Annual Performance Assessment and Composite Analysis Review for the ICDF Landfill FY 2008

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**Idaho Cleanup Project
Idaho Falls, Idaho 83415**

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ABSTRACT

This report addresses low-level waste disposal operations at the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility (ICDF) landfill from the start of operations in Fiscal Year 2003 through Fiscal Year 2008. The ICDF was authorized in the Operable Unit 3-13 Record of Decision for disposal of waste from the Idaho National Laboratory Site CERCLA environmental restoration activities. The ICDF has been operating since 2003 in compliance with the CERCLA requirements and the waste acceptance criteria developed in the CERCLA process.

In developing the Operable Unit 3-13 Record of Decision, U.S. Department of Energy Order (DOE) 435.1, "Radioactive Waste Management," was identified as a "to be considered" requirement for the ICDF. The annual review requirement under DOE Order 435.1 was determined to be an administrative requirement and, therefore, annual reviews were not prepared on an annual basis. However, the landfill has been operating for 5 years and, since the waste forms and inventories disposed of have changed from what was originally envisioned for the ICDF landfill, the ICDF project team has decided that this annual review is necessary to document the changes and provide a basis for any updates in analyses that may be necessary to continue to meet the substantive requirements of DOE Order 435.1.

For facilities regulated under DOE Order 435.1-1, U.S. DOE Manual 435.1-1, "Radioactive Waste Management," IV.P.(4)(c) stipulates that annual summaries of low-level waste disposal operations shall be prepared with respect to the conclusions and recommendations of the performance assessment and composite analysis. Important factors considered in this review include facility operations, waste receipts, and results from monitoring and research and development programs. There have been no significant changes in operations at the landfill in respect to the disposal geometry, the verification of waste characteristics, and the tracking of inventories against total limits that would affect the results and conclusions of the performance assessment. Waste receipts to date and projected waste receipts through Fiscal Year 2012 are both greater than the inventory assessed in the performance assessment and composite analysis. The waste forms disposed of to the landfill are different from the waste form (compacted soil) assessed in the performance assessment. The leak detection system and groundwater monitoring results indicate the landfill has not leaked. The results of the performance assessment/composite analysis are valid (i.e., there is still a reasonable expectation of meeting performance objectives) but the new information indicates less conservatism in the results than previously believed.

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ACRONYMS

CA	composite analysis
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DAS	Disposal Authorization Statement
DD&D	deactivation, decontamination, and decommissioning
DOE	Department of Energy
FY	fiscal year
ICDF	Idaho CERCLA Disposal Facility
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
IPT	In-Pile Tube
IWTS	Integrated Waste Tracking System
LLW	low-level waste
MCM	mixing cell model
OU	operable unit
PA	performance assessment
RSM	Response Surface Model
WAC	waste acceptance criteria
WDS	waste disposition specialist
WGS	waste generator services

Annual Performance Assessment and Composite Analysis Review for the ICDF Landfill FY 2008

1. INTRODUCTION

This report addresses low-level waste (LLW) disposal operations at the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility (ICDF) landfill. The ICDF was authorized in the Operable Unit (OU) 3-13 Record of Decision (DOE-ID 1999) for disposal of waste from the Idaho National Laboratory (INL) Site CERCLA environmental restoration activities. The ICDF has been operating since 2003 in compliance with the CERCLA requirements and the waste acceptance criteria (WAC) developed in the CERCLA process.

In developing the OU 3-13 Record of Decision (DOE-ID 1999), U.S. Department of Energy (DOE) Order 435.1, “Radioactive Waste Management,” (DOE O 435.1) was identified as a “to be considered” requirement for the ICDF. To demonstrate that the disposal facility is protective of human health and the environment—a requirement under DOE O 435.1 that must be met to obtain the Disposal Authorization Statement (DAS) for facility operations—both a performance assessment (PA) and a composite analysis (CA) were prepared (DOE-ID 2003a,b, respectively). In addition, to demonstrate that the ICDF will be in compliance with DOE O 435.1 during operations, a compliance demonstration document was submitted (DOE-ID 2003c). This document cross-walked the process conducted under CERCLA for the ICDF landfill to the requirements under DOE O 435.1. The Low-Level Waste Disposal Facility Federal Review Group reviewed the information submitted and found that the documentation submitted demonstrates compliance with DOE O 435.1 and recommended that disposal authorization be granted for the ICDF landfill (Frei 2003).

Since that time, an annual summary and determination (Bradford 2007) has documented that LLW operations at the ICDF have been conducted within the bounds of the PA/CA (DOE-ID 2003a,b, respectively) and DAS (Frei 2003). The referenced compliance demonstration document (DOE-ID 2003c) states that the annual review requirement under DOE O 435.1 is an administrative requirement and, therefore, annual reviews were not prepared for the ICDF on an annual basis. However, the landfill has been operating for 5 years and, since the waste forms and inventories disposed of have changed from what was originally envisioned for the ICDF landfill, the ICDF project team has decided that this annual review is necessary to document the changes and provide a basis for any updates in analyses that may be necessary to continue to meet the substantive requirements of DOE O 435.1. Therefore, this annual review is more of a comprehensive review covering the last 5 years of operation, not just a review of Fiscal Year (FY) 2008.

For facilities regulated under DOE O 435.1-1, DOE Manual 435.1-1, “Radioactive Waste Management Manual,” IV.P.(4)(c) (DOE M 435.1-1) stipulates that annual summaries of LLW disposal operations shall be prepared with respect to conclusions and recommendations of the PA and CA. This annual review addresses LLW disposal operations at the ICDF landfill (Figure 1-1) from the start of disposals in FY 2003 through FY 2008. The annual review evaluates the adequacy of the approved PA (DOE-ID 2003a) and CA (DOE-ID 2003b), along with the special analysis conducted (EDF-5544), and verifies that the FY 2008 LLW operations were conducted within the bounds of the PA/CA and DOE DAS (Frei 2003). The annual review consists of both an *Annual Determination* (Part I) that confirms existing controls continue to be effective in ensuring that the PA/CA conclusions are valid and an *Annual Summary* (Part II) that summarizes the information and conclusions of the annual determination. Important factors considered in this review include facility operations, waste receipts, and results from monitoring and research and development programs.

1.1 Site Background

As delineated in the *Final Record of Decision, Idaho Nuclear Technology and Engineering Center, Operable Unit 3-13* (DOE-ID 1999), on-Site disposal of CERCLA (42 USC § 9601 et seq.) waste streams at the INL was selected as the remedy for contaminated soil and debris. This alternative includes design, construction, operation, closure, and post-closure monitoring of the ICDF, including the necessary support facilities. The ICDF is a state-of-the-art engineered disposal facility located south of the Idaho Nuclear Technology and Engineering Center (INTEC) in the south-central portion of the INL Site (see Figure 1-1). The major components of the ICDF Complex include the following: disposal cells (landfill); evaporation pond (consisting of two cells) administration trailer; scale; decontamination building (with treatment area) (not in use); contaminated equipment pad (not in use); and staging and storage areas.

Together, the above components of the ICDF provide centralized waste acceptance; inspection; treatment, if necessary; and disposal of CERCLA-generated waste types resulting from remediation and deactivation, decontamination, and decommissioning (DD&D) sites at INL.

A photo of the landfill taken during a recent flyover on September 26, 2008, is shown in Figure 1-2. The ICDF landfill includes layers of liners constructed of both synthetic and geologic materials and is fully compliant with the Resource Conservation and Recovery Act Subpart C. The landfill design disposal capacity is roughly 389,293 m³ (510,000 yd³). It began receiving waste on September 16, 2003. *ICDF Complex Waste Acceptance Criteria* specifies the chemical and radiological WAC for waste disposed of at ICDF (DOE-ID 2009).

1.2 Scope

An annual review of the adequacy of the ICDF PA and CA ensures that the conclusions of the analyses remain valid in accordance with requirements of DOE O 435.1. The purpose of the *Annual Determination* (Part I) is to summarize operations and activities conducted during the year in the context of the assumptions and modeling that form the basis for the conclusions of the PA and CA. If operational changes or other activities occur during the year that show some deviation from the assumptions in the PA and CA, the *Annual Summary* (Part II) includes discussion of the significance of the changes and whether additional actions would be required.

Figure 1-1. Location of the ICDF on the Idaho National Laboratory Site.

Figure 1-2. View of ICDF landfill and evaporation ponds looking east (photo taken September 26, 2008).

PART I – ANNUAL DETERMINATION

In accordance with DOE M 435.1-1 requirements, an annual determination of the continued adequacy of the PA/CA analysis should be made by confirming that existing controls continue to be effective in ensuring that the PA/CA and its conclusions are valid. The determination should consider a review of waste receipts, results of monitoring and research and development activities, and other relevant factors.

I-1. WASTE RECEIPTS

The Integrated Waste Tracking System (IWTS) database provides the actual waste disposal information for the ICDF landfill. This section discusses waste volumes disposed of to the landfill, the radionuclide waste inventory disposed of to the landfill, waste forms disposed of to the landfill, and a comparison of the total individual radionuclide inventory to the operating WAC and the performance-based WAC.

I-1.1 Waste Volumes

After 5 years of operation, 52% of the available volume of the ICDF landfill has been filled based on a recent aerial survey (EDF-9071). A total of 35,270 m³ (46,133 yd³) of waste was disposed of at the ICDF landfill in FY-08 compared to 27,613 m³ (36,117 yd³) disposed of in FY-07. Figure I-1-1 shows the actual and projected volumes of waste disposal through FY-12.

I-1.2 Radionuclide Waste Inventory

The inventory of radionuclides and the total curies of each radionuclide disposed of in the landfill are shown in Table I-1-1. Of the 52 radionuclides with half-lives greater than 5 years disposed of in the landfill, 24 exceed the inventory assessed in the PA (see Table I-1-2). Many of these radionuclides were screened early on and not carried through in the PA groundwater dose assessment. Under current conditions, some of these radionuclides (C-14, Cl-36, H-3, K-40, Ni-59, Th-232, U-233, U-235, U-236, and U-238) would not have been screened and would have been radionuclides of concern for the groundwater pathway. Of the seven radionuclides assessed for the groundwater pathway in the PA (I-129, Np-237, Pu-239, Pu-240, Tc-99, U-234, U-238), the total inventories through FY-08 for three of them (Pu-239, Pu-240, and Tc-99) exceed the inventory assessed in the PA. In addition, Cl-36, Ni-59, and Ni-63 have been disposed of in the landfill and were not in the initial design basis inventory and, therefore, were not assessed in the PA. However, they have been subsequently added to the ICDF WAC (DOE-ID 2009).

The projected total radionuclide inventory for the ICDF landfill through FY-12 based on the last 2 years of waste receipts and known waste profiles identified as candidates for disposal at the ICDF is shown in Table I-1-3. Identified candidate waste profiles include the Materials Test Reactor vessel, CPP-603 soils excavation and debris, low-level secondary waste from Accelerated Retrieval Project sludge repackaging activities, CERCLA LLW debris from Accelerated Retrieval Project maintenance and construction activities, sampling debris, Advanced Test Reactor Complex^a LLW generated from DD&D activities, CPP-601/640 debris waste, and Naval Reactors Facility CERCLA soils. Projected waste receipts for 30 of the radionuclides with half-lives greater than 5 years are greater than the inventory assessed in the PA (Table I-1-3).

a. The Test Reactor Area was renamed the Reactor Technology Complex in 2005 and, then, the Advanced Test Reactor Complex in 2008.

Figure I-1-1. Actual and projected cumulative ICDF landfill disposals through FY-12.

Table I-1-1. Yearly and total actual disposals to the ICDF landfill (data from the Integrated Waste Tracking System).

Radionuclide	Half-life (yr)	Disposal Period					Total (Ci)
		FY-04 ^a (Ci)	FY-05 (Ci)	FY-06 (Ci)	FY-07 (Ci)	FY-08 (Ci)	
Ac-227	2.18E+01				1.01E-06	1.20E-07	1.13E-06
Ac-228	7.02E-04		7.86E-08		3.80E-03	9.98E-07	3.80E-03
Ag-108m	4.18E+02	1.94E-01	4.47E-03	1.68E-02	2.53E-01	4.62E-02	5.14E-01
Ag-110m	6.84E-01	9.81E-03	2.06E-02	2.56E+00	2.65E-01	6.96E-01	3.55E+00
Am-241	4.32E+02	1.78E-02	1.05E-01	9.52E-02	8.75E-02	1.02E-01	4.07E-01
Am-242m	1.41E+02				7.47E-04		7.47E-04
Am-243	7.37E+03		1.76E-05	1.97E-06	1.55E-03	2.14E-06	1.58E-03
Ba-137m	4.85E-06	2.05E+03	1.15E+02	3.01E+02	1.29E+02	8.62E+02	3.46E+03
Be-10	1.51E+06				3.73E-01	1.06E-02	3.84E-01
Bi-212	1.15E-04		7.05E-08		3.00E-03	7.89E-07	3.00E-03
Bi-214	3.78E-05		9.15E-08		3.53E-03	9.27E-07	3.53E-03
C-14	5.70E+03	3.59E-05	9.39E-04	2.88E-04	1.33E+01	1.19E+01	2.52E+01
Ce-144	7.80E-01	7.30E-02	2.71E-02	3.64E-03	7.32E-04	2.42E-04	1.05E-01
Cf-249	3.51E+02				5.22E-05		5.22E-05
Cf-251	8.98E+02				2.78E-29		2.78E-29
Cl-36	3.01E+05				1.27E-01	7.06E-03	1.34E-01
Cm-242	4.46E-01				1.21E-06	1.53E-06	2.74E-06
Cm-243	2.91E+01	1.13E-04	6.30E-04	2.41E-02	5.66E-04	2.26E-05	2.54E-02
Cm-244	1.81E+01	1.13E-04	6.30E-04	2.41E-02	3.21E-01	2.77E-03	3.48E-01

Table I-1-1. (continued).

Radionuclide	Disposal Period						
	Half-life (yr)	FY-04 ^a (Ci)	FY-05 (Ci)	FY-06 (Ci)	FY-07 (Ci)	FY-08 (Ci)	Total (Ci)
Cm-245	8.50E+03				1.91E-04	7.84E-10	1.91E-04
Cm-246	4.76E+03				2.53E-03	5.28E-11	2.53E-03
Cm-247	1.56E+07				2.46E-06	2.86E-17	2.46E-06
Cm-248	3.48E+05				1.32E-05	1.43E-17	1.32E-05
Cm-250	9.70E+03				6.62E-13		6.62E-13
Co-58	1.94E-01	8.48E-05			2.25E-03	2.66E-05	2.37E-03
Co-60	5.27E+00	1.40E-01	2.90E+00	4.55E+00	1.97E+03	1.45E+01	1.99E+03
Cs-134	2.07E+00	5.47E-02	5.25E-02	2.48E-02	3.72E-03	5.97E-03	1.42E-01
Cs-137	3.01E+01	2.19E+03	1.38E+02	3.18E+02	1.39E+02	9.20E+02	3.71E+03
Eu-152	1.35E+01	2.80E-03	5.12E-03	3.00E-01	4.55E+00	3.65E+01	4.14E+01
Eu-154	8.59E+00	7.66E-02	6.40E-03	3.73E-01	3.88E+00	2.73E+01	3.17E+01
Eu-155	4.76E+00	9.01E-04	4.36E-04	3.53E-02	2.55E-04	5.62E-04	3.74E-02
Fe-55	2.74E+00	3.59E-02	5.65E-03	3.24E-03	6.12E-05	1.28E-02	5.76E-02
H-3	1.23E+01	1.08E-01	4.05E-01	2.03E+00	3.11E+04	2.34E+01	3.11E+04
I-129	1.57E+07	1.17E-01	2.48E-02	8.21E-03	2.58E-05	6.74E-05	1.50E-01
I-131	2.20E-02	9.82E-04					9.82E-04
K-40	1.27E+09	3.72E-01	3.34E-02	1.05E-01	6.90E-02	1.08E-02	5.90E-01
Kr-85	1.08E+01				1.41E-05	1.14E-08	1.41E-05
Mn-54	8.55E-01	5.76E-04	9.13E-05	3.03E-04	6.34E-05	2.50E-05	1.06E-03
Nb-94	2.03E+04	1.64E-03	3.02E-02	1.59E-02	3.09E+00	5.22E-03	3.14E+00
Nb-95	9.58E-02	7.68E-04	1.68E-04	4.61E-04	7.04E-05	2.32E-05	1.49E-03
Ni-59	7.60E+04	3.87E-04	1.50E-01	4.68E-02	1.32E+02	6.92E-02	1.33E+02
Ni-63	1.00E+02	1.33E-01	1.58E+01	1.49E+01	2.42E+04	7.42E+00	2.42E+04
Np-237	2.14E+06	4.92E-02	1.32E-03	3.17E-04	2.76E-04	2.61E-03	5.37E-02
Pa-231	3.28E+04				1.49E-06	1.53E-07	1.64E-06
Pa-234	7.64E-04		3.27E-07				3.27E-07
Pb-210	2.23E+01				6.04E-03	1.59E-06	6.04E-03
Pb-212	1.21E-03		7.91E-08		3.46E-03	9.09E-07	3.46E-03
Pb-214	5.10E-05		7.42E-08		3.81E-03	1.00E-06	3.81E-03
Pm-147	2.62E+00	4.10E+03	1.07E-03	4.94E-06	1.23E-02	1.70E-04	4.10E+03
Pu-238	8.77E+01	3.77E-01	1.36E+00	1.25E+01	7.40E-02	6.09E-02	1.44E+01
Pu-239	2.41E+04	3.96E-02	3.17E-01	8.97E+00	2.18E-01	1.52E+00	1.11E+01
Pu-240	6.56E+03	3.94E-02	2.30E-01	8.97E+00	6.55E-02	3.25E-02	9.34E+00
Pu-241	1.43E+01	1.76E-02	1.21E-01	1.33E-02	2.04E+00	8.17E-01	3.01E+00
Pu-242	3.73E+05				1.59E-04	8.86E-07	1.60E-04
Pu-243	5.65E-04			1.97E-06			1.97E-06
Pu-244	8.00E+07				6.33E-11	1.50E-09	1.56E-09
Ra-224	1.00E-02		1.80E-07				1.80E-07
Ra-226	1.60E+03	8.00E-01	4.49E-03	4.11E-02	3.42E-02	9.66E-04	8.80E-01
Ra-228	5.75E+00	1.45E-03					1.45E-03
Ru-103	1.07E-01	6.06E-05					6.06E-05
Ru-106	1.02E+00	1.30E-01	1.22E-01	7.98E-03	1.61E-03	5.30E-04	2.62E-01
Sb-125	2.76E+00	1.80E-01	5.70E-02	5.10E-02	2.89E-02	2.88E-02	3.46E-01
Se-79	1.10E+06					6.02E-06	6.02E-06

Table I-1-1. (continued).

Radionuclide	Disposal Period						
	Half-life (yr)	FY-04 ^a (Ci)	FY-05 (Ci)	FY-06 (Ci)	FY-07 (Ci)	FY-08 (Ci)	Total (Ci)
Sm-151	9.00E+01				3.56E-05	2.89E-08	3.56E-05
Sr-90	2.88E+01	4.16E+01	2.08E+02	2.87E+02	3.09E+01	2.08E+02	7.75E+02
Tc-99	2.11E+05	2.14E-11	3.93E-03	3.20E-03	1.49E-02	5.92E-02	8.13E-02
Th-228	1.91E+00	9.35E-02	5.40E-05	3.50E-04	1.89E-04	2.69E-04	9.43E-02
Th-229	7.34E+03				1.20E-06	1.38E-07	1.34E-06
Th-230	7.54E+04	1.00E-01	2.77E-04	3.06E-04	7.62E-06	2.37E-04	1.01E-01
Th-232	1.41E+10	8.97E-02	1.82E-04	3.01E-04	1.01E-05	2.65E-04	9.04E-02
Th-234	6.60E-02		8.96E-08		2.23E-03	5.86E-07	2.23E-03
Tl-208	5.80E-06		7.42E-08		9.72E-04	2.55E-07	9.72E-04
U-232	6.89E+01				1.73E-04	4.60E-06	1.77E-04
U-233	1.59E+05	2.81E-03	8.40E-03	5.81E-02	9.62E-03	2.19E-03	8.11E-02
U-234	2.46E+05	1.51E-01	7.12E-02	1.01E-01	2.18E-02	2.89E-03	3.47E-01
U-235	7.04E+08	5.82E-02	6.29E-03	1.12E-02	3.25E-03	8.70E-03	8.77E-02
U-236	2.34E+07	5.10E-14	1.34E-04	3.11E-04	5.17E-04	1.55E-05	9.78E-04
U-238	4.47E+09	1.89E-01	3.90E-02	3.40E-02	2.73E-02	2.32E-02	3.12E-01
Y-90	7.30E-03	4.16E+01	2.25E+02	2.87E+02	2.74E+01	1.99E+02	7.80E+02
Zn-65	6.69E-01	8.46E-03	3.28E-04	1.08E-03	4.18E-04	8.45E-05	1.04E-02
Zr-95	1.75E-01	1.93E-04	1.40E-04	4.59E-04	2.72E-04	3.29E-05	1.10E-03
Totals		8.43E+03	7.08E+02	1.25E+03	5.78E+04	2.31E+03	7.05E+04

a. FY-04 includes early disposals in September 2003.

Table I-1-2. Comparison of the performance assessment inventory to actual disposals for radionuclides with half-lives greater than 5 years (data from the Integrated Waste Tracking System).

Radionuclide	t-1/2 (yr)	Actual Disposal through FY-08 (Ci)	PA Inventory (DOE-ID 2003a) (Ci)	Ratio of Actual Disposals to PA Inventory ^a
Cl-36	3.01E+05	1.34E-01	0.00E+00	NA ^b
Ni-59	7.60E+04	1.33E+02	0.00E+00	NA ^b
Ni-63	1.00E+02	2.42E+04	0.00E+00	NA ^b
Cm-250	9.70E+03	6.62E-13	4.20E-25	1.58E+12
Cf-249	3.51E+02	5.22E-05	3.13E-16	1.67E+11
Cm-248	3.48E+05	1.32E-05	1.48E-16	8.92E+10
Cm-247	1.56E+07	2.46E-06	4.85E-16	5.07E+09
Ra-228	5.75E+00	1.45E-03	1.16E-10	1.25E+07
Cm-246	4.76E+03	2.53E-03	1.36E-09	1.86E+06
C-14	5.70E+03	2.52E+01	3.50E-05	7.20E+05
Nb-94	2.03E+04	3.14E+00	6.70E-06	4.69E+05
Be-10	1.51E+06	3.84E-01	8.67E-07	4.43E+05
Cm-243	2.91E+01	2.54E-02	2.70E-06	9.41E+03
Pb-210	2.23E+01	6.04E-03	8.29E-07	7.29E+03
U-233	1.59E+05	8.11E-02	1.94E-05	4.18E+03
Cm-245	8.50E+03	1.91E-04	6.09E-08	3.14E+03

Table I-1-2. (continued).

Radionuclide	t-1/2 (yr)	Actual Disposal through FY-08 (Ci)	PA Inventory (DOE-ID 2003a) (Ci)	Ratio of Actual Disposals to PA Inventory ^a
H-3	1.23E+01	3.11E+04	3.76E+01	8.27E+02
Cm-244	1.81E+01	3.48E-01	1.37E-03	2.54E+02
Pu-244	8.00E+07	1.56E-09	1.93E-11	8.08E+01
Th-229	7.34E+03	1.34E-06	3.89E-08	3.44E+01
Am-242m	1.41E+02	7.47E-04	3.43E-05	2.18E+01
Co-60	5.27E+00	1.99E+03	1.47E+02	1.35E+01
Pu-240	6.56E+03	9.34E+00	1.14E+00	8.19E+00
Am-243	7.37E+03	1.58E-03	2.53E-04	6.25E+00
Ra-226	1.60E+03	8.80E-01	3.60E-01	2.44E+00
Pu-239	2.41E+04	1.11E+01	5.06E+00	2.19E+00
U-235	7.04E+08	8.77E-02	8.37E-02	1.05E+00
Pu-242	3.73E+05	1.60E-04	1.83E-04	8.74E-01
Ag-108m	4.18E+02	5.14E-01	6.07E-01	8.47E-01
Th-232	1.41E+10	9.04E-02	1.18E-01	7.66E-01
Th-230	7.54E+04	1.01E-01	1.32E-01	7.65E-01
U-232	6.89E+01	1.77E-04	4.06E-04	4.36E-01
K-40	1.27E+09	5.90E-01	1.45E+00	4.07E-01
U-238	4.47E+09	3.12E-01	1.48E+00	2.11E-01
Cs-137	3.01E+01	3.71E+03	1.85E+04	2.01E-01
I-129	1.57E+07	1.50E-01	9.85E-01	1.52E-01
Np-237	2.14E+06	5.37E-02	4.88E-01	1.10E-01
Pu-238	8.77E+01	1.44E+01	1.77E+02	8.14E-02
U-234	2.46E+05	3.47E-01	4.57E+00	7.59E-02
Ac-227	2.18E+01	1.13E-06	1.55E-05	7.29E-02
Pu-241	1.43E+01	3.01E+00	4.85E+01	6.21E-02
Eu-152	1.35E+01	4.14E+01	7.34E+02	5.64E-02
Eu-154	8.59E+00	3.17E+01	6.23E+02	5.09E-02
Sr-90	2.88E+01	7.75E+02	1.74E+04	4.45E-02
Pa-231	3.28E+04	1.64E-06	5.30E-05	3.09E-02
Am-241	4.32E+02	4.07E-01	1.81E+01	2.25E-02
Tc-99	2.11E+05	8.13E-02	4.37E+00	1.86E-02
U-236	2.34E+07	9.78E-04	1.53E-01	6.39E-03
Se-79	1.10E+06	6.02E-06	1.26E-01	4.78E-05
Sm-151	9.00E+01	3.56E-05	2.56E+02	1.39E-07
Kr-85	1.08E+01	1.41E-05	8.79E+02	1.60E-08
Cf-251	8.98E+02	2.78E-29	7.22E-19	3.85E-11

a. Ratio of Actual Disposals to PA Inventory greater than one indicates the radionuclide actual disposals are greater than the PA inventory. Exceeding this inventory does not suggest DOE O 435.1 performance objectives have not been met but that the increased disposals need to be assessed. Radionuclide disposals to date meet the WAC (DOE-ID 2009).

b. NA = no ratio given because this radionuclide was not in the PA inventory.

PA performance assessment

Table I-1-3. Comparison of the performance assessment inventory to total projected disposals through FY-12 for radionuclides with half-lives greater than 5 years.

Radionuclide	t-1/2 (yr)	Total Projected Disposal through FY-12 (Ci)	PA Inventory (DOE-ID 2003a) (Ci)	Ratio of Total Projected Disposal through FY-12 to PA Inventory ^a
Cl-36	3.01E+05	6.01E-01	0.00E+00	NA ^b
Ni-59	7.60E+04	5.96E+02	0.00E+00	NA ^b
Ni-63	1.00E+02	1.09E+05	0.00E+00	NA ^b
Cm-250	9.70E+03	2.98E-12	4.20E-25	7.10E+12
Cf-249	3.51E+02	2.35E-04	3.13E-16	7.51E+11
Cm-248	3.48E+05	5.94E-05	1.48E-16	4.01E+11
Cm-247	1.56E+07	1.11E-05	4.85E-16	2.29E+10
C-14	5.70E+03	3.18E+04	3.50E-05	9.09E+08
Pu-244	8.00E+07	6.45E-03	1.93E-11	3.34E+08
Ra-228	5.75E+00	1.45E-03	1.16E-10	1.25E+07
Cm-246	4.76E+03	1.14E-02	1.36E-09	8.38E+06
Nb-94	2.03E+04	1.40E+01	6.70E-06	2.09E+06
Be-10	1.51E+06	1.73E+00	8.67E-07	2.00E+06
Cm-245	8.50E+03	8.62E-03	6.09E-08	3.14E+03
Pb-210	2.23E+01	2.72E-02	8.29E-07	3.28E+04
Cm-243	2.91E+01	2.75E-02	2.70E-06	1.02E+04
U-233	1.59E+05	1.22E-01	1.94E-05	6.29E+03
H-3	1.23E+01	1.40E+05	3.76E+01	3.72E+03
Cm-244	1.81E+01	1.48E+00	1.37E-03	1.08E+03
Th-229	7.34E+03	6.03E-06	3.89E-08	1.55E+02
Am-242m	1.41E+02	3.36E-03	3.43E-05	9.80E+01
Co-60	5.27E+00	8.95E+03	1.47E+02	6.09E+01
Pu-242	3.73E+05	9.19E-03	1.83E-04	5.02E+01
Am-243	7.37E+03	7.94E-03	2.53E-04	3.14E+01
U-232	6.89E+01	7.97E-03	4.06E-04	1.96E+01
Pu-240	6.56E+03	1.53E+01	1.14E+00	1.34E+01
Tc-99	2.11E+05	2.83E+01	4.37E+00	6.48E+00
Pu-239	2.41E+04	2.50E+01	5.06E+00	4.94E+00
Ra-226	1.60E+03	1.00E+00	3.60E-01	2.78E+00
Ag-108m	4.18E+02	1.56E+00	6.07E-01	2.57E+00
Cs-137	3.01E+01	4.69E+04	1.85E+04	2.54E+00
Pu-241	1.43E+01	1.05E+02	4.85E+01	2.16E+00
U-235	7.04E+08	2.02E-01	8.37E-02	1.05E+00
Sr-90	2.88E+01	1.55E+04	1.74E+04	8.91E-01
Th-232	1.41E+10	9.14E-02	1.18E-01	7.66E-01
Th-230	7.54E+04	1.01E-01	1.32E-01	7.65E-01
K-40	1.27E+09	8.70E-01	1.45E+00	4.07E-01
Eu-152	1.35E+01	3.55E+02	7.34E+02	4.84E-01
Eu-154	8.59E+00	2.55E+02	6.23E+02	4.09E-01
Np-237	2.14E+06	1.66E-01	4.88E-01	3.40E-01
U-238	4.47E+09	4.89E-01	1.48E+00	2.11E-01
Ac-227	2.18E+01	5.09E-06	1.55E-05	3.28E-01

Table I-1-3. (continued).

Radionuclide	t-1/2 (yr)	Total Projected Disposal through FY-12 (Ci)	PA Inventory (DOE-ID 2003a) (Ci)	Ratio of Total Projected Disposal through FY-12 to PA Inventory ^a
I-129	1.57E+07	2.11E-01	9.85E-01	2.14E-01
Pu-238	8.77E+01	3.76E+01	1.77E+02	2.12E-01
Am-241	4.32E+02	3.43E+00	1.81E+01	1.90E-01
Pa-231	3.28E+04	7.37E-06	5.30E-05	1.39E-01
U-234	2.46E+05	4.34E-01	4.57E+00	9.50E-02
U-236	2.34E+07	2.84E-03	1.53E-01	1.86E-02
Se-79	1.10E+06	2.71E-05	1.26E-01	2.15E-04
Sm-151	9.00E+01	1.60E-04	2.56E+02	6.25E-07
Kr-85	1.08E+01	6.33E-05	8.79E+02	7.20E-08
Cf-251	8.98E+02	1.25E-28	7.22E-19	1.73E-10

a. Ratio of Actual Disposals to PA Inventory greater than one indicates the radionuclide actual disposals are greater than the PA inventory. Exceeding this inventory does not suggest DOE O 435.1 performance objectives have not been met but that the increased disposals need to be assessed. Radionuclide disposals to date meet the WAC (DOE-ID 2009).

b. NA = no ratio given because this radionuclide was not in the PA inventory.

PA performance assessment

Waste receipts to date for some radionuclides are greater than the inventory assessed in the PA (DOE-ID 2003a). Exceeding the PA inventory does not suggest that the DOE O 435.1 performance objectives have not been met but indicates that the increased disposals need to be assessed. Appendix B presents a summary of the groundwater fate and transport modeling and preliminary results for the proposed technical update to ICDF Landfill PA modeling. This modeling will update the original PA and CA modeling documented in DOE-ID (2003a) and DOE-ID (2003b), respectively. It is presented here in this annual report to demonstrate that the ICDF Landfill is in compliance with DOE Order 435.1 even though the actual radionuclide inventories disposed of are higher in some cases than the design basis inventory for the facility.

I-1.3 Waste Forms

Waste forms at the ICDF landfill include solid debris, metals, activated metals, beryllium, graphite, soils, personal protective equipment, concrete, asphalt, glass, steel, wood, metals, plastic, grout, piping, filters, etc. Waste containers for packaged waste disposals include metal drums, metal boxes, wood boxes, concrete boxes, and cloth soil sacks. The bulk waste, mainly soils and debris (pipe, building rubble, etc.) are hauled to the landfill in dump trucks and roll-offs. Nonstandard waste disposals include the V-9 tank from Test Area North, the Engineering Test Reactor vessel, and the Power Burst Facility reactor vessel.

Waste forms assessed in the PA (DOE-ID 2003a) were conservative, assuming mostly compacted soil. This waste form is conservative compared to containers because it assumes the radionuclides are immediately available for leaching to the environment. Different waste forms (such as metals) will tend to decrease the contaminant flux particularly in the early times. However, increasing the inventory will increase the radionuclide flux. Future evaluations are necessary to evaluate the tradeoffs between increased inventory and releases from other waste forms, in particular from activated metals.

The heavy waste objects (i.e., reactor vessels) are evaluated operationally to ensure there is no negative effect on the landfill liner system. These heavy objects should not impact the PA as the geomembrane liners are not simulated in the PA analysis.

I-1.4 Waste Acceptance Criteria

ICDF Complex Waste Acceptance Criteria specifies the chemical and radiological WAC for waste disposed of at ICDF (DOE-ID 2009). Radionuclide disposals to date meet the ICDF WAC (DOE-ID 2009) (see Table I-1-4). Additionally, although waste receipts for a number of radionuclides exceed the design-based inventory on which the PA results are based, none of these isotopes exceed any of the PA derived WACs (DOE-ID 2003a). However, for many of the radionuclides, performance-based WAC were not calculated because the radionuclide was either screened from further analysis due to the small inventory assessed in the PA or the radionuclide was not considered in the inventory assessed in the PA as a radionuclide that would be disposed of to the landfill. In addition, the operating WAC (DOE-ID 2009) for C-14, Cs-137, Pa-231, Sr-90, and U-232 are less conservative than the performance-based WAC (DOE-ID 2003a). The total waste disposals through FY-08 for these radionuclides are at least 1,000 times smaller than the performance-based values (DOE-ID 2003a), indicating the DOE O 435.1 performance objectives are still being met.

I-1.5 Summary of Waste Receipts

The inventory assessed in the PA (DOE-ID 2003a) is less than the actual and projected disposals for many radionuclides. However, the results of the PA remain valid (i.e., there is still a reasonable expectation of meeting performance objectives), but the actual and projected inventories indicate less conservatism in the PA results than previously believed (see Tables I-1-2 and I-1-3). Appendix B presents a summary of the groundwater fate and transport modeling and preliminary results for the proposed technical update to ICDF Landfill PA modeling. It demonstrates that the ICDF Landfill is in compliance with DOE Order 435.1 even though the actual radionuclide inventories disposed of are higher in some cases than the design-basis inventory for the facility.

The inventory assessed in the PA was also assessed in the CA (DOE-ID 2003b). The results of the CA remain valid (i.e., there is still a reasonable expectation of meeting performance objectives), but the new information indicates less conservatism in the results than previously believed. Sources of residual radioactive material additional to that considered in the CA (DOE-ID 2003b) may be left in place, and more complete information on total inventories continues to become available as DD&D progresses on the Site than what was assumed when the CA was prepared. A groundwater fate and transport model was developed to address the potential for plumes from INL facilities to commingle (DOE-ID 2008a). The flux rates from this modeling could be used in revised CA modeling (see Section I-3 for more detail).

Table I-1-4. Comparison of actual disposals through FY-08 for radionuclides with half-lives greater than 5 years to the performance assessment (DOE-ID 2003a) and ICDF (DOE-ID 2009) waste acceptance criteria.

Radionuclide	t-1/2 (yr)	Actual Disposal through FY-08 (Ci)	PA WAC ^a (DOE-ID 2003a) (Ci)	ICDF WAC (DOE-ID 2009) (Ci)
Cm-250	9.70E+03	6.62E-13	NA ^b	NM
Cf-249	3.51E+02	5.22E-05	NA ^b	2.9E+06
Cm-248	3.48E+05	1.32E-05	NA ^b	2.6E+04
Cm-247	1.56E+07	2.46E-06	NA ^b	5.9E+02
Ra-228	5.75E+00	1.45E-03	NA ^b	NM
Cm-246	4.76E+03	2.53E-03	NA ^b	1.9E+05
C-14	5.70E+03	2.52E+01	2.2E+04	5.1E+05 ^c
Nb-94	2.03E+04	3.14E+00	NA ^b	7.1E+07
Be-10	1.51E+06	3.84E-01	NA ^b	1.2E+06
Cm-243	2.91E+01	2.54E-02	NA ^b	6.3E+01
Pb-210	2.23E+01	6.04E-03	NA ^b	No limit
U-233	1.59E+05	8.11E-02	NA ^b	1.2E+05
Cm-245	8.50E+03	1.91E-04	NA ^b	1.2E+05
H-3	1.23E+01	3.11E+04	1.8E+12	3.8E+04
Cm-244	1.81E+01	3.48E-01	5.1E+06	3.9E+05
Pu-244	8.00E+07	1.56E-09	NA ^b	3.1E+02
Th-229	7.34E+03	1.34E-06	NA ^b	3.1E+09
Am-242m	1.41E+02	7.47E-04	NA ^b	NM
Co-60	5.27E+00	1.99E+03	1.4E+10	1.5E+05
Pu-240	6.56E+03	9.34E+00	7.7E+04	1.1E+03
Am-243	7.37E+03	1.58E-03	7.4E+04	2.5E-01 ^c
Ra-226	1.60E+03	8.80E-01	1.9E+04	3.6E+02
Pu-239	2.41E+04	1.11E+01	7.7E+04	5.1E+03
U-235	7.04E+08	8.77E-02	2.1E+05	8.3E+01
Pu-242	3.73E+05	1.60E-04	8.0E+04	2.4E+03
Ag-108m	4.18E+02	5.14E-01	7.7E+04	6.1E+02
Th-232	1.41E+10	9.04E-02	1.6E+04	1.3E+01
Th-230	7.54E+04	1.01E-01	5.0E+04	1.1E+01
U-232	6.89E+01	1.77E-04	8.3E+04	3.3E+21 ^c
K-40	1.27E+09	5.90E-01	2.6E+05	1.8E+02
U-238	4.47E+09	3.12E-01	2.7E+05	1.5E+03
Cs-137	3.01E+01	3.71E+03	1.2E+06	1.7E+09 ^c
I-129	1.57E+07	1.50E-01	9.9E+00	2.4E+00
Np-237	2.14E+06	5.37E-02	4.2E+04	4.9E+02
Pu-238	8.77E+01	1.44E+01	1.8E+05	7.6E+03
U-234	2.46E+05	3.47E-01	2.4E+05	2.6E+03
Ac-227	2.18E+01	1.13E-06	NA ^b	No limit
Pu-241	1.43E+01	3.01E+00	2.5E+06	4.9E+04
Eu-152	1.35E+01	4.14E+01	1.6E+07	7.3E+05

Table I-1-4. (continued).

Radionuclide	t-1/2 (yr)	Actual Disposal through FY-08 (Ci)	PA WAC ^a (DOE-ID 2003a) (Ci)	ICDF WAC (DOE-ID 2009) (Ci)
Eu-154	8.59E+00	3.17E+01	1.5E+08	6.2E+05
Sr-90	2.88E+01	7.75E+02	9.9E+05	2.7E+09 ^c
Pa-231	3.28E+04	1.64E-06	2.4E+04	1.6E+09 ^c
Am-241	4.32E+02	4.07E-01	8.7E+04	7.6E+03
Tc-99	2.11E+05	8.13E-02	6.7E+04	4.4E+03
U-236	2.34E+07	9.78E-04	2.6E+05	1.5E+02
Se-79	1.10E+06	6.02E-06	4.3E+06	NM
Sm-151	9.00E+01	3.56E-05	2.4E+09	2.6E+05
Kr-85	1.08E+01	1.41E-05	NA ^b	ND
Cf-251	8.98E+02	2.78E-29	NA ^b	1.0E+07
Cl-36	3.01E+05	1.34E-01	NA ^d	1.0E+01
Ni-59	7.60E+04	1.33E+02	NA ^d	7.2E+06
Ni-63	1.00E+02	2.42E+04	NA ^d	4.6E+07

a. Adapted from Table 8-5 of DOE-ID (2003a) minimum value of acute, chronic, and groundwater PA calculations.

b. NA = value not calculated because radionuclide was screened out in early phase of screening assessment based on inventory.

c. These values are less conservative than the PA values (DOE-ID 2003a). However, total waste disposals through FY-08 are at least 1,000 times smaller than these PA values (DOE-ID 2003a).

d. NA = value not calculated because radionuclide was not in the design inventory.

ND indicates no data available

NM needs modeling (DOE-ID 2009)

PA performance assessment

WAC waste acceptance criteria

I-2. MONITORING

The ICDF landfill is a state-of-the-art engineered disposal facility that includes layers of liners constructed of both synthetic and geologic materials and is fully compliant with the Resource Conservation and Recovery Act Subpart C. Leachate is collected above the liners in the leachate collection and recovery system and disposed of into a lined evaporation pond. Below the upper system of liners is a primary leak detection and recovery system (PLDRS) to detect whether the landfill cells are leaking. Below this is another liner underlain by a secondary leak detection and recovery system (SLDRS).

During landfill design, a prediction (considered conservative at the time) of the volume of the leachate and the expected constituent concentrations in the leachate that would be generated over time during both operational and post-closure activities based on the design inventory was developed (INEEL 2005). This formed the basis for an assessment of liner/leachate compatibility. The estimate of leachate chemical composition was used to assess worker exposure to landfill contaminants in the evaporation pond to ensure that worker protection requirements would be met. The Subsurface Transport Over Multiple Phase (STOMP) model was used for fate and transport simulations to ensure that the landfill design would meet remedial action objectives for groundwater (EDF-ER-274). However, since the inventory assessed in the PA (DOE-ID 2003a) is no longer considered conservative, it is not known if the leachate predictions are truly conservative.

Routine sampling of leachate, evaporation pond liquid and sediment, and pump station liquid and monitoring of the PLDRS and SLDRS occur in accordance with Table 3 in the *ICDF Complex Operational and Monitoring Sampling and Analysis Plan* (DOE-ID 2003d). Evaporation pond liquid is analyzed annually for Co-60, Cs-137, I-129, Pu-238, Sr-90, and U-234 using gamma spectroscopy. Gamma spectroscopy analysis for H-3, I-129, Pu-238, Pu-239/240, Sr-90, Tc-99, U-234, U-235, and U-238 occurs every 5 years for sediment in the evaporation pond and quarterly for leachate in the leachate collection and recovery system sump. Leachate is also analyzed monthly for I-129. The leachate volume is compared against the predictions in the “Leachate Contaminant Reduction Time Study” (EDF-ER-274 2005) to determine if the action leakage rate has been exceeded. Monitoring at the ICDF landfill indicates that the landfill has not leaked.

The groundwater monitoring network consists of perched water and aquifer monitoring wells in the immediate vicinity of the ICDF landfill and evaporation pond (see Figure I-2-1). The perched water monitoring wells consist of 17 monitoring zones (many of the wells have multiple completions). The Snake River Plain Aquifer is located approximately 470 ft below ground surface. The ICDF was constructed downgradient of the former INTEC injection well and is located above the existing Sr-90 plume from the injection well. Routine use of the INTEC injection well was discontinued in 1984 when the wastewater was diverted to the INTEC percolation ponds, which received the service wastewater until late August 2002. The injection well was sealed and abandoned in 1989. The ICDF landfill was constructed adjacent to the former percolation ponds. When the ICDF was under construction and during its early operations, perched water existed in two layers at approximately 250 ft and 380 ft below ground surface. The chemical signatures of the perched water collected during ICDF baseline sampling demonstrated that the former percolation ponds were the source of the perched water (Cahn and Ansley 2004). Transducers were installed to monitor the drain out of the perched water. The perched water wells now have insufficient water for sampling, and water levels are monitored as part of the ICDF detection monitoring system.

Figure I-2-1. The ICDF layout and well locations.

The ICDF groundwater detection monitoring network consists of one monitoring well that is upgradient and five monitoring wells that are downgradient of the landfill and evaporation pond. The *ICDF Complex Groundwater Monitoring Plan* (DOE-ID 2007) details the groundwater monitoring requirements associated with the ICDF, including monitoring wells, sample frequency, required analytes, laboratory analysis, fieldwork, and quality control. The *INEEL CERCLA Disposal Facility Groundwater Detection Monitoring Program: Data Analysis Plan* (DOE-ID 2003e) details the approach used to evaluate the groundwater data collected in support of the ICDF detection monitoring program.

The monitoring wells (both perched water and aquifer wells) were sampled for a large list of compounds during baseline sampling. The radionuclides included: Ag-108m, Ag-110m, C-14, Ce-144, Co-60, Cs-134, Cs-137, Eu-152, Eu-154, Eu-155, H-3, I-129, Mn-54, Nb-94, Pu-238, Pu-239/240, Ru-106, Sb-125, Sr-90, Tc-99, U-233/234, U-235, U-238, and Zn-65. The analysis of baseline samples to determine detection monitoring limits is documented in INEEL (2006). The background water quality represents initial baseline conditions because there is preexisting contamination of groundwater under ICDF from upgradient sources at INTEC. Once baseline sampling was completed, the wells were sampled and analyzed quarterly initially and then semiannually. The wells were sampled for indicator parameters, which originally included Tc-99 and Sr-90. Results were compared against detection monitoring limits. In 2007, an analysis of leachate samples was conducted to determine more appropriate indicator parameters based on which contaminants occurred in higher concentrations in leachate than in the groundwater so that a leak from the ICDF could be clearly distinguished from the preexisting INTEC-related contamination (Cahn 2007). On the basis of this evaluation, the indicator parameters were modified. The radionuclides that are now part of detection monitoring are U-233/234 and U-238. Groundwater monitoring reports are prepared annually, with the biennial report including a more detailed statistical evaluation to evaluate whether the detection monitoring limits should be modified. The first biennial report *ICDF Detection Monitoring Biennial Report (2006-2007)* (DOE-ID 2008b) evaluated the analytical results collected from the six Snake River Plain Aquifer wells during calendar years 2006 and 2007 and is the first biennial report following completion of baseline sampling. The groundwater monitoring reports demonstrate that the ICDF is not leaking.

Groundwater monitoring pertaining to the CA conceptual model indicates Sr-90 and Tc-99 are the only radionuclides whose concentrations in groundwater exceed maximum contaminant levels at and downgradient of INTEC. Concentrations of these contaminants are slowly declining as a result of radioactive decay and/or dilution and dispersion. Current trends indicate that concentrations of Sr-90 and Tc-99 will decline below the maximum contaminant level before the year 2095 (DOE-NE-ID 2006b).

I-3. RESEARCH AND DEVELOPMENT

A revised flow and transport model for the ICDF PA is being developed using the modeling protocol established for the original ICDF PA (DOE-ID 2003a). Changes incorporated into the revised PA model include new source release, vadose zone, and groundwater models. For both the source release and vadose zone transport model, the Mixing Cell Model (MCM, Rood 2005) is used. For the groundwater model the recently developed Response Surface Model (RSM) (Rood 2005 and DOE-ID 2008a) will also be used.

The MCM model is used in two steps. The first step is to simulate the leaching of nuclides from the surface soils to the deeper vadose zone, and the second step is to simulate the transport through the vadose zone and mass flux to the aquifer. The basis for the MCM model is described in Rood (2005). The conceptual model defines the unsaturated subsurface environment as a series of individual mixing cells. Within each mixing cell, the moisture content (fraction of the mixing cell volume composed of water) and contaminant concentration are uniform and assumed to equilibrate instantaneously in response to a change in the amount of water or contaminant entering the cell. Each mixing cell may have its own unique properties that include vertical dimensions, bulk density, hydraulic characteristics (e.g., porosity, residual moisture content, and hydraulic conductivity), and sorptive properties. Water balance within each cell is maintained by the difference between inflow and outflow. The water flux or specific discharge entering the uppermost mixing cell (q) is assumed to be the net infiltration rate past the root zone. The net infiltration rate may change with time and, in turn, affect the specific discharge through all remaining cells below it. Water movement is assumed to be downward and under unit gradient conditions within a mixing cell. Specific discharge is assumed to be less than the saturated hydraulic conductivity of any of the materials composing the vadose zone.

The use of MCM allows for consideration of transient infiltration and differential transport of radioactive progeny in the vadose zone. Additionally, the use of MCM will allow evaluation of different waste forms, and initial conditions in the vadose zone (i.e., perched water and contamination), and will be consistent with the modeling methodology used for the Radioactive Waste Management Complex PA (DOE-NE-ID 2007). GWSCREEN (Rood 2003), a simple flow and transport model, is retained in the revised model for transport of radionuclides in the aquifer. The MCM and GWSCREEN models were developed using the conceptual model, assumptions, parameter values, and the source term from the original PA (DOE-ID 2003a). The use of MCM will allow for additional sensitivity cases to be run that involve transient infiltration or initial contamination in the vadose zone. The revised runs will include a revised source term with different waste forms and release mechanisms that cannot be modeled with GWSCREEN but can be modeled with MCM.

The recently developed RSM will be used to simulate regional-scale groundwater transport for the OU 10-08 Site-wide groundwater Remedial Investigation/Baseline Risk Assessment (encompasses the entire INL aquifer) (DOE-ID 2008a). The mathematical basis for the RSM is described in Rood (2005) and DOE-ID (2008a). The model is essentially an abstraction of a detailed flow and transport model where the behavior of the system may be described by the response observed at a receptor to an input at a source. As applied to a numerical model where the model domain is discretized into "nodes," this represents the response at a receptor node to an input at a source node. The response (termed a response function) represents the breakthrough curve at a receptor node from an instantaneously injected conservative tracer at a source node. Concentrations are then calculated by convolution of the response function, time-dependent source-loading rates, and adjustments for decay and retardation. Like GWSCREEN, simplified assumptions are made regarding transport of radioactive progeny, uniform retardation, and uniform porosity.

The RSM retains all the complexity of the underlying flow and transport model but can be executed in a fraction of the time. The RSM could be used in updating the CA to compute transport of radionuclides released from upgradient sources.

Section 7.2 *Further Work* of the PA (DOE-ID 2003a) suggested several ongoing studies and/or research projects that may provide new information that may impact the PA conceptual model assumptions. The status of some of these activities is summarized below and any new information that could be used to refine the PA conceptual model will be incorporated into the next revision of the PA.

- *Because the prediction of flow and transport in the vadose zone has a high level of uncertainty, a tracer test has been conducted and the analyses from this test are pending. Tracers were introduced in the INTEC percolation pond and the sewage treatment pond. Monitoring is currently underway. In the future, when sufficient water is running in the Big Lost River, a tracer will be introduced in the river as well.*

The Big Lost River did not flow during the years 2000 through 2004, therefore, the proposed Big Lost River tracer test was never done. However, the OU 3-14 RI/BRA (DOE-NE-ID 2006b) provides information on the effect of Big Lost River infiltration on contaminant transport. Both the perched water monitoring results and the OU 3-14 vadose zone modeling indicate that anthropogenic recharge (e.g., pipeline water leaks) and precipitation infiltration within the INTEC facility are the most important with respect to contaminant transport beneath the tank farm area; the Big Lost River infiltration is much less important because most of the river water moves rapidly to the deep vadose zone and the Snake River Plain Aquifer, and does not travel laterally very far within the shallow alluvium. Based on this new information, there is no change to the PA conceptual model in this regard.

- *The objective of the study is to follow the transport of the tracer through the vadose zone. The study will provide new information on (1) the horizontal spreading of contaminants in the vadose zone in the vicinity of surface water sources, (2) the velocity of movement in the horizontal directions, (3) the vertical transport velocity, and (4) the total travel time from the surface to the aquifer under relatively well-defined water flux conditions.*

When the Big Lost River flowed briefly during 2006, good data on the water-level response in the perched water and the Snake River Plain Aquifer monitoring wells were obtained. This information is summarized in the *Groundwater Monitoring Report (2006)* (DOE-ID 2007), and gives an indication of vertical and horizontal flow velocities. Similar water-level responses are occurring this year as a result of the recent period of Big Lost River flow from June 18, 2009, to July 4, 2009. The next revision of the PA will incorporate this new information into the conceptual model as applicable.

- *The subsurface science initiative at the INL is actively involved in research to better understand the mechanisms controlling flow and transport of contaminants in the subsurface. The results of this research could modify the conceptual model upon which the ICDF landfill analyses are based. Therefore, the research progress will be monitored and results incorporated into the PA annual reviews. Examples of areas of interest include:*
 - *Unsaturated hydraulic parameter—Appendixes A and B of DOE-NE-ID (2006b) will be reviewed for the most up-to-date hydraulic parameters and incorporated into the conceptual model as applicable.*

- *Distribution coefficients in sediments, basalt matrix, vertical fractures in the vadose zone, and rubble zones in the aquifer*—Appendixes D and J in DOE-NE-ID (2006b) will be reviewed for the most up-to-date K_d values and incorporated into the conceptual model as applicable.
- *Flow and transport in fractures*—Not much new information here. The vadose zone and Snake River Plain Aquifer models basically ignore fractures as discrete flow zones, as it is impossible to fully characterize and model the geometry of fracture systems.
- *Flow and transport interactions at basalt-sediment interfaces*—Appendixes A and B of DOE-NE-ID (2006b) provide some new information on the effect of sedimentary interbeds on flow and transport. This new information will be reviewed and assessed for incorporation into the revised PA conceptual model.
- *Facilitated transport*—The colloidal transport of Pu, Sr, etc., is not dealt with in this new work (DOE-NE-ID 2006b), nor do we have evidence that it's a very important process.
- *Performance of infiltration reducing covers on disposal facilities*—Information from the Radioactive Waste Management Complex (RWMC) Active Low-Level Waste (LLW) Disposal Facility PA pertaining to this topic will be reviewed for applicability (DOE-NE-ID 2007).
- *Source-term releases as influenced by geochemistry*—Appendix E of DOE-NE-ID (2006b) presents some INTEC source terms. This new information will be incorporated into the revised PA conceptual model as applicable.
- *Testing and development of new and better ways to measure parameters and monitor the movement of contaminants in the subsurface*—The “colloidal borescope” that was used in a few wells to monitor horizontal ground water flow velocities across the screened interval may provide some new information for the revised PA conceptual model (ICP 2004).

I-4. OTHER RELEVANT FACTORS

Other relevant factors to be considered include operational and design considerations including PA controls such as waste verification, acceptance and compliance; all of which is discussed below.

I-4.1 Operations, Facility Closure, and Design

Three major CERCLA documents deal with the design, construction, operation, and closure of the ICDF Complex. The first major document is the Staging, Storage, Sizing, and Treatment Facility (SSSTF) Remedial Design/Construction Work Plan (RD/CWP), which describes the SSSTF design and construction (DOE-ID 2002a). The second major document addressing design and construction is the ICDF RD/CWP, which describes landfill and evaporation pond design and construction (DOE-ID 2002b). Operation and closure of the ICDF Complex are discussed in the *ICDF Complex Remedial Action Work Plan* (DOE-ID 2006). There have been no significant changes in operations at the landfill with respect to disposal geometry, the verification of waste characteristics, and the tracking of inventories against total limits that would affect the results and conclusions of the PA/CA (DOE-ID 2003a,b), and there have been no changes in conceptual design closure conditions that would affect the results and conclusions of the PA/CA (DOE-ID 2003a,b). The assumptions and analyses in the PA/CA are consistent with the INL Site future use plans (Kostelnik 2005).

I-4.2 Performance Assessment Controls Waste Verification, Acceptance, and Compliance

NOTE: *There is no process for “certifying” generators. Since all waste destined for the ICDF landfill must be CERCLA-generated from within the INL Site, the generators are all known quantities and all must comply with the requirements/process described below.*

I-4.2.1 Waste Verification and Acceptance

Characterization of all waste submitted for acceptance into the ICDF Complex is the responsibility of the ICDF Complex users (generators). The process for characterizing waste by the generator and acceptance by ICDF is described in the *ICDF Complex Waste Profile and Verification and Sample Guidance*, (DOE-NE-ID 2006a). The generator may use either acceptable knowledge or sampling and analysis to characterize waste. Acceptable knowledge includes both historical data and process knowledge (DOE-NE-ID 2006a). If process knowledge is used rather than (or in addition to) sampling and analysis, documentation must be provided to demonstrate that the information is sufficient to accurately and completely characterize the waste stream.

All waste received at ICDF is tracked using the Integrated Waste Tracking System (IWTS). Before waste is accepted into the ICDF Complex, an IWTS Material Profile must be completed by the Waste Management Waste Generator Services (WGS) organization and approved by the ICDF Waste Disposition Specialist (WDS). As containers of waste are generated, container profiles are prepared by WGS and approved by the ICDF WDS. All waste received at the ICDF must be on the ICDF Complex schedule.

All ICDF Complex users must provide long-term and operational project schedules to ICDF Complex management and operations for planning purposes. Information necessary for the long-term schedules includes, at a minimum, the estimated start date, completion date, waste volume, general class of waste, primary waste forms, and any anticipated need for treatment at the ICDF Complex.

I-4.2.2 Waste Acceptance into the ICDF

The ICDF Complex user works with WGS to complete an IWTS Material Profile for each waste stream. The Material Profile documents all chemical, radiological, and physical characteristics of a waste stream. IWTS automatically assigns the Material Profile a unique identification number, beginning the process of electronic tracking of the waste.

The ICDF WDS reviews the Material Profile and electronically accepts or rejects the waste stream. Once the Material Profile has been approved by ICDF WDS, the ICDF Complex user has approval to send the waste to the ICDF Complex.

An IWTS Container Profile is used to track individual containers of waste belonging to a waste stream identified by, and electronically tied to, the Material Profile. A container in IWTS is defined as a parcel of waste with a defined volume and weight, such as a box, roll-on/roll-off, dump truck, or drum. The Container Profile identifies all chemical, radiological, and physical characteristics for each container. These characteristics are entered as specific values bounded by the maximum/minimum ranges of the associated Material Profile.

The WGS completes a Container Profile for each container of waste to be shipped to the ICDF. A unique bar code number is manually applied to the container and used as the identifier when the corresponding Container Profile is created in IWTS. This bar code number identifies the physical container and electronically ties it to the appropriate Container Profile. After both the Material and Container Profiles are approved by the ICDF WDS, the waste will be assigned a date for shipment to the ICDF Complex.

I-4.2.3 Inventory Tracking and Compliance Limits

Inventory histories for all ICDF storage, staging, treatment, and disposal locations are used to provide real-time data on the current inventory and ensure compliance with facility limits (e.g., operational, WAC). Location-specific inventories are maintained by physical properties (e.g., individual container ID number, total container count, and total volume and weight), radiological properties (e.g., fissile material, individual radionuclides, and activities), and chemical properties (e.g., constituents and amounts).

Numerous compliance checks (e.g., physical, radiological, chemical, operational) have been built into IWTS. “Physical Inventory” checks include gross and net weight, gross and net volume, and container count. “Radiological Inventory” checks include fissile material, reportable quantities, less than DOE Hazard Category III, and user-defined nuclides. “Chemical and Other Inventory” checks include threshold quantities, threshold planning quantities, reportable quantities, flammable material, and user-defined materials. “Operational Inventory” checks include land disposal restrictions, Idaho Administrative Procedures Act, National Emission Standards for Hazardous Air Pollutants, groundwater contaminants of concern, and transuranic radionuclide concentration. Limit compliance reports have been prepared for each limit identified above and are available for the various locations at the ICDF Complex. Limit evaluations are electronically stored for each task and provide objective evidence demonstrating limit compliance.

I-5. SPECIAL ANALYSES AND REVIEWS

A special analysis was performed in 2005 for the ICDF landfill to evaluate the disposal of radionuclides not analyzed in the PA and wastes that exceed the concentrations analyzed for the PA (EDF-5544).

EDF-5544 was prepared to support the disposal of the Power Burst Facility In-Pile Tube (IPT). Performance-based waste concentration thresholds and total inventory thresholds for Ni-59, Ni-63, and Nb-94 were calculated. The average concentrations and total inventories of Ni-59 and Ni-63 and the total inventory of Nb-94 in the IPT are within the generally applicable thresholds derived from this special PA. The average concentration of Nb-94 in the IPT is above the generally applicable radionuclide concentration threshold for Nb-94. But, when the specific disposal configuration for the IPT is accounted for in the intruder post-drilling scenario, the average concentration of Nb-94 in the IPT is acceptable for disposal in the ICDF.

PART II – ANNUAL SUMMARY

DOE M 435.1-1 IV.P (4)(c) states that “Annual summaries of low-level waste disposal operations shall be prepared with respect to the conclusions and recommendations of the performance assessment and composite analysis and a determination of the need to revise the performance assessment or composite analysis.” The annual summary should be prepared by summarizing the information and conclusions from the annual determination. The annual summary includes information on the adequacy of the PA and CA, waste receipts, monitoring and research and development results, summary of changes, and recommended changes.

II-1. ADEQUACY OF PERFORMANCE ASSESSMENT AND COMPOSITE ANALYSIS

The conclusions of the PA remain valid (i.e., there is still a reasonable expectation of meeting performance objectives), but the new information indicates less conservatism in the results than previously believed. Waste receipts to date and projected waste receipts through FY-12 are both greater than the inventory assessed in the PA and CA. Some of the waste forms disposed of to the landfill are different from the waste form (compacted soil) assessed in the PA and CA. Appendix B presents a summary of the groundwater fate and transport modeling and preliminary results for the proposed technical update to ICDF Landfill PA modeling. It demonstrates that the ICDF Landfill is in compliance with DOE Order 435.1 even though the actual radionuclide inventories disposed of are higher in some cases than the design-basis inventory for the facility.

II-2. WASTE RECEIPTS

After 5 years of operation, 52% of the available volume of the ICDF landfill has been filled based on a recent aerial survey (EDF-9071). A total of 35,270 m³ (46,133 yd³) of waste was disposed of at the ICDF landfill in FY-08 compared to 27,613 m³ (36,117 yd³) disposed of in FY-07.

Waste receipts to date are greater than the inventory assessed in the PA (DOE-ID 2003a). Exceeding the PA inventory does not suggest that the DOE O 435.1 performance objectives have not been met but indicates that the increased disposals need to be assessed.

Waste forms assessed in the PA (DOE-ID 2003a) were conservative, assuming mostly compacted soil. This waste form is conservative compared to containers because it assumes the radionuclides are immediately available for leaching to the environment; whereas, waste containers cannot enter the environment until the containers fail. Radionuclides in metals cannot enter the environment until the metal corrodes.

II-3. MONITORING, RESEARCH AND DEVELOPMENT RESULTS

The leak detection system and groundwater monitoring results indicate the landfill has not leaked.

Groundwater monitoring pertaining to the CA conceptual model indicates Sr-90 and Tc-99 are the only radionuclides whose concentrations in groundwater exceed maximum contaminant levels at and downgradient of INTEC. Concentrations of these contaminants are slowly declining as a result of radioactive decay and/or dilution and dispersion. Current trends indicate that concentrations of Sr-90 and Tc-99 will decline below the maximum contaminant level before the year 2095 (DOE-NE-ID 2006b). A groundwater fate and transport model was developed to address the potential for plumes from INL facilities to commingle (DOE-ID 2008a). The flux rates from this modeling could be used in revised CA modeling.

II-4. SUMMARY OF CHANGES

There were no significant discovered changes in facility operations or maintenance pertaining to disposal geometry, verification of waste characteristics, and tracking of inventories against total limits, or in facility closure design that would affect the PA/CA results. However, waste receipts to date and projected waste receipts through FY-12 are both greater than the inventories assessed in the PA (DOE-ID 2003a) and CA (DOE-ID 2003b). The waste forms (reactor vessels, tanks, DD&D debris, activated metal, etc.) disposed of in the landfill are different from the waste form (compacted soil) assessed in the PA and CA.

Research and development changes include a revised groundwater model for the ICDF PA that is being developed using the modeling protocol established for the original ICDF PA (DOE-ID 2003a). Changes incorporated into the revised PA model include new source release and vadose zone transport models using MCM (Rood 2005). MCM allows for consideration of transient infiltration and differential transport of radioactive progeny in the vadose zone. Additionally, MCM will allow for evaluation of different waste forms and initial conditions in the vadose zone (i.e., perched water and contamination). MCM will also allow for additional sensitivity cases to be run that involve transient infiltration or initial contamination in the vadose zone. These model improvements will allow for a more detailed PA analysis. In addition, the Site-wide Waste Area Group 10 groundwater model RSM provides a consistent large-scale groundwater model for assessing the aggregate of residual radioactive material that is likely to add to the dose from the ICDF landfill for the CA analysis.

II-5. RECOMMENDED CHANGES

There are no plans for changes in disposal facility design or operations pertaining to the disposal geometry, the verification of waste characteristics, the tracking of waste inventories against total limits, in facility closure design, or in the PA maintenance program. The inventory assessed in the PA (DOE-ID 2003a) is less than the actual and projected disposals for many radionuclides. However, the results of the PA remain valid (i.e., there is still a reasonable expectation of meeting performance objectives), but the actual and projected waste inventories indicate less conservatism in the PA results than previously believed (see Table I-1-4). Appendix B presents a summary of the groundwater fate and transport modeling and preliminary results for the proposed technical update to ICDF Landfill PA modeling. It demonstrates that the ICDF Landfill is in compliance with DOE Order 435.1 even though the actual radionuclide inventories disposed of are higher in some cases than the design-basis inventory for the facility.

It is therefore recommended that a technical update to the PA be performed to reflect an upper-bound projected inventory using the new source release and vadose zone transport model MCM (Rood 2005). It is recommended that a technical update to the CA be considered after the PA results are known. The CA update would use upper-bound projections of waste receipts, actual waste forms, updated INL source terms, varying infiltration rates, the new source release and vadose zone transport model, and the OU 10-08 Site-wide groundwater modeling results (DOE-ID 2008a).

PART III – REFERENCES

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Appendix A

ICDF Landfill Disposal Authorization Statement and FY 2007 Annual Review

Memorandum

DATE: July 1, 2003

REPLY TO
ATTN OF: EM-43 (Jane Talarico, 301-903-7131)

SUBJECT: Idaho National Engineering and Environmental Laboratory Comprehensive
Environmental Response, Compensation, and Liability Act Disposal Facility Landfill

TO: Elizabeth Sellers, Manager
Idaho Operations Office

On December 2, 2002, Idaho Operations Office submitted the compliance demonstration document that cross-walked the process conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for the Idaho National Engineering and Environmental Laboratory CERCLA Disposal Facility (ICDF) Landfill to the requirements under DOE Order 435.1 *Radioactive Waste Management*. The Idaho Operations Office also submitted a Performance Assessment, a Composite Analysis and the Waste Acceptance Criteria for the ICDF Landfill, and the Final Record of Decision for the Idaho Nuclear Technology and Engineering Center (INTEC). The Low-Level Waste Disposal Facility Federal Review Group reviewed the information submitted and has found that the documentation submitted demonstrates compliance with DOE Order 435.1 *Radioactive Waste Management* and has recommended that disposal authorization be granted for the ICDF Landfill.

As allowed under the provisions of DOE Order 435.1, the Record of Decision for the INTEC signed in 1999 documents the siting, design, operation, and closure and post-closure requirements, rather than a separate Disposal Authorization Statement. The disposal approval of the ICDF Landfill is granted with the understanding that the following information will be provided to the LFRG for review by December 2003:

1. Submit a revised Performance Assessment providing information that demonstrates the long-term protectiveness for the ICDF cover system.
2. Submit a revised Performance Assessment to include justifications for all assumptions; all assumptions and input parameters should have a reference where they are derived from or the justification for the use of the value.
3. Revise the Composite Analysis to include a scheme for monitoring groundwater for technetium-99 and carbon-14. Add tables to the revised Composite Analysis listing the wells sampled along with the concentrations for both technetium-99 and carbon-14.
4. Revise the Composite Analysis to include justifications for assumptions and input parameters.

Congratulations on a successful completion of this critical step in assuring the performance of the ICDF landfill. If you have any questions, please call me or the LFRG co-chairs Jay Rhoderick (301) 903-7211 and Barry Smith (301) 903-4482.

A handwritten signature in black ink that reads "Mark W. Frei". The signature is written in a cursive, flowing style.

Mark W. Frei
Acting Deputy Assistant Secretary for
Project Completion
Environmental Management

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October 2, 2007

CCN 305664

Mr. Richard B. Provencher
Deputy Manager
U.S. Department of Energy
Idaho Operations Office (DOE-ID)
1955 Fremont Avenue
Idaho Falls, ID 83415-1222

SUBJECT: Contract No. DE-AC07-05ID14516 - ICDF Complex Performance Assessment and Composite Analysis compliance Evaluation per DOE Order 435.1

Dear Mr. Provencher:

The purpose of this letter is to document CWI's 2007 evaluation of the Performance Assessment (PA) for the Idaho CERCLA Disposal Facility (DOE/ID-10978), U.S. Department of Energy Manual 435.1-1, "Radioactive Waste Management," Section IV.P. (4)(a) states, "Performance assessments and composite analyses shall be reviewed and revised when changes in waste forms or containers, radionuclide inventories, facility design and operations, closure concepts, or the improved understanding of the performance of the waste disposal facility in combination with the features of the site on which it is located alter the conclusions or the conceptual model(s) of the existing performance assessment or composite analysis."

The disposal approval for the ICDF was granted in a July 2003 letter from Mr. M. Frei to Ms. E. Sellers. Since the initial landfill waste disposal operations began in September 2003, ICDF has been in total compliance with the applicable performance objectives. The PA for the ICDF landfill documents the projected radiological dose impacts associated with the disposal of low-level radioactive waste at the ICDF landfill. This evaluation was conducted to verify compliance with the applicable radiological criteria of the Department of Energy (DOE) and the Environmental Protection Agency (EPA) for protection of the public and the environment. This evaluation addresses low-level waste disposal operations conducted to date at the ICDF.

Radioactive waste forms, containers, and inventories received to date have not been outside the originally established envelope other than the PBF in pile tube that was approved in a Special Performance Assessment. Thus, the ICDF Performance Assessment (DOE/ID-10978) performance objectives have been met, and a revision to the PA is not required at this time.

A review of the radiological inventory received to date compared to the ICDF Complex Waste Acceptance Criteria (WAC)-allowed total limits indicates adequate current remaining volume to accomplish the projected waste receipts throughout the term of the CWI contract. The ICDF WAC is based on a combination of the total allowable radiological inventory that may impact the environment and the protection of worker health and safety.

Projected waste disposal volumes for the ICDF during the remaining years of the CWI contract are included in the following table.

		FY08	FY09	FY10	FY11	FY12	
ER							
LLW	INTEC	233	1,395	4,170	4,170	1,565	
	PBF	0	0	762	2,953	0	
	TAN	233	1,395	4,932	7,123	1,565	
	TRA	5,046	3,107	1,594	2,727	0	
D&D							
LLW	INTEC	310	700	1,040	825	465	
	PBF	0	15	59	174	1,800	
	TAN	17,200	0	0	0	0	
	TRA	297	384	364	614	242	
	RWMC	610	0	0	0	120	
MLLW	INTEC	35	14	18	15	0	
	PBF	0	0	0	0	0	
	TAN	18	0	0	0	0	
	TRA	4	12	7	13	0	
	RWMC	0	0	0	0	0	
		FY08	FY09	FY10	FY11	FY12	TOTAL
LLW totals		23,696	5,601	7,989	11,463	4,192	52,941
MLLW totals		57	26	25	28	0	136
Total		23,753	5,627	8,014	11,491	4,192	53,077

As of 09/30/07, 233,226 yd³ (approximately 46%) of the available 510,000 yd³ of landfill capacity has been utilized. In FY-2007, a total of 36,001 cubic yards (27,526 cubic meters) of waste was disposed into the ICDF landfill.

In the upcoming years, ICDF anticipates the receipt of the MTR and PBF reactor vessels and related waste streams. These reactor vessels may constitute a minor variance from the initial waste projections developed for the landfill. However, these vessels have all had Engineering Evaluation/Cost Analyses (EE/CAs) conducted and have been or will be approved by the EPA and DEQ, which will document their acceptability at ICDF. CWI will continue to evaluate the wastes disposed into the ICDF landfill in comparison with the original basis for the PA and CA to determine if and/or when these documents should be updated in accordance with DOE 435-1.

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If you have further questions, please contact Mr. Jack Simonds of my staff at (208) 526-2770.

Sincerely,

Jeffrey D. Bradford, Vice President
Waste Management

WMH:tds

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Disposition Authority: ENV-1-h-1

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NOTE: Original disposition authority, retention schedule, and Uniform Filing Code applied by the sender may not be appropriate for all recipients. Make adjustments as needed.

Appendix B

Preliminary Results of the ICDF Landfill Performance Assessment Technical Update

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Preliminary Results of the ICDF Landfill Performance Assessment Technical Update

B-1. INTRODUCTION

This appendix provides a summary of the groundwater fate and transport modeling and preliminary results for the technical update to Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility (ICDF) Landfill Performance Assessment (PA) and Composite Analysis (CA) modeling. This modeling will update the original PA and CA modeling documented in DOE-ID (2003a) and DOE-ID (2003b), respectively. It is presented here in this annual report to demonstrate that the ICDF Landfill is in compliance with DOE Order 435.1 even though the actual radionuclide inventories disposed of are higher in some cases than the design basis inventory for the facility.

B-2. METHODOLOGY

In this section, the methodology for the technical update to the PA is described and contrasted with the methodology used in the 2003 PA (DOE-ID 2003a).

B-2.1 Conceptual Model

The conceptual model is illustrated in Figures B-1 and B-2. Figure B-1 illustrates the conceptual model while the cover remains intact. Water runs off the top of the cover and to the sides where it infiltrates the surrounding soil. A small amount of water passes through the cover and comes in contact with the waste. The leachate collection system is assumed to be functioning up until the cover is installed, and then fail, allowing the small amount of water that infiltrates through the cover to pass through the waste and clay liner and into the unsaturated zone. Water flow is primarily downward toward the aquifer. Because the leachate collection system remains functioning before cover installation, no releases occur prior to cover placement. Radionuclides in the waste are assumed to be homogeneously mixed in soil and readily available for leaching and transport. The unsaturated zone is composed of fractured basalt and sedimentary interbeds. Water flow through the fractured basalt is relatively rapid and unsaturated transit times are primarily controlled by the sedimentary interbed thickness. The initial moisture content in the sedimentary interbeds is based on background recharge rates.

The conceptual model for after cover failure is shown in Figure B-2. Water is assumed to transmit through the failed cover and leach and transport radionuclides through the unsaturated zone to the aquifer. Radionuclides that reach the aquifer advect and disperse in the aquifer. A hypothetical well is placed 100-m downgradient from the downgradient edge of the disposal facility. Water is drawn from the first 15-m section of the aquifer and used as a potable source, crop irrigation, and animal watering.

Figure B-1. Conceptual model of ICDF Landfill while engineered cover remains intact.

Figure B-2. Conceptual model of ICDF after engineered cover failure.

B-2.2 Key Assumptions

In general, many of the key assumptions used in this preliminary analysis are the same as used in the 2003 PA (DOE-ID 2003a). The key assumptions are outlined below and differences between the technical update and the 2003 PA are noted.

- Radionuclides remain contained within the disposal structure up to the time of closure.
- An engineered cover is placed over the facility and limits infiltration to 0.1 mm/yr. The engineered cover remains intact as long as periodic maintenance is performed during the 100-year period of institutional control. The engineered cover is assumed to remain intact for 500 years, and then fail over a 500-year period. After the engineered cover fails, infiltration through the cover returns to its background rate (1 cm/yr).
- Water flux through the unsaturated zone is transient and depends on whether the engineered cover is functioning. In the 2003 PA, water flux through the unsaturated zone remained constant over all time and was set at the background infiltration rates of 1 cm/yr.
- The waste is homogeneously mixed with soil. No release from the ICDF Landfill is assumed during its operational lifetime (2003 to 2018).
- Radionuclides that leach from the waste soil travel vertically and mix instantaneously in a clay layer below the waste.
- Release from the waste and clay layer is described by first-order processes.
- Flow and transport through the fractured basalt is modeled explicitly. In the 2003 PA, unsaturated zone water travel times through fractured basalt are instantaneous leaving only travel times through the sedimentary interbeds to be important.
- The aquifer is composed of an equivalent homogeneous porous medium of infinite lateral extent and finite thickness.

B-2.3 Source Term

The source term used in this appendix represents the actual disposals in the ICDF Landfill through FY 2008 as presented in Table I-1-1 of this report. The radionuclides identified as contaminants of concern in the 2003 PA (DOE-ID 2003a) (I-129, Np-237, Pu-239, Pu-240, Tc-99, U-234, and U-238) were analyzed as well as some additional radionuclides (C-14, Cl-36, and H-3) that have been identified as important groundwater contaminants of concern for other sites on the INL Site. The final technical update to this ICDF Landfill PA will include the actual waste disposed of along with the waste projected to be disposed of until closure of the facility.

B-2.4 Numerical Models

Two models are used to compute fate and transport in the technical update to the ICDF PA. Leaching from the ICDF Landfill and unsaturated transport is performed with the Mixing Cell Model (MCM) (Rood 2005). MCM performs transient flow and transport calculations in a one-dimensional heterogeneous model domain. The radionuclide flux from the unsaturated zone to the aquifer computed with MCM is then input into the GWSCREEN (Rood 1999) aquifer model. The 2003 PA (DOE-ID 2003a) used the unsaturated and saturated model in GWSCREEN, combined with an external source-term model that was used to compute groundwater concentrations. The unsaturated model in GWSCREEN assumes homogeneity and therefore, the fractured basalts were ignored.

B-2.5 Parameter Values

In general, parameter values used in the 2003 PA are to be used in the technical update (Table B-1 and Table B-2). A new stratigraphic interpretation is incorporated into the technical update and therefore, the sedimentary interbed thickness differs from the 2003 PA. In the 2003 PA, the total interbed thickness was 22.7 m. In the technical revision, the total interbed thickness is 16.78 m (Figure B-3). In addition, the unsaturated fractured basalt is explicitly modeled in the technical revision. The all-pathways dose model used in the 2003 PA was used without modification.

Table B-1. Nuclide independent parameter values for the technical update to the ICDF performance assessment.

Parameter	Value	Reference/Comments
Source Length (m)	160	DOE-ID (2003a)
Source Width (m)	194	DOE-ID (2003a)
Source Thickness (m)	12.56	DOE-ID (2003a)
Clay layer thickness (m)	0.9	DOE-ID (2003a)
Infiltration rate through cover and into waste, 0-500 years (cm/yr)	0.01	NUREG 1573, Section 3.2.2. Cover is assumed to remain intact for 500 years
Infiltration rate through cover, 500–1,000 years, 1000 yr to ∞ (cm/yr)	0.01 to 1.0 0.01	Infiltration linearly increases from 0.01 to 1 cm/yr during the 500–100 yr time frame. 1 cm/yr (background infiltration rates) for >1000 years.
Bulk density in source (g/cm ³)	1.946	DOE-ID (2003a)
Bulk density - unsaturated zone (g/cm ³)	1.359	DOE-ID (2003a)
Bulk density - clay layer (g/cm ³)	1.586	DOE-ID (2003a)
Bulk density - basalt (g/cm ³)	2.0	DOE-NE-ID (2007)
Bulk density of aquifer (g/cm ³)	2.491	DOE-ID (2003a)
van Genuchten α (1/m) in waste	1.066	DOE-ID (2003a)
van Genuchten n in waste	1.53	DOE-ID (2003a)
Saturated hydraulic conductivity in waste (m/yr)	31.5	DOE-ID (2003a)
Total porosity of waste (m ³ /m ³)	0.266	DOE-ID (2003a)
Residual moisture content of waste (m ³ /m ³)	0.072	DOE-ID (2003a)
van Genuchten α (1/m) in clay	0.8	DOE-ID (2003a)
van Genuchten n in clay	1.09	DOE-ID (2003a)
Saturated hydraulic conductivity in clay (m/yr)	0.0315	DOE-ID (2003a)
Total porosity of clay (m ³ /m ³)	0.39	DOE-ID (2003a)
Residual moisture content of clay (m ³ /m ³)	0.07	DOE-ID (2003a)
van Genuchten α (1/m) in unsaturated interbeds	1.066	DOE-ID (2003a)
van Genuchten n in unsaturated interbeds	1.523	DOE-ID (2003a)
Saturated hydraulic conductivity in interbeds (m/yr)	21.3	DOE-ID (2003a)
Total porosity of interbeds (m ³ /m ³)	0.487	DOE-ID (2003a)
Residual moisture content of interbeds (m ³ /m ³)	0.072	DOE-ID (2003a)

Table B-1. (continued).

Parameter	Value	Reference/Comments
van Genuchten α (1/m) in unsaturated basalt	2.5	DOE-NE-ID (2007)
van Genuchten n in unsaturated basalt	10	DOE-NE-ID (2007)
Saturated hydraulic conductivity in basalt (m/yr)	91	DOE-NE-ID (2007)
Total porosity of (m ³ /m ³)	0.05	DOE-NE-ID (2007)
Residual moisture content of interbeds (m ³ /m ³)	0.001	DOE-NE-ID (2007)
Unsaturated thickness (m)	143.73	Interpreted from stratigraphic data
Unsaturated dispersivity (m)	2.92	1/10th the unsaturated thickness
Longitudinal dispersivity in the aquifer (m)	3.31	DOE-ID (2003a)
Vertical dispersivity in the aquifer (m)	$\alpha \times 1.16 \times 10^{-3}$	Whelen et al. 1996 (α = longitudinal dispersivity)
Transverse dispersivity (m)	0.662	DOE-ID (2003a)
Aquifer thickness (m)	76	DOE-ID (1994)
Well screen thickness (m)	15	DOE-ID (1994)
Darcy velocity in aquifer (m/yr)	21.9	DOE-ID (2003a)
Porosity of aquifer (m ³ /m ³)	0.06	DOE-ID (2003a)
Receptor location (meters from center of source)	180	DOE-ID PA Guidance (2003a)

Figure B-3. Unsaturated zone stratigraphy used in the technical update to the ICDF Landfill Performance Assessment.

Table B-2. Nuclide dependent transport parameters in the technical update to the ICDF Landfill Performance Assessment. K_d values are from DOE-ID (2003a).

Nuclide/Progeny	Half-Life (years)	Number of Progeny	Waste/Interbed K _d (mL/g) ^{a,c}	Clay K _d (mL/g) ^a	Ingestion DCF (rem/Ci) ^b	All-Pathways Dose/Unit Concentration (rem-m ³ / Ci- yr) ^d
C-14	5730	0	5	1	2.09E+03	5.55E+03
Cl-36	3.01 × 10 ⁵	0	0	0	3.03E+03	1.24E+05
H-3	12.3	0	0	0	6.40E+01	1.16E+02
I-129	1.57 × 10 ⁷	0	0	1	2.8E+05	4.54E+05
Np-237	2.14 × 10 ⁶	2	8	55	4.4E+06	3.42E+06
U-233	1.59 × 10 ⁵		6	63	2.9E+05	2.34E+05
Th-229	7430		100	1,700	3.5E+06	3.10E+06
Pu-239	21,400	3	140	1,700	3.4E+06	2.71E+06
U-235	7.04 × 10 ⁸		6	63	2.7E+05	2.15E+05
Pa-231	32,800		550	2,700	1.1E+07	8.10E+06
Ac-227	21.8		450	2,400	1.4E+07	1.13E+07
Pu-240	6570	4	140	1,700	3.5E+06	2.71E+06
U-236	2.34 × 10 ⁷		6	63	2.7E+05	2.17E+05
Th-232	1.41 × 10 ¹⁰		100	1,700	2.7E+06	2.06E+06
Ra-228	5.75		100	9,100	1.4E+06	1.15E+06
Th-228	1.91		100	1,700	4.0E+05	6.19E+05
Tc-99	2.13 × 10 ⁵	0	0.2	1	1.5E+03	3.37E+03
U-234	2.44 × 10 ⁵	3	6	63	2.8E+05	2.29E+05
Th-230	75,400		100	1,700	5.5E+05	4.19E+05
Ra-226	1,600		100	1,900	1.3E+06	1.06E+06
Pb-210	22		100	710	5.4E+06	5.76E+06
U-238	4.47 × 10 ⁹	4	6	63	2.6E+05	2.18E+05
U-234	2.44 × 10 ⁵		6	63	2.8E+05	2.29E+05
Th-230	75,400		100	1,700	5.5E+05	4.19E+05
Ra-226	1,600		100	1,900	1.3E+06	1.06E+06
Pb-210	22		100	710	5.4E+06	5.76E+06

a. Jenkins (2001).

b. From EPA (1988).

c. The aquifer basalt K_d is always 1/25 the waste/interbed K_d.

d. All-pathway Dose Conversion Factors (DCFs) include short-lived progeny that are assumed to be in secular equilibrium with the parent in the environment.

B-3. PRELIMINARY RESULTS

In this section, preliminary results from the groundwater flow and transport models and dose assessment models are presented.

B-3.1 Groundwater Concentrations

Preliminary results for radionuclide concentrations in the aquifer at the point of compliance are illustrated in Figures B-4 for fission and activation products and B-5 for actinides. Maximum concentrations and time of maximums are summarized in Table B-3. During the compliance period, concentrations are minimal due to the presence of the engineered barrier. The leading edge of non-sorbing radionuclide plumes driven by infiltration from the failing cover arrive at the aquifer in about the year 2900. Sorbing radionuclides arrive at a later time.

Figure B-4. Preliminary results of fission and activation product aquifer concentration as a function of time at the point of compliance (100 m downgradient from the downgradient edge of the ICDF disposal facility).

Figure B-5. Preliminary results of actinide aquifer concentrations as a function of time at the point of compliance (100 m downgradient from the downgradient edge of the ICDF disposal facility).

Table B-3. Preliminary results of maximum radionuclide concentrations in the aquifer at the point of compliance and time of maximum concentration for the compliance and post-compliance period.

Nuclide	Progeny	Maximum During 1000-yr Compliance Period (pCi/L)	Maximum Post Compliance Period (pCi/L)	Time of Maximum During Compliance Period (yr)	Time of Maximum, Post Compliance Period (yr)
I-129		2.25E-01	2.09E+00	3010	3.51E+03
Tc-99		2.64E-02	7.78E-01	3010	3.76E+03
C-14		1.47E-07	3.75E+00	3010	1.17E+04
Cl-36		1.73E+00	3.69E+00	3010	3.18E+03
H-3		7.18E-18	1.22E-19	2334	3.01E+03
Ni-59		4.39E-21	6.10E-01	3010	1.62E+05
Np-237		9.21E-13	1.97E-02	3010	2.58E+04

Table B-3. (continued).

Nuclide	Progeny	Maximum During 1000-yr Compliance Period (pCi/L)	Maximum Post Compliance Period (pCi/L)	Time of Maximum During Compliance Period (yr)	Time of Maximum, Post Compliance Period (yr)
Pu-240	U-233	2.86E-14	2.62E-03	3010	3.18E+04
	Th-229	1.37E-19	1.38E-04	3010	4.28E+04
		2.71E-17	8.97E-04	3010	3.58E+04
	U-236	2.43E-14	9.94E-04	3010	2.98E+04
	Th-232	6.13E-26	1.29E-10	3010	1.00E+05
	Ra-228	2.07E-28	1.08E-13	3010	9.80E+04
Pu-239	Th-228	8.05E-32	2.44E-17	3010	1.00E+05
		9.06E-18	4.54E-03	3010	1.12E+05
	U-235	9.85E-16	8.22E-05	3010	4.08E+04
	Pa-231	4.81E-32	5.41E-07	3010	7.68E+04
Pa-231	Ac-227	1.64E-31	2.14E-10	3010	7.58E+04
		4.27E-46	9.67E-13	3010	1.98E+05
	Ac-227	1.33E-44	3.85E-16	3010	1.98E+05
Th-230		1.28E-24	3.77E-04	3010	1.70E+05
	Ra-226	1.72E-25	3.72E-04	3010	1.70E+05
	Pb-210	4.57E-26	3.61E-05	3010	1.70E+05
U-238		4.48E-11	1.49E-01	3010	2.05E+04
	U-234	1.27E-13	9.14E-03	3010	2.88E+04
	Th-230	5.87E-20	1.45E-04	3010	6.48E+04
	Ra-226	1.50E-22	1.39E-04	3010	6.68E+04
	Pb-210	8.06E-24	1.34E-05	3010	6.68E+04
U-234		4.97E-11	1.57E-01	3010	2.05E+04
	Th-230	2.41E-17	2.10E-03	3010	5.38E+04
	Ra-226	6.25E-20	2.02E-03	3010	5.58E+04
	Pb-210	3.37E-21	1.94E-04	3010	5.58E+04
U-233		1.16E-11	3.57E-02	3010	2.00E+04
	Th-229	5.76E-17	1.69E-03	3010	2.98E+04
U-235		3.26E-10	4.45E-02	3010	1.80E+04
	Pa-231	2.99E-26	1.76E-04	3010	4.08E+04
	Ac-227	7.29E-26	6.96E-08	3010	4.18E+04
U-236		1.41E-13	4.67E-04	3010	2.05E+04
	Th-232	3.67E-25	4.84E-11	3010	9.20E+04
	Ra-228	1.24E-27	4.06E-14	3010	9.40E+04
	Th-228	4.79E-31	9.17E-18	3010	9.40E+04

B-3.2 All-Pathways Doses

The preliminary results of the all-pathways doses are presented in Figure B-6 for fission and activation products and Figure B-7 for actinides. Table B-4 presents the maximum dose during the compliance and post-compliance period and the time of maximum dose. At no time in the future is the 25 mrem/yr effective dose equivalent (EDE) dose limit exceeded. Therefore, the actual and projected inventories do not exceed the DOE O 435.1 performance objective of 25 mrem/yr EDE.

Figure B-6. Preliminary results of fission and activation product all-pathways effective dose equivalent (EDE) as a function of time at the point of compliance (100 m downgradient from the downgradient edge of the ICDF disposal facility). The Total line represents the fission and activation product and actinide doses.

Figure B-7. Preliminary results of actinide all-pathways effective dose equivalent (EDE) as a function of time at the point of compliance (100 m downgradient from the downgradient edge of the ICDF disposal facility). The Total line represents the fission and activation product and actinide doses.

Table B-4. Preliminary results of maximum all-pathways effective dose equivalent (EDE) at the point of compliance and time of maximum concentration for the compliance and post-compliance period.

Nuclide	Progeny	Maximum During 1000-yr Compliance Period (mrem/yr)	Maximum Post Compliance Period (mrem/yr)	Time of Maximum During Compliance Period (yr)	Time of Maximum, Post Compliance Period (yr)
I-129		1.02E-01	9.46E-01	3010	3509
Tc-99		8.90E-05	2.62E-03	3010	3759
C-14		8.16E-10	2.08E-02	3010	11,659
Cl-36		2.15E-01	4.57E-01	3010	3184
H-3		8.33E-22	1.42E-23	2334	3011
Ni-59		9.84E-25	1.37E-04	3010	160,009
Np-237		2.81E-13	6.01E-03	3010	25,759
	U-233	4.40E-15	4.04E-04	3010	31,759
	Th-229	2.50E-19	2.50E-04	3010	42,759
Total Np-237		2.85E-13	6.55E-03	3010	26,759
Pu-240		1.92E-17	6.37E-04	3010	35,759
	U-236	3.40E-15	1.39E-04	3010	29,759
	Th-232	4.01E-26	8.41E-11	3010	102,009
	Ra-228	8.40E-29	4.36E-14	3010	102,009
	Th-228	1.37E-33	4.14E-19	3010	102,009
Total Pu-240		3.42E-15	7.67E-04	3010	34,759
Pu-239		6.43E-18	3.23E-03	3010	112,009
	U-235	1.38E-16	1.15E-05	3010	40,759
	Pa-231	6.54E-32	7.35E-07	3010	76,759
	Ac-227	4.94E-30	6.44E-09	3010	76,759
Total Pu-239		1.44E-16	3.23E-03	3010	112,009
Pa-231		5.80E-46	1.32E-12	3010	198,009
	Ac-227	3.99E-43	1.16E-14	3010	198,009
Total Pa-231		4.00E-43	1.33E-12	3010	198,009
Th-230		7.74E-25	2.28E-04	3010	170,009
	Ra-226	1.42E-25	3.07E-04	3010	168,009
	Pb-210	3.36E-24	2.66E-03	3010	170,009
Total Th-230		4.28E-24	3.19E-03	3010	170,009
U-238		6.50E-12	2.16E-02	3010	20,509
	U-234	1.87E-14	1.35E-03	3010	28,759
	Th-230	3.55E-20	8.79E-05	3010	64,759
	Ra-226	1.24E-22	1.15E-04	3010	66,759
	Pb-210	5.92E-22	9.84E-04	3010	66,759
Total U-238		6.52E-12	2.29E-02	3010	21,509

Table B-4. (continued).

Nuclide	Progeny	Maximum During 1000-yr Compliance Period (mrem/yr)	Maximum Post Compliance Period (mrem/yr)	Time of Maximum During Compliance Period (yr)	Time of Maximum, Post Compliance Period (yr)
U-234		7.36E-12	2.33E-02	3010	20,509
	Th-230	1.46E-17	1.27E-03	3010	52,759
	Ra-226	5.16E-20	1.67E-03	3010	55,759
	Pb-210	2.48E-19	1.43E-02	3010	55,759
Total U-234		7.36E-12	3.01E-02	3010	25,759
U-233		1.79E-12	5.50E-03	3010	20,009
	Th-229	1.05E-16	3.08E-03	3010	29,759
Total U-233		1.79E-12	8.02E-03	3010	23,759
U-235		4.56E-11	6.23E-03	3010	18,009
	Pa-231	4.06E-26	2.40E-04	3010	41,759
	Ac-227	2.19E-24	2.10E-06	3010	40,759
Total U-235		4.56E-11	6.34E-03	3010	18,509
U-236		1.97E-14	6.53E-05	3010	20,509
	Th-232	2.40E-25	3.16E-11	3010	92,009
	Ra-228	5.02E-28	1.64E-14	3010	92,009
	Th-228	8.14E-33	1.56E-19	3010	92,009
Total U-236		1.97E-14	6.53E-05	3010	21,009
Total		3.17E-01	1.25E+00	3010	3359

B-3.3 Water Resource Impact Assessment

DOE M 435.1-1 does not contain a specific performance objective (e.g., dose or concentration standard) for water resource impacts; instead, the PA shall include an assessment of impacts to water resources. Groundwater protection is evaluated by comparing predicted concentrations in groundwater with Idaho Rules for public drinking water systems. The Idaho Rules for public drinking water systems include meeting the maximum contaminant levels (MCLs) for radionuclides of concern and the beta-gamma dose equivalent (DE) limit of 4 mrem/yr. The beta-gamma DE is not calculated in the same manner as the all-pathways dose. The beta-gamma DE is calculated using the MCLs in drinking water which are based on 4 mrem/yr DE calculated using data in National Bureau of Standards Handbook 69 and assuming 730 liters of water consumed per year. During the compliance time, the beta-gamma DE is less than one well below the 4 mrem/yr DE dose limit. The predicted concentrations for the radionuclides of concern are below the MCLs. Therefore, the actual and projected inventories are protective of the groundwater during the 1,000-yr compliance period.

Figure B-8. Preliminary results of beta-gamma dose equivalent as a function of time at the point of compliance (100 m downgradient from the downgradient edge of the ICDF disposal facility).

B-3.4 Summary

The actual inventories disposed of to the ICDF Landfill meet the DOE Order 435.1 performance objective of 25 mrem/yr and is protective of the groundwater resource during the compliance period. The preliminary results are summarized in Table B-6.

Table B-6. Comparison of performance objectives and ICDF Landfill preliminary performance assessment results.

Performance Objective	Standard	Performance Assessment Results	
		Compliance Period	Post-Compliance Period
All-pathways (DOE O 435.1)	25 mrem/year EDE	0.32 mrem/year	1.3 mrem/year
Groundwater protection (40 CFR 141) (IDAPA 58.01.08)	Beta-gamma dose < 4 mrem/yr DE	0.91	8.4 ^b
	MCL of 5 pCi/L for Ra-226 and Ra-228	6.3E-20	2.4E-3 pCi/L
	MCL of 15 pCi/L for gross alpha	9.2E-13	2.6E-02 pCi/L
	MCL of 30 µg/L for uranium	7.8E-15 µg/L	4.6E-4 µg/L
	MCL of 8 pCi/L for Sr-90	N/A ^a	N/A ^a
	MCL of 20,000 pCi/L for H-3	7.2E-18 pCi/L	1.2E-19 pCi/L
<p>a. Not applicable; Sr-90 is not a groundwater pathway contaminant of concern at the ICDF because of the decay that would take place in the vadose zone due to short half-life.</p> <p>b. The principle contributing radionuclide is I-129.</p> <p>EDE effective dose equivalent</p> <p>MCL maximum contaminant level</p>			

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