or is relevant and appropriate under the circumstances of the release or threatened release of such hazardous substance or pollutant or contaminant, the remedial action selected under section 9604 of this title or secured under section 9606 of this title shall require, at the completion of the remedial action, a level or standard of control for such hazardous substance or pollutant or contaminant which at least attains such legally applicable or relevant and appropriate standard, requirement, criteria, or limitation. Such remedial action shall require a level or standard of control which at least attains Maximum Contaminant Level Goals established under the Safe Drinking Water Act (42 U.S.C. 300f et seq.) and water quality criteria established under section 304 or 303 of the Clean Water Act (33 U.S.C. 1314, 1313), where such goals or criteria are relevant and appropriate under the circumstances of the release or threatened release.

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Appendix C  
Supporting Tables

Values from Washington State Regulations are NOT Reported When the Values Are  
Applicable Because the Federal Regulations Are Adopted by Reference

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**Table C-1 Numeric Requirements For Protecting The Public from Radioactive Materials**

<b>DOE Order on "Radioactive Waste Management"</b> <b>DOE M 435.1 (DOE 1999b)</b>	
All pathways (<1,000 years)	25 mrem/year
<b>DOE Order for "Radiation Protection of the Public and the Environment"</b> <b>DOE Order 5400.5(II)(1)(a) (DOE 1993)</b>	
All pathways (from all DOE facilities at the site)	100 mrem/year
<b>Federal "Standards for Protection Against Radiation"</b> <b>10 CFR 20.1301</b>	
All pathways from action	100 mrem/year
All pathways from action	2 mrem/hour
<b>Federal "Licensing Requirements for the Land Disposal of Radioactive Waste"</b> <b>10 CFR 61.41</b>	
All pathways (whole body)	25 mrem/year
All pathways (thyroid)	75 mrem/year
All pathways (other organs)	25 mrem/year
<b>Washington State "Radioactive Waste – Licensing Land Disposal"</b> <b>WAC 246-250-170</b>	
All pathways (whole body)	25 mrem/year
All pathways (thyroid)	75 mrem/year
All pathways (other organs)	25 mrem/year
<b>Federal Standard for DOE Workers</b> <b>10 CFR 835.208</b>	
All Pathways-all sources (controlled Area)	100 mrem/year
<b>CERCLA Guidance for Radiation Protection of Public</b> <b>CERCLA –EPA 1999</b>	
All Pathways (Incremental lifetime cancer risk)	<b>Do NOT use dose as standard</b> <b>10<sup>-4</sup></b>

**Table C-2 Numeric Requirements For Protecting The Public from Hazardous Chemicals**

<b>CERCLA Standard for Risk</b> <b>40 CFR 300.430(e)(2)(i)(A)(2)</b>	
Carcinogens (excess lifetime cancer risk)(single material)	10 <sup>-6</sup>
Carcinogens (excess lifetime cancer risk)(multiple materials)	10 <sup>-4</sup>
<b>Washington State Model Toxics Control Act</b> <b>WAC 173-340(720-760)</b>	
Carcinogens (excess lifetime cancer risk)(single chemical)	10 <sup>-6</sup>
Carcinogens (excess lifetime cancer risk)(multiple chemicals)	10 <sup>-5</sup>
Hazard index (noncarcinogen)	1.0

**Table C-3 Numeric Requirements of Relevant Worker Protection Regulations**

<b>Federal Standard for DOE Workers 10 CFR 835, Subpart C</b>	
All pathways (effective dose equivalent)	5,000 mrem/year
Sum of deep dose equivalent for external exposures and the committed dose equivalent to any organ or tissue other than the lens of the eye	50,000 mrem
Lens of the eye (dose equivalent)	15,000 mrem
Shallow dose equivalent to the skin or any extremity	50,000 mrem
Embryo/fetus	500 mrem
Minor	500 mrem/year
Air Dose	5,000 mrem/year

<b>Federal "Standards for Protection Against Radiation" 10 CFR 20, Subpart C</b>	
All pathways (effective dose equivalent)	5,000 mrem/year
Sum of deep dose equivalent for external exposures and the committed dose equivalent to any organ or tissue other than the lens of the eye	50,000 mrem
Lens of the eye (dose equivalent)	15,000 mrem
Shallow dose equivalent to the skin or any extremity	50,000 mrem
Minor (10% of above)	500 mrem/year
Embryo/fetus	500 mrem
Air Dose	5,000 mrem/year
Uranium intake to body	10 mg/week

<b>Washington State "Radiation Protection Standards" WAC 246-221-010</b>	
All-Pathways	5,000 mrem/year
Sum of deep dose equivalent for external exposures and the committed dose equivalent to any organ or tissue other than the lens of the eye	50,000 mrem
Lens of the eye (annual limit)	15,000 mrem
Shallow dose equivalent to the skin or any extremity (annual limit)	50,000 mrem
Uranium intake to body	10 mg/week

**Table C-4 Numeric Requirements For Protecting An Inadvertent Intruder**

<b>DOE Order on "Radioactive Waste Management" DOE M 435.1</b>	
Intruder (> 100 years or larger)	100 mrem/year (continuous)
Intruder (> 100 years or larger)	500 mrem (single event)

<b>Federal "Licensing Requirements for the Land Disposal of Radioactive Waste" 10 CFR 61. 41</b>	
Only Class C disposal	See Table C.8

**Table C-5 Numeric Requirements of Relevant Drinking Water Regulations (3 Sheets)**

<b>DOE Order for "Radiation Protection of the Public and the Environment"</b> <b>DOE Order 5400.5 (II)(d) (DOE 1993)</b>	
Radionuclides	4 mrem/year
Ra-226 plus Radium-228	$5 \times 10^{-9}$ $\mu$ Ci/ml (= 5 pCi/l)
Alpha emitters (but not Rn nor U)	$1.5 \times 10^{-8}$ $\mu$ Ci/ml (=15 pCi/l)

<b>Federal Drinking Water Standards</b> <b>40 CFR 141.XX</b>		
<b>40 CFR 141.11</b>		
Arsenic		0.05 mg/l
<b>40 CFR 141.12</b>		
Trihalomethanes		0.10 mg/l
<b>40 CFR 141.15 (does not apply after 12/8/2003)</b>		
Ra-226+Ra-228		5 pCi/l
Alpha activity (except Rn and U)		15 pCi/l
<b>40 CFR 141.16 (does not apply after 12/8/2003)</b>		
Beta and photon activity (2 L/d)		4 mrem/year
H-3		20,000 pCi/l
Sr-90		8 pCi/l
<b>40 CFR 141, Subpart F, Sections 51 – 55 are goals only</b>		
<b>40 CFR 141.55 (effective 12/8/2003)</b>		
Ra-226 + Ra-228		zero
Alpha activity (except Rn and U)		zero
Beta and photon activity		Zero
Uranium		zero
<b>40 CFR 141.61</b>		
CAS #	Constituent	Limit
50-32-8	Benzo[a]purene	0.0002 mg/l
56-23-5	Carbon tetrachloride <sup>(a)</sup>	0.005 mg/l
57-74-9	Chlordane	0.002 mg/l
71-43-2	Benzene <sup>(a)</sup>	0.005 mg/l
71-55-6	1,1,1-Trichloroethane <sup>(a)</sup>	0.2 mg/l
72-20-8	Endrin	0.002 mg/l
72-43-5	Methoxychlor	0.04 mg/l
75-01-4	Vinyl chloride	0.002 mg/l
75-35-4	1,1-Dichloroethylene <sup>(a)</sup>	0.007 mg/l
75-09-2	Dichloromethane (Methylene Chloride) <sup>(a)</sup>	0.005 mg/l
75-99-0	Dalapon	0.2 mg/l
76-44-8	Heptachlor	0.004 mg/l
77-47-4	Hexachlorocyclopentadiene	0.05 mg/l
78-87-5	1,2-Dichloropropane	0.005 mg/l
79-00-5	1,1,2-Trichloroethane <sup>(a)</sup>	0.005 mg/l
79-01-6	Trichloroethylene <sup>(a)</sup>	0.005 mg/l
85-00-7	Diquat	0.02 mg/l
87-86-5	Pentachlorophenol	0.001 mg/l
88-85-7	Dinoseb	0.007 mg/l
90-50-1	$\sigma$ -Dichlorobenzene	0.06 mg/l

**Table C-5 Numeric Requirements of Relevant Drinking Water Regulations (3 Sheets)**

<b>40 CFR 141.61 (cont.)</b>			
CAS #	Constituent		Limit
93-72-1	2,4,5-TP		0.05 mg/l
94-75-7	2,4-D		0.07 mg/l
95-47-6	o-Xylene <sup>(a)</sup>		0.7 mg/l
96-12-8	Dibromochloropane		0.00002 mg/l
100-41-4	Ethyl benzene <sup>(a)</sup>		0.7 mg/l
100-42-5	Styrene		0.1 mg/l
103-23-1	Di(2-ethylhexyl) adipate		0.4 mg/l
106-46-7	para Dichlorobenzene <sup>(a)</sup>		0.075 mg/l
106-93-4	Ethylene dibromide <sup>(a)</sup>		0.00005 mg/l
107-06-2	1,2 Dichloroethane		0.005 mg/l
108-74-1	Hexachlorbenzene		0.001 mg/l
108-88-3	Toluene <sup>(a)</sup>		1.0 mg/l
108-90-7	Monochlorobenzene		0.1 mg/l
116-06-3	Aldicarb		0.003 mg/l
117-81-7	Di(2-ethylhexyl) phthalate <sup>(a)</sup>		0.006 mg/l
120-82-1	1,2,4-Trichloro-benzene		0.07 mg/l
122-34-9	Simazine		0.004 mg/l
127-18-4	1,1,2,2-Tetrachloroethene		0.005 mg/l
145-73-3	Endothall		0.1 mg/l
156-59-2	Cis-1,2-Dichloroethylene		0.07 mg/l
156-60-5	Trans-1,2-Dichloroethylene		0.1 mg/l
1024-57-3	Heptachlor epoxide		0.0002 mg/l
1071-53-6	Glyphosate		0.7 mg/l
1330-20-7	Xylenes (total) <sup>(a)</sup>		10. mg/l
1336-36-3	Polychlorinated biphenyls		0.0005 mg/l
1563-66-2	Carbofuran		0.04 mg/l
1646-87-3	Aldicarb sulfoxide		0.004 mg/l
1656-87-4	Aldicarb sulfone		0.002 mg/l
1746-01-6	2,3,7,8-TCDD (Dioxin)		3x10 <sup>-8</sup> mg/l
1912-24-9	Altazine		0.003 mg/l
1918-02-1	Picloram		0.5 mg/l
8001-35-2	Toxaphene		0.003 mg/l
15972-60-8	Alachlor		0.002 mg/l
23235-22-0	Oxamyl (Vydate)		0.2 mg/l
<b>40 CFR 141.62</b>			
Antimony	0.006 mg/l	Barium	2.0 mg/l
Beryllium	0.004 mg/l	Cadmium	0.005 mg/l
Chromium	0.1 mg/l	Cyanide	0.2 mg/l
Fluoride	4.0 mg/l	Mercury	0.002 mg/l
Nitrate (as N)	10. mg/l	Nitrite (as N)	1. mg/l
Nitrate + Nitrite (as N)	10. mg/l	Selenium	0.05 mg/l
Thallium	0.002 mg/l		
<b>Federal Drinking Water Goals 40 CFR 143.3</b>			
Aluminum	0.05 to 0.2 mg/l	Chloride	250. mg/l
Copper	1.0 mg/l	Fluoride	2.0 mg/l
Iron	0.3 mg/l	Manganese	0.05 mg/l

**Table C-5 Numeric Requirements of Relevant Drinking Water Regulations (3 Sheets)**

Silver	0.1 mg/l	Sulfate	250. mg/l
Zinc	5.0 mg/l		

<b>CERCLA Standard for Risk</b> 40 CFR 300.430(e)(2)(i)(B)			
Maximum contaminant level goals greater than zero shall be attained			

<b>Washington State "Public Water Supplies" Regulation</b> WAC 246-290-310(3)			
Antimony	0.006 mg/l	Arsenic	0.05 mg/l
Barium	2.0 mg/l	Beryllium	0.004 mg/l
Cadmium	0.005 mg/l	Chloride	250. mg/l
Chromium	0.1 mg/l	Cyanide	0.2 mg/l
Fluoride	2.0 mg/l	Iron	0.3 mg/l
Manganese	0.05 mg/l	Mercury	0.002 mg/l
Nickel	0.1 mg/l	Nitrate (as N)	10.0 mg/l
Nitrite (as N)	1.0 mg/l	Selenium	0.05 mg/l
Silver	0.1 mg/l	Sulfate	250. mg/l
Thalium	0.002 mg/l	Zinc	5.0 mg/l

<sup>a</sup> Greater than 100 analytical detects in tank waste or greater than 20 analytical detects in TWINS Solid/Liquid Hits. Taken from Table B.1 of Wiemers 1998.

**Table C-6 Numeric Requirements of Relevant Groundwater Regulations (4 Sheets)**

Federal "Land Disposal Restrictions" Regulations 40 CFR 264.94			
Arsenic	0.05 mg/l	Barium	1.0 mg/l
Cadmium	0.01 mg/l	Chromium	0.05 mg/l
Lead	0.05 mg/l	Mercury	0.002 mg/l
Selenium	0.01 mg/l	Silver	0.05 mg/l
Endrin	0.0002 mg/l	Lindane	0.004 mg/l
Methoxychlor	0.1 mg/l	Toxaphene	0.005 mg/l
2,4-D	0.1 mg/l	2,4,5-TP Silvex	0.01 mg/l

"Water Quality Standards for the Groundwaters of the State of Washington" WAC 173-200-040			
Alpha emitters			15 pCi/l
Beta emitters			50 pCi/l
H-3			20,000 pCi/l
Sr-90			8 pCi/l
Ra 226 plus Ra-228			5 pCi/l
Ra 226			3 pCi/l
Chemical			
Arsenic	0.00005 mg/l	Barium	1 mg/l
Cadmium	0.01 mg/l	Chloride	250. mg/l
Chromium	0.05 mg/l	Copper	1. mg/l
Fluoride	4. mg/l	Iron	0.30 mg/l
Lead	0.05 mg/l	Manganese	0.05 mg/l
Mercury	0.002 mg/l	Selenium	0.01 mg/l
Silver	0.05 mg/l	Zinc	5. mg/l
Sulfate (SO <sub>4</sub> )	250. mg/l	Nitrate (as N)	10. mg/l
2-4 D			0.10 mg/l
2,4,5-TP Silvex			0.01 mg/l
Acrylamide			0.00002 mg/l
Acrylonitrile			0.00007 mg/l
Aldrin			0.000005 mg/l
Aniline			0.014 mg/l
Aramite			0.003 mg/l
Azobenzene			0.0007 mg/l
Benzene <sup>(a)</sup>			0.001 mg/l
Benzidine			0.0000004 mg/l
Benzo(a)pyrene			0.000008 mg/l
Benzotrichloride			0.000007 mg/l
Benzyl chloride			0.0005 mg/l
Bis(chloroethyl)ether			0.00007 mg/l
"Water Quality Standards for the Groundwaters of the State of Washington" WAC 173-200-040			
Bis(chloromethyl)ether			0.0004 mg/l
Bis(2-ethylhexyl)phthalate <sup>(a)</sup>			0.006 mg/l
Bromodichloromethane			0.0003 mg/l
Bromoform			0.005 mg/l
Carbazole			0.005 mg/l

**Table C-6 Numeric Requirements of Relevant Groundwater Regulations (4 Sheets)**

Carbon tetrachloride <sup>(a)</sup>	0.0003 mg/l
Chlordane	0.00006 mg/l
Chlorodibromomethane	0.0005
Chloroform <sup>(a)</sup>	0.007 mg/l
4 Chloro-2-methyl aniline	0.0001 mg/l
4 Chloro-2-methyl aniline hydrochloride	0.0002 mg/l
o-Chloronitrobenzene	0.003 mg/l
p-Chloronitrobenzene	0.005 mg/l
Chlorthalonil	0.030 mg/l
Diallate	0.001 mg/l
DDT (includes DDE and DDD)	0.0003 mg/l
1,2 Dibromomethane	0.000001 mg/l
1,4-Dichlorobenzene <sup>(a)</sup>	0.004 mg/l
3,3' Dichlorobenzidine	0.0002 mg/l
1,1 Dichloroethane <sup>(a)</sup>	0.001 mg/l
1,2 Dichloroethane (ethylene chloride)	0.0005 mg/l
1,2 Dichloropropane	0.0006 mg/l
1,3 Dichloropropene	0.0002 mg/l
Dichlorvos	0.0003 mg/l
Dieldrin	0.000005 mg/l
3,3' Dimethoxybenzidine	0.006 mg/l
3,3 Dimethylbenzidine	0.000007 mg/l
1,2 Dimethylhydrazine	0.060 mg/l
2,4 Dinitrotoluene	0.0001 mg/l
2,6 Dinitrotoluene	0.0001 mg/l
1,4 Dioxane	0.007 mg/l
1,2 Diphenylhydrazine	0.00009 mg/l
Direct Black 38	0.000009 mg/l
Direct Blue 6	0.000009 mg/l
Direct Brown 95	0.000009 mg/l
Endrin	0.0002 mg/l
Epichlorohydrin	0.008 mg/l
Ethyl acrylate	0.002 mg/l
Ethylene dibromide	0.000001 mg/l
Ethylene thiourea	0.002 mg/l
Folpet	0.020 mg/l
Furazolidone	0.00002 mg/l
Furium	0.000002 mg/l
Furmecyclox	0.003 mg/l
Heptachlor	0.00002 mg/l
Heptachlor Epoxide	0.000009 mg/l
Hexachlorobenzene	0.00005 mg/l
Hexachlorocyclohexane (alpha)	0.000001 mg/l
Hexachlorocyclohexane (technical)	0.00005 mg/l
Hexachlorodibenzo-p-dioxin, mix	0.00000001 mg/l
Hydrazine/Hydrazine sulfate	0.00003 mg/l
Lindane	0.00006 mg/l

**Table C-6 Numeric Requirements of Relevant Groundwater Regulations (4 Sheets)**

2 Methoxy-5-nitroaniline	0.002 mg/l
2 Methylaniline	0.0002 mg/l
2 Methylaniline hydrochloride	0.0005 mg/l
4,4' Methylene bis(N,N'-dimethyl) aniline	0.002 mg/l
Methoxychlor	0.1 mg/l
Methylene chloride (dichloromethane) (a)	0.005 mg/l
Mirex	0.00005 mg/l
Nitrofurazone	0.00006 mg/l
N-Nitrosodiethanolamine	0.00003 mg/l
N-Nitrosodiethylamine	0.0000005 mg/l
N-Nitrosodimethylamine	0.000002 mg/l
N-Nitrosodiphenylamine	0.017 mg/l
N-Nitroso-di-n-propylamine	0.00001 mg/l
N-Nitrosopyrrolidine	0.00004 mg/l
N-Nitroso-di-n-butylamine	0.00002 mg/l
N-Nitroso-N-methylethylamine	0.000004 mg/l
PAH	0.00001 mg/l
PBBs	0.00001 mg/l
PCBs	0.00001 mg/l
o-Phenylenediamine	0.000005 mg/l
Propylene oxide	0.00001 mg/l
2,3,7,8-Tetrachlorodibenzo-p-dioxin	0.0000000006 mg/l
Tetrachloroethylene (perchloroethylene)	0.0008 mg/l
p,p',p,p'-Tetrachlorotoluene	0.000004 mg/l
2,4 Toluenediamine	0.000002 mg/l
o-Toluidine	0.0002 mg/l
Toxaphene	0.00008 mg/l
Trichloroethylene (a)	0.003 mg/l
2,4,6-Trichlorophenol	0.004 mg/l
Trimethyl phosphate	0.002 mg/l
Vinyl chloride	0.00002 mg/l

**Washington State "Model Toxics Control Act"**  
**WAC 173-340-730**

Exposure to multiple hazardous substances / more than one pathway

Total excess cancer risk (carcinogen)	$1 \times 10^{-5}$
Hazard index (noncarcinogen)	1

Chemical		Washington State "Dangerous Waste Regulations"	
		WAC 173-303-645	
Arsenic	0.05 mg/l	Barium	1 mg/l
Cadmium	0.01 mg/l	Chromium	0.05 mg/l
Lead	0.05 mg/l	Mercury	0.002 mg/l
Selenium	0.01 mg/l	Silver	0.05 mg/l
Endrin			0.0002 mg/l
Methoxychlor			0.1 mg/l
2-4 D			0.10 mg/l

**Table C-6 Numeric Requirements of Relevant Groundwater Regulations (4 Sheets)**

2,4,5-TP Silvex	0.01 mg/l
Lindane	0.004 mg/l
Toxaphene	0.005 mg/l

<sup>a</sup> Greater than 100 analytical detects in tank waste or greater than 20 analytical detects in TWINS Solid/Liquid Hits. Taken from Table B.1 of Wiemers 1998.



**Table C-7 Summary of Numeric Requirements of Relevant Drinking Water and Groundwater Regulations (7 Sheets)**

A blank entry in the cell means that the corresponding regulation does not cover the indicated contaminant.

2,3,7,8-TCDD (Dioxin)	3x10 <sup>-8</sup> mg/l							
2,4,5-TP Silvex	0.05 mg/l		0.01 mg/l		0.01 mg/l		0.01 mg/l	0.01 mg/l
Acrylamide					0.00002 mg/l			
Acrylonitrile					0.00007 mg/l			
Alachlor	0.002 mg/l							
Aldicarb	0.003 mg/l							
Aldicarb sulfoxide	0.004 mg/l							
Aldicarb sulfone	0.002							
Aldrin					0.000005 mg/l			
Altazine	0.003 mg/l							
Amiline					0.014 mg/l			
Aramite					0.003 mg/l			
Azobenzene					0.0007 mg/l			
Benzene <sup>(a)</sup>					0.001 mg/l			
Benzidine					0.000004 mg/l			
Benzo(a)pyrene	0.002 mg/l				0.000008 mg/l			
Benzotrithloride					0.000007 mg/l			
Benzyl chloride					0.0005 mg/l			
Bis(chloroethyl)ether					0.00007 mg/l			
Bis(chloromethyl)ether					0.0004 mg/l			
Bis(2-ethylhexyl)phthalate <sup>(a)</sup>					0.006 mg/l			
Bromodichloromethane					0.0003 mg/l			
Bromoform					0.005 mg/l			
Carbazole		40 CFR 141		WAC 246-290-310	WAC 173-200-040	40 CFR 264.94	WAC 173-303-645	WAC 173-303-645
Carbofuran					0.005 mg/l			
Carbonyl sulfide	0.04 mg/l							
Carbon tetrachloride <sup>(a)</sup>	0.005 mg/l						0.0003 mg/l	
Chlordane	0.002 mg/l						0.00006 mg/l	
Chlorodibromomethane							0.0005 mg/l	

**Table C-7 Summary of Numeric Requirements of Relevant Drinking Water and Groundwater Regulations (7 Sheets)**  
 A blank entry in the cell means that the corresponding regulation does not cover the indicated contaminant.

Chloroform <sup>(a)</sup>					0.007 mg/l	
4 Chloro-2-methyl aniline					0.0001 mg/l	
4 Chloro-2-methyl aniline hydrochloride					0.0002 mg/l	
o-Chloronitrobenzene					0.003 mg/l	
p-Chloronitrobenzene					0.005 mg/l	
Chlorthalonil					0.030 mg/l	
Dalapon	0.2 mg/l					
Diallate					0.001 mg/l	
DDT (includes DDE and DDD)					0.0003 mg/l	
Dibromochloropane	0.00002 mg/l					
1,2 Dibromomethane					0.000001 mg/l	
Para-Dichlorobenzene	0.075 mg/l					
σ-Dichlorobenzene	0.06 mg/l				0.004 mg/l	
1,4-Dichlorobenzene <sup>(a)</sup>					0.0002 mg/l	
3,3' Dichlorobenzidine					0.001 mg/l	
1,1 Dichloroethane	0.007 mg/l					
	<b>40 CFR 141</b>	<b>WAC 246-290-310</b>	<b>40 CFR 264.94</b>	<b>WAC 173-200-040</b>	<b>WAC 173-303-645</b>	
1,2 Dichloroethane (ethylene chloride)	0.005 mg/l				0.0005 mg/l	
Cis-1,2-Dichloroethylene <sup>(a)</sup>	0.07 mg/l					
Trans-1,2-Dichloroethylene <sup>(a)</sup>						
Dichloromethane <sup>(a)</sup>	0.005 mg/l					
1,2 Dichloropropane	0.005 mg/l				0.0006 mg/l	
1,3 Dichloropropene					0.0002 mg/l	

**Table C-7 Summary of Numeric Requirements of Relevant Drinking Water and Groundwater Regulations (7 Sheets)**

A blank entry in the cell means that the corresponding regulation does not cover the indicated contaminant.

Dichlorvos					0.0003 mg/l	
Dieldrin					0.000005 mg/l	
3,3' Dimethoxybenzidine					0.006 mg/l	
3,3 Dimethylbenzidine					0.000007 mg/l	
1,2 Dimethylhydrazine					0.060 mg/l	
2,4 Dinitrotoluene					0.0001 mg/l	
2,6 Dinitrotoluene					0.0001 mg/l	
Dinoseb	0.007 mg/l					
1,4 Dioxane					0.007 mg/l	
1,2 Diphenylhydrazine					0.00009 mg/l	
Diquat	0.02 mg/l					
Direct Black 38					0.000009 mg/l	
Direct Blue 6					0.000009 mg/l	
Direct Brown 95					0.000009 mg/l	
Di(2-ethylhexyl) adiapite	0.4 mg/l					
	40 CFR 141	WAC 246-290-310	40 CFR 264.94	WAC 173-200-040	WAC 173-303-645	
Di(2-ethylhexyl) phthalate	0.006 mg/l					
Endothall	0.1 mg/l					
Endrin	0.002 mg/l		0.0002 mg/l		0.0002 mg/l	0.0002 mg/l
Epichlorohydrin					0.008 mg/l	
Ethyl acrylate					0.002 mg/l	
Ethyl benzene <sup>(a)</sup>	0.7 mg/l					
Ethylene dibromide	0.00005 mg/l				0.000001 mg/l	

**Table C-7 Summary of Numeric Requirements of Relevant Drinking Water and Groundwater Regulations (7 Sheets)**

A blank entry in the cell means that the corresponding regulation does not cover the indicated contaminant.

Ethylene thiourea						0.002 mg/l	
Folpet						0.020 mg/l	
Furazolidone						0.00002 mg/l	
Furium						0.000002 mg/l	
Furmecyclox						0.003 mg/l	
Glyphosate		0.7 mg/l					
Heptachlor		0.004 mg/l				0.00002 mg/l	
Heptachlor Epoxide		0.0002 mg/l				0.000009 mg/l	
Hexachlorobenzene		0.001 mg/l				0.00005 mg/l	
Hexachlorocyclohexane (alpha)		0.05 mg/l				0.000001 mg/l	0.004 mg/l
Hexachlorocyclohexane (technical)						0.00005 mg/l	
Hexachlorodibenzo-p-dioxin, mix						0.00000001 mg/l	
Hydrazine/Hydrazine sulfate						0.00003 mg/l	
Lindane					0.004 mg/l	0.00006 mg/l	0.004 mg/l
		<b>40 CFR 141</b>	<b>WAC 246-290-310</b>	<b>40 CFR 264.94</b>	<b>WAC 173-200-040</b>	<b>WAC 173-303-645</b>	<b>WAC 173-303-645</b>
2 Methoxy-5-nitroaniline						0.002 mg/l	
2 Methylamine						0.0002 mg/l	
2 Methylamine hydrochloride						0.0005 mg/l	
4,4' Methylene bis(N,N'-dimethyl) aniline						0.002 mg/l	
Methoxychlor		0.04 mg/l		0.1 mg/l		0.1 mg/l	0.1 mg/l
Methylene chloride (dichloromethane)						0.005 mg/l	
Mirex						0.00005 mg/l	
Monochlorobenzene		0.1 mg/l					



**Table C-7 Summary of Numeric Requirements of Relevant Drinking Water and Groundwater Regulations (7 Sheets)**

A blank entry in the cell means that the corresponding regulation does not cover the indicated contaminant.

2,4-Toluenediamine				0.000002 mg/l	
Toluene <sup>(a)</sup>	1.0 mg/l				
o-Toluidine				0.0002 mg/l	
Toxaphene	0.003 mg/l		0.005 mg/l	0.00008 mg/l	0.005 mg/l
1,2,4-Trichloro-benzene	0.07 mg/l				
Trichloroethylene	0.005 mg/l			0.003 mg/l	
1,1,1-Trichloroethane <sup>(a)</sup>	0.2 mg/l				
1,1,2-Trichloroethane <sup>(a)</sup>	0.005 mg/l				
2,4,6-Trichlorophenol				0.004 mg/l	
Trihalomethanes	0.10 mg/l				
	<b>40 CFR 141</b>	<b>WAC 246-290-310</b>	<b>40 CFR 264.94</b>	<b>WAC 173-200-040</b>	<b>WAC 173-303-645</b>
Trimethyl phosphate				0.002 mg/l	
Vinyl chloride	0.002 mg/l			0.00002 mg/l	
Xylenes (total) <sup>(a)</sup>	10. mg/l				
o-Xylene <sup>(a)</sup>	0.7 mg/l				

<sup>a</sup> Greater than 100 analytical detects in tank waste or greater than 20 analytical detects in TWINS Solid/Liquid Hits. Taken from Table B.1 of Wicimers 1998.

**Table C-8 Numeric Requirements Of Relevant Surface Water Regulations  
(For Drinking Water Standards, see Table C.5)**

<b>“Water Quality Standards for Surface Waters of the State of Washington”</b>					
<b>WAC 173-201A-040</b>					
Ammonia	4.0	mg/l	Arsenic	0.19	mg/l
Cadmium (a)	0.00082	mg/l	Chloride	230.	mg/l
Copper (a)	0.0087	mg/l	Chromium	0.011	mg/l
Cyanide	0.0052	mg/l	Lead (a)	0.00178	mg/l
Mercury	0.000012	mg/l	Nickel (a)	0.120	mg/l
Selenium	0.005	mg/l	Zinc (a)	0.080	mg/l

a based on Columbia River at Pasco having a mean hardness of 73 mg/l (DOE 1988)

<b>“Water Quality Standards for Surface Waters of the State of Washington”</b>					
<b>WAC 173-201A-050</b>					
Radionuclides	0.08 of WAC 246-221-290 Or EPA drinking water standards (40 CFR 141, see Table C.5 above)				
H-3	80000.	pCi/l	Se-79	640.	pCi/l
Sr-90	40.	pCi/l	Zr-93	3200.	pCi/l
Nb-93m	16000.	pCi/l	Tc-99	4800.	pCi/l
Sn-126	320.	pCi/l	I-129	16.	pCi/l
Cs-137	80.	pCi/l	Ra-226	4.8	pCi/l
Ra-228	4.8	pCi/l	Th-232	2.4	pCi/l
Pa-231	0.48	pCi/l	U-233	24.	pCi/l
U-234	24.	pCi/l	U-235	24.	pCi/l
U-236	24.	pCi/l	U-238	24.	pCi/l
Np-237	1.6	pCi/l	Pu-239	1.6	pCi/l
Pu-240	1.6	pCi/l	Am-241	1.6	pCi/l
Am-243	1.6	pCi/l			

<b>Washington State “Model Toxics Control Act”</b>	
<b>WAC 173-340-730</b>	
Exposure to multiple hazardous substances / more than one pathway	
Total excess cancer risk (carcinogen)	1x10 <sup>-5</sup>
Hazard index (noncarcinogen)	1.0

**Table C-9 Numeric Requirements of Relevant Air Regulations**

<b>DOE Order on Radioactive Waste Management DOE O 435.1</b>			
Air emissions (except radon)		10 mrem/year	
Air emissions (radon)		20 pCi/m <sup>2</sup> s	
<b>DOE Order on Radiation Protection of the Public and the Environment DOE Order 5400.5(II)(b) (DOE 1993)</b>			
Air emissions		10 mrem/year	
<b>National Primary and Secondary Ambient Air Quality Standards 40 CFR 50</b>			
<b>Limits for Average Maximum</b>			
Sulfur oxides	0.50 ppm for 3 hours	0.14 ppm for 24 hours	0.030 ppm for 1 year
Carbon Monoxide		35 ppm for 1 hour	9 ppm for 8 hours
Ozone		0.12 ppm for 1 hour	0.08 ppm for 8 hours
Nitrogen Dioxide			0.053 ppm
Lead			1.5 µg/m <sup>3</sup>
<b>“National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities”, 40 CFR 61.92</b>			
Air emission (except radon)		10 mrem/year	
<b>“National Emission Standards for Radon Emissions from Department of Energy Facilities”, 40 CFR 61.192</b>			
Air emissions (radon)		20 pCi/m <sup>2</sup> s	
<b>Washington State “General Regulations for Air Pollution Sources” WAC 173-480-040</b>			
Sulfur dioxide		1 ppm	
<b>Washington State “Ambient Air Quality Standards for Radionuclides” WAC 173-480-040</b>			
Air emissions (except radon) (whole body)		25 mrem/year	
Air emissions (except radon) (critical organ)		75 mrem/year	
<b>Washington State “Radiation Protection – Air Emissions” WAC 246-247-040</b>			
References WAC 173-480 and 40 CFR 61			
<b>Washington State “Model Toxics Control Act” WAC 173-340-750</b>			
Exposure to multiple hazardous substances / more than one pathway			
Total excess cancer risk (carcinogen)		1x10 <sup>-5</sup>	
Hazard index (noncarcinogen)		1.0	

**Table C-10 Numeric Requirements of Relevant Regulations for Concentrations in Waste  
(8 Sheets)**

<b>WTP Contract (DOE 2002b)</b>			
Sr-90	20 Ci/m <sup>3</sup>	Tc-99 (a)	0.1 Ci/m <sup>3</sup>
Cs-137	3 Ci/m <sup>3</sup>		
Must meet requirements of WAC 173-303 and 10 CFR 268			
On average, 80% of Tc99 delivered from vendor shall be removed			
Contact surface dose rate must be less than 1000 mrem/hr			
Using 7 day PCT test, leach amount less than 2g/m <sup>2</sup>			
Using VHT, leach rate less than 50 g/(m <sup>2</sup> day)			

<b>Licensing Requirements for the Land Disposal of Radioactive Waste” 10CFR61.55 (Class C)</b>			
C-14	8. Ci/m <sup>3</sup>	C-14 (activated metal)	80. Ci/m <sup>3</sup>
Ni-59 (activated metal)	220. Ci/m <sup>3</sup>	Ni-63	700. Ci/m <sup>3</sup>
Ni-63 (activated metal)	7000 Ci/m <sup>3</sup>	Sr-90	7000. Ci/m <sup>3</sup>
Nb-94 (activated metal)	0.2 Ci/m <sup>3</sup>	Tc-99	3. Ci/m <sup>3</sup>
I-129	0.08 Ci/m <sup>3</sup>	Cs-137	4600. Ci/m <sup>3</sup>
Alpha emitters (with half-lives greater than 5 years)			100 nCi/g
Pu-241	3500 nCi/g	Cm-242	20000 nCi/g

<b>“Toxicity Characteristics” – TCLP limits 40 CFR 261.24</b>			
Arsenic	5 mg/l	Barium	100 mg/l
Cadmium	1 mg/l	Chromium	5 mg/l
Lead	5 mg/l	Mercury	0.2 mg/l
Selenium	1mg/l	Silver	5 mg/l
CAS #	Constituent		
56-23-5	Carbon tetrachloride <sup>(a)</sup>		0.5 mg/l
57-74-9	Chlordane		0.03 mg/l
58-89-9	Lindane		0.4 mg/l
67-66-3	Chloroform <sup>(a)</sup>		6.0 mg/l
67-72-1	Hexachloroethane		3.0 mg/l
71-43-2	Benzene <sup>(a)</sup>		0.5 mg/l
72-20-4	Endrin		0.02 mg/l
72-43-5	Methoxychlor		10.0 mg/l
75-01-4	Vinyl chloride		0.2 mg/l
75-35-4	1,1-Dichloroethylene <sup>(a)</sup>		0.7 mg/l
76-04-8	Heptachlor		0.008 mg/l
78-93-3	Methyl ethyl ketone <sup>(a)</sup>		200. mg/l
79-01-6	Trichloroethylene <sup>(a)</sup>		0.5 mg/l
87-68-3	Hexachlorobutadiene		0.5 mg/l
87-86-5	Pentachlorophenol		100. mg/l
88-06-2	2,4,6-Trichlorophenol		2.0 mg/l
93-72-1	2,4,5-TP (Silvex)		1.0 mg/l
94-75-7	2,4-D		10.0 mg/l
95-48-7	o-Cresol		200.0 mg/l
95-95-4	2,4,5-Trichlorophenol		400.0 mg/l
98-95-3	Nitrobenzene		2.0 mg/l

**Table C-10 Numeric Requirements of Relevant Regulations for Concentrations in Waste  
(8 Sheets)**

<b>“Toxicity Characteristics” – TCLP limits (cont.)</b> <b>40 CFR 261.24</b>		
106-44-5	p-Cresol	200.0 mg/l
106-46-7	1,4-Dichlorobenzene <sup>(a)</sup>	7.5 mg/l
107-06-2	1,2-Dichloroethane	0.5 mg/l
108-39-4	m-Cresol	200.0 mg/l
108-90-7	Chlorobenzene	100 mg/l
110-86-1	Pyridine <sup>(a)</sup>	5. mg/l
118-74-1	Hexachlorobenzene	0.13 mg/l
121-14-2	2,4-Dinitrotoluene	0.13 mg/l
127-18-4	1,1,2,2-Tetrachloroethene <sup>(a)</sup>	0.7 mg/l
8001-35-2	Toxaphene	0.5 mg/l

<b>RCRA “Treatment Standards”</b> <b>40 CFR 268.40</b>	
Establishes treatment standards	
Standards bounded by 40 CFR 268.48	

<b>RCRA “(Universal Treatment Standards)”</b> <b>40 CFR 268.48</b>		
		<b>TCLP result limits</b>
Antimony		1.15 mg/l
Arsenic		5.0 mg/l
Barium		21. mg/l
Beryllium		1.22 mg/l
Cadmium		0.11 mg/l
Chromium (total)		0.60 mg/l
Lead		0.75 mg/l
Mercury		0.025 mg/l
Nickel		11.0 mg/l
Selenium		5.7 mg/l
Silver		0.14 mg/l
Thallium		0.20 mg/l
Vanadium		1.6 mg/l
Zinc		4.3 mg/l
		<b>TCLP result limits</b>
Cyanide (total)		590 mg/kg
Cyanide (amenable)		30 mg/kg
CAS #	Constituent	<b>TCLP result limits</b>
67-56-1	Methanol <sup>(a)</sup>	0.75 mg/l
75-15-0	Carbon disulfide	4.8 mg/l
108-94-1	Cyclohexanone <sup>(a)</sup>	0.75 mg/l
50-29-3	p,p'-DDT	0.087 mg/kg
50-32-8	Benzo(a)pyrene	3.4 mg/kg

**Table C-10 Numeric Requirements of Relevant Regulations for Concentrations in Waste  
(8 Sheets)**

CAS #	Constituent	Concentration limit
51-28-5	2,4-Dinitrophenol	160 mg/kg
CAS #	Constituent	Concentration limit
52-85-7	Famphur	15 mg/kg
53-19-0	o,p'-DDD	0.087 mg/kg
53-70-3	Dibenz(a,h)anthracene	8.2 mg/kg
53-96-3	2-Acetylaminofluorene	140 mg/kg
55-18-5	N-Nitrosodiethylamine	28 mg/kg
56-23-5	Carbon tetrachloride <sup>(a)</sup>	6 mg/kg
56-38-2	Parathion	4.6 mg/kg
56-49-5	3-Methylcholanthrene	15 mg/kg
56-55-3	Benz(a)anthracene	3.4 mg/kg
57-47-6	Physostigmine	1.4 mg/kg
57-64-7	Physostigmine salicylate	1.4 mg/kg
57-74-9	Chlordane (alpha and gamma isomers)	0.26 mg/kg
58-89-9	gamma-BHC	0.066 mg/kg
58-90-2	2,3,4,6-Tetrachlorophenol	7.4 mg/kg
59-50-7	p-Chloro-m-cresol	14 mg/kg
59-89-2	N-Nitrosomorpholine	2.3 mg/kg
60-29-7	Ethyl ether	160 mg/kg
60-57-1	Dieldrin	0.13 mg/kg
62-44-2	Phenacetin	16 mg/kg
62-53-3	Aniline	14 mg/kg
62-75-9	N-Nitrosodimethylamine	2.3 mg/kg
63-25-2	Carbaryl	0.14 mg/kg
64-00-6	m-Cumenyl methylcarbamate	1.4 mg/kg
67-64-1	Acetone <sup>(a)</sup>	160 mg/kg
67-66-3	Chloroform <sup>(a)</sup>	6 mg/kg
67-72-1	Hexachloroethane	30 mg/kg
71-36-3	n-Butyl alcohol <sup>(a)</sup>	2.6 mg/kg
71-43-2	Benzene <sup>(a)</sup>	10 mg/kg
71-55-6	1,1,1-Trichloroethane <sup>(a)</sup>	6 mg/kg
72-20-8	Endrin	0.13 mg/kg
72-43-5	Methoxychlor	0.18 mg/kg
72-54-8	p,p'-DDD	0.087 mg/kg
72-55-9	p,p'-DDE	0.087 mg/kg
74-83-9	Bromomethane/Methylbromide	15 mg/kg
74-87-3	Chloromethane/Methyl chloride <sup>(a)</sup>	30 mg/kg
74-88-4	Iodomethane	65 mg/kg
74-95-3	Dibromomethane	15 mg/kg
75-00-3	Chloroethane	6 mg/kg
75-01-4	Vinyl chloride	6 mg/kg
75-09-2	Methylene chloride <sup>(a)</sup>	30 mg/kg
75-25-2	Tribromomethane/Bromoform	15 mg/kg
75-27-4	Bromodichloromethane	15 mg/kg
75-34-3	1,1-Dichloroethane	6 mg/kg
75-35-4	1,1-Dichloroethylene <sup>(a)</sup>	6 mg/kg
75-69-4	Trichlorofluoromethane <sup>(a)</sup>	30 mg/kg
75-71-8	Dichlorodifluoromethane <sup>(a)</sup>	7.2 mg/kg
76-01-7	Pentachloroethane	6 mg/kg

**Table C-10 Numeric Requirements of Relevant Regulations for Concentrations in Waste  
(8 Sheets)**

CAS #	Constituent	Concentration limit
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane <sup>(a)</sup>	30 mg/kg
76-44-8	Heptachlor	0.066 mg/kg
77-47-4	Hexachlorocyclopentadiene	2.4 mg/kg
78-83-1	Isobutyl alcohol	170 mg/kg
78-87-5	1,2-Dichloropropane	18 mg/kg
78-93-3	Methyl ethyl ketone <sup>(a)</sup>	36 mg/kg
79-00-5	1,1,2-Trichloroethane <sup>(a)</sup>	6 mg/kg
79-01-6	Trichloroethylene <sup>(a)</sup>	6 mg/kg
79-06-1	Acrylamide	23 mg/kg
79-34-5	1,1,2,2-Tetrachloroethane	6 mg/kg
80-62-6	Methyl methacrylate	160 mg/kg
82-68-8	Pentachloronitrobenzene	4.8 mg/kg
83-32-9	Acenaphthene	3.4 mg/kg
84-66-2	Diethyl phthalate	28 mg/kg
84-74-2	Di-n-butyl phthalate	28 mg/kg
85-01-8	Phenanthrene	5.6 mg/kg
85-44-9	Phthalic anhydride	28 mg/kg
85-68-7	Butyl benzyl phthalate	28 mg/kg
86-30-6	Diphenylnitrosamine	13 mg/kg
86-73-7	Fluorene	3.4 mg/kg
87-65-0	2,6-Dichlorophenol	14 mg/kg
87-68-3	Hexachlorobutadiene	5.6 mg/kg
87-86-5	Pentachlorophenol	7.4 mg/kg
88-06-2	2,4,6-Trichlorophenol	7.4 mg/kg
88-74-4	o-Nitroaniline	14 mg/kg
88-75-5	o-Nitrophenol	13 mg/kg
88-85-7	2-sec-Butyl-4,6-dinitrophenol/ Dinoseb/dinitrophenol/Dinoseb	2.5 mg/kg
91-20-3	Naphthalene	5.6 mg/kg
91-58-7	2-Chloronaphthalene	5.6 mg/kg
91-80-5	Methapyrilene	1.5 mg/kg
93-72-1	Silvex/2,4,5-TP	7.9 mg/kg
93-76-5	2,4,5-Trichlorophenoxy acetic acid/2,4,5-T	7.9 mg/kg
94-59-7	Safrole	22 mg/kg
94-75-7	2,4-Dichlorophenoxyacetic acid/2,4-D	10 mg/kg
95-48-7	o-Cresol	5.6 mg/kg
95-50-1	o-Dichlorobenzene	6 mg/kg
95-57-8	2-Chlorophenol	5.7 mg/kg
95-94-3	1,2,4,5-Tetrachlorobenzene	14 mg/kg
95-95-4	2,4,5-Trichlorophenol	7.4 mg/kg
96-12-8	1,2-Dibromo-3-chloropropane	15 mg/kg
96-18-4	1,2,3-Trichloropropane	30 mg/kg
96-86-2	Acetophenone	9.7 mg/kg
97-63-2	Ethyl methacrylate	160 mg/kg
98-87-3	Benzal chloride	6 mg/kg
98-95-3	Nitrobenzene	14 mg/kg
99-55-8	5-Nitro-o-toluidine	28 mg/kg
100-01-6	p-Nitroaniline	28 mg/kg
100-02-7	p-Nitrophenol	29 mg/kg
100-21-0	Phthalic acid	28 mg/kg

**Table C-10 Numeric Requirements of Relevant Regulations for Concentrations in Waste  
(8 Sheets)**

CAS #	Constituent	Concentration limit
100-25-4	1,4-Dinitrobenzene	2.3 mg/kg
100-41-4	Ethyl benzene <sup>(a)</sup>	10 mg/kg
100-75-4	N-Nitrosopiperidine	35 mg/kg
101-14-4	4,4-Methylene bis(2-chloroaniline)	30 mg/kg
101-27-9	Barban	1.4 mg/kg
101-55-3	4-Bromophenyl phenyl ether	15 mg/kg
105-67-9	2,4-Dimethylphenol	14 mg/kg
106-44-5	p-Cresol	5.6 mg/kg
106-46-7	p-Dichlorobenzene <sup>(a)</sup>	6 mg/kg
106-47-8	p-Chloroaniline	16 mg/kg
106-93-4	1,2-Dibromoethane/Ethylene dibromide <sup>(a)</sup>	15 mg/kg
107-05-1	3-Chloropropylene	30 mg/kg
107-06-2	1,2-Dichloroethane	6 mg/kg
107-12-0	Ethyl cyanide/Propanenitrile <sup>(a)</sup>	360 mg/kg
107-13-1	Acrylonitrile	84 mg/kg
108-10-1	Methyl isobutyl ketone <sup>(a)</sup>	33 mg/kg
108-39-4	m-Cresol	5.6 mg/kg
108-88-3	Toluene <sup>(a)</sup>	10 mg/kg
108-90-7	Chlorobenzene	6 mg/kg
108-95-2	Phenol	6.2 mg/kg
110-86-1	Pyridine <sup>(a)</sup>	16 mg/kg
111-44-4	bis(2-Chloroethyl)ether	6 mg/kg
111-91-1	bis(2-Chloroethoxy)methane	7.2 mg/kg
114-26-1	Propoxur	1.4 mg/kg
117-84-0	Di-n-octyl phthalate	28 mg/kg
118-74-1	Hexachlorobenzene	10 mg/kg
120-12-7	Anthracene	3.4 mg/kg
120-58-1	Isosafrole	2.6 mg/kg
120-82-1	1,2,4-Trichlorobenzene	19 mg/kg
120-83-2	2,4-Dichlorophenol	14 mg/kg
121-14-2	2,4-Dinitrotoluene	140 mg/kg
121-44-8	Triethylamine	1.5 mg/kg
122-39-4	Diphenylamine	13 mg/kg
122-42-9	Propham	1.4 mg/kg
123-91-1	1,4-Dioxane	170 mg/kg
124-48-1	Chlorodibromomethane	15 mg/kg
126-72-7	tris-(2,3-Dibromopropyl) phosphate	0.1 mg/kg
126-98-7	Methacrylonitrile	84 mg/kg
126-99-8	2-Chloro-1,3-butadiene	0.28 mg/kg
127-18-4	Tetrachloroethylene <sup>(a)</sup>	6 mg/kg
129-00-0	Pyrene	8.2 mg/kg
131-11-3	Dimethyl phthalate	28 mg/kg
141-78-6	Ethyl acetate	33 mg/kg
143-50-0	Kepone	0.13 mg/kg
156-60-5	trans-1,2-Dichloroethylene	30 mg/kg
191-24-2	Benzo(g,h,i)perylene	1.8 mg/kg
193-39-5	Indeno(1,2,3-c,d) pyrene	3.4 mg/kg
205-99-2	Benzo(b)fluoranthene	6.8 mg/kg
206-44-0	Fluoranthene	3.4 mg/kg

**Table C-10 Numeric Requirements of Relevant Regulations for Concentrations in Waste  
(8 Sheets)**

CAS #	Constituent	Concentration limit
207-08-9	Benzo(k)fluoranthene	6.8 mg/kg
208-96-8	Acenaphthylene	3.4 mg/kg
218-01-9	Chrysene	3.4 mg/kg
298-00-0	Methyl parathion	4 mg/kg
298-02-2	Phorate	4.6 mg/kg
298-04-4	Disulfoton	6.2 mg/kg
309-00-2	Aldrin	0.066 mg/kg
315-18-4	Mexacarbate	1.4 mg/kg
319-84-6	alpha-BHC	0.066 mg/kg
319-85-7	beta-BHC	0.066 mg/kg
319-86-8	delta-BHC	0.066 mg/kg
465-73-6	Isodrin	0.066 mg/kg
534-52-1	4,6-Dinitro-o-cresol	160 mg/kg
541-73-1	m-Dichlorobenzene	6 mg/kg
606-20-2	2,6-Dinitrotoluene	28 mg/kg
608-93-5	Pentachlorobenzene	10 mg/kg
621-64-7	Di-n-propylnitrosamine	14 mg/kg
630-20-6	1,1,1,2-Tetrachloroethane	6 mg/kg
759-94-4	EPTC	1.4 mg/kg
789-02-6	o,p'-DDT	0.087 mg/kg
924-16-3	N-Nitroso-di-n-butylamine	17 mg/kg
930-55-2	N-Nitrosopyrrolidine	35 mg/kg
959-98-8	Endosulfan I	0.066 mg/kg
1024-57-3	Heptachlor epoxide	0.066 mg/kg
1031-07-8	Endosulfan sulfate	0.13 mg/kg
1114-71-2	Pebulate	1.4 mg/kg
1129-41-5	Metolcarb	1.4 mg/kg
1330-20-7	Xylenes-mixed isomers (sum of o-, m-, and p-xylene concentrations) <sup>(a)</sup>	30 mg/kg
1336-36-3	Total PCBs (sum of all PCB isomers, or all Aroclors)	10 mg/kg
1563-38-8	Carbofuran phenol	1.4 mg/kg
1563-66-2	Carbofuran	0.14 mg/kg
1646-88-4	Aldicarb sulfone	0.28 mg/kg
1929-77-7	Vernolate	1.4 mg/kg
2008-41-5	Butylate	1.4 mg/kg
2032-65-7	Methiocarb	1.4 mg/kg
2212-67-1	Molinate	1.4 mg/kg
2303-17-5	Triallate	1.4 mg/kg
2631-37-0	Promecarb	1.4 mg/kg
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin(OCDD)	0.005 mg/kg
3424-82-6	o,p'-DDE	0.087 mg/kg
7421-93-4	Endrin aldehyde	0.13 mg/kg
8001-35-2	Toxaphene	2.6 mg/kg
10061-01-5	cis-1,3-Dichloropropylene	18 mg/kg
10061-02-6	trans-1,3-Dichloropropylene	18 mg/kg
10595-95-6	N-Nitrosomethylethylamine	2.3 mg/kg
10605-21-7	Carbenzadim	1.4 mg/kg
621-64-7	Di-n-propylnitrosamine	14 mg/kg
630-20-6	1,1,1,2-Tetrachloroethane	6 mg/kg
16752-77-5	Methomyl	0.14 mg/kg

**Table C-10 Numeric Requirements of Relevant Regulations for Concentrations in Waste  
(8 Sheets)**

CAS #	Constituent	Concentration limit
17804-35-2	Benomyl	1.4 mg/kg
22781-23-3	Bendiocarb	1.4 mg/kg
23135-22-0	Oxamyl	0.28 mg/kg
23422-53-9	Formetanate hydrochloride	1.4 mg/kg
23564-05-8	Thiophanate-methyl	1.4 mg/kg
23950-58-5	Pronamide	1.5 mg/kg
33213-65-9	Endosulfan II	0.13 mg/kg
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin(1,2,3,4,6,7, 8-HpCDD)	0.0025 mg/kg
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofluran (OCDF)	0.005 mg/kg
39638-32-9	bis(2-Chloroisopropyl) ether	7.2 mg/kg
52888-80-9	Prosulfocarb	1.4 mg/kg
55285-14-8	Carbosulfan	1.4 mg/kg
55673-89-7	1,2,3,4,6,7,8-Heptachlorodibenzofluran (1,2,3,4,7,8,9-HpCDF)	0.0025 mg/kg
59669-26-0	Thiodicarb	1.4 mg/kg
67562-39-5	1,2,3,4,6,7,8-Heptachlorodibenzofluran (1,2,3,4,6,7,8-HpCDF)	0.0025 mg/kg
NA	Dithiocarbamates (total)	28 mg/kg
NA	HxCDDs (All Hexachlorodibenzo-p-dioxins)	0.001 mg/kg
NA	HxCDFs (All Hexachlorodibenzofurans)	0.001 mg/kg
NA	PeCDDs (All Pentachlorodibenzo-p-dioxins)	0.001 mg/kg
NA	PeCDFs (All Pentachlorodibenzofurans)	0.001 mg/kg
NA	TCDDs (All Tetrachlorodibenzo-p-dioxins)	0.001 mg/kg
NA	TCDFs (All Tetrachlorodibenzofurans)	0.001 mg/kg

Washington State "Dangerous Waste Regulations" – TCLP Result Limits WAC 173-303-090			
Arsenic	5 mg/l	Barium	100 mg/l
Cadmium	1 mg/l	Chromium	5 mg/l
Lead	5 mg/l	Mercury	0.2 mg/l
Selenium	1 mg/l	Silver	5 mg/l
CAS #	Constituent	TCLP result limit	
56-23-5	Carbon tetrachloride <sup>(a)</sup>	0.5 mg/l	
57-74-9	Chlordane	0.03 mg/l	
58-89-9	Lindane	0.4 mg/l	
67-66-3	Chloroform <sup>(a)</sup>	6 mg/l	
67-72-1	Hexachloroethane	3 mg/l	
71-43-2	Benzene <sup>(a)</sup>	0.5 mg/l	
72-20-8	Endrin	0.02 mg/l	
72-43-5	Methoxychlor	10 mg/l	
75-01-4	Vinyl chloride	0.2 mg/l	
75-35-4	1,1-Dichloroethylene <sup>(a)</sup>	0.7 mg/l	
76-44-8	Heptachlor (and its epoxide)	0.008 mg/l	
78-93-3	Methyl ethyl ketone <sup>(a)</sup>	200 mg/l	
79-01-6	Trichloroethylene <sup>(a)</sup>	0.5 mg/l	
87-68-3	Hexachlorobutadiene	0.5 mg/l	
87-86-5	Pentachlorophenol	100 mg/l	
88-06-2	2,4,6-Trichlorophenol	2 mg/l	
93-72-1	2,4,5-TP (Silvex)	1 mg/l	
94-75-7	2,4-D	10 mg/l	
95-48-7	o-Cresol	200 mg/l	

**Table C-10 Numeric Requirements of Relevant Regulations for Concentrations in Waste  
(8 Sheets)**

CAS #	Constituent (a)	TCLP result limit
95-95-4	2,4,5-Trichlorophenol	400 mg/l
98-95-3	Nitrobenzene	2 mg/l
106-44-5	p-Cresol	200 mg/l
106-46-7	1,4-Dichlorobenzene <sup>(a)</sup>	7.5 mg/l
107-06-2	1,2-Dichloroethane	0.5 mg/l
108-39-4	m-Cresol	200 mg/l
108-90-7	Chlorobenzene	100 mg/l
110-86-1	Pyridine <sup>(a)</sup>	5 mg/l
118-74-1	Hexachlorobenzene	0.13 mg/l
121-14-2	2,4-Dinitrotoluene	0.13 mg/l
127-18-4	Tetrachloroethylene <sup>(a)</sup>	0.7 mg/l
8001-35-2	Toxaphene	0.5 mg/l
NA	Sum of m-, o-, and p- Cresol	200 mg/l

<sup>a</sup> Greater than 100 analytical detects in tank waste or greater than 20 analytical detects in TWINS Solid/Liquid Hits. Taken from Table B.1 of Wiemers 1998.

Appendix D

TPA M45  
Requirements on Risk Assessments

Does Not Include M45-55

(Through Change Package M-45-02-03)

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**M45-00 COMPLETE CLOSURE OF ALL SINGLE-SHELL TANK FARMS 9/30/24**

*Procedures for modifying the retrieval criteria list above, and for process requests for exceptions to the criteria, are outlined in Appendix H to the agreement.*

*For the purposes of this agreement all units located within the boundary of each tank farm will be closed in accordance with WAC 173-303-610.*

**M45-02 SUBMIT ANNUAL UPDATES TO SST RETRIEVAL SEQUENCE DOCUMENT 9/30/00 and annually thereafter**

*The report will also detail tank selection rationale based on the primary objective of maximizing risk reduction through the retrieval of mobile, long-lived radionuclides or potential airborne contaminants and principle non radiological hazardous constituents in a manner which is sensitive to waste treatment facility requirements and infrastructure constraints.*

**M45-00C COMPLETE RENEGOTIATION OF SECOND PHASE (I.E. 9/30/2006 THROUGH 9/30/2015) SST WASTE RETRIEVAL ACTIVITIES 2/28/04**

*These negotiations shall take into account variables such as work in progress, e.g., does tank waste treatment complex acquisition initiative and environmental and human health risks associated with releases from DOE's SSTs. Negotiations shall be designed to establish a sufficient number of agreement milestones and target dates to effectively drive each phase of the work including but not limited to 1.) waste retrieval technology development, 1.) retrieval performance evaluations, 3.) leak detection, monitoring, and mitigation, 4.) selection of SST retrieval sequence, 5.) design construction and operation of SST waste retrieval systems, and 6.) closure planning and closure plan development.*

*SST waste will be retrieved on a priority basis with the goals of reducing environmental risk and treatment process optimization. DOE and Ecology will agree on the criteria to determine environmental risk reduction.*

**M45-03-T03 SUBMIT S-112 SALTCAKE WASTE RETRIEVAL TECHNOLOGY DEMONSTRATION FUNCTIONS AND REQUIREMENTS DOCUMENT complete**

*This document will establish demonstration system specifications (including LDMM system specifications) and will also include a scoping level retrieval performance evaluation (RPE). The functions and requirements document and its associated RPE shall provide environmental and human health risk evaluation data/information associated with estimated waste volumes to be retrieved, the maximum volume which could leak during retrieval, and risk from residual waste. This document will detail known and estimated radionuclide contamination and contaminant migration within the vadose zone as bases of calculation. LDMM and RPE documentation provided will be adequate to provide Ecology to access the adequacy of the demonstration systems.*

**M45-03-T04 SUBMIT C-104 SLUDGE/HARD HEEL, CONFINED SLUICING AND ROBOTIC TECHNOLOGIES WASTE RETRIEVAL TECHNOLOGY DEMONSTRATION FUNCTIONS AND REQUIREMENTS DOCUMENT**

**complete**

*This document will establish demonstration system specifications (including LDMM system specifications) and will also include a scoping level retrieval performance evaluation (RPE). The functions and requirements document and its associated RPE shall provide environmental and human health risk evaluation data/information associated with estimated waste volumes to be retrieved, the maximum volume which could leak during retrieval, and risk from residual waste. This document will detail known and estimated radionuclide contamination and contaminant migration within the vadose zone as bases of calculation. LDMM and RPE documentation provided will be adequate to provide Ecology to access the adequacy of the demonstration systems.*

**M45-05-T16 SUBMIT S-102 INITIAL WASTE RETRIEVAL DEMONSTRATION FUNCTIONS AND REQUIREMENTS DOCUMENT**

**10/31/02**

*This document will establish demonstration system specifications (including LDMM system specifications) and will also include a scoping level retrieval performance evaluation (RPE). The functions and requirements document and its associated RPE shall provide environmental and human health risk evaluation data/information associated with estimated waste volumes to be retrieved, the maximum volume which could leak during retrieval, and risk from residual waste. This document will detail known and estimated radionuclide contamination and contaminant migration within the vadose zone as bases of calculation. LDMM and RPE documentation provided will be adequate to provide Ecology to access the adequacy of the demonstration systems.*

**M45-13 INTERIM COMPLETION OF S-112 SST WASTE RETRIEVAL AND CLOSURE DEMONSTRATION PROJECT**

**6/30/06**

*The S-112 waste retrieval/closure demonstration project will be considered interim complete when the following criteria have been met:*

- 1. Full scale waste retrieval has been completed in accordance with applicable regulatory requirements including Washington Hazardous Waste Management Act requirements set by this agreement and the approved S-112 Saltcake Waste Retrieval Technology Functions and Requirements Document (DOE will document project data and results in a waste retrieval and closure demonstration project report).*
- 2. Remaining wastes have been adequately characterized and a risk assessment approved by Ecology has been completed for residuals that remain in the tank*
- 4. If appropriate, DOE has requested and Ecology has approved an exception to waste retrieval criteria pursuant to Agreement Appendix H.*

**M45-14 INTERIM COMPLETION OF C-104 SST WASTE RETRIEVAL AND CLOSURE DEMONSTRATION PROJECT**

6/30/08

*The C-104 waste retrieval/closure demonstration project will be considered interim complete when the following criteria have been met:*

1. *Full scale waste retrieval has been completed in accordance with applicable regulatory requirements including Washington Hazardous Waste Management Act requirements set by this agreement and the approved C-104 Sludge/Hard Heel, Confined Shuicing And Robotic Technologies Waste Retrieval Technology Demonstration Functions and Requirements Document (DOE will document project data and results in a waste retrieval and closure demonstration project report).*
2. *Remaining wastes have been adequately characterized and a risk assessment approved by Ecology has been completed for residuals that remain in the tank*
4. *If appropriate, DOE has requested and Ecology has approved an exception to waste retrieval criteria pursuant to Agreement Appendix H.*

**M45-15 INTERIM COMPLETION OF S-102 SST WASTE RETRIEVAL AND CLOSURE DEMONSTRATION PROJECT**

6/30/07

*The S-102 waste retrieval/closure demonstration project will be considered interim complete when the following criteria have been met:*

1. *Full scale waste retrieval has been completed in accordance with applicable regulatory requirements including Washington Hazardous Waste Management Act requirements set by this agreement and the approved S-102 Initial Waste Retrieval Technology Functions and Requirements Document (DOE will document project data and results in a waste retrieval and closure demonstration project report).*
2. *Remaining wastes have been adequately characterized and a risk assessment approved by Ecology has been completed for residuals that remain in the tank*
4. *If appropriate, DOE has requested and Ecology has approved an exception to waste retrieval criteria pursuant to Agreement Appendix H.*

**M45-16 INTERIM COMPLETION OF S-105, S-106, and S-103 SST WASTE RETRIEVAL AND CLOSURE DEMONSTRATION PROJECT**

7/31/10

*The S-105, S-106, and S-103 waste retrieval/closure demonstration project will be considered interim complete when the following criteria have been met:*

1. *Full scale waste retrieval has been completed in accordance with applicable regulatory requirements including Washington Hazardous Waste Management Act requirements set by this agreement and the approved S-105, S-106, and S-103 Waste Retrieval and Closure Demonstration Functions and Requirements Document (DOE will document project data and results in a waste retrieval and closure demonstration project report).*
2. *Remaining wastes have been adequately characterized and a risk assessment approved by Ecology has been completed for residuals that remain in the tank*
4. *If appropriate, DOE has requested and Ecology has approved an exception to waste retrieval criteria pursuant to Agreement Appendix H.*

**M45-05-T17 SUBMIT S-105, S-106, and S-103 WASTE RETRIEVAL AND CLOSURE  
DEMONSTRATION FUNCTIONS AND REQUIREMENTS DOCUMENT** 4/30/05

*This document will establish demonstration system specifications (including LDMM system specifications) and will also include a scooping level retrieval performance evaluation (RPE) for each tank. The functions and requirements document and its associated RPE shall also provide, as a separate evaluation for each of the three tanks, environmental and human health risk evaluation data/information associated with estimated waste volumes to be retrieved, the maximum volume which could leak during retrieval, and risk from residual waste. This document will detail known and estimated radionuclide contamination and contaminant migration within the vadose zone as bases of calculation. LDMM and RPE documentation provided will be adequate to provide Ecology to access the adequacy of the demonstration systems. ... The retrieval functions and requirements documentation will document all pertinent retrieval and closure requirements, e.g., those specific to the extent of retrieval necessary to allow closure.*

**M45-05H INTERIM COMPLETION OF C-106 SST WASTE RETRIEVAL AND  
CLOSURE DEMONSTRATION PROJECT** 4/30/04

*The C-106 waste retrieval/closure demonstration project will be considered interim complete when the following criteria have been met:*

- 1. Full scale waste retrieval has been completed in accordance with applicable regulatory requirements including Washington Hazardous Waste Management Act requirements set by this agreement and the approved C-106 Sludge/Hard Heel, Confined Sluicing And Robotic Technologies Waste Retrieval Technology Demonstration Functions and Requirements Document (DOE will document project data and results in a waste retrieval and closure demonstration project report).*
- 2. Remaining wastes have been adequately characterized and a risk assessment approved by Ecology has been completed for residuals that remain in the tank*
- 4. If appropriate, DOE has requested and Ecology has approved an exception to waste retrieval criteria pursuant to Agreement Appendix H.*

**M45-05I-T01 CONDUCT C-106 RETRIEVAL AND CLOSURE DEMONSTRATION  
PROJECT 30% DESIGN CONSULTATION** 1/31/03

*The briefing shall provide a project status report and environment and human health evaluation data/information associated with estimated waste volumes to be retrieved and with the estimated waste volume of residual waste. Target leak detection thresholds will also be provided. The information provided will provided estimated radionuclide contamination and contaminant migration within the vadose zone as basis of the calculation.*

**M45-05M-T01 SUBMIT C-106 WASTE RETRIEVAL RESULTS , ANALYSIS OF  
RESIDUAL WASTE(S), AND (IF APPROPRIATE) REQUEST FOR  
EXCEPTION TO THE CRITERIA PURSUANT TO AGREEMENT  
APPENDIX H** 2/27/04

**M45-06-T20 SUBMIT SST SYSTEM IMPLEMENTATION PLAN IN SUPPORT OF RETRIEVAL AND CLOSURE ACTIVITIES**

**6/30/24 and every 2 years thereafter**

*Major work areas covered in the implementation plan will include waste retrieval operable units, characterization, technologies development to support closure, risk assessments, and groundwater monitoring strategies.*

**M45-06A SUBMIT A CERTIFIED (FRAMEWORK) SST SYSTEM CLOSURE PLAN AND C-106 WASTE RETRIEVAL AND CLOSURE DEMONSTRATION PLAN, AS AN APPLICATION FOR THE MODIFICATION OF THE HANFORD SITE-WIDE HAZARDOUS WASTE FACILITY PERMIT TO ECOLOGY.**

**12/19/02**

*This submittal will include all closure plan elements. Additional the closure plan will include the following:*

- 1. Characterization approach for residual wastes*
- 2. A risk assessment methodology inclusive of the assumptions, approach, conceptual model, and metrics (e.g. point of compliance and receptor scenario).*

*The characterization requirements and the risk assessment methodology will jointly be developed by DOE and Ecology prior to submittal.*

**M45-06B SUBMIT A CERTIFIED (FRAMEWORK) SST SYSTEM CLOSURE PLAN MODIFICATION AND S-112 WASTE RETRIEVAL AND CLOSURE DEMONSTRATION PLAN, AS AN APPLICATION FOR THE MODIFICATION OF THE HANFORD SITE-WIDE HAZARDOUS WASTE FACILITY PERMIT TO ECOLOGY.**

**3/31/05**

*This submittal will include all closure plan elements. Additional the closure plan will include the following:*

- 1. Characterization approach for residual wastes*
- 2. A risk assessment methodology inclusive of the assumptions, approach, conceptual model, and metrics (e.g. point of compliance and receptor scenario).*

*The characterization requirements and the risk assessment methodology will jointly be developed by DOE and Ecology prior to submittal.*

**M45-06C SUBMIT A CERTIFIED (FRAMEWORK) SST SYSTEM CLOSURE PLAN MODIFICATION AND S-102 WASTE RETRIEVAL AND CLOSURE DEMONSTRATION PLAN, AS AN APPLICATION FOR THE MODIFICATION OF THE HANFORD SITE-WIDE HAZARDOUS WASTE FACILITY PERMIT TO ECOLOGY.**

**3/31/06**

*This submittal will include all closure plan elements. Additional the closure plan will include the following:*

- 1. Characterization approach for residual wastes*
- 2. A risk assessment methodology inclusive of the assumptions, approach, conceptual model, and metrics (e.g. point of compliance and receptor scenario).*

*The characterization requirements and the risk assessment methodology will jointly be developed by DOE and Ecology prior to submittal.*

**M45-06D SUBMIT A CERTIFIED (FRAMEWORK) SST SYSTEM CLOSURE PLAN MODIFICATION AND C-104 WASTE RETRIEVAL AND CLOSURE DEMONSTRATION PLAN, AS AN APPLICATION FOR THE MODIFICATION OF THE HANFORD SITE-WIDE HAZARDOUS WASTE FACILITY PERMIT TO ECOLOGY. 6/30/07**

*This submittal will include all closure plan elements. Additional the closure plan will include the following:*

1. *Characterization approach for residual wastes*
2. *A risk assessment methodology inclusive of the assumptions, approach, conceptual model, and metrics (e.g. point of compliance and receptor scenario).*

*The characterization requirements and the risk assessment methodology will jointly be developed by DOE and Ecology prior to submittal.*

**M45-06E SUBMIT A CERTIFIED (FRAMEWORK) SST SYSTEM CLOSURE PLAN MODIFICATION AND S-105, S-106, and S-103 WASTE RETRIEVAL AND CLOSURE DEMONSTRATION PLAN, AS AN APPLICATION FOR THE MODIFICATION OF THE HANFORD SITE-WIDE HAZARDOUS WASTE FACILITY PERMIT TO ECOLOGY. 12/31/08**

*This submittal will include all closure plan elements. Additional the closure plan will include the following:*

1. *Characterization approach for residual wastes*
2. *A risk assessment methodology inclusive of the assumptions, approach, conceptual model, and metrics (e.g. point of compliance and receptor scenario).*

*The characterization requirements and the risk assessment methodology will jointly be developed by DOE and Ecology prior to submittal.*