From: Trefethen, Jean
Sent: Thursday, October 02, 2014 10:49 AM
To: Nguyen, John-Chau
Subject: FW: Cement studies
Attachments: RegioalBinningReport98.pdf

From: Tom Harlan [mailto:harlan@mdh-law.com]
Sent: Tuesday, September 23, 2014 1:55 PM
To: Trefethen, Jean
Cc: Bianca Chance
Subject: Cement studies

Jean-

This is the third of four emails to you regarding the concrete studies. This contains the Regional Binning for Continued Storage of Spent Nuclear Fuel and High-Level Wastes report. Thanks.

Regards

TH

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Regional Binning for Continued Storage Of Spent Nuclear Fuel and High-Level Wastes

October 1998

Prepared for Jason Technologies
6655 West Sahara Avenue
Las Vegas, NV 89102

Report Prepared for Use in Preparation
of the Yucca Mountain
Environmental Impact Statement

Report by: W. Lee Poe, Jr.
Tetra Tech NUS, Inc.
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Aiken, SC 29803

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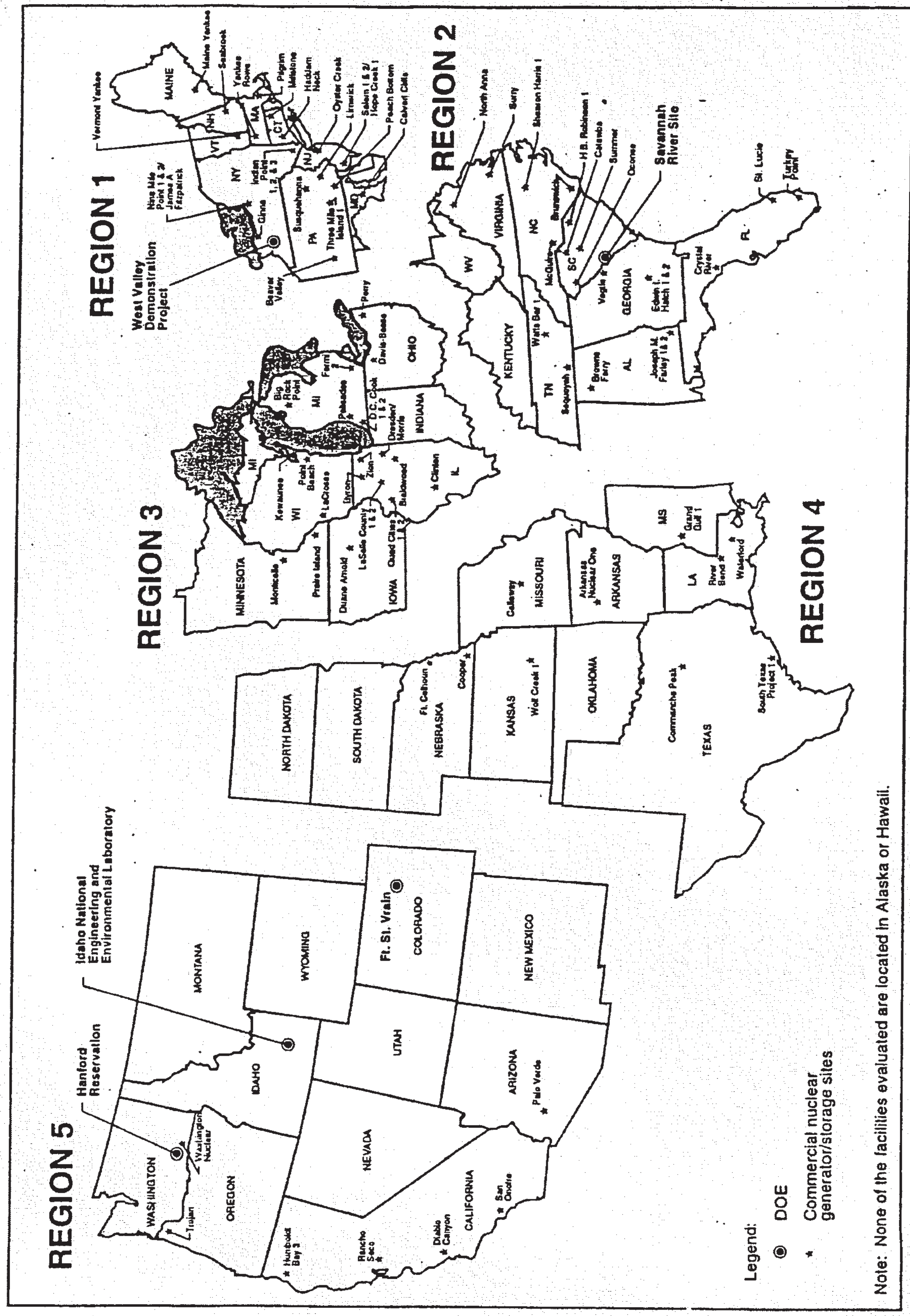
Introduction

In the Continued Storage Analysis Report (CSAR) (Reference 1), DOE decided to analyze the environmental consequences of continuing to store the commercial spent nuclear fuel (SNF) at 72 commercial nuclear power sites and DOE-owned spent nuclear fuel and high-level waste at five Department of Energy sites by region rather than by individual site. This analysis assumes that three commercial facilities pairs -- Salem and Hope Creek, Fitzpatrick and Nine-Mile Point, and Dresden and Morris -- share common storage due to their proximity to each other. The five regions selected for this analysis are shown on Figure 1. Regions 1, 2, and 3 are the same as those used by the Nuclear Regulatory Commission in their regulatory oversight of commercial power reactors. NRC Region 4 was subdivided into two regions to more appropriately define the two different climates that exist in NRC Region 4.

A single hypothetical site in each region was assumed to store all the SNF and HLW in that region. Such a site does not exist and has no geographic location but is a mathematical construct for analytical purposes. To ensure that the calculated results for the regional analyses reflect appropriate inventory, facility and material degradation, and radionuclide transport, the waste inventories, engineered barriers, and environmental conditions for the hypothetical sites were developed from data for each of the existing sites within the given region. Weighting criteria to account for the amount and types of SNF and HLW at each site were used in the development of the environmental data for the regional site, such that the results of the analyses for the hypothetical site were representative of the sum of the results of each actual site if they had been modeled independently.

This report defines the actual site data used in development of this hypothetical site, shows how the individual site data was weighted to develop the regional site, and provides the weighted data used in the CSAR analysis. It is divided into Part 1 that defines time-dependent releases from each regional site, Part 2 that defines transport conditions through the groundwater, and Part 3 that defines transport through surface water and populations using the surface waters for drinking.



YUCCA MTN EIS/Pubsonly/Grfx/RBCS of SNF & HLW/1 Analy regions of the US.AI

Figure 1. Analytical regions of the United States.

Part 1
Regional Site Data Used to Determine Time-Dependent Release Data

This part describes the regional site data used to determine time-dependent release data. The regional input data is provided in Appendix A. The table numbers of this section and of Appendix A are inter-linked to simplify data evaluation. For example a single table in Part 1 provides data for all regions. Five linked tables in Appendix A provide more detailed data by region. The text in Part 1 explains how the Part 1 tables were developed. The text in Appendix A describes the source of the data in the tables in the Appendix.

1.1 Amounts of SNF and HLW

The left portion of Table 1-1 summarizes the regional location of the 63,000 metric tons heavy metal (MTHM) of commercial SNF considered in the No Action alternative. The right portion of the table gives the regional location of DOE's SNF and HLW. It also gives the major assumptions on storage configuration.

Table 1-1. Amounts of spent nuclear fuel and high-level radioactive waste in each geographic region.

Region	MTHM in PWR	MTHM in BWR	Total MTHM	MTHM with juvenile clad failure	MTHM with stainless steel cladding	MTHM surrogate SNF	Storage configuration	Canisters of HLW	Storage configuration
1	7,179	9,652	16,830	16	412			300	Surface cask
2	14,509	4,389	18,898[b]	19	0	28.6	Surface cask	6,022[c]	Subsurface vault
3	7,998	6,683	14,682	15	171				
4	5,330	1,839	7,170	7	0				
5	4,811	610	5,420	5	144	2,290 14	Subsurface vault Surface vault	1,993	Subsurface vault
Totals	39,827	23,173	63,000	62	727	2,333		8,315	

a All analyzed as stored on surface.
b. Includes surplus plutonium in mixed oxide spent nuclear fuel which is assumed to behave like normal spent nuclear fuel.
c. Includes surplus plutonium in can-in-canister.

Three different time-dependent releases (called fluxes in the remainder of this report) were analyzed because of differences in packaging, material forms, etc as described in the CSAR (Reference 1). These are for commercial SNF (CSNF), DOE-SNF, and DOE-HLW.

The complete inventory of CSNF was considered to be PWR fuel even though approximately 37 percent are BWR fuel. This simplifying assumption minimized the calculational process and could be made because both PWR and BWR fuel follow the same deterioration process. The consequences of this simplification were corrected by converting the calculated flux (expressed as grams UO_2 released for each 70-year lifetime period) to the appropriate radionuclide content using the source data for PWR and BWR fuel in the region. This makes the appropriate correction for differences in PWR and BWR fuels.

All of the DOE SNF is assumed to be surrogate Category 1 SNF (a metallic fuel with Zircaloy cladding that is primarily N-Reactor fuel) to be consistent with the TSPA analysis. The total amount of DOE SNF was considered to be 2,333 MTU and uses the average fission product content of Categories 1, 4, 5, 6, 8, and 11. These values were summed from the site-specific data given in Appendix A. The DOE SNF flux were expressed as gU/70-year period.

The DOE-HLW inventory assumed 8,315 canisters of borosilicate glass HLW. The DOE-HLW flux were expressed as grams glass/70-year period.

The Base Case Inventory assumption for DOE HLW was that it included all of the HLW at SRS (6,022 canisters including surplus plutonium in Can-In-Canister), all at WVDP (300 canisters), and the remainder of the 8,315 canisters is from Hanford (1,993 canisters). HLW fluxes were expressed as grams glass/70-year period.

The assumptions on quantities of CSNF, DOE SNF, and DOE HLW and their chemical and radiological contents are based on Appendix A of the Yucca Mountain EIS (Reference 2).and on the Draft Analysis Bases for Yucca Mountain Monitored Repository Environmental Impact Statement (Reference 3).

1.2 Weighting SNF & HLW

1.2.1 SENSITIVITY STUDY FOR CSNF

Reference 4 describes a sensitivity study that was done to determine which radionuclides contributed most to the population dose commitment from expected commercial SNF deterioration from long term exposure to the environment. In this sensitivity study, the commercial SNF waste package was assumed to deteriorate as discussed in Reference 5 and to begin releasing radionuclides to the environment in approximately 1,200 years and to continue releasing radionuclides until all of the SNF had dissolved. This sensitivity analysis determined the population dose commitment from drinking river water. The sensitivity was a comparison of all the flux of SNF released to the surface streams as soon as available to that if the flux was delayed 10 years and 100 years. This delay reflected impacts of transport through the groundwater causing the two delay times and its associated retention of some radionuclides on the soil column. The sensitivity study showed that most of the cumulative 10,000-year population dose commitment was due to plutonium and americium released from the SNF. The results were 99.47, 99.64, and 98.58 percent for zero delay, 10-year delay, and 100-year delay, respectively.

1.2.2 CURIES OF AMERICIUM AND PLUTONIUM USED IN REGIONAL WEIGHTING

The total curies of americium and plutonium expected to be released over the 10,000 year period from each location were estimated based upon the following assumptions:

- Radionuclides Am-241, Am-242/242m, Am-243, Pu-238, Pu-239, Pu-240, Pu-241, and Pu-242 were considered. Radionuclides Am-241, Am-242/242m, Pu-238, and Pu-241 were found to be insignificant (in terms of curies released) and were ignored in further evaluations. This left Am-243, Pu-239, Pu-240 and Pu-242 which were carried into further evaluations.

- Releases from all commercial SNF clad with stainless steel or within the category of juvenile failure (0.1 percent of the Zircaloy clad SNF).

- Release of all the curies of Am-Pu contained in DOE-SNF Categories 1, 4, 6, 8, and 11 as provided in Table A.2.2-4 of Reference 2.

- One, eight, and two percent of the HLW at Hanford, SRS, and West Valley was respectively assumed to dissolve during the first 10,000 years. These estimates reflect amounts, packaging, storage, and environments at each site.

Table 1-2 gives the curies of americium-plutonium calculated to be released by region and material type.

Table 1-2. Curies of Am and Pu expected to be released over 10,000 years.

Region	Commercial SNF: Juvenile failure	Commercial SNF: Stainless steel clad	DOE SNF	DOE HLW	Total
Region 1	15,300	423,000	NA	75	438,000
Region 2	18,900	NA	15,000	10,400	44,300
Region 3	13,900	171,000	NA	NA	185,000
Region 4	7,100	NA	NA	NA	7,100
Region 5	5,400	150,000	675,000	69	830,000
% by Category	4.0	49.4	45.9	0.7	

NA = not applicable; that particular material is not present in that region.

1.3 Determination of Regional Environmental Conditions Significant to Life of SNF or HLW

The total curies of Am-243, Pu-239, Pu-240 and Pu-242 expected to be released over the 10,000-year period of analysis were used as the parameter to weight the environmental conditions within the region. For each site in a region, each environmental parameter (see Table 1-3), was multiplied by the total curies of americium-plutonium released at that site. The results for each parameter and site in a region were summed to get a region total for each environmental parameter. Each total was divided by the total curies of americium and plutonium in the region to determine the average value for each environmental parameter in each region. The curies of americium-plutonium considered to be released from each site were multiplied by the environmental parameter for that site then they were summed. That sum was divided by the sum of curies of americium-plutonium expected to be released within 10,000 years to get the weighted environmental values.

The environmental parameters determined for each region are shown in Table 1-3.

Table 1-3. Regional environmental parameters.

Region	Concrete cask life, yr.	Precipitation rate, in/yr.	Rain days, % of yr.	Total wet days, % of yr.	Precipitation chemistry: pH	Precipitation chemistry: Cl^-, wt %	Precipitation chemistry: SO_3^{--}, wt. %	Average temperature ^0F
Region 1	95	42.2	30.2	30.8	4.4	6.9×10^{-5}	1.5×10^{-4}	51.7
Region 2	704	52.2	29.3	53.9	4.7	3.9×10^{-5}	9.0×10^{-5}	63.1
Region 3	72	32.5	32.9	41.8	4.7	1.6×10^{-5}	2.4×10^{-4}	49.8
Region 4	749	42.4	30.8	49.2	4.6	3.5×10^{-5}	1.1×10^{-4}	61.9
Region 5	3.530	10.5	23.6	23.7	5.3	2.1×10^{-5}	2.5×10^{-5}	54.9

Part 2
Regional Site Data Used to Determine Underground Transport

This part describes the ground water parameters used to calculate the delay times encountered in transport of radionuclides between the location of continued storage sites and surface water that could potentially reach populations. The information is divided into two subsections: vadose zone and saturated zone. As described in Part 1 the information in this section is calculated flow parameters showing times, in years, for water and plutonium to flow from the point of release to the Saturated zone or to the point of discharge to surface water.

In this part of the report there is one table for each region where continued storage is assumed. Appendix B also has five tables; one for each region. Each of the Appendix tables shows the site-specific data from each region. The text in Part 2 discusses how Part 2 tables were developed. The text associated with Appendix B provides the source of the data in the tables in the Appendix.

2.1 Vadose Zone Transport

The calculated flow time for water and plutonium are given in Tables 2.1-1 through 2.1-5. These calculated values describe the times required for flow of these materials through the vadose zone at each storage location and is used, as appropriate. Water and plutonium transport in these tables are used as examples of how the data are used as described in Reference 9. These flow times are based on the site-specific data given in Appendix B.

Table 2.1-1. Transport times for radioactive nuclides in Region 1.

				Vadose zone		Saturated zone		
Region	Site	Fuel type	MEPAS Kd for Pu, ml/g	Water flow time, years	Pu flow time, years	GW travel time, years	Pu flow time, years	Combined total Pu flow time Vad. + Sat., years
1	Haddam Neck	PWR	10	0.7	47	1.3	96	143
1	Millstone	PWR & BWR	10	1.3	94	14.3	1,094	1,188
1	Salem/Hope Creek	PWR & BWR	10	4.0	282	7.2	554	836
1	Pilgrim	BWR	10	3.6	258	1.3	96	354
1	Seabrook	PWR	100	2.8	1,369	2.7	204	1,573
1	Maine Yankee	PWR	10	0.8	59	5.8	443	501
1	Calvert Cliffs	PWR	100	0.8	327	5.7	3,344	3,671
1	Oyster Creek	BWR	10	0.8	56	2.6	201	257
1	Fitzpatrick/Nine Mile Point	BWR	100	0.7	273	12.5	953	1,226
1	Ginna	PWR	100	3.0	1,139	8.6	655	1,794
1	Indian Point	PWR & BWR	10	0.7	47	5.7	433	480
1	Yankee-Rowe	PWR	10	1.3	73	1.1	612	685
1	Beaver Valley	PWR	100	2.6	1,256	56.1	4,295	5,552
1	Limerick	BWR	0	0.4	0	10.0	10	10
1	Peach Bottom	BWR	10	0.5	33	1.8	141	174
1	Susquehanna	BWR	100	4.4	2,094	12.9	13	2,107
1	Three Mile Island	PWR	10	0.7	47	0.3	26	73
1	Vermont Yankee	BWR	10	0.8	43	1.1	65	108
1	West Valley Demo Project	DOE HLW	10	0.5	43	32.2	5,441	5,484

Table 2.1-2. Transport times for radioactive nuclides in Region 2.

Region	Site	Fuel type	MEPAS Kd for Pu, ml/g	Vadose zone: Water flow time, years	Vadose zone: Pu flow time, years	Saturated zone: GW travel time, years	Saturated zone: Pu flow time, years	Combined total Pu flow time Vad. + Sat., years
2	Browns Ferry	BWR	10	0.6	35	5.6	426	461
2	Farley	PWR	10	2.2	153	26.3	2,193	2,346
2	Crystal River	PWR	100	0.8	327	5.0	421	749
2	St. Lucie	PWR	100	10.3	4,944	90.1	6,896	11,840
2	Turkey Point	PWR	10	3.8	268	28.3	2,167	2,435
2	Hatch	BWR	10	1.3	70	77.9	5,960	6.030
2	Vogtle	PWR	10	3.2	174	24.1	1,461	1,635
2	Brunswick	PWR	250	2.6	1,957	255.1	312,596	314,552
2	Catawba	PWR	100	1.3	491	3.3	1,950	2,441
2	Harris	PWR & BWR	100	1.1	511	11.0	848	1,359
2	McGuire	PWR	100	1.7	655	9.5	695	1,350
2	Oconee	PWR	250	3.6	2,739	6.9	4,038	6,777
2	Robinson	PWR	10	1.4	96	35.2	2,692	2,787
2	Summer	PWR	100	2.5	982	11.2	11	993
2	Sequoyah	PWR	100	3.8	1,473	10.8	5,782	7,255
2	Watts Bar	PWR	250	2.4	1,800	5.8	7,153	8,953
2	North Anna	PWR	100	0.8	327	5.6	3,269	3,597
2	Surry	PWR	100	2.5	982	9.6	5,627	6,609
2	Savannah River Site	DOE SNF	10	2.9	187	7.9	700	887
2	Savannah River Site	DOE HLW	10	2.9	187	12.7	1.120	1.306

Table 2-1-3. Transport times for radioactive nuclides in Region 3.

Region	Site	Fuel type	MEPAS Kd for Pu, ml/g	Vadose zone: Water flow time, years	Vadose zone: Pu flow time, years	Saturated zone: GW travel time, years	Saturated zone: Pu flow time, years	Combined total Pu flow time Vad. + Sat., years
3	Duane Arnold	BWR	10	1.5	104	24.8	1,896	2,000
3	Braidwood	PWR	10	1.1	80	414.7	31,735	31,815
3	Byron	PWR	100	0.8	315	35.7	23,431	23,747
3	Clinton	BWR	10	0.5	32	1.3	99	131
3	Dresden/Morris	PWR & BWR	100	0.5	210	26.5	2,028	2,238
3	Lasalle County	BWR	100	1.4	526	15.4	934	1,460
3	Quad Cities	BWR	10	2.6	184	2.1	163	347
3	Zion	PWR	10	1.7	123	10.2	779	902
3	Big Rock Point	BWR	10	0.7	49	15.4	15	65
3	Cook	PWR	10	1.3	92	2.0	156	248
3	Enrico Fermi	BWR	100	2.7	1,051	9.0	9	1,060
3	Palisades	PWR	10	13.9	757	13.9	846	1,603
3	Monticello	BWR	10	1.7	123	15.4	1,178	1,301
3	Prairie Island	PWR	10	13.9	983	2.0	156	1,139
3	Davis-Besse	PWR	250	2.0	1,525	33.7	34	1,559
3	Perry	BWR	100	2.8	1,329	75.0	44,023	45,352
3	Kewaunee	PWR	10	0.9	61	15.4	1,178	1,240
3	Lacrosse	BWR	10	0.9	61	1.9	147	208
3	Point Beach	PWR	10	5.6	303	3.1	191	493

Table 2-1-4. Transport times for radioactive nuclides in Region 4.

				Vadose zone		Saturated zone		
Region	Site	Fuel type	MEPAS Kd for Pu, ml/g	Water flow time, years	*Pu flow time, years	GW travel time, years	Pu flow time, years	Combined total Pu flow time Vad. + Sat., years
4	Arkansas Nuclear One	PWR	100	0.8	327	958.7	515,513	515,840
4	Wolf Creek	PWR	100	4.0	1,917	575.8	337,951	339,868
4	River Bend	BWR	10	4.3	306	9.3	715	1,021
4	Waterford	PWR	100	4.7	1,800			1,800
4	Callaway	PWR	100	1.8	683	112.4	8,605	9,288
4	Grand Gulf	BWR	100	5.9	2,291	16.2	1,240	3,531
4	Cooper	BWR	100	1.1	548	3.9	301	848
4	Fort Calhoun	PWR	100	0.2	110	4.6	350	459
4	Comanche Peak	PWR	100	4.6	2,190			2,190
4	South Texas	PWR	10	7.1	386	68.8	5,267	5,653

Table 2-1-5. Transport times for radioactive nuclides in Region 5.

				Vadose zone		Saturated zone		
Region	Site	Fuel type	MEPAS Kd for Pu, ml/g	Water flow time, years	Pu flow time, years	GW travel time, years	Pu flow time, years	Combined total Pu flow time Vad. + Sat., years
5	Palo Verde	PWR	10	4.8	260		0	260
5	Diablo Canyon	PWR	100	2.9	1,717	1.7	1,007	2,724
5	Humboldt Bay	BWR	10	0.9	64	1.8	137	201
5	Rancho Seco	PWR	10	53.7	3,802		0	3,802
5	San Onofre	PWR	0	14.3	14	2.3	1,353	1,367
5	Trojan	PWR	100	3.5	1,367	5.6	3,258	4,625
5	Washington Nuclear	BWR	10	61.8	4,373	6.9	527	4,900
5	Hanford	DOE SNF	10	73.1	4,740	20.3	1,551	6,292
5	Hanford	DOE HLW	10	73.1	4,740	20.3	1,551	6,292
5	Idaho National Engr Laboratory	DOE SNF	10	22.2	1,085	173.7	25,284	26,370
5	Fort St Vrain	DOE SNF	10	6.2	437	39.9	3,050	3,488

The flow times in the vadose zone were calculated from the site-specific storage parameters given in Appendix B Tables B.2.1-1, B.2.1-2, B.2.1-3, B.2.1-4, and B.2.1-5. Formulae are given below for these calculations:

Water flow time (WFT) = (TV)*(MC)*(100)/(PR)

Where:

WFT = water flow time, yr.
TV = thickness of vadose zone, feet.
PR = precipitation rate, ft/yr.
MC = moisture content of soil; Vol. % = average of soil porosity (Vol. %) and field capacity (Vol. %).

Pu flow time = [(WFT)*(100BD)*(K_d)/(MC)] + 1

Where:

Pu flow time expressed in years
BD = bulk density; g/cm^3
K_d = distribution coefficient; ml/g

Distribution coefficients for Pu in Tables 2.1-1 through 2.1-5 were 10, 100, or 250 depending on the clay content of the soils (Reference 10). A K_d of 10 assumes a clay content <10%; 100 assumes between 10 and 29% clay; and 250 assumes soils with >30% clay.

2.2 Saturated Zone Transport

The calculated flow times for water and plutonium through the saturated zone also are given in Tables 2.1-1 through 2.1-5. These calculated values describe the times for flow of these materials through the saturated zone to the point where they emerge into surface streams.

A general assumption was made that the storage locations were 1,600 feet from existing reactors and up gradient (groundwater) from the reactors. This 1,600 feet is the average present distance from the reactors to the independent spent fuel storage installations (ISFSI). The saturated groundwater flow rate across this 1,600 feet was assumed to be the same as the groundwater flow rate between the reactors and the point of groundwater emergence to surface streams (in Reference 11).

The flow times in the saturated zone were calculated from site-specific storage parameters given in the information in Appendix B Tables. Formulae are given below for these calculations:

Groundwater Water flow time (GWFT) = (TD)/(GWV).

Where:

GWFT = groundwater flow time in years
TD = total distance from ISFSI to point of emergence of groundwater into surface waters, ft.
GWV = groundwater velocity, ft/yr

- Where available, groundwater velocities assumed the groundwater velocities between the reactor and point of emergence into surface waters. These are given in column 10 of Tables B.2.2-1 through B.2.2-5 (Reference 11).

- Where velocities were not available it was estimated using engineering judgments of groundwater conditions considered to be typical.

Pu saturated flow time = (GWV)*[(100SBD)*(SK_d)/(SEP) + 1]

Where:

Pu flow time expressed in years

SBD = bulk density in the Saturated zone; g/cm^3

SK_d = distribution coefficient in the saturated zone; ml/g. Depends upon the clay content of the soil and used Reference 10 (MEPAS value ranges).

SEP = effective porosity of saturated soils (vol %) was estimated at 60% of the saturated zone total soil porosity.

Part 3
Regional Site Data Used to Determine Surface Water Transport and Populations Using Surface Waters for Drinking

Table 3-1 shows the total downstream (summed for each facility) population drinking water contaminated by facility degradation by region and the sum of the population using river water as a drinking water source divided by river flow (cfs) at each of these population centers (Sum Population/Flow). The values shown as the Sum of Population/River Flow consider the populations downstream of each of the storage locations. Using this term simplifies the consequence calculations for each location by determining a single value that reflects the full range of affected populations and river flows for that storage location. This value corrects for stream flow increases as the rivers flow downstream. For example for the Duane Arnold commercial SNF location; degradation products from this SNF would enter the Cedar River and flow to the Gulf of Mexico via the Mississippi River. On this flow to the Gulf, the stream waters are used by thirty-six municipal water districts to supply drinking water to approximately 3 million users. At Duane Arnold the Sum Population/Flow is 9.96 people per cfs. From this value and the 3 million drinking water population, one can calculate the mean river flow to be 310,000 cfs. This can be compared to the flow of the Cedar River near the site of 3,300 cfs and to the Mississippi River at the river mouth of 494,000 cfs. The consequence from the total population drinking water would be the same if the calculations use the sum of the product of each population group using the water times actual stream flow or if the total population and the mean river flow is used. Total populations and mean river flow were used in these calculations.

Table 3-1. Regional population and river data.

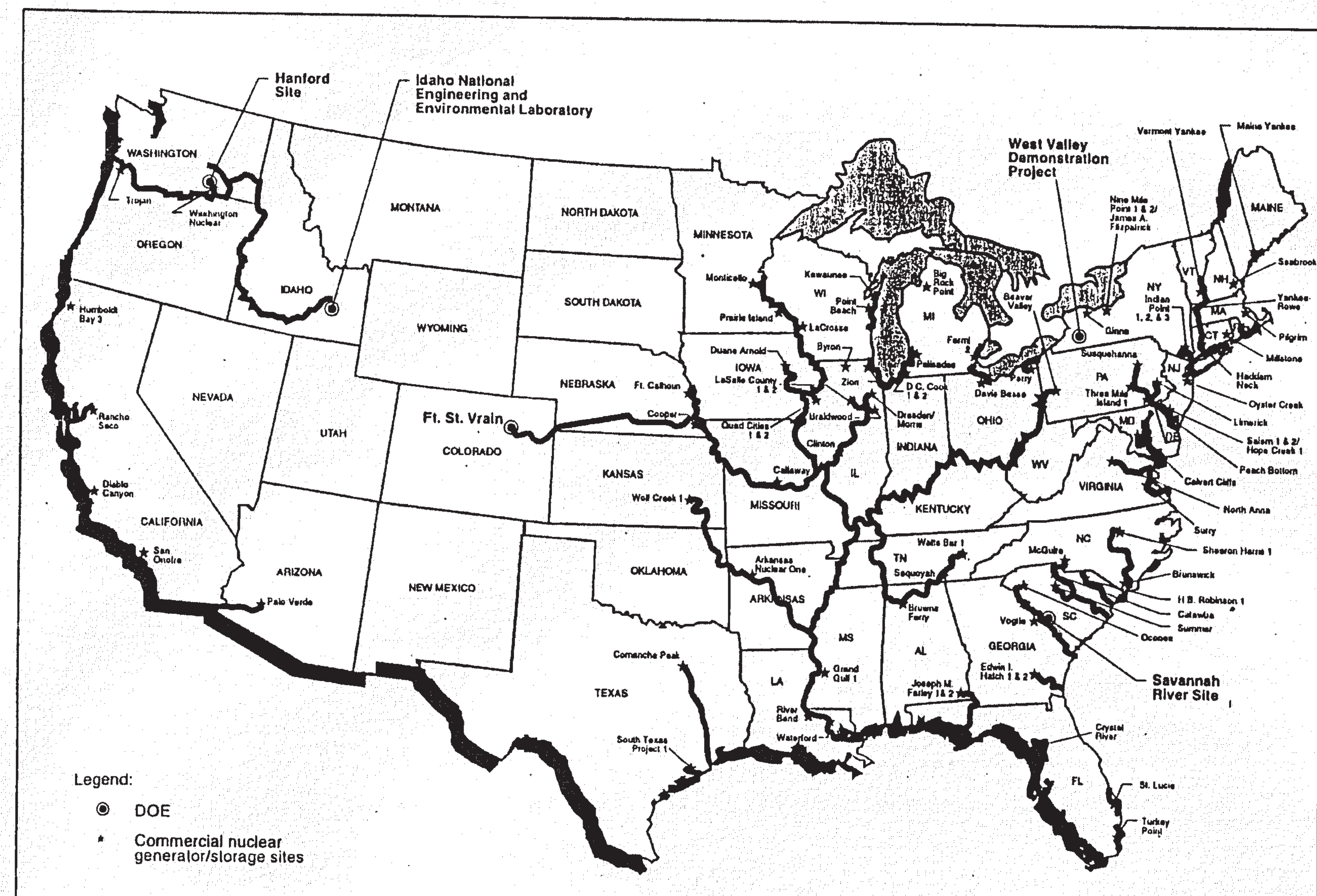
	Population affected		Sum population/flow	
Region	Total	Weighted	Total	Weighted
Region 1	1.6×10^{7}	2.1×10^{6}	1.4×10^{3}	1.9×10^{2}
Region 2	1.3×10^{7}	3.7×10^{5}	6.8×10^{2}	2.3×10^{1}
Region 3	4.4×10^{7}	3.1×10^{6}	2.2×10^{2}	1.6×10^{1}
Region 4	2.7×10^{7}	2.6×10^{6}	1.6×10^{2}	1.5×10^{1}
Region 5	5.7×10^{6}	1.9×10^{5}	4.3×10^{1}	1.5×10^{0}
Totals	NA	8.3×10^{6}	NA	2.4×10^{2}

The data for the individual storage locations in each region was summed to give a single region value. Those values are given columns 2 and 4 on Table 3-1. These values are used to calculate dose consequence in Reference 9. Table 3-1 also gives weighted Populations and Sum Population/Flow values for each region. These weighted values were determined, as described in Section 1-3, from the curies of americium and plutonium expected to be released times the value being weighted then dividing the sum of these calculations by the total curies released from the region. Since these values reflect only sites that impact drinking water users, sites that discharge to salt waters with no drinking water populations receive no weight. These weighted values then were used to determine the population dose commitment as described in Reference 9.

Figure 2 shows the relationship of individual storage sites and the major waterways that will be affected as the materials stored degrade. As can be seen by comparing Figures 1 and 2, portions of the material degrading in Regions 1, 2, 3, and 5 discharge to the Mississippi River and flow to the Gulf of Mexico and affect drinking water populations in Region 4. Using the weighted values for population from Table 3-1 overestimate the national population affected by the degradation of the materials stored by double counting some of the populations. In an attempt to determine a number of individuals that would be exposed to SNF and HLW degradation products, the total drinking water file was combined and sorted by states then grouped into the five regions. This analysis is documented in Reference 12. Table 3-2 gives the number of regional water drinkers and shows that 30.5 million people will be affected by this assumed SNF and HLW deterioration.

Table 3-2. Regional drinking water users

Region	Millions of water users
1	6.7
2	5.3
3	13.1
4	5.3
5	0.16
Total in United States	30.5



YUCCA MTN EIS/Pubsonly/Grfx/RBCS SNF & HLW/02 SNF & HLW Strg Loca.AI

Figure 2. SNF and HLW storage locations; major waterways highlighted.

EIS Related Information

References

Reference 1. "Draft Continued Storage Analysis Report", Revision 0F, September 25, 1998.

Reference 2. Appendix A, "Spent Nuclear Fuel and High-Level Radioactive Waste Inventory and Characteristics", Revision 0A, May 4, 1998.

Reference 3. "Draft Analysis Bases for Yucca Mountain Repository Environmental Impact Statement", Revision 0F, August 28, 1998.

Reference 4. "Sensitivity Study of Effects on Population Dose Commitment of Flow-Time Through the Vadose-Saturated Zones, by W. L. Poe, Tetra Tech NUS, Aiken, SC, July 1998.

Reference 5. BPNWD (Battelle Pacific Northwest Division), 1998, "No Action Alternative Analysis for Commercial Spent Nuclear Fuel, DOE High-Level Waste, and DOE Spent Nuclear Fuel – Source Term Estimates", Richland, WA, May 1998.

Reference 6. "Waste Quantities, Mix and Throughput Study Report", Table F-1. Document Number #B00000000-01717-5705-00059, Revision 01.

Reference 7. "National Weather Conditions Affecting Long-Term Degradation of Commercial Spent Nuclear Fuel and DOE Spent Nuclear Fuel and High-Level Waste," by W. L. Poe and P. F. Wise, Tetra Tech NUS, Inc., Aiken, SC, October 1998.

Reference 8. "Long term Degradation of Concrete Presently Used for Storage of Spent Nuclear Fuel and High-Level Waste," Rev. 1, by W. L. Poe, Tetra Tech NUS, Inc., Aiken, SC, October 1998.

Reference 9. "Radionuclide Transport and Dose Commitment from Drinking Water from Continued Storage and Degradation of Spent Nuclear Fuel and High-Level Waste Materials Under Loss of Institutional Control", by A. L. Toblin, Tetra Tech NUS, Gathersburg, MD, October 1998.

Reference 10. "Multimedia Environmental Pollutant Assessment System (MEPAS) Application Guidance, Volume 1 – User Guide," by J. G. Droppo et al., PNL-7216, Pacific Northwest Laboratory, Richland, WA.

Reference 11. "Groundwater Transport Conditions Near Commercial Reactor and DOE Sites", by A. T. Jenkins, Tetra Tech NUS, Oak Ridge, TN.

Reference 12. "Regional Drinking Water Population by State." By R. G. Davis, Tetra Tech NUS, Inc., Aiken, SC, November 1998.

Reference 13. "Population Affected from Continued Storage and Degradation of Spent Nuclear Fuels and High-Level Waste," by D. S. Sinkowski, Tetra Tech NUS, Inc., Aiken, SC, October 1998.

Appendix A
Regional Data

The original sources of the data used in Tables A.1.1-1, A.1.1-2, A.1.1-3, A.1.1-4, and A.1.1-5 are described below:

- Column 1 is the name of the site being used for storage of materials scheduled. These tables assume that the materials remain at the sites for the 10,000-year analysis period. The data for commercial SNF came from the YM EIS Appendix A (Reference 3), Table A.2.1-1. The analysis assumes the DOE SNF is surrogate N-Reactor fuel from categories 1, 4, 5, 6, 8, and 11 from YM EIS Appendix A Table A.2.2-2. The location of the DOE HLW was obtained from Reference 6.
- Column 2 data came from YM EIS Appendix A Table A.2.1-1.
- Column 3 is a near-by city with meteorological data. This data was used in Reference 7 for calculating concrete degradation.
- Column 4 is the State where the storage area is located.
- Column 5 contains the amounts of CSNF from YM EIS Appendix A Table A.2.1-4.
- Column 6 is the difference between column 5 and 7.
- Column 7 data was provided by Joe Zeigler in a May 28, 1998 FAX. Data was confirmed by Joe Rivers and Dave Zabranski (DOE-RW)
- Column 8 is Juvenile Zircaloy failures which were calculated as (0.001)X(MTHM of Zircaloy-clad SNF).

Table A.1.1-1. Region 1 SNF and HLW inventory.

Site	Fuel type	Site location near-by city	State	Total MTHM	MTHM in Zircaloy	MTHM in stainless steel	MTHM in juvenile failure
Haddam Neck	PWR	Bridgeport	CT	420	60	360	0.06
Millstone	PWR	Bridgeport	CT	807	807	0	0.81
Millstone	BWR	Bridgeport	CT	902	902	0	0.90
Salem/Hope Creek	PWR	Wilmington	DE	560	560	0	0.56
Salem/Hope Creek	BWR	Wilmington	DE	1,099	1,099	0	1.10
Pilgrim	BWR	Boston	MA	527	527	0	0.53
Seabrook	PWR	Portland	MA	425	425	0	0.43
Maine Yankee	PWR	Portland	ME	536	536	0	0.54
Calvert Cliffs	PWR	Baltimore	MD	1,142	1,142	0	1.14
Oyster Creek	BWR	Atlantic City	NJ	699	699	0	0.70
Fitzpatrick/Nine Mile Point	BWR	Syracuse	NY	1,812	1,812	0	1.81
Ginna	PWR	Rochester	NY	463	463	0	0.46
Indian Point	PWR	New York	NY	1,134	1,134	0	1.13
Indian Point 1	BWR	New York	NY	31	0	31	0.00
Yankee-Rowe	PWR	Albany	NY	127	106	21	0.11
Beaver Valley	PWR	Pittsburgh	PA	1,018	1,018	0	1.02
Limerick	BWR	Philadelphia	PA	1,143	1,143	0	1.14
Peach Bottom	BWR	Philadelphia	PA	1,554	1,554	0	1.55
Susquehanna	BWR	Wilks Barr	PA	1,276	1,276	0	1.28
Three Mile Island	PWR	Middletown	PA	548	548	0	0.55
Vermont Yankee	BWR	Albany, NY	VT	609	609	0	0.61
West Valley Demo Project	DOE HLW	Buffalo	NY	*			
Region total				16,830	16,419	412	16

* See Table 1-1 for quantity of HLW.

Table A.1.1-2. Region 2 SNF and HLW inventory.

Site	Fuel type	Site location near-by city	State	Total MTHM	MTHM in Zircaloy	MTHM in stainless steel	MTHM in juvenile failure
Browns Ferry	BWR	Huntsville	AL	1,932	1,932	0	1.93
Farley	PWR	Montgomery	AL	1,174	1,174	0	1.17
Crystal River	PWR	Tampa	FL	512	512	0	0.51
St. Lucie	PWR	West Palm Beach	FL	1,020	1,020	0	1.02
Turkey Point	PWR	Miami	FL	1,074	1,074	0	1.07
Hatch	BWR	Macon	GA	1,446	1,446	0	1.45
Vogtle	PWR	Augusta	GA	1,080	1,080	0	1.08
Brunswick	PWR	Wilmington	NC	137	137	0	0.14
Brunswick	BWR	Wilmington	NC	759	759	0	0.76
Catawba	PWR	Charlotte	NC	1,148	1,148	0	1.15
Harris	PWR	Raleigh	NC	498	498	0	0.50
Harris	BWR	Raleigh	NC	252	252	0	0.25
McGuire	PWR	Charlotte	NC	1,439	1,439	0	1.44
Oconee	PWR	Greenville	SC	1,865	1,865	0	1.87
Robinson	PWR	Columbia	SC	384	384	0	0.38
Summer	PWR	Spartanburg	SC	526	526	0	0.53
Sequoyah	PWR	Chattanooga	TN	1,023	1,023	0	1.02
Watts Bar	PWR	Chattanooga	TN	251	251	0	0.25
North Anna	PWR	Richmond	VA	1,184	1,184	0	1.18
Surry	PWR	Norfolk	VA	1,194	1,194	0	1.19
Savannah River Site	DOE-SNF	Augusta	GA	*			
Savannah River Site	DOE-HLW	Augusta	GA	*			
Region total				18,898	18,898	0	19

*See Table 1-1 for quantity of DOE-SNF and DOE-HLW.

Table A.1.1-3. Region 3 SNF and HLW inventory.

Site	Fuel type	Site location near-by city	State	Total MTHM	MTHM in Zircaloy	MTHM in stainless steel	MTHM in juvenile failure
Duane Arnold	BWR	Des Moines	IA	467	467	0	0.47
Braidwood	PWR	Peoria	IL	1,029	1,029	0	1.03
Byron	PWR	Rockford	IL	1,068	1,068	0	1.07
Clinton	BWR	Springfield	IL	477	477	0	0.48
Dresden/Morris	BWR	Peoria	IL	2,013	2,013	0	2.01
Dresden/Morris	PWR	Peoria	IL	133	0	133	0.00
Lasalle County	BWR	Peoria	IL	952	952	0	0.95
Quad Cities	BWR	Moline	IL	1,277	1,277	0	1.28
Zion	PWR	Chicago	IL	1,052	1,052	0	1.05
Big Rock Point	BWR	Alpena	MI	58	58	0	0.06
Cook	PWR	South Bend	IN	1,433	1,433	0	1.43
Enrico Fermi	BWR	Detroit	MI	523	523	0	0.52
Palisades	PWR	Grand Rapids	MI	585	585	0	0.59
Monticello	BWR	Saint Cloud	MN	426	426	0	0.43
Prairie Island	PWR	Minneapolis	MN	866	866	0	0.87
Davis-Besse	PWR	Toledo	OH	505	505	0	0.51
Perry	BWR	Cleveland	OH	452	452	0	0.45
Kewaunee	PWR	Milwaukee	WI	451	451	0	0.45
Lacrosse	BWR	La Crosse	WI	38	0	38	0.00
Point Beach	PWR	Milwaukee	WI	876	876	0	0.88
Region total				14,682	14,511	171	15

Table A.1.1-4. Region 4 SNF & HLW inventory.

Site	Fuel type	Site location near-by city	State	Total MTHM	MTHM in Zircaloy	MTHM in stainless steel	MTHM in juvenile failure
Arkansas Nuclear One	PWR	Little Rock	AR	1,109	1,109	0	1.11
Wolf Creek	PWR	Wichita	KS	630	630	0	0.63
River Bend	BWR	Baton Rouge	LA	531	531	0	0.53
Waterford	PWR	New Orleans	LA	500	500	0	0.50
Callaway	PWR	Columbia	MO	702	702	0	0.70
Grand Gulf	BWR	Vicksburg	MS	856	856	0	0.86
Cooper	BWR	Omaha	NE	452	452	0	0.45
Fort Calhoun	PWR	Omaha	NE	379	379	0	0.38
Comanche Peak	PWR	Dallas	TX	998	998	0	1.00
South Texas	PWR	Victoria	TX	1,012	1,012	0	1.01
Region total				7,170	7,170	0	7

Table A.1.1-5. Region 5 SNF and HLW inventory.

Site	Fuel type	Site location near-by city	State	Total MTHM	MTHM in Zircaloy	MTHM in stainless steel	MTHM in juvenile failure
Palo Verde	PWR	Phoenix	AZ	1,674	1,674	0	1.67
Diablo Canyon	PWR	Santa Maria	CA	1,126	1,126	0	1.13
Humboldt Bay	BWR	Eureka	CA	29	29	0	0.03
Rancho Seco	PWR	Sacramento	CA	228	228	0	0.23
San Onofre	PWR	San Diego	CA	1,423	1,279	144	1.28
Trojan	PWR	Portland	OR	359	359	0	0.36
Washington Nuclear	BWR	Richland (Hanford)	WA	581	581	0	0.58
Hanford	DOE SNF	Richland (Hanford)	WA	*			
Hanford	DOE HLW	Richland (Hanford)	WA	*			
Idaho National Engr Laboratory	DOE SNF	Idaho Falls	ID	*			
Fort St Vrain	DOE SNF	Fort Collins	CO	*			
Region total				5,420	5,276	144	5

* See Table 1-1 for quantity of DOE-SNF and DOE-HLW.

The original source of the data used in Tables A.1.2-1, A.1.2-2, A.1.2-3, A.1.2-4. and A.1.2-5 are described below:

- Columns 1 and 2 are the same as in Tables A.1.1-1, A.1.1-2, A.1.1-3, A.1.1-4, and A.1.1-5.
- The curies Am-Pu in columns 3 and 4 were obtained by multiplying the mass from Tables A.1.1-1, A.1.1-2, A.1.1-3, A.1.1-4, and A.1.1-5 by 1040 curies per MTHM. This factor was determined by summing the curies of Am-243, Pu-239, Pu-240 and Pu-242 from Table A.2.1-8 of YM EIS Appendix A and converting the curies of Am-Pu per fuel assembly to curies per fuel MTHM. This calculation assumes that all of the stainless steel clad SNF and all of the SNF with juvenile Zircaloy failure would be released during the 10,000-year period.
- The curies of Am-Pu in DOE SNF was obtained for the same four radionuclides from the information given for categories 1, 4, 5, 6, 8, and 11 in YM EIS Appendix A Table A.2.2-4 for each DOE site. Calculations showed the amount of Am-Pu in the DOE SNF at Hanford to be 557,000 curies, at INEEL to be 114,000 curies, at SRS to be 15,000 curies. DOE-SNF curie content at Fort St. Vrain was not provided in YM EIS Appendix A Table A.2.2-4 and was estimated to be 4,300. This estimate assumed that the Fort St. Vrain SNF had the average Am-Pu content of other DOE SNF. Mass of Fort St. Vrain DOE SNF was obtained from YM EIS Appendix A Table A.2.2-2. This

calculation assumed that all of the Am-Pu in the surrogate DOE-SNF would be released during the 10,000-year period. These values are presented in column 5.

- The curies of Am-Pu released from DOE HLW were based on assumptions of the amount of HLW that would be released during the 10,000-year period: 1% of Hanford HLW, 8% of SRS HLW, and 2% of West Valley HLW. These estimates were based on preliminary flux calculations made by Pacific Northwest National Laboratory that reflected the expected storage conditions and the environmental conditions of the sites.

- Using the above estimates of fraction of HLW dissolved at each site and the Am-Pu content for the four radionuclides from YM EIS Appendix A Tables A.2.2-3, A.2.2-5, and A.2.2-6 for Hanford, SRS, and WVDP, respectively the curies of Am-Pu released were determined. The calculated values are: Hanford 69, SRS 10.400, WVDP 75. These values are presented in column 6 of the attached tables.

Table A.1.2-1. Region 1 Am-Pu curies released in 10,000 years.

Site	Fuel type	Ci Am and Pu in juvenile C SNF	Ci Am and Pu in SS CSNF	Ci Am and Pu in DOE SNF	Ci Am and Pu in DOE HLW
Haddam Neck	PWR	62	374,400		
Millstone	PWR	839	0		
Millstone	BWR	776	0		
Salem/Hope Creek	PWR	582	0		
Salem/Hope Creek	BWR	945	0		
Pilgrim	BWR	453	0		
Seabrook	PWR	442	0		
Maine Yankee	PWR	557	0		
Calvert Cliffs	PWR	1188	0		
Oyster Creek	BWR	601	0		
Fitzpatrick/Nine Mile Point	BWR	1558	0		
Ginna	PWR	481	0		
Indian Point	PWR	1179	0		
Indian Point 1	BWR	0	26,660		
Yankee-Rowe	PWR	110	21,840		
Beaver Valley	PWR	1059	0		
Limerick	BWR	983	0		
Peach Bottom	BWR	1336	0		
Susquehanna	BWR	1097	0		
Three Mile Island	PWR	570	0		
Vermont Yankee	BWR	524	0		
West Valley Demo Project	DOE HLW				74.6
Region total		15,344	422,900	0	75
				Total Ci	438,318

Table A.1.2-2. Region 2 Am-Pu curies released in 10,000 years.

Site	Fuel type	Ci Am and Pu in juvenile CSNF	Ci Am and Pu in SSCSNF	Ci Am and Pu in DOE SNF	Ci Am and Pu in DOE HLW
Browns Ferry	BWR	1661	0		
Farley	PWR	1220	0		
Crystal River	PWR	532	0		
St. Lucie	PWR	1061	0		
Turkey Point	PWR	1117	0		
Hatch	BWR	1244	0		
Vogtle	PWR	1124	0		
Brunswick	PWR	142	0		
Brunswick	BWR	653	0		
Catawba	PWR	1194	0		
Harris	PWR	518	0		
Harris	BWR	217	0		
McGuire	PWR	1496	0		
Oconee	PWR	1940	0		
Robinson	PWR	399	0		
Summer	PWR	547	0		
Sequoyah	PWR	1064	0		
Watts Bar	PWR	261	0		
North Anna	PWR	1231	0		
Surry	PWR	1242	0		
Savannah River Site	DOE-SNF			15,000	
Savannah River Site	DOE-HLW				10,400
Region total		18,864	0	15,000	10,400
				Total Ci	44,264

Table A.1.2-3. Region 3 Am-Pu curies released in 10,000 years.

Site	Fuel type	Ci Am and Pu in juvenile C SNF	Ci Am and Pu in SS CSNF	Ci Am and Pu in DOE SNF	Ci Am and Pu in DOE HLW
Duane Arnold	BWR	401	0		
Braidwood	PWR	1070	0		
Byron	PWR	1110	0		
Clinton	BWR	411	0		
Dresden/Morris	BWR	1731	0		
Dresden/Morris	PWR	0	138,320		
Lasalle County	BWR	819	0		
Quad Cities	BWR	1098	0		
Zion	PWR	1094	0		
Big Rock Point	BWR	50	0		
Cook	PWR	1490	0		
Enrico Fermi	BWR	450	0		
Palisades	PWR	609	0		
Monticello	BWR	367	0		
Prairie Island	PWR	901	0		
Davis-Besse	PWR	526	0		
Perry	BWR	389	0		
Kewaunee	PWR	469	0		
Lacrosse	BWR	0	32,653		
Point Beach	PWR	911	0		
Region total		13,895	170,973	0	0
				Total Ci	184,868

Table A.1.2-4. Region 4 Am-Pu curies released in 10,000 years.

Site	Fuel type	Ci Am and Pu in juvenile C SNF	Ci Am and Pu in SS CSNF	Ci Am and Pu in DOE SNF	Ci Am and Pu in DOE HLW
Arkansas Nuclear One	PWR	1154	0		
Wolf Creek	PWR	655	0		
River Bend	BWR	457	0		
Waterford	PWR	520	0		
Callaway	PWR	730	0		
Grand Gulf	BWR	736	0		
Cooper	BWR	389	0		
Fort Calhoun	PWR	394	0		
Comanche Peak	PWR	1037	0		
South Texas	PWR	1053	0		
Region total		7,125	0	0	0
				Total Ci	7,125

Table A.1.2-5. Region 5 Am-Pu curies released in 10,000 years.

Site	Fuel type	Ci Am and Pu in juvenile C SNF	Ci Am and Pu in SS CSNF	Ci Am and Pu in DOE SNF	Ci Am and Pu in DOE HLW
Palo Verde	PWR	1741	0		
Diablo Canyon	PWR	1172	0		
Humboldt Bay	BWR	25	0		
Rancho Seco	PWR	238	0		
San Onofre	PWR	1330	149,760		
Trojan	PWR	373	0		
Washington Nuclear	BWR	499	0		
Hanford	DOE SNF			557,000	
Hanford	DOE HLW				69
Idaho National Engr Laboratory	DOE SNF			114,000	
Fort St Vrain	DOE SNF			4,320	
Region total		5,377	149,760	675,320	69
				Total Ci	830,526

The source of the data in Tables A.1.3-1, A.1.3-2, A.1.3-3, A.1.3-4, and A.1.3-5 are described below.

- Columns 1 and 2 are same as discussed previously.
- The methodology for determining concrete life for commercial SNF storage is described in Reference 8 and actual calculated values are described in Reference 7. Reference 7 documented the preparation of Figure A.1-1 which divided the United States into five relatively constant concrete-failure zones.

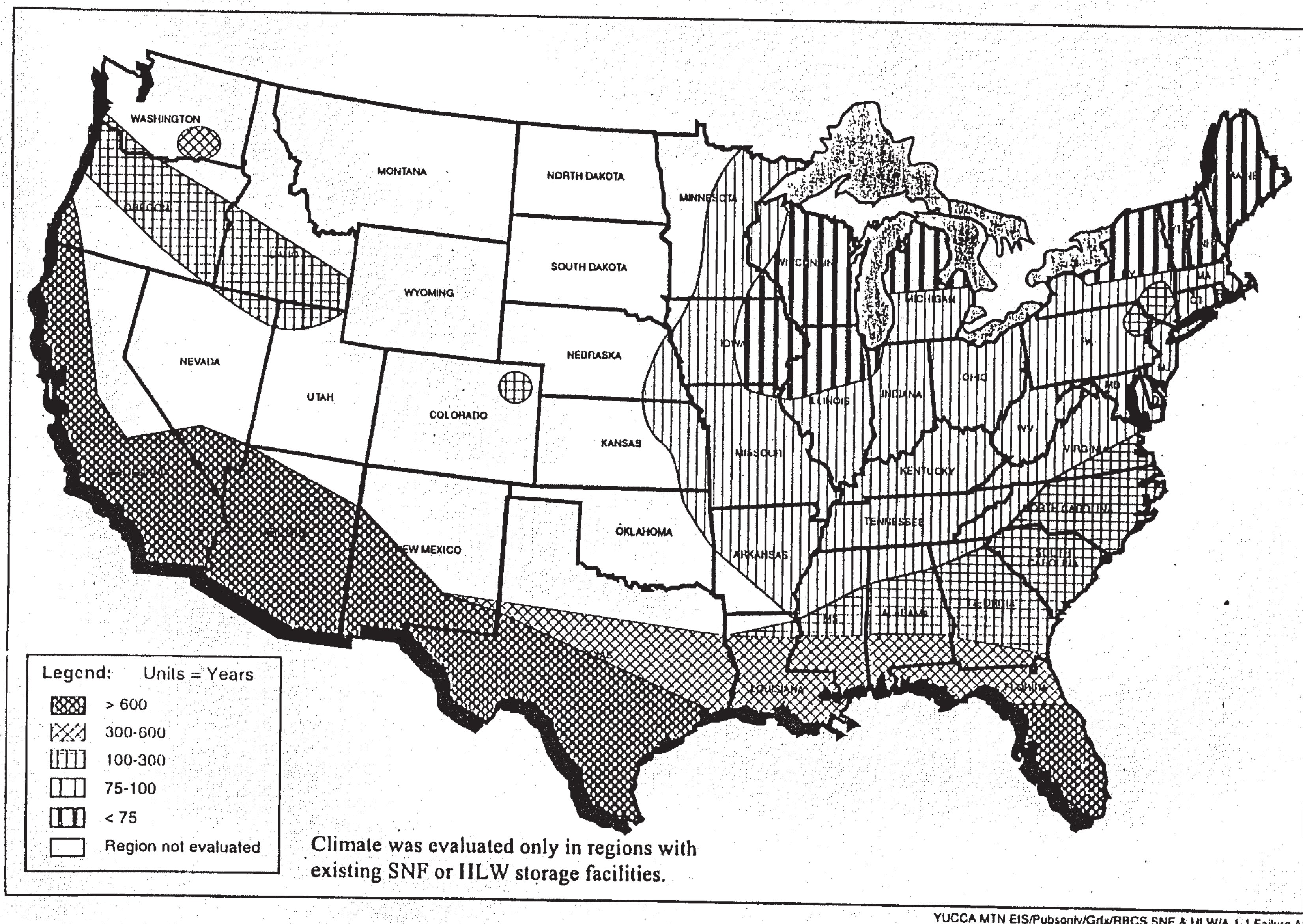


Figure A.1-1. Failure times for above-ground concrete storage modules.

These failure zones were used to determine the failure times used in the regional analysis. Failure times were selected for use on Tables A.1.3-1, A.1.3-2, A.1.3-3, A.1.3-4, and A.1.3-5 from values near the mid-range of the failure times. Failure times for each zones used are listed below.

Failure time range (yrs)	Failure time used (yrs.)
<75	67
75-100	87
100-300	200
300-600	450
>600	3550

- The methodology used to identify precipitation regions is described in Reference 7. That reference identified precipitation regions based upon precipitation rates as shown in Figure A.1-2. Precipitation rates, shown in the fourth column of Tables A.1.3-1, A.1.3-2, A.1.3-3, A.1.3-4, and A.1.3-5, were used for each site within the region. The rate was valued near the mid range of the precipitation range. Precipitation rates used in the following tables were as follows:

Precipitation range (in/yr)	Rate, in/yr
<30	10.5
30-35	32.5
35-40	37.5
40-45	42.5
>45	52.2

  The region <30" used the average precipitation rate for the commercial SNF, DOE SNF, and DOE HLW which is 10.5"/yr. The >45' region used a precipitation rate of 52.2"/yr to represent precipitation rates between 45"/yr and rates larger than 60"/yr along the Gulf Coast in parts of LA, MS, and AL.

- The approach used to obtain data on relative humidity (Columns 5 and 6) is described in Reference 7. This data was not binned by region but site specific data is shown on these tables.

- The seventh column is the percent of days with rain.

- The eighth column is the sum of fraction of days with precipitation and fraction of time with that relative humidity exceeds 85 percent. The data in this eighth column was used to develop the stainless steel corrosion rate. Where relative humidity is greater than 85 percent, the corrosion of this stainless steel tend to behave just as it does with precipitation.

- The precipitation chemistry information shown in columns 9, 10, and 11 of Tables A.1.3-1, A.1.3-2, A.1.3-3, A.1.3-4, and A.1.3-5 were obtained from Figures A.1-3, A.1-4, and A.1-5. The source of the three figures is described in Reference 7. These three chemistry components of precipitation are the primary environmental parameters that affect waste package, cladding, and SNF and HLW degradation. The chloride and sulfate concentrations (Columns 10 and 11) are expressed as weight percent impurity while in the two associated figures they are expressed as molarity. The conversion between the two is straightforward.

- The data in the last column is the mean average temperature for each site. The source of this data is described in Reference 7. It is a 30-year annual average temperature.

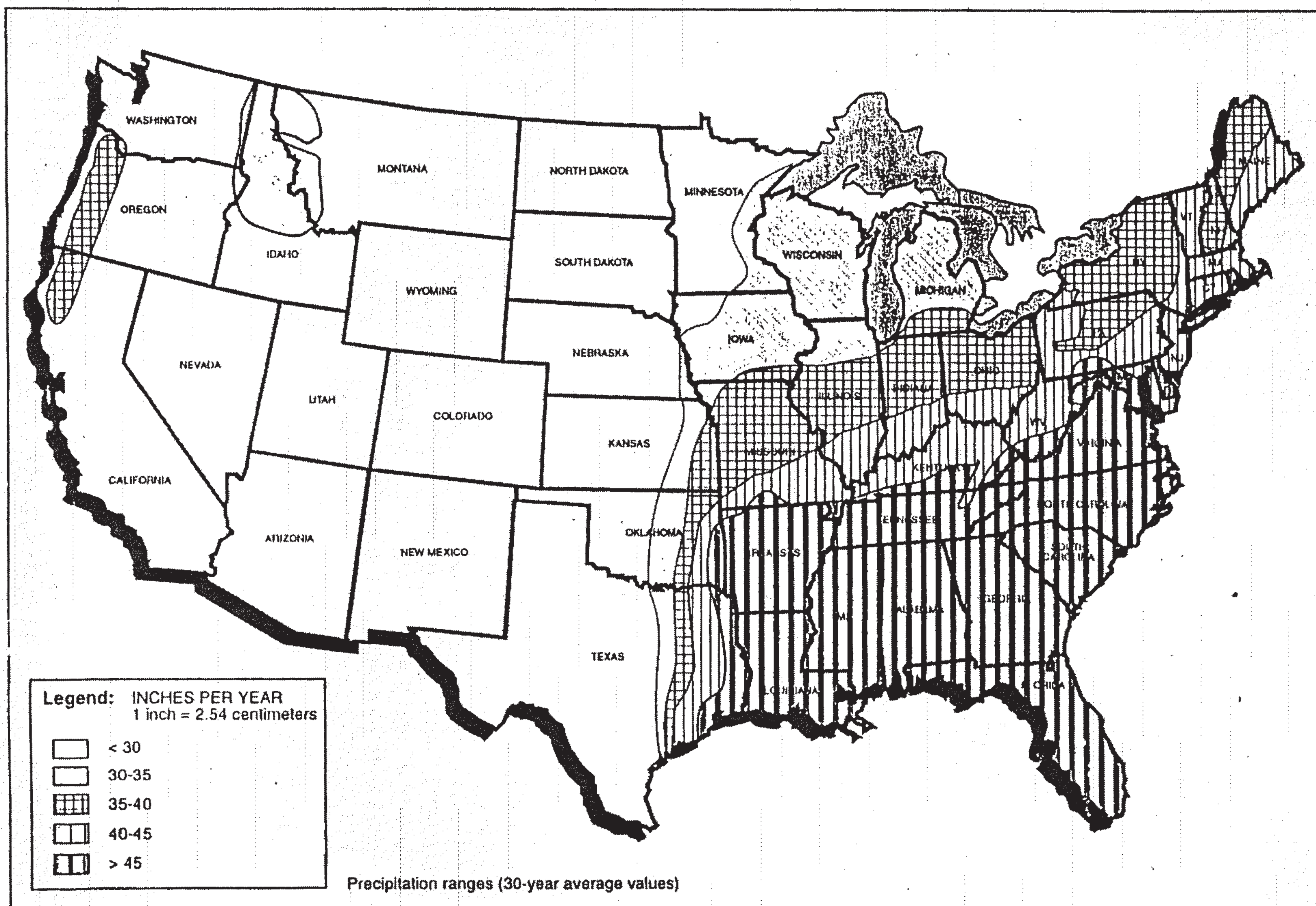


Figure A.1-2. Regional precipitation.

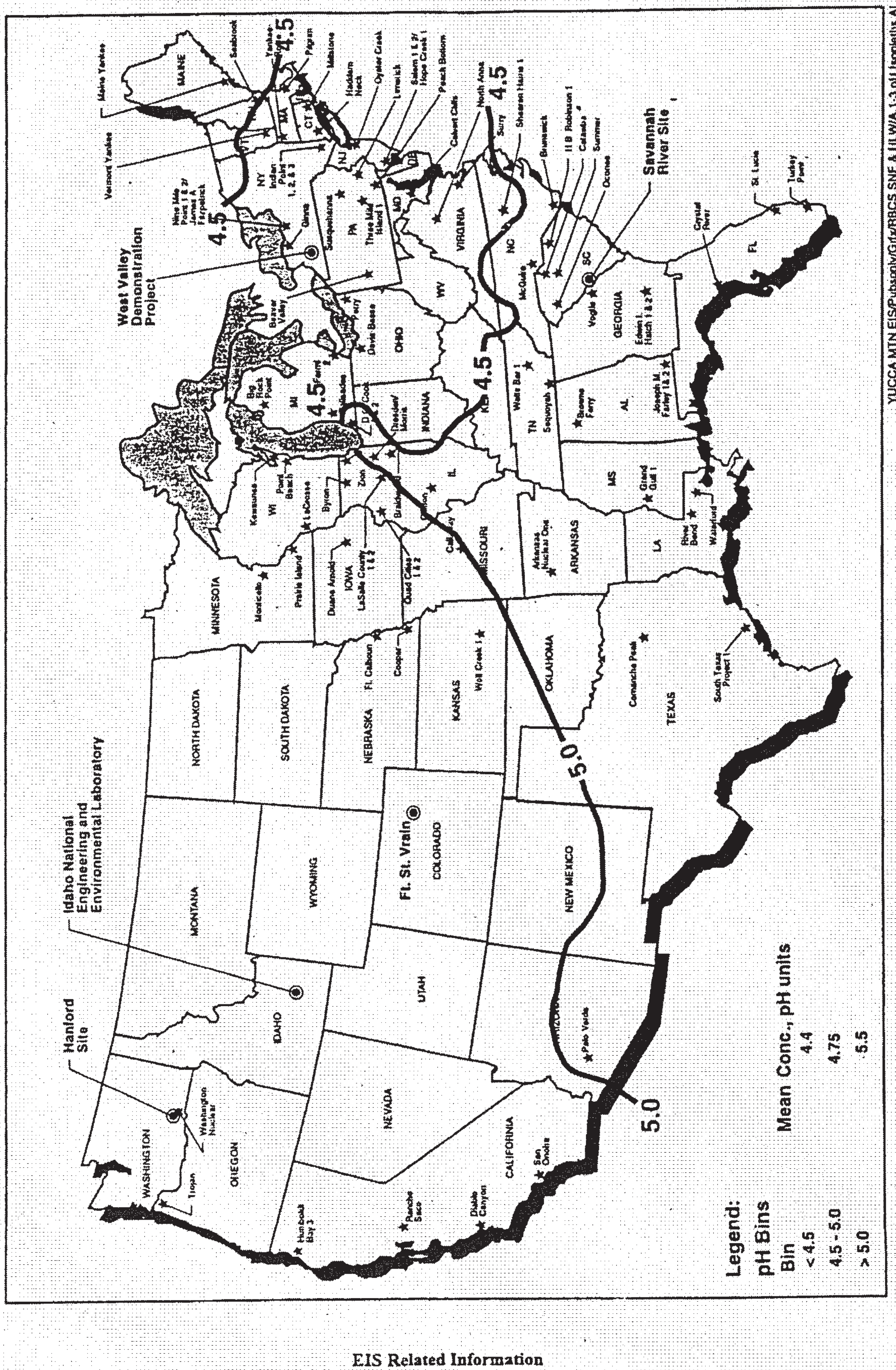


Figure A.1-3. pH isopleths.

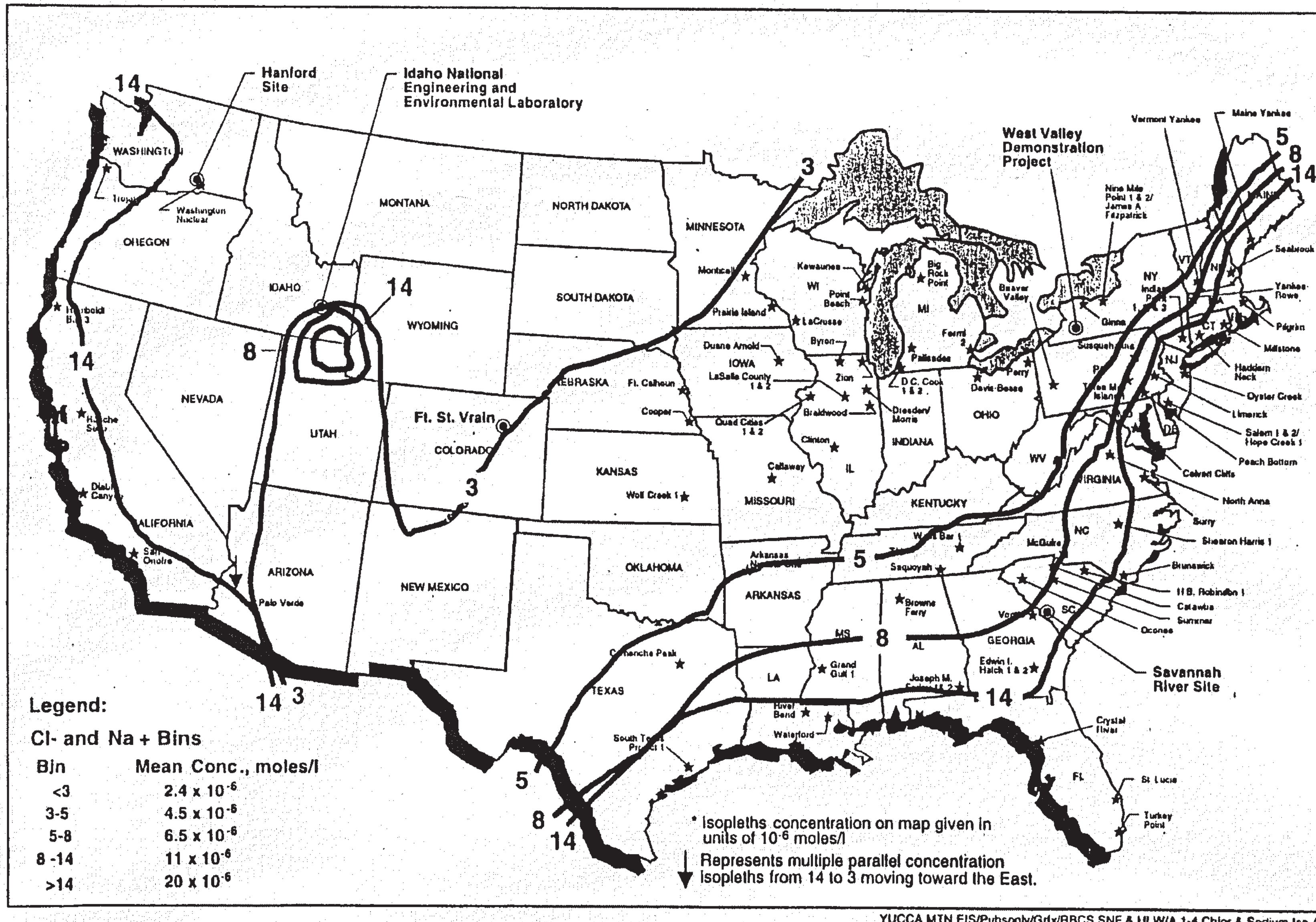


Figure A.1-4. Chloride and sodium concentration isopleths*.

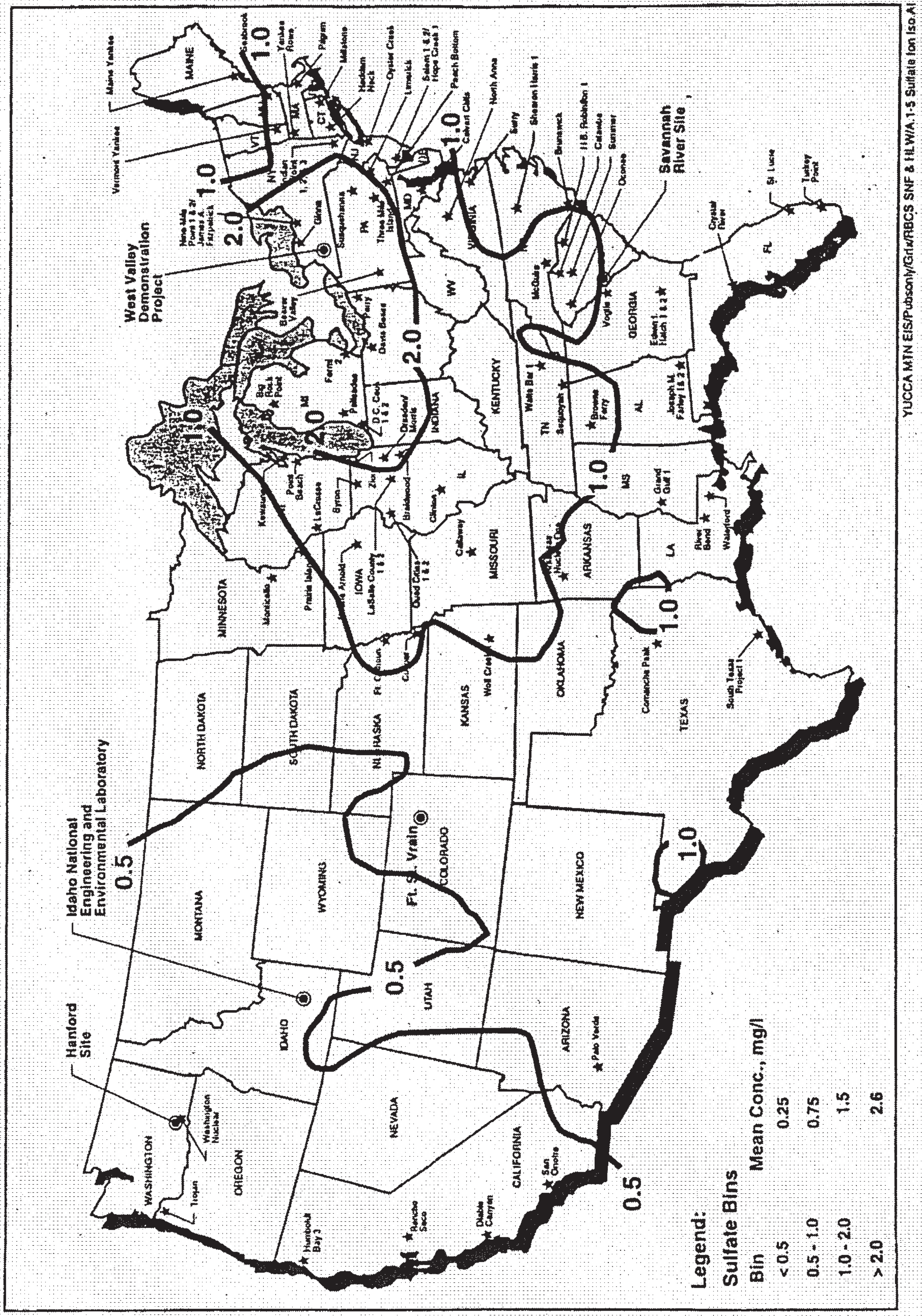


Figure A.1-5. Sulfate ion concentration isopleths.

Table A.1.3-1. Region I environmental parameters.

Site	Fuel type	Concrete life	Precipitation rate used, in/yr	Relative humidity: Time 6 hr/month RH>85%	Relative humidity: Percent of year	Rain-days: Percent of year	Total: Wet days % of year	Precipitation chemistry data: pH	Precipitation chemistry data: C⁻, wt %	Precipitation chemistry data: $SO_4^=$ wt %	Average temp for year, °F
Haddam Neck	PWR	87	42.5	0	0.0	30.1	30.1	4.4	7.1E-05	1.5E-04	51.7
Millstone	PWR	87	42.5	0	0.0	30.1	30.1	4.4	7.1E-05	1.5E-04	51.7
Millstone	BWR	87	42.5	0	0.0	30.1	30.1	4.4	7.1E-05	1.5E-04	51.7
Salem/Hope Creek	PWR	87	42.5	0	0.0	30.1	30.1	4.4	7.1E-05	1.5E-04	54.2
Salem/Hope Creek	BWR	87	42.5	0	0.0	30.1	30.1	4.4	7.1E-05	1.5E-04	54.2
Pilgrim	BWR	87	42.5	0	0.0	30.1	30.1	4.4	7.1E-05	7.5E-05	51.3
Seabrook	PWR	67	32.5	6	12.5	32.9	45.4	4.75	7.1E-05	1.5E-04	45.4
Maine Yankee	PWR	67	42.5	6	12.5	30.1	42.6	4.75	7.1E-05	7.5E-05	45.4
Calvert Cliffs	PWR	200	52.2	0	0.0	29.3	29.3	4.4	7.1E-05	7.5E-05	58.0
Oyster Creek	BWR	67	42.5	8	16.7	30.1	46.8	4.4	7.1E-05	1.5E-04	53.0
Fitzpatrick/Nine Mile Point	BWR	67	37.5	4	8.3	30.7	39.0	4.4	1.6E-05	2.6E-04	47.4
Ginna	PWR	67	37.5	5	10.4	30.7	41.1	4.4	1.6E-05	2.6E-04	47.6
Indian Point	PWR	200	42.5	0	0.0	30.1	30.1	4.4	7.1E-05	1.5E-04	54.6
Indian Point 1	BWR	200	42.5	0	0.0	30.1	30.1	4.4	7.1E-05	1.5E-04	54.6
Yankee-Rowe	PWR	67	37.5	5	10.4	30.7	41.1	4.4	3.9E-05	1.5E-04	47.4
Beaver Valley	PWR	87	42.5	2	4.2	30.1	34.3	4.4	1.6E-05	2.6E-04	50.3
Limerick	BWR	200	42.5	1.5	3.1	30.1	33.3	4.4	7.1E-05	1.5E-04	54.3
Peach Bottom	BWR	200	42.5	0	0.0	30.1	30.1	4.4	7.1E-05	1.5E-04	54.3
Susquehanna	BWR	87	42.5	2	4.2	30.1	34.3	4.4	3.9E-05	2.6E-04	49.1
Three Mile Island	PWR	87	42.5	0	0.0	30.1	30.1	4.4	3.9E-05	2.6E-04	52.9
Vermont Yankee	BWR	67	42.5	5	10.4	30.1	40.6	4.4	1.6E-05	1.5E-04	47.4
West Valley Demo Project	DOE HLW	67	42.5	5	10.4	30.1	40.5	4.4	7.1E-05	1.5E-04	54.6

EIS Related Information

Table A.1.3-2. Region 2 environmental parameters.

Site	Fuel type	Concrete life	Precipitation rate used, in/yr	Relative humidity: Time 6 hr/month RH>85%	Relative humidity: Percent of year	Rain-days: Percent of year	Total: Wet days % of year	Precipitation chemistry data: pH	Precipitation chemistry data: Cl^-, wt %	Precipitation chemistry data: $SO_4^=$ wt %	Average temp for year, °F
Browns Ferry	BWR	87	52.2	9	18.8	29.3	48.1	4.75	2.3E-05	1.5E-04	60.3
Farley	PWR	200	52.2	16	33.3	29.3	62.6	4.75	3.9E-05	7.5E-05	64.9
Crystal River	PWR	3550	52.2	17	35.4	29.3	64.7	4.75	7.1E-05	7.5E-05	72.3
St. Lucie	PWR	3550	52.2	4	8.3	29.3	37.6	4.75	7.1E-05	7.5E-05	74.7
Turkey Point	PWR	3550	52.2	5	10.4	29.3	39.7	4.75	7.1E-05	7.5E-05	75.9
Hatch	BWR	200	52.2	11	22.9	29.3	52.2	4.75	3.9E-05	7.5E-05	64.8
Vogtle	PWR	200	52.2	14	29.2	29.3	58.5	4.75	3.9E-05	7.5E-05	63.2
Brunswick	PWR	200	52.2	13	27.1	29.3	56.4	4.75	7.1E-05	7.5E-05	63.4
Brunswick	BWR	200	52.2	13	27.1	29.3	56.4	4.75	7.1E-05	7.5E-05	63.4
Catawba	PWR	200	52.2	4	8.3	29.3	37.6	4.75	1.6E-05	1.5E-04	60.1
Harris	PWR	200	52.2	10	20.8	29.3	50.1	4.4	3.9E-05	7.5E-05	59.3
Harris	BWR	200	52.2	10	20.8	29.3	50.1	4.4	3.9E-05	7.5E-05	59.3
McGuire	PWR	200	52.2	4	8.3	29.3	37.6	4.75	1.6E-05	1.5E-04	60.1
Oconee	PWR	200	52.2	7	14.6	29.3	43.9	4.75	1.6E-05	1.5E-04	60.0
Robinson	PWR	3550	52.2	12	25.0	29.3	54.3	4.75	3.9E-05	1.5E-04	60.1
Summer	PWR	200	52.2	12	25.0	29.3	54.3	4.75	1.6E-05	1.5E-04	63.4
Sequoyah	PWR	87	52.2	13	27.1	29.3	56.4	4.75	2.3E-05	1.5E-04	59.3
Watts Bar	PWR	87	52.2	13	27.1	29.3	56.4	4.75	2.3E-05	1.5E-04	59.3
North Anna	PWR	87	52.2	9	18.8	29.3	48.1	4.4	7.1E-05	7.5E-05	57.7
Surry	PWR	200	52.2	1	2.1	29.3	31.4	4.4	3.9E-05	7.5E-05	59.2
Savannah River Site	DOE SNF	200	52.2	14	29.2	29.3	58.5	4.75	3.9E-05	7.5E-05	63.2
Savannah River Site	DOE HLW	Weather Prot lost 150yrs	52.2	14	29.2	29.3	58.5	4.75	3.9E-05	7.5E-05	63.2

Table A.1.3-3. Region 3 environmental parameters.

Site	Fuel type	Concrete life	Precipitation rate used, in/yr	Relative humidity: Time 6 hr/month RH>85%	Relative humidity: Percent of year	Rain-days: Percent of year	Total: Wet days % of year	Precipitation chemistry data: pH	Precipitation chemistry data: Cl^-, wt %	Precipitation chemistry data: $SO_4^=$ wt %	Average temp for year, °F
Duane Arnold	BWR	87	32.5	2	4.2	32.9	37.0	4.4	1.6E-05	1.5E-04	49.9
Braidwood	PWR	67	32.5	4	8.3	32.9	41.2	4.75	1.6E-05	2.6E-04	50.7
Byron	PWR	87	32.5	6	12.5	32.9	45.4	4.4	1.6E-05	1.5E-04	47.7
Clinton	BWR	87	37.5	3	6.3	30.7	36.9	4.75	1.6E-05	1.5E-04	50.7
Dresden/Morris	BWR	67	32.5	4	8.3	32.9	41.2	4.75	1.6E-05	2.6E-04	50.7
Dresden/Morris	PWR	67	32.5	4	8.3	32.9	41.2	4.75	1.6E-05	2.6E-04	50.7
Lasalle County	BWR	67	32.5	4	8.3	32.9	41.2	4.4	1.6E-05	2.6E-04	50.7
Quad Cities	BWR	67	32.5	3	6.3	32.9	39.1	4.4	1.6E-05	1.5E-04	49.6
Zion	PWR	67	32.5	2	4.2	32.9	37.0	4.4	1.6E-05	2.6E-04	46.1
Big Rock Point	BWR	67	32.5	4	8.3	32.9	41.2	4.4	1.6E-05	2.6E-04	47.1
Cook	PWR	87	32.5	2	4.2	32.9	37.0	4.4	1.6E-05	2.6E-04	49.5
Enrico Fermi	BWR	67	32.5	2	4.2	32.9	37.0	4.4	1.6E-05	2.6E-04	48.7
Palisades	PWR	67	32.5	3.5	7.3	32.9	40.2	4.4	1.6E-05	2.6E-04	49.5
Monticello	BWR	87	32.5	4	8.3	32.9	41.2	4.4	1.6E-05	7.5E-05	41.5
Prairie Island	PWR	87	32.5	1	2.1	32.9	35.0	4.4	1.6E-05	7.5E-05	44.9
Davis-Besse	PWR	87	37.5	1.5	3.1	30.7	33.8	4.4	1.6E-05	2.6E-04	48.5
Perry	BWR	87	37.5	1	2.1	30.7	32.8	4.4	1.6E-05	2.6E-04	49.6
Kewaunee	PWR	67	32.5	2	4.2	32.9	37.0	4.4	1.6E-05	1.5E-04	46.1
Lacrosse	BWR	87	32.5	6	12.5	32.9	45.4	4.4	1.6E-05	1.5E-04	46.2
Point Beach	PWR	67	32.5	2	4.2	32.9	37.0	4.4	1.6E-05	1.5E-04	46.1

Table A.1.3-4. Region 4 environmental parameters.

				Relative humidity		Rain-days	Total	Precipitation chemistry data			
Site	Fuel type	Concrete life	Precipitation rate used, in/yr	Time 6 hr/month RH>85%	Percent of year	Percent of year	Wet days % of year	pH	C', wt %	$SO_4^=$ wt %	Average temp for year, °F
Arkansas Nuclear One	PWR	200	52.2	5	10.4	29.3	39.7	4.75	1.6E-05	7.5E-05	60.6
Wolf Creek	PWR	200	32.5	0	0.0	32.9	32.9	4.4	1.6E-05	1.5E-04	56.2
River Bend	BWR	450	52.2	16	33.3	29.3	62.6	4.75	7.1E-05	7.5E-05	67.7
Waterford	PWR	450	52.2	16	33.3	29.3	62.6	4.75	7.1E-05	7.5E-05	68.1
Callaway	PWR	87	37.5	5.5	11.5	30.7	42.1	4.4	1.6E-05	1.5E-04	53.9
Grand Gulf	BWR	450	52.2	19	39.6	29.3	68.9	4.75	3.9E-05	1.5E-04	64.2
Cooper	BWR	87	32.5	2	4.2	32.9	37.0	4.4	1.6E-05	1.5E-04	50.7
Fort Calhoun	PWR	87	32.5	2	4.2	32.9	37.0	4.4	1.6E-05	1.5E-04	50.7
Comanche Peak	PWR	450	32.5	2	4.2	32.9	37.0	4.75	2.3E-05	7.5E-05	65.4
South Texas	PWR	3550	42.5	19	39.6	30.1	69.7	4.75	7.1E-05	7.5E-05	69.9

Table A.1.3-5. Region 5 environmental parameters.

				Relative humidity		Rain-days	Total	Precipitation chemistry data			
Site	Fuel type	Concrete life	Precipitation rate used, in/yr	Time 6 hr/month RH>85%	Percent of year	Percent of year	Wet days % of year	pH	C', wt %	$SO_4^=$ wt %	Average temp for year, °F
Palo Verde	PWR	3550	10.5	0	0.0	23.6	23.6	4.75	1.6E-05	7.5E-05	72.6
Diablo Canyon	PWR	3550	10.5	17	35.4	23.6	59.0	4.4	7.1E-05	2.5E-05	57.3
Humboldt Bay	BWR	3550	37.5	6	12.5	30.7	43.2	4.4	7.1E-05	2.5E-05	52.7
Rancho Seco	PWR	3550	10.5	6	12.5	23.6	36.1	4.4	7.1E-05	2.5E-05	60.6
San Onofre	PWR	3550	10.5	0	0.0	23.6	23.6	4.4	7.1E-05	2.5E-05	64.2
Trojan	PWR	200	37.5	10	20.8	30.7	51.5	5.5	7.1E-05	2.5E-05	53.7
Washington Nuclear	BWR	450	10.5	0	0.0	23.6	23.6	5.5	8.5E-06	2.5E-05	53.3
Hanford	DOE SNF	Weather Prot lost 150yrs	10.5	0	0.0	23.6	23.6	5.5	8.5E-06	2.5E-05	53.3
Hanford	DOE HLW	Weather Prot lost 150yrs	10.5	0	0.0	23.6	23.6	5.5	8.5E-06	2.5E-05	53.3
Idaho National Engr Laboratory	DOE SNF	Weather Prot lost 150yrs	10.5	0	0.0	23.6	23.6	5.5	1.6E-05	2.5E-05	50.3
Fort St Vrain	DOE SNF	Weather Prot lost 150yrs	10.5	3	6.3	23.6	29.9	4.4	8.5E-06	7.5E-05	51.5

EIS Related Information

Appendix B
Transport through Groundwater

B.1 Water Flow Through the Vadose Zone

The information contained in Tables B.2.1-1, B.2.1-2, B.2.1-3, B.2.1-4, and B.2.1-5 was obtained from Reference 11 and is presented here by region.

Table B.2.1-1. Physical data for vadose zone in Region 1.

			Vadose zone					
Region 1	Site	Fuel type	Clay content, wt %	Thickness, to saturated zone, ft	Bulk density, g/cm3	Porosity, vol %	Field capacity, vol %	Sat. hydraulic conductivity, cm/sec
1	Haddam Neck	PWR	1	10	1.64	38	9	6.6E-03
1	Millstone	PWR & BWR	3	20	1.64	38	9	6.6E-03
1	Salem/Hope Creek	PWR & BWR	3	60	1.64	38	9	6.6E-03
1	Pilgrim	BWR	1	55	1.64	38	9	6.6E-03
1	Seabrook	PWR	10	25	1.48	44.2	17.5	7.2E-04
1	Maine Yankee	PWR	1	12.5	1.64	38	9	6.6E-03
1	Calvert Cliffs	PWR	15	10	1.42	46.3	27.5	2.0E-04
1	Oyster Creek	BWR	3	12	1.64	38	9	6.6E-03
1	Fitzpatrick/Nine Mile Point	BWR	15	6	1.42	46.3	27.5	2.0E-04
1	Ginna	PWR	15	25	1.42	46.3	27.5	2.0E-04
1	Indian Point	PWR & BWR	1	10	1.64	38	9	6.6E-03
1	Yankee-Rowe	PWR	6	15	1.49	43.7	12	1.9E-03
1	Beaver Valley	PWR	10	30	1.48	44.2	17.5	7.2E-04
1	Limerick	BWR	0	40	1.65	5	2.5	
1	Peach Bottom	BWR	3	7	1.64	38	9	6.6E-03
1	Susquehanna	BWR	10	50	1.48	44.2	17.5	7.2E-04
1	Three Mile Island	PWR	3	10	1.64	38	9	6.6E-03
1	Vermont Yankee	BWR	6	10	1.49	43.7	12	1.9E-03
1	West Valley Demo Project	DOE HLW	3	8	1.88	35.2	9	3.9E-04

Table B.2.1-2. Physical data for vadose zone in Region 2.

			Vadose zone					
Region 2	Site	Fuel type	Clay content, wt %	Thickness, to saturated zone, ft	Bulk density, g/cm3	Porosity, vol %	Field capacity, vol %	Sat. hydraulic conductivity, cm/sec
2	Browns Ferry	BWR	6	10	1.50	40	10	2.0E-04
2	Farley	PWR	3	40	1.64	38	9	6.6E-03
2	Crystal River	PWR	15	10	1.42	46.3	27.5	2.0E-04
2	St. Lucie	PWR	10	145	1.48	44.2	17.5	7.2E-04
2	Turkey Point	PWR	1	70	1.64	38	9	6.6E-03
2	Hatch	BWR	6	20	1.49	43.7	12	1.9E-03
2	Vogtle	PWR	6	50	1.49	43.7	12	1.9E-03
2	Brunswick	PWR	47	25	1.36	48.6	42	2.6E-05
2	Catawba	PWR	15	15	1.42	46.3	27.5	2.0E-04
2	Harris	PWR & BWR	10	15	1.48	44.2	17.5	7.2E-04
2	McGuire	PWR	15	20	1.42	46.3	27.5	2.0E-04
2	Oconee	PWR	47	35	1.36	48.6	42	2.6E-05
2	Robinson	PWR	1	25	1.64	38	9	6.6E-03
2	Summer	PWR	15	30	1.42	46.3	27.5	2.0E-04
2	Sequoyah	PWR	15	45	1.42	46.3	27.5	2.0E-04
2	Watts Bar	PWR	47	23	1.36	48.6	42	2.6E-05
2	North Anna	PWR	15	10	1.42	46.3	27.5	2.0E-04
2	Surry	PWR	15	30	1.42	46.3	27.5	2.0E-04
2	Savannah River Site	DOE SNF	6	50	1.60	40	10	1.0E-04
2	Savannah River Site	DOE HLW	6	50	1.60	40	10	1.0E-04

Table B.2.1-3. Physical data for vadose zone in Region 3.

			Vadose zone					
Region 3	Site	Fuel type	Clay content, wt %	Thickness, to saturated zone, ft	Bulk density, g/cm3	Porosity, vol %	Field capacity, vol %	Sat. hydraulic conductivity, cm/sec
3	Duane Arnold	BWR	1	17	1.64	38	9	6.6E-03
3	Braidwood	PWR	3	13	1.64	38	9	6.6E-03
3	Byron	PWR	15	6	1.42	46.3	27.5	2.0E-04
3	Clinton	BWR	1	6	1.64	38	9	6.6E-03
3	Dresden/Morris	PWR & BWR	15	4	1.42	46.3	27.5	2.0E-04
3	Lasalle County	BWR	15	10	1.42	46.3	27.5	2.0E-04
3	Quad Cities	BWR	1	30	1.64	38	9	6.6E-03
3	Zion	PWR	3	20	1.64	38	9	6.6E-03
3	Big Rock Point	BWR	3	8	1.64	38	9	6.6E-03
3	Cook	PWR	3	15	1.64	38	9	6.6E-03
3	Enrico Fermi	BWR	15	20	1.42	46.3	27.5	2.0E-04
3	Palisades	PWR	6	135	1.49	43.7	12	1.9E-03
3	Monticello	BWR	3	20	1.64	38	9	6.6E-03
3	Prairie Island	PWR	1	160	1.64	38	9	6.6E-03
3	Davis-Besse	PWR	47	14	1.36	48.6	42	2.6E-05
3	Perry	BWR	10	28	1.48	44.2	17.5	7.2E-04
3	Kewaunee	PWR	3	10	1.64	38	9	6.6E-03
3	Lacrosse	BWR	1	10	1.64	38	9	6.6E-03
3	Point Beach	PWR	6	54	1.49	43.7	12	1.9E-03

Table B.2.1-4. Physical data for vadose zone in Region 4.

			Vadose zone					
Region 1	Site	Fuel type	Clay content, wt %	Thickness, to saturated zone, ft	Bulk density, g/cm3	Porosity, vol %	Field capacity, vol %	Sat. hydraulic conductivity, cm/sec
4	Arkansas Nuclear One	PWR	15	10	1.42	46.3	27.5	2.0E-04
4	Wolf Creek	PWR	10	35	1.48	44.2	17.5	7.2E-04
4	River Bend	BWR	3	80	1.64	38	9	6.6E-03
4	Waterford	PWR	15	55	1.42	46.3	27.5	2.0E-04
4	Callaway	PWR	15	15	1.42	46.3	27.5	2.0E-04
4	Grand Gulf	BWR	15	70	1.42	46.3	27.5	2.0E-04
4	Cooper	BWR	10	10	1.48	44.2	17.5	7.2E-04
4	Fort Calhoun	PWR	10	2	1.48	44.2	17.5	7.2E-04
4	Comanche Peak	PWR	10	40	1.48	44.2	17.5	7.2E-04
4	South Texas	PWR	6	90	1.49	43.7	12	1.9E-03

Table B.2.1-5. Physical data for vadose zone in Region 5.

			Vadose zone					
Region 1	Site	Fuel type	Clay content, wt %	Thickness, to saturated zone, ft	Bulk density, g/cm3	Porosity, vol %	Field capacity, vol %	Sat. hydraulic conductivity, cm/sec
5	Palo Verde	PWR	6	15	1.49	43.7	12	1.9E-03
5	Diablo Canyon	PWR	10	10	1.50	40	10	6.5E-03
5	Humboldt Bay	BWR	1	12	1.64	38	9	6.6E-03
5	Rancho Seco	PWR	1	200	1.64	38	9	6.6E-03
5	San Onofre	PWR	0	50	1.50	40	10	6.5E-03
5	Trojan	PWR	15	30	1.42	46.3	27.5	2.0E-04
5	Washington Nuclear	BWR	1	230	1.64	38	9	6.6E-03
5	Hanford	DOE SNF	3	246	1.66	40	12	6.6E-03
5	Hanford	DOE HLW	3	246	1.66	40	12	6.6E-03
5	Idaho National Engr Laboratory	DOE SNF	3	62	1.50	48.7	14	7.0E-05
5	Fort St Vrain	DOE SNF	3	23	1.64	38	9	6.6E-03

B.2 Water Flow Through the Saturated Zone

The information in columns 4 through 11 of Tables B.2.2-1, B.2.2-2, B.2.2-3, B.2.2-4, and B.2.2-5 was obtained from Reference 11 and is presented here by region. The information in column 12 was added as is described in Section 2.2 of this report. Column 13 is the sum of the distance from the reactor to the point of groundwater emergence into surface streams and the 1,600 feet given in column 12.

Table B.2.2-1. Physical data for saturated zone in Region 1.

Region	Site	Fuel type	Saturated zone: Clay content, wt %	Kd for Pu, ml/g	Distance to out-fall, ft	Bulk density, g/cm3	Porosity, vol %	Reactor GW travel distance, yrs	Reactor GW travel time, yrs	Soil classification C= course F= fine	ISFSI added distance, ft	ISFSI GW travel distance, ft
Region 1											to ISFSI	
1	Haddam Neck	PWR	1	10	50	1.64	38	492		C	1600	2092
1	Millstone	PWR & BWR	3	10	30	1.64	38	1001	6	C	1600	2601
1	Salem/Hope Creek	PWR & BWR	1	10	60	1.64	38	623	2	F	1600	2223
1	Pilgrim	BWR	1	10	55	1.64	38	492		C	1600	2092
1	Seabrook	PWR	1	10	25	1.64	38	361	0	C	1600	1961
1	Maine Yankee	PWR	1	10	7.5	1.64	38	2756	4	F	1600	4356
1	Calvert Cliffs	PWR	10	100	50	1.48	44.2	492		F	1600	2092
1	Oyster Creek	BWR	3	10	17	1.64	38	984	1	C	1600	2584
1	Fitzpatrick/Nine Mile Point	BWR	1	10	35	1.64	38	1638.5	6	F	1600	3238.5
1	Ginna	PWR	1	10	10	1.64	38	1542		F	1600	3142
1	Indian Point	PWR & BWR	1	10	10	1.64	38	476	1	F	1600	2076
1	Yankee-Rowe	PWR	15	100	15	1.42	46.3	295		C	1600	1895
1	Beaver Valley	PWR	1	10	41	1.64	38	449	12	F	1600	2049
1	Limerick	BWR	0	0	100	1.65	5	787	3	F	1600	2387
1	Peach Bottom	BWR	3	10	7	1.64	38	295		F	1600	1895
1	Susquehanna	BWR	0	0	50	1.65	5	4000	9	C	1600	5600
1	Three Mile Island	PWR	3	10	10	1.64	38	591	0	C	1600	2191
1	Vermont Yankee	BWR	6	10	10	1.49	43.7	197		C	1600	1797
1	West Valley Demo Project	DOE HLW	3	10	20	2.10	21.9	2000	32	C	0	2000

EIS Related Information

Table B.2.2-2. Physical data for saturated zone in Region 2.

			Saturated zone									
Region	Site	Fuel type	Clay content, wt %	Kd for Pu, ml/g	Distance to out-fall, Ft	Bulk density, g/cm3	Porosity, vol %	Reactor GW travel distance, yrs	Reactor GW travel time, yrs	Soil classification C= course F= fine	ISFSI added distance, ft	ISFSI GW travel distance, ft
2	Browns Ferry	BWR	1	10	44	1.64	38	492		F	1600	2092
2	Farley	PWR	0	10	80	1.65	35	984	10	F	1600	2584
2	Crystal River	PWR	0	10	80	1.65	35	295		F	1600	1895
2	St. Lucie	PWR	3	10	145	1.64	38	699	27	C	1600	2299
2	Turkey Point	PWR	1	10	70	1.64	38	164		C	1600	1764
2	Hatch	BWR	1	10	35	1.64	38	984	30	C	1600	2584
2	Vogtle	PWR	6	10	50	1.49	43.7	2789	15	C	1600	4389
2	Brunswick	PWR	47	250	35	1.36	48.6	492	60	C	1600	2092
2	Catawba	PWR	10	100	55	1.48	44.2	689	1	F	1600	2289
2	Harris	PWR & BWR	0	10	85	1.65	38	2395	7	F	1600	3995
2	McGuire	PWR	0	10	30	1.65	40	1969		F	1600	3569
2	Oconee	PWR	10	100	10	1.48	44.2	984		F	1600	2584
2	Robinson	PWR	1	10	25	1.64	38	591		C	1600	2191
2	Summer	PWR	0	0	30	1.65	5	3100	7	F	1600	4700
2	Sequoyah	PWR	15	100	45	1.42	46.3	1000	4	F	1600	2600
2	Watts Bar	PWR	47	250	23	1.36	48.6	984	2	F	1600	2584
2	North Anna	PWR	10	100	40	1.48	44.2	492		F	1600	2092
2	Surry	PWR	10	100	30	1.48	44.2	2001		F	1600	3601
2	Savannah River Site	DOE-SNF	6	10	50	2.00	40	2000	8	C	0	2000
2	Savannah River Site	DOE-HLW	6	10	50	2.00	40	3200	13	C	0	3200

Table B.2.2-3. Physical data for saturated zone in Region 3.

			Saturated zone									
Region	Site	Fuel type	Clay content, wt %	Kd for Pu, ml/g	Distance to out-fall, Ft	Bulk density, g/cm3	Porosity, vol %	Reactor GW travel distance, yrs	Reactor GW travel time, yrs	Soil classification C= course F= fine	ISFSI added distance, ft	ISFSI GW travel distance, ft
3	Duane Arnold	BWR	3	10	20	1.64	38	1766		F	1600	3366
3	Braidwood	PWR	3	10	14	1.64	38	21120	385	C	1600	22720
3	Byron	PWR	15	100	10	1.50	40	3609	25	F	1600	5209
3	Clinton	BWR	1	10	14	1.64	38	1000	1	C	1600	2600
3	Dresden/Morris	PWR & BWR	1	10	7	1.64	38	2001		F	1600	3601
3	Lasalle County	BWR	6	10	17	1.49	43.7	492		F	1600	2092
3	Quad Cities	BWR	1	10	30	1.64	38	591		C	1600	2191
3	Zion	PWR	3	10	20	1.64	38	3412		C	1600	5012
3	Big Rock Point	BWR	0	0	42	1.65	5	488		F	1600	2088
3	Cook	PWR	3	10	20	1.64	38	492		C	1600	2092
3	Enrico Fermi	BWR	0	0	80	1.65	5	459	2	F	1600	2059
3	Palisades	PWR	6	10	135	1.49	43.7	295		F	1600	1895
3	Monticello	BWR	3	10	30	1.64	38	492		F	1600	2092
3	Prairie Island	PWR	1	10	160	1.64	38	492		C	1600	2092
3	Davis-Besse	PWR	0	0	100	1.65	5	2973		F	1600	4573
3	Perry	BWR	10	100	28	1.48	44.2	800	25	F	1600	2400
3	Kewaunee	PWR	3	10	60	1.64	38	492		F	1600	2092
3	Lacrosse	BWR	1	10	160	1.64	38	370		C est	1600	1970
3	Point Beach	PWR	6	10	54	1.49	43.7	1631		C	1600	3231

EIS Related Information

Table B.2.2-4. Physical data for saturated zone in Region 4.

			Saturated zone									
Region	Site	Fuel type	Clay content, wt %	Kd for Pu, ml/g	Distance to out-fall, Ft	Bulk density, g/cm3	Porosity, vol %	Reactor GW travel distance, yrs	Reactor GW travel time, yrs	Soil classification C= course F= fine	ISFSI added distance, ft	ISFSI GW travel distance, ft
4	Arkansas Nuclear One	PWR	15	100	20	1.42	46.3	492	225	F	1600	2092
4	Wolf Creek	PWR	10	100	35	1.48	44.2	2592	356	C	1600	4192
4	River Bend	BWR	1	10	80	1.64	38	10007	8	F	1600	11607
4	Waterford	PWR	3	10	55	1.64	38	NA	NA	F	1600	NA
4	Callaway	PWR	1	10	20	1.64	38	2494	69	F	1600	4094
4	Grand Gulf	BWR	1	10	50	1.64	38	7317	13	F est	1600	8917
4	Cooper	BWR	1	10	56	1.64	38	197		F	1600	1797
4	Fort Calhoun	PWR	1	10	60	1.64	38	492		F	1600	2092
4	Comanche Peak	PWR	0	10	150	1.65	5	NA	NA	F	1600	NA
4	South Texas	PWR	3	10	90	1.64	38	16077	63	C	1600	17677

Table B.2.2-5. Physical data for saturated zone in Region 5.

			Saturated zone									
Region	Site	Fuel type	Clay content, wt %	Kd for Pu, ml/g	Distance to out-fall, Ft	Bulk density, g/cm3	Porosity, vol %	Reactor GW travel distance, yrs	Reactor GW travel time, yrs	Soil classification C= course F= fine	ISFSI added distance, ft	ISFSI GW travel distance, ft
5	Palo Verde	PWR	6	10	15	1.49	43.7	NA	NA	C	1600	NA
5	Diablo Canyon	PWR	0	10	5	1.65	5	492		C	1600	2092
5	Humboldt Bay	BWR	1	10	50	1.64	38	550		C	1600	2150
5	Rancho Seco	PWR	1	10	200	1.64	38	NA		F	1600	NA
5	San Onofre	PWR	0	10	850	1.65	5	492	1	C	1600	2092
5	Trojan	PWR	10	100	30	1.48	44.2	295		F	1600	1895
5	Washington Nuclear	BWR	1	10	230	1.64	38	16011	6	C	1600	17611
5	Hanford	DOE SNF	1	10	30	1.64	38	37000	20	C	0	37000
5	Hanford	DOE HLW	1	10	30	1.64	38	37000	20	C	0	37000
5	Idaho National Engr Laboratory	DOE SNF	0	10	250	1.90	23	317000	174	BR	0	317000
5	Fort St Vrain	DOE SNF	1	10	25	1.64	38	4500	29	C	1600	6100

Appendix C
Site Data Used
To Determine Surface Water Transport and
Populations Using Surface Waters for Drinking

Tables C.3.1-1, C.3.1-2. C.3-1.3, C.3.1-4, and C.3.1-5 provide a summation of the number of people drinking water from rivers that might transport contamination from degradation of SNF or HLW stored at those sites. This data was developed in Reference 13.

Table C.3.1-1. Drinking water population (affected by degrading storage) in Region 1.

			Population exposed		
Region	Site	State	Population	Sum pop/flow pop/cfs	River Mouth flow (cfs)
1	Haddam Neck	CT	0.00E+00	0.00	
1	Millstone	CT	0.00E+00	0.00	
1	Salem/Hope Creek	DE	0.00E+00	0.00	
1	Pilgrim	MA	0.00E+00	0.00	
1	Seabrook	MA	0.00E+00	0.00	
1	Maine Yankee	ME	0.00E+00	0.00	
1	Calvert Cliffs	MD	0.00E+00	0.00	
1	Oyster Creek	NJ	0.00E+00	0.00	
1	Fitzpatrick/Nine Mile Point	NY	6.90E+04	3.13	22020
1	Ginna	NY	6.27E+05	28.47	22020
1	Indian Point	NY	0.00E+00	0.00	
1	Yankee-Rowe	NY	0.00E+00	0.00	
1	Beaver Valley	PA	6.10E+06	40.62	494000
1	Limerick	PA	2.83E+06	1205.45	2700
1	Peach Bottom	PA	1.73E+06	44.24	39200
1	Susquehanna	PA	2.00E+06	52.05	39200
1	Three Mile Island	PA	1.87E+06	48.05	39200
1	Vermont Yankee	VT	0.00E+00	0.00	
1	West Valley Demo Project	NY	1.30E+06	6.46	190000

Table C.3.1-2. Drinking water population (affected by degrading storage) in Region 2.

Region	Site	State	Population exposed		
			Population	Sum pop/flow pop/cfs	River Mouth flow (cfs)
2	Browns Ferry	AL	2.69E+06	12.39	494000
2	Farley	AL	0.00E+00	0.00	
2	Crystal River	FL	0.00E+00	0.00	
2	St. Lucie	FL	0.00E+00	0.00	
2	Turkey Point	FL	0.00E+00	0.00	
2	Hatch	GA	0.00E+00	0.00	
2	Vogtle	GA	6.28E+04	6.06	12000
2	Brunswick	NC	0.00E+00	0.00	
2	Catawba	NC	2.54E+05	41.36	14689
2	Harris	NC	5.19E+05	105.21	5609
2	McGuire	NC	7.22E+05	151.51	14689
2	Oconee	SC	5.35E+05	130.52	12000
2	Robinson	SC	1.80E+03	0.18	10014
2	Summer	SC	3.43E+05	47.12	14689
2	Sequoyah	TN	3.52E+06	32.58	494000
2	Watts Bar	TN	3.53E+06	33.11	494000
2	North Anna	VA	1.50E+03	3.75	400
2	Surry	VA	0.00E+00	0.00	
2	Savannah River Site	SC	6.28E+04	6.06	12000
2	Savannah River Site	SC	6.28E+04	6.06	12000

Table C.3.1-3. Drinking water population (affected by degrading storage) in Region 3.

Region	Site	State	Population exposed		
			Population	Sum pop/flow pop/cfs	River Mouth flow (cfs)
3	Duane Arnold	IA	3.09E+06	9.96	494000
3	Braidwood	IL	2.70E+05	16.91	494000
3	Byron	IL	3.09E+06	9.96	494000
3	Clinton	IL	2.96E+06	8.17	494000
3	Dresden/Morris	IL	3.10E+06	16.90	494000
3	Lasalle County	IL	3.10E+06	16.91	494000
3	Quad Cities	IL	3.33E+06	14.59	494000
3	Zion	IL	7.96E+06	44.99	177011
3	Big Rock Point	MI	5.42E+03	0.03	177011
3	Cook	MI	5.32E+05	3.00	177011
3	Enrico Fermi	MI	5.42E+05	2.77	196032
3	Palisades	MI	2.08E+05	1.18	177011
3	Monticello	MN	3.33E+06	14.59	494000
3	Prairie Island	MN	3.33E+06	14.59	494000
3	Davis-Besse	OH	7.34E+05	3.74	196032
3	Perry	OH	1.93E+06	9.86	196032
3	Kewaunee	WI	2.01E+05	1.13	177011
3	Lacrosse	WI	3.33E+06	14.59	494000
3	Point Beach	WI	2.01E+05	1.13	177011

Table C.3.1-4. Drinking water population (affected by degrading storage) in Region 4.

Region	Site	State	Population exposed: Population	Sum pop/flow pop/cfs	River Mouth flow (cfs)
4	Arkansas Nuclear One	AR	2.36E+06	4.78	494000
4	Wolf Creek	KS	2.44E+06	22.31	494000
4	River Bend	LA	2.36E+06	4.78	494000
4	Waterford	LA	2.31E+06	0.08	494000
4	Callaway	MO	4.25E+06	23.92	494000
4	Grand Gulf	MS	2.36E+06	4.78	494000
4	Cooper	NE	5.01E+06	36.76	494000
4	Fort Calhoun	NE	5.27E+06	44.13	494000
4	Comanche Peak	TX	2.55E+05	17.41	8387
4	South Texas	TX	0.00E+00		

Table C.3.1-5. Drinking water population (affected by degrading storage) in Region 5.

Region	Site	State	Population exposed: Population	Sum pop/flow pop/cfs	River Mouth flow (cfs)
5	Palo Verde	AZ	0.00E+00	0.00	
5	Diablo Canyon	CA	0.00E+00	0.00	
5	Humboldt Bay	CA	0.00E+00	0.00	
5	Rancho Seco	CA	0.00E+00	0.00	
5	San Onofre	CA	0.00E+00	0.00	
5	Trojan	OR	3.71E+04	0.16	230000
5	Washington Nuclear	WA	1.64E+05	1.04	230000
5	Hanford	WA	1.64E+05	1.04	230000
5	Hanford	WA	1.64E+05	1.04	230000
5	Idaho National Engr Laboratory	ID	1.56E+05	2.30	230000
5	Fort St Vrain	CO	5.01E+06	36.93	494000