ENGINEERING CHANGE NOTICE

Page 1 of 25 (handwritten; initialed 1/12)

☒ DM ☐ FM ☐ TM

1a. ECN 721358 R0

1b. Proj. ECN W- - R

2. Request Information	3a. Design Inputs	3b. Design Outputs / References	3c. Engineering Evaluation / Estimate / Approval to Proceed w/ the Design
Record Information on the ECN-1 Form	Record Information on the ECN-2 Form	Record Information on the ECN-3 Form	Record Information on the ECN-4 Form

4. Originator's Name, Organization, MSIN, & Phone No.
Fred M. Mann, Environmental Engineering, E6-35, (509) 373-3978

5. USQ Number No. TF- - R- ☒ N/A ☐ Refer to Work Package

6. Date January 12, 2004

* **7. Title** Supporting Documents for Tank Farm Closure Performance Analyses

8. Bldg. / Facility No. NA

9. Equipment / Component ID NA

10. Approval Designator NA

11. Documents/Drawings Changed by this ECN (Record the information on the ECN-5 Form, including sheet and revision numbers.)

12. Design Basis Documents? ☐ Yes ☒ No

13. Safety Designation ☐ SC ☐ SS ☐ GS ☒ N/A

14. Expedited / Off-Shift ECN? ☐ Yes ☒ No

15a. Work Package Number NA

15b. Modification Work Completed NA
Responsible Engineer / Date

15c. Restored to Original Status (TM) NA
Responsible Engineer / Date

16. Fabrication Support ECN? ☐ Yes ☒ No

17. Description of the Change (Use ECN Continuation pages, as needed)
Complete Revision

18. Justification of the Change (Use ECN Continuation pages, as needed)
Update to include inputs from regulatory agency

19. ECN Category
☒ Direct Revision
☐ Supplemental
☐ Void/Cancel

ECN Type
☐ Supercedure
☐ Closure
☐ Change Prior

20. Distribution

Name	MSIN	Name	MSIN
See attached			

Release Stamp
JAN 12 2004
DATE: HANFORD RELEASE
STA: 15 ID: 20

* Per telecon w/ F.M. Mann, 1/12/04 - J. Aardal / Sta, 15

ENGINEERING CHANGE NOTICE

Page 2 of 25 jda 1/12

☒ DM ☐ FM ☐ TM

1a. ECN 721358 R 0

1b. Proj. ECN W- - R

21. Engineering Check	22. Design Verification Required?	23. Closeout / Cancel / Void
Record Information on the ECN-6 Form as required	☐ Yes ☒ No If Yes, as a minimum attach the one page checklist from TFC-ENG-DESIGN-P-17.	☐ Yes ☒ No If Yes, Record Information on the ECN-7 Form and attach form(s).

24. Revisions Planned (Include a brief description of the contents of each revision)

Total re-write for both documents

Note: All Revisions shall have the approvals of the affected organizations as identified in block 10 "Approval Designator," on page 1 of this ECN.

25a. Commercial Grade Item Dedication Numbers (associated with this design change)	25b. Engineering Data Transmittal Numbers (associated with this design change, e.g., new drawings, new documents)
NA	631755 and 631754

26a. Design Cost Estimate	26b. Materials / Procurement Costs	26c. Estimated Labor Hours
NA	NA	NA

27. Field Change Notice(s) Used?

☐ Yes ☒ No

If Yes, Record Information on the ECN-8 or ECN-9 Form, attach form(s), and identify permanent changes.

NOTE: ECNs are required to record and approve all FCNs issued. If the FCNs have not changed the original design media then they are just incorporated into the design media via an ECN. If the FCN did change the original design media then the ECN will include the necessary engineering changes to the original design media.

28. Approvals

Facility/Project Signatures		Date	A/E Signatures		Date
Design Authority			Originator/Design Agent	Anthony J. Knepp (signature)	Jan 12, 2004
Team Lead/Lead Engr.			Professional Engineer		
Resp. Engineer	Fred M. Mann (signature)	Jan 12, 2004	Project Engineer		
Resp. Manager	Frank J. Anderson (signature)	Jan 12, 2004	Quality Assurance		
Quality Assurance			Safety		
IS&H Engineer			Designer		
NS&L Engineer			Environ. Engineer		
Environ. Engineer			Other	Terry Sams (signature)	Jan 12, 2004
Project Engineer			Other	Michael Connelly (signature)	
Design Checker			DEPARTMENT OF ENERGY / OFFICE OF RIVER PROTECTION		
Design Verifier			Signature or a Control Number that tracks the Approval Signature		
Operations					
Radcon			ADDITIONAL SIGNATURES		
EQRG					
Other					

ECN - 1 ENGINEERING REQUEST FORM Page 3 of 15 ☒ DM ☐ FM ☐ TM	1a. **ECN** 721358 **R** 0 1b. **Proj. ECN** W- - R

Requestor's Name (Print)	*Date*	REA Reference
Fred M. Mann	Jan 12, 2004	NA

Equipment Name	Estimated Need Date
NA	Jan 12, 2004

Problem/Issue Statement

Re-write including regulatory input

Purpose for the Proposed Modification

Re-write for including regulatory input

Basis for the Estimated Need Date

Needs to be released to regulators

Requestor's Signature	*Date*
	Jan 12, 2004

Responsible Engineering Manager Approval

Work Package Number (If Known)	Estimated Evaluation ROM Cost	*CACN*
NA	$NA	110172
Process as a Simple Modification? ☒ Yes ☐ No	*Assigned to (Team Lead)*	*Date*
Responsible Engineering Manager (Print) James Field	☒ Approve ☐ Reject	*Date* Jan 12, 2004

If rejected, explain reason for rejection:

(Once rejected the Responsible Engineering Manager returns the request to the Requestor)

Italicized text items need to be addressed. Standard text items need to be addressed as applicable to the problem/issue described.

ECN - 5
DRAWING / DOCUMENT CHANGE LIST FORM

Sheet 1 of ECN – 5
Page 4 of 15 jda 1/12

☒ DM ☐ FM ☐ TM

1a. **ECN** 721358 **R** 0

1b. **Proj. ECN** W- - R

List of Engineering Drawings/Documents Changed (Use the attached checklist for guidance)

Dwg./Doc. Number (Sheet/Page, Rev)	Title/Type	Shared	PC-002/ SDD/ HNF-3240/ HNF-4184	Existing Change Document Nos.
RPP-14283, Rev 0	Performance Objectives for Tank Farm Closure Performance Assessments	☐	☐	
RPP-14284, Rev 0	Contents of Long-Term Performance Analyses to Support the Retrieval and Closure of Tanks for the WA State Dept of Ecology	☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	

Submitted to Document Service Center Prior to ECN Release?

☐ Yes ☒ No

List of Non-Engineering Documents Needing Change

Document Number/Revision, Sheet/Page (If Available)	Document Title	Document Owner (Organization)	Individual Notified	Method	Date Notified

ECN - 5
DRAWING / DOCUMENT CHANGE LIST FORM

Sheet 2 of ECN – 5
Page 5 of 5 jdla 1/12

☒ DM ☐ FM ☐ TM

1a. **ECN** 721358 **R** 0

1b. **Proj. ECN** W- - R

Drawings/Documents to be Modified Checklist

System Design Description	☐ Yes ☐ No xN/A	Security Plan	☐ Yes ☐ No xN/A
Functional Design Criteria	☐ Yes ☐ No xN/A	Emergency Plan	☐ Yes ☐ No xN/A
Functional Requirements	☐ Yes ☐ No xN/A	Calculations (General)	☐ Yes ☐ No xN/A
Specification (Equipment or Operating)	☐ Yes ☐ No xN/A	Operating Procedure	☐ Yes ☐ No xN/A
Criticality Specification	☐ Yes ☐ No xN/A	System / Subsystem Specifications	☐ Yes ☐ No xN/A
Design Report	☐ Yes ☐ No xN/A	Material Specification / BOM	☐ Yes ☐ No xN/A
Training Plan	☐ Yes ☐ No xN/A	Sampling Plan	☐ Yes ☐ No xN/A
Equipment Specification	☐ Yes ☐ No xN/A	Inspection Plan	☐ Yes ☐ No xN/A
Procurement Specification	☐ Yes ☐ No xN/A	Spare Parts List	☐ Yes ☐ No xN/A
Construction Specification	☐ Yes ☐ No xN/A	Test Specification	☐ Yes ☐ No xN/A
Vendor Information	☐ Yes ☐ No xN/A	Acceptance Test Plan	☐ Yes ☐ No xN/A
Design Drawings	☐ Yes ☐ No xN/A	Acceptance Test Procedure	☐ Yes ☐ No xN/A
Safety Analysis / FSAR / SAR / DSA	☐ Yes ☐ No xN/A	Pre-Operational Test Procedure	☐ Yes ☐ No xN/A
Technical Safety Requirement	☐ Yes ☐ No xN/A	Operation Test Plan	☐ Yes ☐ No xN/A
Master Equipment List	☐ Yes ☐ No xN/A	Operational Test Procedure	☐ Yes ☐ No xN/A
Safety Equipment List	☐ Yes ☐ No xN/A	ASME Coded Item / Vessel	☐ Yes ☐ No xN/A
Functional Analysis	☐ Yes ☐ No xN/A	Automated Control Configuration Plan	☐ Yes ☐ No xN/A
Environmental Requirement / Review	☐ Yes ☐ No xN/A	Computer / Automated Control Software Plan	☐ Yes ☐ No xN/A
Scope Description Document	☐ Yes ☐ No xN/A	Process Control Plan	☐ Yes ☐ No xN/A
Seismic / Stress / Structural Analysis	☐ Yes ☐ No xN/A	Process Control Procedure	☐ Yes ☐ No xN/A
Engineering Study	☐ Yes ☐ No xN/A	Purchase Requisition	☐ Yes ☐ No xN/A
Interface Control Drawing / Document	☐ Yes ☐ No xN/A	Hazards Review	☐ Yes ☐ No xN/A
Maintenance Procedure(s)	☐ Yes ☐ No xN/A	JCS PM Activity Datasheet	☐ Yes ☐ No xN/A
Setpoint / Tolerance Document	☐ Yes ☐ No xN/A		☐ Yes ☐ No xN/A
	☐ Yes ☐ No xN/A		☐ Yes ☐ No xN/A
	☐ Yes ☐ No xN/A		☐ Yes ☐ No xN/A

DISTRIBUTION SHEET

To	From	Page 1 of 2
Distribution	Fred Mann	Date January 13, 2004
Project Title/Work Order		EDT No.
Supporting Documents for Tank Farm Closure Performance Analyses		ECN No. 721358 R0

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
DOE-ORP					
R.W. Lober (1 hard copy)	H6-60	x			
P.E. LaMont (1 hard copy)	H6-60	x			
R.B. Yasek (1 hard copy)	H6-60	x			
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DOE Reading Room (1 hard copy)	H2-53	x			

DISTRIBUTION SHEET

To	From	Page 2 of 2
Distribution	Fred Mann	Date January 13, 2004
Project Title/Work Order		EDT No.
Supporting Documents for Tank Farm Closure Performance Analyses		ECN No. 721358 R0

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
Washington State Dept. of Ecology					
1315 E. 4th, Kennewick, WA 99336					
Suzanne Dahl (5 hard copies)	B5-18	x			

RPP-14283, Rev. 1

Performance Objectives for Tank Farm Closure Performance Assessments

FM Mann, A.J. Knepp, and M. Connelly
CH2M Hill Hanford Group, Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-99RL14047

EDT/ECN: 721358R0 UC: 2000
Cost Center: 7G130 Charge Code: 119638/AJ60
B&R Code: N/A Total Pages: ~~113~~ 114 [initials] 1/12

Key Words: Tank Closure, Performance Objective, Performance Assessment

Abstract: This report documents the performance objectives (metrics, times of analyses, and times of compliance) to be used in performance assessments on Hanford SIte tank farm closure.

JAN 12 2004
DATE:
STA: 15
HANFORD RELEASE
ID: 20

Janis Aardal, 1-12-2004
Release Approval per M. A. Williams Date

Release Stamp

Approved For Public Release

RECORD OF REVISION

(1) Document Number
RPP-14283

Page 1

(2) Title
Performance Objectives for Tank Farm Closure Performance Assessments

Change Control Record

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
		(5) Cog. Engr.	(6) Cog. Mgr. Date
1 RS	(7) Complete revision per ECN 721358RO	(See ECN- FM Mann	721358-R0, 1/12/04) FJ Anderson

PERFORMANCE OBJECTIVES
FOR
TANK FARM CLOSURE PERFORMANCE ASSESSMENTS

F.M. Mann, A.J. Knepp, and M. Connelly
CH2M Hill Hanford Group, Inc.

January 2004

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Table of Contents

List of Tables

List of Figures

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
ILCR	incremental lifetime cancer risk
ILAW	immobilized low-activity waste
IRIS	Integrated Risk Information System
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission
PA	performance assessment
RCRA	Resource Conservation and Recovery Act
TCLP	Toxicity Characteristic Leaching Procedure
TPA	Tri-Party Agreement
TWRS	Tank Waste Remediation System
TWINS	TWRS Information System
USC	United States code
WAC	Washington Administrative Code
WMA	waste management area

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1.0 OVERVIEW

Tank Farm Closure Performance Assessments are studies of the long-term impacts to public health and safety as well as to the environment. They provide information to decision makers on the impacts of baseline activities and other alternatives actively under consideration. The intent is to provide sufficient information so that decision makers dealing with tank farm closure have an adequate understanding of the long-term consequences of closure decisions.

To be meaningful, results from a numeric performance assessment of the consequences of an action must be compared to 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 that call for performance assessments (whether they are federal such as the Department of Energy (DOE) order on radioactive waste management [DOE 1999a] and its implementing guides, or those from Washington State such as the regulations implementing the Model Toxics Control Act [WAC 173-340]) usually require that the determination of performance objectives be one of the first steps performed. These performance objectives not only set comparison levels 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. Whenever regulations are cited in this document, the reader is reminded that not all regulations dealing with tank farm closure are included. Rather, only those that are needed for the study of long-term impacts are included.

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, but rather are comparison points for performance assessments, the three components of the performance objective will be renamed in this document to 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 (HFFACO) (HFACCO 1989), a number of performance 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 (*Performance Objectives for the Hanford Immobilized Low-Activity Waste (ILAW) Performance Assessment* [Mann 2002]) created for the 2005 Immobilized Low-Activity Waste Performance Assessment (ILAW PA). The performance objectives in this document will be used in future performance analyses for tank waste retrieval or tank closure activities. These performance analyses are described in

Contents of Performance Assessments to Support the Retrieval and Closure of Tanks for the Washington State Department of Ecology (Mann 2003) and summarized in Table 1.1.

Table 1.1. Important Features of Tank Farm Performance Analyses.

Category	Purpose	Significant Feature
Master Performance Assessment	Provides the most complete and current analyses	Provides the root document (which is maintained) on which the following analyses will be based. The first version will be issued in September 2004.
Post Retrieval Tank Performance Analysis	Determines whether additional retrieval of waste is necessary	Determines inventory of key contaminants in residual waste in tank and in any retrieval leaks. Performs 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 Performance Analysis	Determines whether closure of tank can proceed using the methods proposed	Determines 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. Provides worker risk information for proposed closure options.
Tank Farm Feasibility Study	Determines actions that are needed to close a tank farm or WMA	Determines impacts from various options to close tank farm or WMA. Provides worker risk information for proposed closure options.
Tank Farm Closure Performance Analysis	Determines whether closure actions as implemented have been successful	Determines impacts from closed tank farm or WMA, once all closure activities (except possibly final surface barrier) are completed.

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.

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, and
- Public involvement.

Based on an analysis of these regulatory requirements, the performance assessment must evaluate risks to the following:

- General Public
- Workers

- Inadvertent Intruders
- Groundwater
- Surface Water
- Air Resources.

In addition, there are restrictions on the waste itself if it is disposed of near surface.

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 for a set of contaminants (e.g., beta/photon emitters or non-cancerous chemicals) are summarized in Table 1.2a. The objectives for specific contaminants are displayed in Tables 1.2b (groundwater), 1.2c (surface water), 1.2d (air), and 1.2e (land disposal). The values for these objectives were chosen to be the most restrictive of the relevant or potentially applicable regulations.

Many of the objectives specify concentrations (e.g., [mg-contaminant]/[kg of soil] or [pCi-contaminant]/[liter of groundwater]). Such objectives are independent of an exposure scenario. Other objectives (e.g., all pathways dose, incidental cancer risk) require that the exposure scenario (e.g., industrial, residential, Native American) be specified in order to calculate values for comparison. This document does not specify the exposure scenarios that will used to calculate values for comparison.

As described in the following sections,

2. Background
3. Regulations
4. Points of Assessment
5. Times of Assessment
6. Public Involvement

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

Table 1.2a. Key Performance Objectives for Tank Closure.[a] (Standards for Specific Contaminants are Given in the Following Tables)

Protection of General Public and Workers [b, c, d]	
All-pathways dose from only this facility	25 mrem in a year [e]
All-pathways dose including other Hanford Site sources	100 mrem in a year [e]
Chemical Carcinogens (Incremental Lifetime Cancer Risk)	10^{-5} [f]
Non cancer-causing chemicals (hazard index)	1 [f]
Protection of an Inadvertent Intruder [e,g]	
Acute exposure	500 mrem
Continuous exposure	100 mrem in a year
Protection of Groundwater Resources [b, c, d, h, j]	
Alpha emitters	
^{226}Ra plus ^{228}Ra	5 pCi/l
All others (excluding uranium)	15 pCi/l
Beta and photon emitters	4 mrem in a year
Protection of Surface Water Resources [b, k]	
Alpha emitters	
^{226}Ra plus ^{228}Ra	0.3 pCi/l [m]
All others (excluding uranium)	15 pCi/l [m]
Beta and photon emitters	4 mrem in a year [m]
^{99}Tc	900 pCi/l [o]
^{129}I	1 pCi/l [o]
Chromium	0.05 mg/l [k]
Nitrate (as nitrogen)	10 mg/l [k]
Uranium	0.03 mg/l [k]
Protection of Air Resource [b, n]	
Radon (flux through surface)	20 pCi m^{-2} s^{-1}
All other radionuclides	10 mrem in a year

[a] All doses are calculated as effective dose equivalents. Values given are in addition to any existing amounts or background.

[b] Evaluated for 1,000 years, but calculated to the time of peak or 10,000 years, whichever is longer.

[c] Groundwater use starts at the time when groundwater contaminated by Hanford Site operations before the year 2000 is estimated to be potable.

[d] Evaluated at the point of maximal exposure, but no closer than the fenceline 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.

[e] Main driver is DOE Orders on *Radioactive Waste Management* (DOE 1999a).

[f] Main driver is Washington State Model Toxics Control Act (WAC 173-340).

[g] Evaluated for 500 years, but calculated from 100 to 1,000 years.

[h] All concentrations are in water taken from a well.

[j] Main driver is National Primary Drinking Water Regulations (40 CFR 141).

[k] Evaluated at well at the edge of the Columbia River; no mixing with the river is assumed.

[m] Main driver is Washington State Surface Water Standards (WAC 173-201A).

[n] Main driver is National Emission Standards for Hazardous Air Pollutants (40 CFR 61H and 40 CFR 61Q).

[o] Main driver is *National Interim Primary Drinking Water Regulations* (EPA 1976].

Table 1.2b. Performance Standards of Specific Contaminants for Groundwater Protection. Standards are provided only for those organics most often found in tank waste (see Appendix A, Table A.1). Values are the most restrictive ones from DOE 5400.5, 40 CFR 141, 40 CFR 264.94, WAC 173-200, WAC 173-303, WAC 246-290 (See Tables C-5, C-6, C-7)

Radionuclides			
H-3	20,000 pCi/l	Sr-90	8 pCi/l
Ra-226	3 pCi/l	Ra-226 and Ra-228	5 pCi/l
Uranium	30 μg/l	—	
Inorganic Chemicals			
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)	1. mg/l
Nitrate + Nitrite (as N)	10. mg/l	Selenium	0.01 mg/l
Silver	0.05 mg/l	Sulfate (as SO_4)	250. mg/l
Thalium	0.002 mg/l	Zinc	5.0 mg/l
Organic Chemicals			
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 1.2c. Performance Standards of Specific Chemicals for Surface Water Protection.
Values that are the same as drinking water standards (Table 1.2b) are not repeated. Values are the most restrictive ones from Table 1.2b and WAC 173-201A (see Appendix C, Table C-8).

Contaminant	Performance Standard	Contaminant	Performance Standard
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/
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 1.2d. Performance Standards of Specific Chemicals for Air Resources Protection.
Source is 40 CFR 50.

Contaminant	Limits for Average Maximum		
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 (annual)
Lead			1.5 μg/m^3 (quarterly)

Table 1.2e. Performance Standards of Specific Chemicals for Land Disposal.

(3 Pages)

Standards are provided only for those organics most often find in tank waste (see Appendix A, Table A.1) Values are the most restrictive ones from DOE 435.1, 10 CFR 61.55, 40 CFR 261, 40 CFR 268, WAC 173-303 (See Appendix C, Table C-10)

Radionuclides			
Radionuclide	**Concentration limit**	**Radionuclide**	**Concentration limit**
C-14	8. Ci/m^3	C-14 (activated metal)	80. Ci/m^3
Ni-59 (activated metal)	220. Ci/m^3	Ni-63	700. Ci/m^3
Ni-63 (activated metal)	7000 Ci/m^3	Sr-90	7000. Ci/m^3
Nb-94 (activated metal)	0.2 Ci/m^3	Tc-99	3. Ci/m^3
I-129	0.08 Ci/m^3	Cs-137	4600. Ci/m^3
Alpha emitters (with half-lives greater than 5 years)			100 nCi/g
Pu – 241	3500 nCi/g	Cm-242	20000 nCi/g

Inorganic Chemicals			
Chemical	**TCLP Limit**	**Chemical**	**TCLP Limit**
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	—	
Cyanide (total)	590 mg/kg	Cyanide (amenable)	30 mg/kg

Organic Chemicals		
CAS #	**Constituent**	**TCLP Limit**
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

Organic Chemicals (cont.)		
CAS #	**Constituent**	**TCLP Limit**
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
CAS #	**Constituent**	**Concentration limit**
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
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

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 1999a). Before hazardous chemical waste can be disposed of at a newly constructed disposal unit, a performance assessment must be prepared as a component of the Resource Conservation and Recovery Act (RCRA; 42 USC 6901 et seq.) Part B Permit Application, and then approved by the Washington State Department of Ecology (Ecology) (as authorized by EPA as part of the RCRA delegation). Similarly, before a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; 42 USC 9601 et seq.) contaminated site is remediated, a remedial investigation/feasibility study (including a performance assessment) must be prepared and EPA must approve the action through a Record of Decision. The purpose of 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 1999a), (Appendix B.1), as well as the Washington State regulations implementing RCRA (Washington Administrative Code 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 performance 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. Additional regulations, requirements, and guidance will need to be met for tank farm closure. That additional information is not repeated in this document.

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 these wastes, separate the wastes 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 twelve (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 (7) 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 1999a) 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 2001a). Since the tanks are in the Part A portion of the Hanford Site-Wide Hazardous Waste Facility Permit, a performance assessment is also required as part of the modification of the Site's permit. The HFFACO lists a large number of performance 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. It was 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}H, ^{129}I, ^{99}Tc, U, NO_3, and CCl_4. The first contaminants have multiple sources, while the last (CCl_4) comes from past discharges from the Plutonium Finishing Plant.

2.4 CONTAMINANTS (RADIOISOTOPES AND HAZARDOUS MATERIALS)

Tank waste contains both radionuclides as well as hazardous materials (as defined by RCRA or the Washington Dangerous Waste regulations). Thus, both sets of contaminants of concern (CoCs) must be considered. In general, the contaminants of concern to be actually analyzed in the tank closure performance assessments and the documents created from them will be based on the result of screening analyses of the impacts. In some cases, where prior agreement with the regulatory bodies has occurred, a more limited set may be used.

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 *Hanford Immobilized Low-Activity Performance*

Assessment: 2001 Version (Mann 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 1998).

Previous assessments (Mann 2001, Knepp 2001, Kincaid 1998, Wood 1996, and Wood 1995) have agreed on the important CoCs for the groundwater pathway. The 2001 ILAW PA (Mann 2001) found ^{99}Tc and ^{129}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}Tc, NO_3, and uranium as the key CoCs. The composite analysis for the Hanford Site (Kincaid 1998) found ^{3}H, ^{129}I, and ^{99}Tc as the major CoCs. The performance assessments for solid waste disposal (Wood 1995 and 1996) again found ^{99}Tc as the main CoC.

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 (DOE 1999a) 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.

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 (HFSUWG 1992a) and a detailed report (HFSUWG 1992b) of its findings. The *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement and Comprehensive Land-Use Plan* (DOE 1999f) is heavily based on the work of the Hanford Future Site Uses Working Group. However, DOE's land use planning extends for only 50 years instead of the 100 years forecast by the working group.

The HFSUWG 1992a-1 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."

The record of decision (DOE 1999h) for the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999f) 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 (Clinton 2000) was established along the river corridor as well in lands at the northern and western edges of the site.

Most recently, DOE, EPA, and Ecology (DOE 2002a) put forth a risk framework that delineates the following 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[a,b]

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[c]	Industrial use; data for informational use only	Multiple land use; data for informational use only	Recreational use
X[c] →	Industrial use; other uses for informational use only	Multiple land use	Recreational use

a Attachment of letter of DOE 2002a

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 141 (Federal 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 process of identifying relevant regulations was guided by the CERCLA process (EPA 1988, EPA 1989). Table 3.1 lists the regulations that were reviewed and that were judged potentially relevant to performance assessments dealing with tank farm closure.

Table 3.1. List of Relevant Regulations
(3 Pages)

REGULATION	COMMENT
Federal Regulations	
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.
National 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.
Identification and Listing of Hazardous Waste (40 CFR 261, particularly Subparts B and C)	Establishes which wastes are subject to RCRA.
Ground Water Protection Standards (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.

Table 3.1. List of Relevant Regulations
(3 Pages)

REGULATION	COMMENT
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).
DOE Orders and Policies	
Radioactive Waste Management (DOE Order 435.1) [DOE 1999a]	DOE order covering disposal of low-level waste, released July 9, 1999.
General Environmental Protection Program (DOE Order 5400.1) (DOE 1990)	Lists executive orders, laws, and regulations which DOE actions must meet.
Radiation Protection of the Public and the Environment (DOE Order 5400.5) (DOE 1993)	Provides exposure limits for general activities.
Department of Energy Radiological Health and Safety Policy (DOE Policy 441.1) (DOE 1996a)	Establishes basis of DOE's radiological control programs.
Washington State Regulations	
Water Quality Standards for Ground Waters of the State of Washington (WAC 173-200)	Sets standards for groundwaters in the State of Washington.
Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201A)	Sets standards for surface waters in the State of Washington.
Dangerous Waste Regulations (WAC 173-303)	Implements RCRA in the State of Washington.
Minimal Functional Standards for Solid Waste Handling (WAC 173-304)	Sets requirements for landfills.
Model Toxics Control Act Cleanup Regulations (WAC 173-340)	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 ($1x10^{-6}$ risk), are the major criteria identified in the regulation as groundwater cleanup criteria.
General Regulations for Air Pollution Source (WAC 173-400)	Establish technically feasible and reasonably attainable standards to control emission or air contaminants.
Ambient Air Quality Standards and Emission Limits for Radionuclides (WAC 173-480)	Sets emission standards into air for radionuclides in the State of Washington.
Radiation Protection Standards (WAC 246-221)	Sets radiation protection standards for the state of Washington.
Radiation Protection – Air emissions (WAC 246-247)	Sets radioactive air emissions standards.

Table 3.1. List of Relevant Regulations
(3 Pages)

REGULATION	COMMENT
Radioactive Waste – Licensing and Disposal (WAC 246-250)	Sets requirements for disposal of low-level radioactive wastes in the State of Washington.
Standards for Public Water Supplies (WAC 246-290) (310)	Defines requirements to protect consumers using public drinking water supplies.
Other	
EPA Memorandum, "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination," OSWER No. 9200.4-18 (EPA 1997) Mostly superceded by: EPA Directive, *Radiation Risk Assessment at CERCLA, Q&A (*EPA 1999*)*	Provides guidance on cleanup levels at CERCLA sites.
"Hanford Guidance for Radiological Cleanup" (WDOH/320-015)	Provide interim regulatory guidance for Hanford Site Cleanup.

Chemicals and radionuclides tend to be regulated separately. Chemical waste management (including the management of the chemical components of radioactive mixed waste) is regulated by Ecology and EPA pursuant to RCRA (42 United States Code [USC] 6901 et seq.) and the Washington State Hazardous Waste Management Act (revised Code of Washington [RCW] Chapter 70.105). 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) 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 1989). This agreement among the 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. 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 (AEA; 42 USC 2011). 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 establishing performance objectives for tank farm closure performance assessments because:

- Requirements are for different environmental actions (for example, the disposal of uranium mill tailings, transuranic, or high-level waste, which are covered by 10 CFR 60, 10 CFR 961, 40 CFR 191, 40 CFR 192, 40 CFR 194, and 40 CFR 197).

- Requirements dealing with general environmental concerns (e.g., the National Environmental Policy Act – NEPA [42 USC 4321], National Historic Preservation Act of 1996 [16 USC 470], Archeological and Historic Preservation Act [16 USC 461], protection of cultural resources [DOE 2001b], Native American treaty rights [Appendix A of DOE 1999f], environmental justice [59 FR 7629], Endangered Species Act [16 USC 1531], and Department of Game Procedures [WAC 232-012]) 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 sub-sections of this section:

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

discuss how the regulations affect the various pathways and media investigated by the tank closure performance assessments. Quantitative limits from the regulations are contained in the tables in Appendix C.

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., ICRP 26 and 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 1999a) and the NRC (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 (DNFSB 1994) noted that a member of the public could receive exposures from several sources at a DOE site. Guidance from DOE-Headquarters (DOE 1996a) is that protection of the general public from multiple sources should be based on *Radiation Protection of the Public and the Environment*, DOE Order 5400.5 (DOE 1993). 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 to be 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 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 (40 CFR 300.430). In general, the EPA uses the approach of finding applicable and relevant regulations (ARAR). 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" (EPA 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} …)" (EPA 1999). Under CERCLA, the administrator has extensive flexibility in balancing risk mitigation against other factors. The CERCLA guidance (EPA 1999) continues "EPA generally uses $1\text{x}10^{-4}$ 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) 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 EPA's 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 a performance objective from all sources of 100 mrem/yr.

3.2.3 Chemicals

Although there are three sets of regulations, CERCLA, RCRA (as implemented by the State of Washington), and the Washington State Dangerous Waste laws and regulations that 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 incremental 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 noncarcenogenic chemicals, the hazard index is used. Contaminant concentrations are weighted by the contaminant-specific hazard index and then summed. The requirements are that the sum be less than unity. Contaminant-specific indices will be tabulated in the dosimetry data package prepared for the tank closure performance assessment activity, currently *Exposure Scenarios And Unit Dose Factors For The Hanford Tank Waste Performance Assessment* (Rittman 2003).

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 O 5400.5 {DOE 1993}] and federal regulations for workers [10 CFR 835]), 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 incremental lifetime cancer risk (ILCR). 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} ILCR.

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. Also the hazard index from noncarcinogenic chemicals must be less than 1.

3.3 PROTECTION FOR WORKERS

For these performance assessments, as for others performed under DOE orders on long-term radioactive waste management for closed facilities, 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 Tank Closure Program. As seen from Table C.1 (Protection of General Public) and Table C.3 (Protection of Workers), protection of the general public 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 1999a, 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 GROUNDWATER RESOURCES

3.5.1 Introduction

The protection of groundwater 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 time frames 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's plan (DOE/RL 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 (WAC 173-200-030 and WAC 173-340-720) that the highest beneficial use of groundwater is as a source of drinking water. In the past most performance assessments at the Hanford Site have generalized the requirements from 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 twenty-five people and located at the point of assessment of the disposal facility.

Table C.5 provides the performance standards for drinking water standards. 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

There is fair agreement among the regulations about requirements for radionuclides. 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 of 40 CFR 141 (40 CFR 141, Subpart F) and 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* (TWRS EIS) (DOE 1996c), 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 2001).

The “National Primary Drinking Water Regulations” 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).

Washington State regulations for drinking water (WAC 246-290-310) are based on 10 CFR 141. It should be noted that radionuclides in Washington State drinking water are regulated by the Washington State Department of Health, while water quality standards 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 ^{99}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 (Evans 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 1998).

3.5.4 Limits on Key Contaminants

DOE's Office of River Protection (ORP) and the Washington State Department of Ecology (Ecology) have agreed that key contaminants (^{99}Tc, ^{129}I, Cr, NO_3, and U) should receive additional attention in tank closure performance assessments. These contaminants are those expected to cause the largest groundwater impacts from tank farm closure. For these contaminants, the maximum derived concentration limits as documented in the "National Primary Drinking Water Regulations" (40 CFR 141) or the *National Interim Primary Drinking Water Regulations* [EPA 1976] will be used.

3.5.5 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. Especially at the Hanford Site, this is quite reasonable 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) (DOE 2002a). The agreement basically 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 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.

3.5.6 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 or where agreement has been reached between ORP and Ecology.

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 (WAC 173-201A) 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. After consultation with staff from the Washington State Department of Ecology, the EPA drinking water standard was chosen to be the performance objective for radionuclides.

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 1.2c. However, for organic chemicals, only those organic chemicals that have been detected frequently in tank waste are included in Table 1.2c.

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 61H and 40 CFR 61Q) are the same as those found in the DOE manual on radioactive waste management (DOE 1999b). 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^2s.

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 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 the 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.

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 future impacts as estimated by performance assessments are compared against the levels set in Section 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 is that the spatial resolution of the computer 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 fenceline of the facility or beyond
- The maximum point of impact at the edge of the 200 Area core zone or beyond
- 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. The following sections provide information for choosing the points of assessment for tank farm closure performance assessments.

4.3 PROTECTION OF THE GENERAL PUBLIC, WORKERS, AND GROUNDWATER

Past work (e.g., Mann 2001, 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.

DOE, RCRA, and the State of Washington differ on the location of the point of compliance. RCRA (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." The State of Washington (WAC 173-340-720(8)(a)) states: "For ground water, the point of compliance is the point or points where the ground water cleanup levels established under sub-section (3), (4), (5), or (6) of this section must be attained for the site to be in compliance with cleanup standards." The AEA (DOE M 435.1[IV.P92)(b)]; DOE 1999b) states: "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 the *Technical Basis for DOE M 435.1* (DOE 1999e), "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 …'".

Given that fencelines are often about 100 meters away from the tanks and given the relatively poor spatial resolution of the computer models, the choice between the fenceline and 100 meters from the facility is usually moot. Rather, the choice that should be made is 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 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 performance 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.

The suggested points of assessment are

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

Times of assessment for each of these points are discussed in Section 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 1998), with updates expected from the System Assessment Capability. Such an approach allows for straightforward calculations and comparisons without biasing the comparisons.

Figure 4.1. Location of groundwater concentrations of radionuclides above drinking water standards. (From Hartmann 2002)

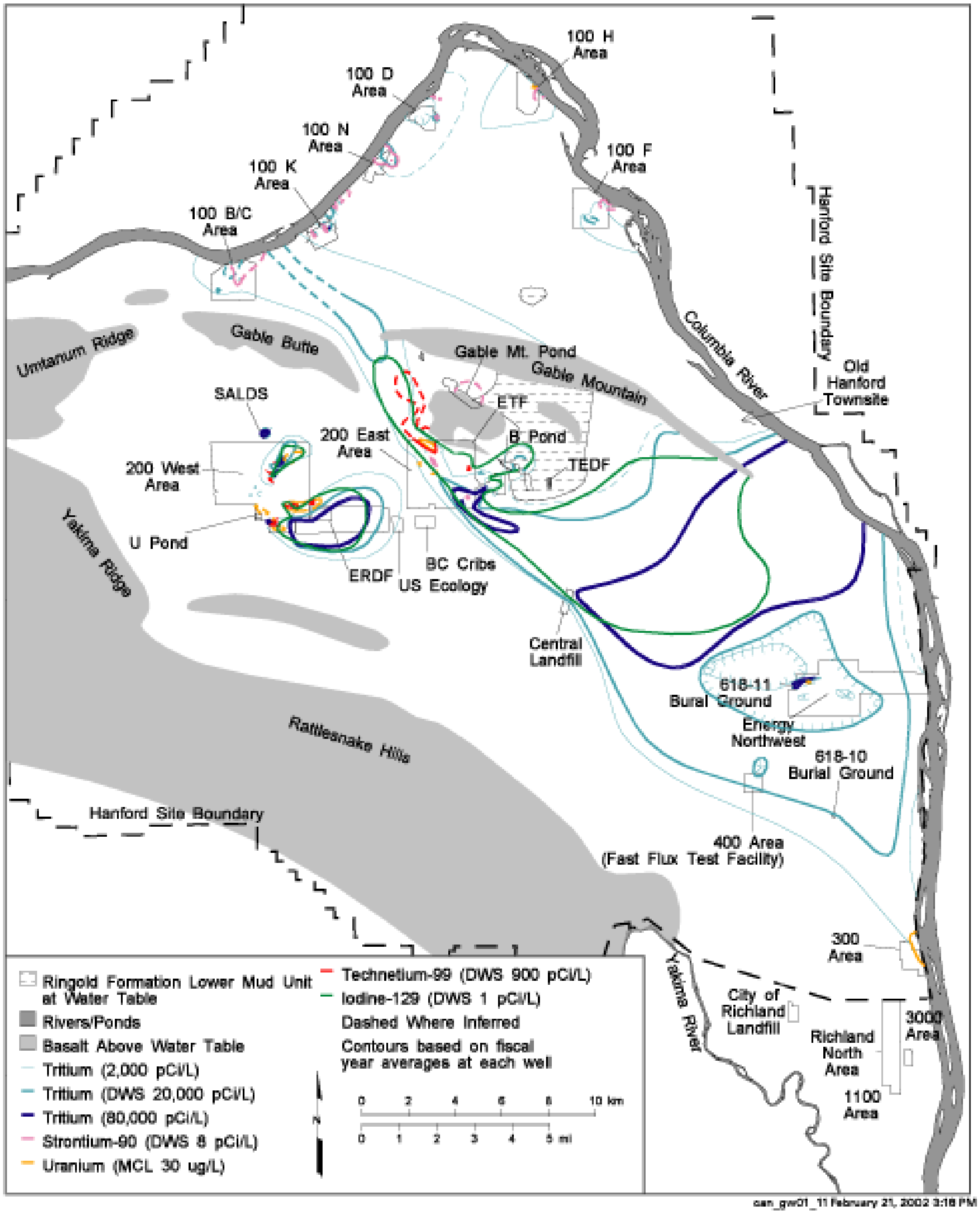
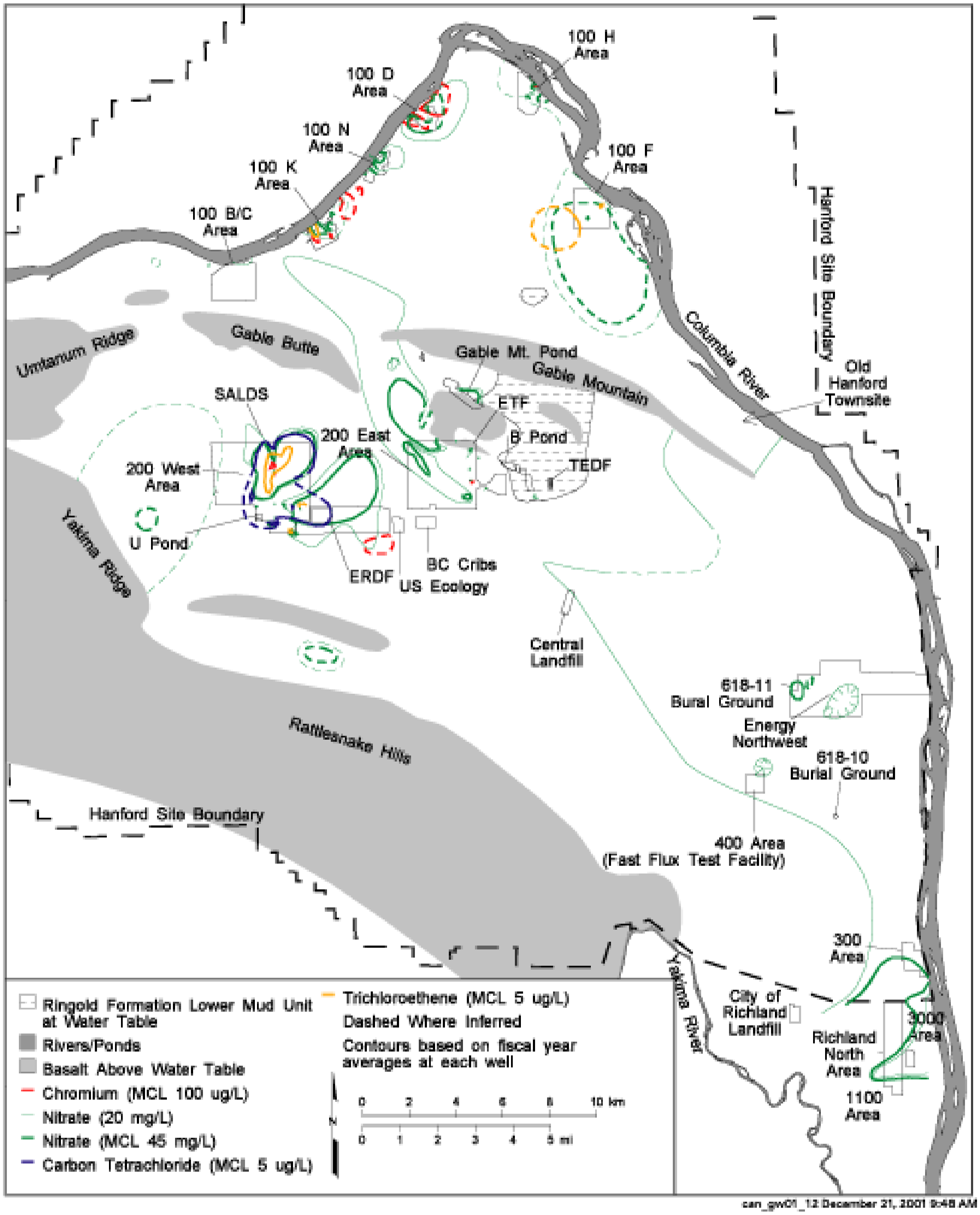


Figure 4.2. Location of groundwater concentrations of chemicals above drinking water standards. (From Hartmann 2002). Note that the MCL for Nitrate is 10 mg/L as nitrogen or 45 mg/L when expressed as nitrate.



For the tank closure performance assessments, the fenceline point of the waste management area containing the tank(s) will be the main point of calculation. Based on previous work (Mann 2001 and Knepp 2002), this point is expected to have the largest impacts. However, the performance assessment analyses will be sensitive to the possibility that overlapping plumes further downgradient may yield higher concentrations. The other points (edge of 200 Area Core Zone and just before groundwater reaches 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^3/s [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. That is, the concentration in the Columbia River will be estimated as being the concentration in the groundwater just before it enters the 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 performance assessments, the points of assessment will be

- At the facility for protection of the inadvertent intruder and air resources,
- At the point of maximum estimated impact, but no nearer than the fenceline 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 Section 3 at points specified in Section 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 times 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 times 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
- 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. The following text provides information for choosing the times of assessment for tank farm closure performance assessments.

It is the policy of the DOE (DOE O 5400.5; DOE 1993) that the department will not release land until all resources are protected. 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); DOE 1999b) 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 1994) which had recommended 10,000 years. Appendix B.1.4 (*Technical Basis for DOE M 435.1*; DOE 1999e) 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 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 Grout Performance Assessment (Kincaid 1995), the 200 West Area Solid Waste Performance Assessment (Wood 1995), and the 200 East Area Solid Waste Performance Assessment (Wood 1996).

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

5.3 PROTECTION OF THE GENERAL PUBLIC, WORKERS, AND GROUNDWATER

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 1998) estimated groundwater impacts from 200 Area sources. (The composite analysis was approved by DOE/HQ (DOE 1999g). 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

(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. Also, which criteria of beneficial use should be applied is uncertain. As noted in Section 3.5, there are various groundwater criteria that 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 steams 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) does 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); DOE 1999b) requires that it must be maintained to reflect new information and understanding. Through the development of the System Assessment Capability (SAC) and its associated data bases, 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 performance assessments. However, results will be provided starting in the year 2000 AD.

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 (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 choice of the end time is usually not significant as the decay of key radionuclides normally overcomes the ingrowth of any other radionuclides (usually actinides) or other concentration mechanism.

The inadvertent intrusion time of assessment differs slightly between regulations. Current DOE guidance (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 (DOE 1996b). 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 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 1995 and Wood 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 performance 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.

6.0 PUBLIC INVOLVEMENT

It is important that Hanford stakeholders have the opportunity to affect the performance objectives used in the tank closure performance assessments. Public comments were requested on the documents (Mann 1994, Mann 1999a, Mann 1999b, and 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:

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

7.0 REFERENCES

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16 USC 461, Archeological and Historic Preservation Act of 1996. Online at http://www4.law.cornell.edu/uscode/16/ch1A.html

16 USC 470, National Historic Preservation Act of 1996. Online at http://www4.law.cornell.edu/uscode/16/ch1B.html

16 USC 1431 et seq., Marine Protection, Research, and Sanctuaries Act. Online at 1431

16 USC 1531, Endangered Species Act (ESA) of 1973. Online at http://www4.law.cornell.edu/uscode/16/ch35.html

42 U.S.C. 300f et seq., Safe Drinking Water Act. Online at http://www4.law.cornell.edu/uscode/42/ch6AschXII.html

42 USC 2011, Atomic Energy Act (AEA) of 1954. Online at http://www4.law.cornell.edu/uscode/42/ch23.html

42 USC 4321, National Environmental Policy Act (NEPA) of 1969. Online at http://ceq.eh.doe.gov/nepa/regs/nepa/nepaeqia.htm

42 USC 6901 et seq., Resource Conservation and Recovery Act (RCRA) of 1976. Online at http://www4.law.cornell.edu/uscode/42/ch82.html

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APPENDIX A

ORGANIC CHEMICALS CONSIDERED

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Table A.1. Most Often Detected Organic Chemicals in Tank Waste.
(2 Pages)

Organic compounds whose vapor was detected in more than 100 independent samples from tank waste or who have been detected more than 20 times in the solid or liquid phase, as entered into the TWRS Information System (TWINS). Data 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

Table A.1. Most Often Detected Organic Chemicals in Tank Waste.
(2 Pages)

Organic compounds whose vapor was detected in more than 100 independent samples from tank waste or who have been detected more than 20 times in the solid or liquid phase, as entered into the TWRS Information System (TWINS). Data taken from Table B.1 of Wiemers 1998.

CAS#	Constituent	CAS#	Constituent
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-

APPENDIX B

KEY REGULATIONS

The regulations and guidance cited in this Appendix deal with the information needed for the creation of tank farm closure performance assessments. They are not, however, all of the regulations, requirements, or guidance needed for the closure of the tank farms or components inside those farms.

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1.1 B.1 DOE ORDER ON RADIOACTIVE WASTE MANAGEMENT (DOE O 435.1)

1.1.1 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*." [DOE 1999b]

1.1.2 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* (DOE 1999b). 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 that hazardous waste is termed "dangerous waste" in the 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 $pCi/m^2/s$ (0.74 $Bq/m^2/s$) 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."

1.1.3 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 1999c) concerning how to use the *Radioactive Waste Management Manual*. 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^2/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 1999d). Guidance explicitly stated 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 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."

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

Further information is given in the *Technical Basis for DOE M 435.1* (DOE 1999e). In particular, the sections on the performance objectives and performance assessment give 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 the 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 1996d] 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 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 1988] 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 1996e], 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 judgment. 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.”

1.2 B.2. WASHINGTON STATE DANGEROUS WASTE REGULATIONS (WAC 173-303)

1.2.1 B.2.1 Introduction

The 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.

Although Section 160 does not apply to Hanford tanks − the section applies to containers, which are portable devices − it gives insight into the definition of empty. 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 requirements for maximum volume after retrieval (see Milestone M-45-00) are 360 cubic feet for 100 series tanks and a volume of 30 cubic feet for 200 series tanks, unless the Appendix H process of the TPA is implemented on the tank.

1.2.2 B2.2 Closure and Postclosure

Sub-section (2) of Section 610 (Closure and Postclosure) requires 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 post-closure 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 sub-section, 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 unless exempt according to WAC 173-303-2(a). Sub-section 3 describes the groundwater protection standard in general terms. Sub-section 4 authorizes the Department of Ecology to specify the contaminants of concern in the permit. Sub-section 5 provides concentration limits. The sub-section 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 sub-section, 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 sub-section." Table 1 is reproduced as Table C.6. Sub-section (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."

Sub-section (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 sub-section (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. Sub-section (7) defines the time of compliance as "the compliance period during which the ground water protection of sub-section (3) of this section applies." Sub-sections (8) through (11) provide general groundwater monitoring requirements. In particular, sub-section (11) describes the requirements for a corrective action program. Section 646 furthers describes "corrective actions".

1.2.3 B2.3 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.

1.2.4 B2.4 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.

1.3 B.3 MODEL TOXICS CONTROL ACT (70.105D RCW)

The 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.

Under 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 (1×10^{-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 1733-340-720 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.

The WAC also requires terrestrial ecological evaluations. “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 ecological evaluation is required if the site meets any of the following criteria (WAC 173-340-7491): 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.”

1.4 B.4 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (42 USC 9601 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.

APPENDIX C

SUPPORTING TABLES

Values from Washington State Regulations are NOT reported when the state values are adopted by reference from the federal values. This reduces redundancy as the values from regulations are already stated.

These tables contain numeric values obtained from regulations and orders that impact the creation of performance assessments. The tables do not contain all numeric values (e.g., soil cleanup values determined, at least partially from performance assessments) that will be used in tank farm closure.

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

DOE Order on "Radioactive Waste Management" DOE M 435.1 (DOE 1999b)	
All pathways (<1,000 years)	25 mrem/year

DOE Order for "Radiation Protection of the Public and the Environment" DOE Order 5400.5(II)(1)(a) (DOE 1993)	
All pathways (from all DOE facilities at the site)	100 mrem/year

Federal "Standards for Protection Against Radiation" 10 CFR 20.1301	
All pathways from action	100 mrem/year
All pathways from action	2 mrem/hour

Federal "Licensing Requirements for the Land Disposal of Radioactive Waste" 10 CFR 61. 41	
All pathways (whole body)	25 mrem/year
All pathways (thyroid)	75 mrem/year
All pathways (other organs)	25 mrem/year

Washington State "Radioactive Waste – Licensing Land Disposal" WAC 246-250-170	
All pathways (whole body)	25 mrem/year
All pathways (thyroid)	75 mrem/year
All pathways (other organs)	25 mrem/year

Federal Standard for DOE Workers 10 CFR 835.208	
All Pathways-all sources (controlled Area)	100 mrem/year

CERCLA Guidance for Radiation Protection of Public CERCLA – EPA 1999	
All Pathways	Do NOT use dose as standard
Incremental lifetime cancer risk	10^{-4}

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

CERCLA Standard for Risk **40 CFR 300.430(e)(2)(i)(A)(2)**	
Carcinogens (excess lifetime cancer risk) (single material)	10^{-6}
Carcinogens (excess lifetime cancer risk) (multiple materials)	10^{-4}

Washington State Model Toxics Control Act **WAC 173-340(720-760)**	
Carcinogens (excess lifetime cancer risk) (single chemical)	10^{-6}
Carcinogens (excess lifetime cancer risk) (multiple chemicals)	10^{-5}
Hazard index (noncarcinogen)	1.0

Table C.3. Numeric Requirements of Relevant Worker Protection Regulations.

Federal Standard for DOE Workers 10 CFR 835, Subpart C	
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

Federal "Standards for Protection Against Radiation" 10 CFR 20, Subpart C	
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

Washington State "Radiation Protection Standards" WAC 246-221-010	
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.

DOE Order on "Radioactive Waste Management" DOE M 435.1 (DOE 1999b)	
Intruder (> 100 years or larger)	100 mrem/year (continuous)
Intruder (> 100 years or larger)	500 mrem (single event)

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

Table C.5. Numeric Requirements of Relevant Drinking Water Regulations.
(3 Pages)

DOE Order for "Radiation Protection of the Public and the Environment" DOE Order 5400.5 (II)(d) (DOE 1993)	
Radionuclides	4 mrem/year
Ra-226 plus Radium-228	$5x10^{-9}$ µCi/ml (= 5 pCi/l)
Alpha emitters (but not Rn nor U)	$1.5x10^{-8}$ µCi/ml (=15 pCi/l)

Federal Drinking Water Standards 40 CFR 141.XX		
40 CFR 141.11		
Arsenic		0.01 mg/l
40 CFR 141.12		
Trihalomethanes		0.10 mg/l
40 CFR 141.15 (does not apply after 12/8/2003)		
Ra-226+Ra-228		5 pCi/l
Alpha activity (except Rn and U)		15 pCi/l
40 CFR 141.16 (does not apply after 12/8/2003)		
Beta and photon activity (2 L/d)		4 mrem/year
H-3		20,000 pCi/l
Sr-90		8 pCi/l
40 CFR 141.66 (Effective 12/8/2003)		
Ra-226+Ra-228		5 pCi/l
Alpha activity (except Rn and U)		15 pCi/l
Beta and photon activity (2 L/d)		4 mrem/year
H-3		20,000 pCi/l
Sr-90		8 pCi/l
Uranium		30 µg/l
40 CFR 141, Subpart F, Sections 51 – 55 are goals only		
40 CFR 141.55 (effective 12/8/2003)		
Ra-226 + Ra-228		zero
Alpha activity (except Rn and U)		zero
Beta and photon activity		zero
Uranium		zero
40 CFR 141.61		
CAS #	Constituent	Limit
50-32-8	Benzo[a]purene	0.0002 mg/l
56-23-5	Carbon tetrachloride (a)	0.005 mg/l

Table C.5. Numeric Requirements of Relevant Drinking Water Regulations.
(3 Pages)

57-74-9	Chlordane	0.002 mg/l
71-43-2	Benzene (a)	0.005 mg/l
71-55-6	1,1,1-Trichloroethane (a)	0.2 mg/l
72-20-8	Endrin	0.002 mg/l
72-43-5	Methoxychlor	0.04 mg/l
40 CFR 141.61 (cont.)		
CAS #	Constituent	Limit
75-01-4	Vinyl chloride	0.002 mg/l
75-35-4	1,1-Dichloroethylene (a)	0.007 mg/l
75-09-2	Dichloromethane (Methylene Chloride) (a)	0.005 mg/l
75-99-0	Dalapon	0.2 mg/l
76-44-8	Heptachlor	0.0004 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 (a)	0.005 mg/l
79-01-6	Trichloroethylene (a)	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	σ-Dichlorobenzene	0.06 mg/l
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 (a)	0.7 mg/l
96-12-8	Dibromochloropane	0.00002 mg/l
100-41-4	Ethyl benzene (a)	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 (a)	0.075 mg/l
106-93-4	Ethylene dibromide (a)	0.00005 mg/l
107-06-2	1,2 Dichoroethane	0.005 mg/l
108-74-1	Hexachlorbenzene	0.001 mg/l
108-88-3	Toluene (a)	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 (a)	0.006 mg/l
120-82-1	1,2,4-Trichloro-benzene	0.07 mg/l
122-34-9	Simazine	0.004 mg/l

Table C.5. Numeric Requirements of Relevant Drinking Water Regulations.
(3 Pages)

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) (a)	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)	$3x10^{-8}$ mg/l
1912-24-9	Atrazine	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

40 CFR 141.62			
Antimony	0.006 mg/l	Barium	2.0 mg/l
Beryllium	0.004 mg/l	Cadmium	0.005 mg/l
Chromium (total)	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	—	—

Federal Drinking Water Goals 40 CFR 143.3			
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
Silver	0.1 mg/l	Sulfate	250. mg/l
Zinc	5.0 mg/l	—	—

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

Table C.5. Numeric Requirements of Relevant Drinking Water Regulations.
(3 Pages)

Washington State "Public Water Supplies" Regulation 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

a Organic compounds whose vapor was detected in more than 100 independent samples from tank waste or who have been detected more than 20 times in the solid or liquid phase, as entered into the TWINS database. Data taken from Table B.1 of Wiemers 1998.

Table C.6. Numeric Requirements of Relevant Groundwater Regulations.

(4 Pages)

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
Methoxyclor	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 (SO4)	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 (a)	0.001 mg/l

Table C.6. Numeric Requirements of Relevant Groundwater Regulations.
(4 Pages)

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	0.0000004 mg/l
Bis(2-ethylhexyl)phthalate (a)	0.006 mg/l
Bromodichloromethane	0.0003 mg/l
Bromoform	0.005 mg/l
Carbazole	0.005 mg/l
Carbon tetrachloride (a)	0.0003 mg/l
Chlordane	0.00006 mg/l
Chlorodibromomethane	0.0005
Chloroform (a)	0.007 mg/l
4 Chloro-2-methyl aniline	0.0001 mg/l
4 Chloro-2-methyl analine 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 (a)	0.004 mg/l
3,3' Dichlorobenzidine	0.0002 mg/l
1,1 Dichloroethane (a)	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

Table C.6. Numeric Requirements of Relevant Groundwater Regulations.
(4 Pages)

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
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

Table C.6. Numeric Requirements of Relevant Groundwater Regulations.
(4 Pages)

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,a,a,a-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)	$1x10^{-5}$
Hazard index (noncarcinogen)	1

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

a Organic compounds whose vapor was detected in more than 100 independent samples from tank waste or who have been detected more than 20 times in the solid or liquid phase, as entered into the TWINS database. Data taken from Table B.1 of Wiemers 1998.

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

	DOE O 5400.5	40 CFR 141. (before 12/03)	WAC-173-200-04
Radionuclides			
Beta and photon activity	4 mrem/y	4 mrem/y	50 pCi/l
Alpha emitters (but not Ra and U)	15 pCi/l	15 pCi/l	15 pCi/l
H-3		20,000 pCi/l	20,000 pCi/l
Sr-90		8 pCi/l	8 pCi/l
Ra-226			3 pCi/l
Ra-226 and Ra-228	5 pCi/l	5 pCi/l	5 pCi/l

	40 CFR 141	WAC 246-290-310	40 CFR 264.94	WAC 173-200-040	WAC 173-303-645
Antimony	0.006 mg/l	0.006 mg/l			
Arsenic	0.01 mg/l	0.05 mg/l	0.05 mg/l	0.00005 mg/l	0.05 mg/l
Barium	2.0 mg/l	2.0 mg/l	1. mg/l	1. mg/l	1. mg/l
Beryllium	0.004 mg/l	0.004 mg/l			
Cadmium	0.005 mg/l	0.005 mg/l	0.01 mg/l	0.01 mg/l	0.01 mg/l
Chloride		250. mg/l		250. mg/l	
Chromium		0.1 mg/l	0.05 mg/l	0.05 mg/l	0.05 mg/l
Copper				1. mg/l	
Cyanide	0.2 mg/l	0.2 mg/l			
Fluoride	4.0 mg/l	2.0 mg/l		4. mg/l	
Iron		0.3 mg/l		0.30 mg/l	
Lead			0.05 mg/l	0.05 mg/l	0.05 mg/l
Manganese		0.05 mg/l		0.05 mg/l	
Mercury	0.002 mg/l	0.002 mg/l	0.002 mg/l	0.002 mg/l	0.002 mg/l

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

Nickel		0.1 mg/l			
Nitrate (as N)	10. mg/l	10.0 mg/l		10. mg/l	
Nitrite (as N)	1. mg/l	1.0 mg/l			
Nitrate + Nitrite (as N)	10. mg/l				
Selenium	0.05 mg/l	0.05 mg/l	0.01 mg/l	0.01 mg/l	0.01 mg/l
	40 CFR 141	**WAC 246-290-310**	**40 CFR 264.94**	**WAC 173-200-040**	**WAC 173-303-645**
Silver		0.1 mg/l	0.05 mg/l	0.05 mg/l	0.05 mg/l
Sulfate (as SO_4)		250. mg/l		250. mg/l	
Thalium	0.002 mg/l	0.002 mg/l			
Zinc		5.0 mg/l		5. mg/l	
2-4 D	0.07 mg/l		0.1 mg/l	0.10 mg/l	0.10 mg/l
2,3,7,8-TCDD (Dioxin)	$3x10^{-8}$ mg/l				
2,4,5-TP Silvex	0.05 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	
Atrazine	0.003 mg/l				
Aniline				0.014 mg/l	

Table C.7. Summary of Numeric Requirements of Relevant Drinking Water and Groundwater Regulations.

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

(8 Pages)

	40 CFR 141	**WAC 246-290-310**	**40 CFR 264.94**	**WAC 173-200-040**	**WAC 173-303-645**
Aramite				0.003 mg/l	
Azobenzene				0.0007 mg/l	
Benzene [(a)]				0.001 mg/l	
Benzidine				0.0000004 mg/l	
Benzo(a)pyrene	0.002 mg/l			0.000008 mg/l	
Benzotrichloride				0.000007 mg/l	
Benzyl chloride				0.0005 mg/l	
Bis(chloroethyl)ether				0.00007 mg/l	
Bis(chloromethyl)ether				0.0000004 mg/l	
Bis(2-ethylhexyl)phthalate [(a)]				0.006 mg/l	
Bromodichloromethane				0.0003 mg/l	
Bromoform				0.005 mg/l	
Carbazole				0.005 mg/l	
Carbofuran	0.04 mg/l				
Carbon tetrachloride [(a)]	0.005 mg/l			0.0003 mg/l	
Chlordane	0.002 mg/l			0.00006 mg/l	
Chlorodibromomethane				0.0005 mg/l	
Chloroform [(a)]				0.007 mg/l	
4 Chloro-2-methyl aniline				0.0001 mg/l	
4 Chloro-2-methyl analine hydrochloride				0.0002 mg/l	
o-Chloronitrobenzene				0.003 mg/l	

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

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				
	40 CFR 141	**WAC 246-290-310**	**40 CFR 264.94**	**WAC 173-200-040**	**WAC 173-303-645**
1,4-Dichlorobenzene [(a)]				0.004 mg/l	
3,3' Dichlorobenzidine				0.0002 mg/l	
1,1 Dichloroethane	0.007 mg/l			0.001 mg/l	
1,2 Dichloroethane (ethylene chloride)	0.005 mg/l			0.0005 mg/l	
Cis-1,2-Dichloroethylene [(a)]	0.07 mg/l				
Trans-1,2-Dichloroethylene [(a)]	0.1 mg/l				
Dichloromethane [(a)]	0.005 mg/l				
1,2 Dichloropropane	0.005 mg/l			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	

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

	40 CFR 141	WAC 246-290-310	40 CFR 264.94	WAC 173-200-040	WAC 173-303-645
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				
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 [(a)]	0.7 mg/l				
Ethylene dibromide	0.00005 mg/l			0.000001 mg/l	
Ethylene thiourea				0.002 mg/l	
Folpet				0.020 mg/l	

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

Furazolidone				0.00002 mg/l	
Furium				0.000002 mg/l	
Furmecyclox				0.003 mg/l	
Glyphosate	0.7 mg/l				
Heptachlor	0.0004 mg/l			0.00002 mg/l	
Heptachlor Epoxide	0.0002 mg/l			0.000009 mg/l	
	40 CFR 141	**WAC 246-290-310**	**40 CFR 264.94**	**WAC 173-200-040**	**WAC 173-303-645**
Hexachlorobenzene	0.001 mg/l			0.00005 mg/l	
Hexachlorocyclohexane (alpha)	0.05 mg/l			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			0.004 mg/l	0.00006 mg/l	0.004 mg/l
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	0.04 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.
A blank entry in the cell means that the corresponding regulation does not cover the indicated contaminant.
(8 Pages)

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	
	40 CFR 141	**WAC 246-290-310**	**40 CFR 264.94**	**WAC 173-200-040**	**WAC 173-303-645**
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	
Oxamyl (Vydate)	0.2 mg/l				
PAH				0.00001 mg/l	
PBBs				0.00001 mg/l	
PCBs	0.0005 mg/l			0.00001 mg/l	
Pentachlorophenol	0.001 mg/l				
o-Phenylenediamine				0.000005 mg/l	
Picloram	0.5 mg/l				
Propylene oxide				0.00001 mg/l	
Simazine	0.004 mg/l				
Styrene	0.1 mg/l				
2,3,7,8-Tetrachlorodibenzo-p-dioxin				0.0000000006 mg/l	
Tetrachloroethylene (perchloroethylene)	0.005 mg/l			0.0008 mg/l	

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

p,a,a,a-Tetrachlorotoluene				0.000004 mg/l	
2,4 Toluenediamine				0.000002 mg/l	
Toluene [(a)]	1.0 mg/l				
	40 CFR 141	**WAC 246-290-310**	**40 CFR 264.94**	**WAC 173-200-040**	**WAC 173-303-645**
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 [(a)]	0.2 mg/l				
1,1,2-Trichloroethane [(a)]	0.005 mg/l				
2,4,6-Trichlorophenol				0.004 mg/l	
Trihalomethanes	0.10 mg/l				
Trimethyl phosphate				0.002 mg/l	
Vinyl chloride	0.002 mg/l			0.00002 mg/l	
Xylenes (total) [(a)]	10. mg/l				
o-Xylene [(a)]	0.7 mg/l				

a Organic compounds whose vapor was detected in more than 100 independent samples from tank waste or who have been detected more than 20 times in the solid or liquid phase, as entered into the TWINS database. Data taken from Table B.1 of Wiemers 1998.

Table C.8. Numeric Requirements Of Relevant Surface Water Regulations.

(For Drinking Water Standards, see Table C.5.)

"Water Quality Standards for Surface Waters of the State of Washington" WAC 173-201A-040			
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/
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)

"Water Quality Standards for Surface Waters of the State of Washington" WAC 173-201A-050			
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	—	

Washington State "Model Toxics Control Act" WAC 173-340-730	
Exposure to multiple hazardous substances / more than one pathway	
Total excess cancer risk (carcinogen)	$1x10^{-5}$
Hazard index (noncarcinogen)	1.0

Table C.9. Numeric Requirements of Relevant Air Regulations.
(2 Pages)

DOE Order on Radioactive Waste Management DOE O 435.1	
Air emissions (except radon)	10 mrem/year
Air emissions (radon)	20 pCi/m^2s

DOE Order on Radiation Protection of the Public and the Environment DOE Order 5400.5(II)(b) (DOE 1993)	
Air emissions	10 mrem/year

National Primary and Secondary Ambient Air Quality Standards 40 CFR 50			
	Limits for Average Maximum		
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 (annual)
Lead			1.5 µg/m3 (quarterly)

"National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities," 40 CFR 61.92	
Air emission (except radon)	10 mrem/year

"National Emission Standards for Radon Emissions from Department of Energy Facilities," 40 CFR 61.192	
Air emissions (radon)	20 pCi/m^2s

Washington State "General Regulations for Air Pollution Sources" WAC 173-480-040	
Sulfur dioxide	1 ppm

Washington State "Ambient Air Quality Standards for Radionuclides" WAC 173-480-040	
Air emissions (except radon) (whole body)	25 mrem/year
Air emissions (except radon) (critical organ)	75 mrem/year

Table C.9. Numeric Requirements of Relevant Air Regulations.
(2 Pages)

Washington State "Radiation Protection – Air Emissions" WAC 246-247-040
References WAC 173-480 and 40 CFR 61

Washington State "Model Toxics Control Act" WAC 173-340-750	
Exposure to multiple hazardous substances / more than one pathway	
Total excess cancer risk (carcinogen)	$1x10^{-5}$
Hazard index (noncarcinogen)	1.0

Table C.10. Numeric Requirements of Relevant Regulations for Concentrations in Waste.
(9 Pages)

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

"Toxicity Characteristics" – TCLP limits 40 CFR 261.24			
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 (a)	0.5 mg/l
57-74-9	Chlordane	0.03 mg/l
58-89-9	Lindane	0.4 mg/l
67-66-3	Chloroform (a)	6.0 mg/l
67-72-1	Hexachloroethane	3.0 mg/l
71-43-2	Benzene (a)	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 (a)	0.7 mg/l
76-04-8	Heptachlor	0.008 mg/l
78-93-3	Methyl ethyl ketone (a)	200. mg/l
79-01-6	Trichloroethylene (a)	0.5 mg/l
87-68-3	Hexachlorobutadiene	0.5 mg/l
"Toxicity Characteristics" – TCLP limits (cont.) 40 CFR 261.24		
87-86-5	Pentachlorophenol	100. mg/l
88-06-2	2,4,6-Trichlorophenol	2.0 mg/l

Table C.10. Numeric Requirements of Relevant Regulations for Concentrations in Waste.
(9 Pages)

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
106-44-5	p-Cresol	200.0 mg/l
106-46-7	1,4-Dichlorobenzene (a)	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	Chlorobenzenr	100 mg/l
110-86-1	Pyridine (a)	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 (a)	0.7 mg/l
8001-35-2	Toxaphene	0.5 mg/l

RCRA "Treatment Standards" 40 CFR 268.40	
Establishes treatment standards	
Standards bounded by 40 CFR 268.48	

RCRA "(Universal Treatment Standards)" 40 CFR 268.48	
	TCLP result limits
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

Table C.10. Numeric Requirements of Relevant Regulations for Concentrations in Waste.
(9 Pages)

Zinc		4.3 mg/l
		TCLP result limits
Cyanide (total)		590 mg/kg
Cyanide (amenable)		30 mg/kg
CAS #	**Constituent**	**TCLP result limits**
67-56-1	Methanol [(a)]	0.75 mg/l
75-15-0	Carbon disulfide	4.8 mg/l
108-94-1	Cyclohexanone [(a)]	0.75 mg/l
CAS #	**Constituent**	**Concentration limit**
50-29-3	p,p'-DDT	0.087 mg/kg
50-32-8	Benzo(a)pyrene	3.4 mg/kg
51-28-5	2,4-Dinitrophenol	160 mg/kg
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 [(a)]	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 [(a)]	160 mg/kg
67-66-3	Chloroform [(a)]	6 mg/kg

Table C.10. Numeric Requirements of Relevant Regulations for Concentrations in Waste.
(9 Pages)

67-72-1	Hexachloroethane	30 mg/kg
71-36-3	n-Butyl alcohol [(a)]	2.6 mg/kg
71-43-2	Benzene [(a)]	10 mg/kg
71-55-6	1,1,1-Trichloroethane [(a)]	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
CAS #	**Constituent**	**Concentration limit**
72-55-9	p,p'-DDE	0.087 mg/kg
74-83-9	Bromomethane/Methylbromide	15 mg/kg
74-87-3	Chloromethane/Methyl chloride [(a)]	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 [(a)]	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 [(a)]	6 mg/kg
75-69-4	Trichlorofluoromethane [(a)]	30 mg/kg
75-71-8	Dichlorodifluoromethane [(a)]	7.2 mg/kg
76-01-7	Pentachloroethane	6 mg/kg
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane [(a)]	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 [(a)]	36 mg/kg
79-00-5	1,1,2-Trichloroethane [(a)]	6 mg/kg
79-01-6	Trichloroethylene [(a)]	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

Table C.10. Numeric Requirements of Relevant Regulations for Concentrations in Waste.
(9 Pages)

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
CAS #	**Constituent**	**Concentration limit**
88-85-7	2-sec-Butyl-4,6-dinitrophenol/ Dinosebdinitrophenol/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-Chloropchenol	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
100-25-4	1,4-Dinitrobenzene	2.3 mg/kg

Table C.10. Numeric Requirements of Relevant Regulations for Concentrations in Waste.
(9 Pages)

100-41-4	Ethyl benzene [(a)]	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 [(a)]	6 mg/kg
106-47-8	p-Chloroaniline	16 mg/kg
106-93-4	1,2-Dibromoethane/Ethylene dibromide [(a)]	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 [(a)]	360 mg/kg
107-13-1	Acrylonitrile	84 mg/kg
108-10-1	Methyl isobutyl ketone [(a)]	33 mg/kg
108-39-4	m-Cresol	5.6 mg/kg
108-88-3	Toluene [(a)]	10 mg/kg
CAS #	**Constituent**	**Concentration limit**
108-90-7	Chlorobenzene	6 mg/kg
108-95-2	Phenol	6.2 mg/kg
110-86-1	Pyridine [(a)]	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

Table C.10. Numeric Requirements of Relevant Regulations for Concentrations in Waste.
(9 Pages)

126-98-7	Methacrylonitrle	84 mg/kg
126-99-8	2-Chloro-1,3-butadiene	0.28 mg/kg
127-18-4	Tetrachloroethylene [(a)]	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
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
CAS #	**Constituent**	**Concentration limit**
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

Table C.10. Numeric Requirements of Relevant Regulations for Concentrations in Waste.
(9 Pages)

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) [(a)]	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
17804-35-2	Benomyl	1.4 mg/kg
22781-23-3	Bendiocarb	1.4 mg/kg
23135-22-0	Oxamyl	0.28 mg/kg
CAS #	**Constituent**	**Concentration limit**
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

Table C.10. Numeric Requirements of Relevant Regulations for Concentrations in Waste.
(9 Pages)

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 (a)	0.5 mg/l
57-74-9	Chlordane	0.03 mg/l
58-89-9	Lindane	0.4 mg/l
67-66-3	Chloroform [(a)]	6 mg/l
67-72-1	Hexachloroethane	3 mg/l
71-43-2	Benzene [(a)]	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 [(a)]	0.7 mg/l
76-44-8	Heptachlor (and its epoxide)	0.008 mg/l
78-93-3	Methyl ethyl ketone [(a)]	200 mg/l
CAS #	**Constituent (a)**	**TCLP result limit**
79-01-6	Trichloroethylene (a)	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

Table C.10. Numeric Requirements of Relevant Regulations for Concentrations in Waste.
(9 Pages)

94-75-7	2,4-D	10 mg/l
95-48-7	o-Cresol	200 mg/l
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 (a)	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 (a)	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 (a)	0.7 mg/l
8001-35-2	Toxaphene	0.5 mg/l
NA	Sum of m-, o-, and p- Cresol	200 mg/l

a Organic compounds whose vapor was detected in more than 100 independent samples from tank waste or who have been detected more than 20 times in the solid or liquid phase, as entered into the TWINS database. Data taken from Table B.1 of Wiemers 1998.

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