Appendix G

Authorizations and Consultations

Appendix G

Authorizations and Consultations

Table G-1 contains a list of the environmental-related authorizations, permits, and certifications potentially required by Federal, State, local, and affected Native American tribal agencies related to the construction and operation of one or more new nuclear units at the proposed Grand Gulf early site permit site.

Table G-1. Federal, State, and Local Authorizations

Agency	Authority	Requirement	Activity Covered
U.S. Nuclear Regulatory Commission	10 CFR Part 50	Domestic Licensing of Production and Utilization Facilities	Construction permit for a new nuclear power plant
U.S. Nuclear Regulatory Commission	10 CFR Part 52	Combined License	Issuance of a combined license for new nuclear power plants
U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration Fisheries	Endangered Species Act 16 USC 1536	Consultation	Consultation concerning potential impacts to threatened and endangered species
	16 USC 1539	Incidental Take Permit	Project related mortality and modification of critical habitat of Federal threatened and endangered species
U.S. Fish and Wildlife Service	Migratory Bird Treaty Act 16 USC 703	Consultation	Consultation concerning potential impacts to migratory birds
U.S. Army Corps of Engineers	Clean Water Act 33 USC 1251	Section 404 Permit	Aquatic resource alteration permit (wetland filling, stream alteration)
	33 CFR Part 209	Dredge and Fill Discharge Permit	Permit for discharge of dredged spoils
U.S. Coast Guard	14 USC 81, 83, 85, 633/49 USC 1655(b)		Navigation markers - authorization to protect river navigation from hazards connected with temporary construction activities in the river.
Federal Aviation Administration	Federal Aviation Act 14 CFR 77.13	Notice	Notice to the Federal Aviation Administration for structures over 200 ft in height (e.g., construction cranes and cooling towers)

Table G-1. (contd)

Agency	Authority	Requirement	Activity Covered
Mississippi Department of Environmental Quality	Regulation APC-S-2	Permit to Construct Permit to Operate	Permit for the construction and/or operation of air emissions equipment
Mississippi Department of Environmental Quality	Regulation APC-S-5	Permit	Mississippi regulations for the prevention of significant deterioration of air quality
Mississippi Department of Environmental Quality	Regulation APC-S-6	Permit	Air operating permit under Title V of the Federal Clean Air Act
Mississippi Department of Environmental Quality	Regulation HW-1	Permit	Hazardous waste management regulations
Mississippi Department of Environmental Quality	Regulation LW-1	Permit	Surface water and groundwater use and protection regulations
Mississippi Department of Environmental Quality	Regulation SW-2	Permit	Non-hazardous solid waste management regulations and criteria
Mississippi Department of Environmental Quality	Regulation UST-2	Permit	Underground storage tank regulations
Mississippi Department of Environmental Quality	Regulation WPC-1	National Pollutant Discharge Elimination System Storm Water Permit	Waste water regulations for National Pollutant Discharge Elimination System permits, water quality based effluent limitations, and water quality certification
Mississippi Department of Environmental Quality	Regulation WPC-2		Water quality criteria for intrastate, interstate, and coastal waters
Mississippi Department of Environmental Quality	Regulation WPC-3	Certification	Regulations for the certification of municipal and domestic waste water facility operators
Mississippi Department of Wildlife, Fisheries, and Parks	Natural Heritage Program	Scientific Collection Permit	Ecological monitoring programs
Mississippi Public Service Commission	MS Code of 1972 SEC. 77-3-11	Certificate of Public Convenience and Necessity	Certificate that the present and future public convenience and necessity require or will require the operation of such equipment for facility
Louisiana Department of Wildlife and Fisheries	Natural Heritage Program	Scientific Collection Permit	Ecological monitoring programs

Appendix H

Data and Information to Support Specific Analyses

Appendix H

Data and Information to Support Specific Analyses

The data and information used by the U.S. Nuclear Regulatory Commission (NRC) staff to support specific analyses in the course of evaluating the proposed Grand Gulf early site permit (ESP) site and included in this appendix are:

- Section H.1 - Support Information for Projected Populations (see Chapter 2 for discussion)
- Section H.2 - Environmental Impacts of Transportation, which discusses the effects of both incident-free transportation, transportation accidents, and the environmental effects of radioactive waste shipments (see Section 6.2 for further discussion)
- Section H.3 - Support Information for Radiological Dose Assessment, which compares the System Energy Resources, Inc.'s assessment of the radiological impact of the proposed Grand Gulf ESP site with the NRC staff's independent assessment of the radiological impacts of normal operation for a new nuclear unit
- Section H.4 - References.

H.1 Support Information for Projected Populations (Chapter 2)

The projected resident population within 16 km (10 mi) of the proposed Grand Gulf ESP facility is shown in Table H-1 and discussed in Chapter 2. The projected resident population within 80 km (50 mi) of the proposed Grand Gulf ESP facility is shown in Table H-2 and also discussed in Chapter 2.

Table H-1. Projected Resident Population within 16 Kilometers (10 Miles) of the Proposed Grand Gulf Early Site Permit Facility

Sector/Year	0-2 km (0-1 mi)	2-3 km (1-2 mi)	3-5 km (2-3 mi)	5-6 km (3-4 mi)	6-8 km (4-5 mi)	8-16 km (5-10 mi)	Total
			North				
2002	0	3	0	0	0	10	13
2030	0	3	0	0	0	10	13
2040	0	3	0	0	0	10	13
2050	0	3	0	0	0	10	13
2060	0	3	0	0	0	10	13
2070	0	3	0	0	0	10	13

Table H-1. (contd)

Sector/Year	0-2 km (0-1 mi)	2-3 km (1-2 mi)	3-5 km (2-3 mi)	5-6 km (3-4 mi)	6-8 km (4-5 mi)	8-16 km (5-10 mi)	Total
N-NE							
2002	0	11	0	0	0	3	14
2030	0	11	0	0	0	3	14
2040	0	11	0	0	0	3	14
2050	0	11	0	0	0	3	14
2060	0	11	0	0	0	3	14
2070	0	11	0	0	0	3	14
NE							
2002	0	0	0	0	29	3	32
2030	0	0	0	0	31	3	34
2040	0	0	0	0	32	3	35
2050	0	0	0	0	33	3	36
2060	0	0	0	0	34	3	37
2070	0	0	0	0	34	4	38
E-NE							
2002	0	14	0	45	27	102	188
2030	0	15	0	48	29	110	202
2040	0	15	0	50	30	112	207
2050	0	16	0	51	30	115	212
2060	0	16	0	52	31	118	218
2070	0	17	0	53	32	121	223
East							
2002	0	17	0	84	68	173	342
2030	0	18	0	90	73	186	368
2040	0	19	0	93	75	191	377
2050	0	19	0	95	77	195	386
2060	0	20	0	97	79	200	396
2070	0	20	0	100	81	205	406
E-SE							
2002	0	0	0	0	0	851	851
2030	0	0	0	0	0	915	915
2040	0	0	0	0	0	938	938
2050	0	0	0	0	0	961	961
2060	0	0	0	0	0	985	985
2070	0	0	0	0	0	1010	1010

Table H-1. (contd)

Sector/Year	0-2 km (0-1 mi)	2-3 km (1-2 mi)	3-5 km (2-3 mi)	5-6 km (3-4 mi)	6-8 km (4-5 mi)	8-16 km (5-10 mi)	Total
SE							
2002	0	0	10	0	212	3312	3534
2030	0	0	11	0	228	3560	3799
2040	0	0	11	0	234	3649	3894
2050	0	0	11	0	239	3741	3991
2060	0	0	12	0	245	3834	4091
2070	0	0	12	0	252	3930	4193
S-SE							
2002	0	6	8	0	42	513	569
2030	0	6	9	0	45	551	612
2040	0	7	9	0	46	565	627
2050	0	7	9	0	47	579	643
2060	0	7	9	0	49	594	659
2070	0	7	9	0	50	609	675
South							
2002	0	0	4	0	0	96	100
2030	0	0	4	0	0	99	103
2040	0	0	4	0	0	100	104
2050	0	0	4	0	0	101	105
2060	0	0	4	0	0	102	106
2070	0	0	4	0	0	103	107
S-SW							
2002	0	0	0	0	0	1362	1362
2030	0	0	0	0	0	1464	1464
2040	0	0	0	0	0	1501	1501
2050	0	0	0	0	0	1538	1538
2060	0	0	0	0	0	1577	1577
2070	0	0	0	0	0	1616	1616
SW							
2002	0	0	0	0	0	6	6
2030	0	0	0	0	0	6	6
2040	0	0	0	0	0	7	7
2050	0	0	0	0	0	7	7
2060	0	0	0	0	0	7	7
2070	0	0	0	0	0	7	7

Table H-1. (contd)

Sector/Year	0-2 km (0-1 mi)	2-3 km (1-2 mi)	3-5 km (2-3 mi)	5-6 km (3-4 mi)	6-8 km (4-5 mi)	8-16 km (5-10 mi)	Total
W-SW							
2002	0	0	0	0	0	98	98
2030	0	0	0	0	0	101	101
2040	0	0	0	0	0	102	102
2050	0	0	0	0	0	103	103
2060	0	0	0	0	0	104	104
2070	0	0	0	0	0	105	105
West							
2002	0	0	0	0	0	101	101
2030	0	0	0	0	0	104	104
2040	0	0	0	0	0	105	105
2050	0	0	0	0	0	106	106
2060	0	0	0	0	0	107	107
2070	0	0	0	0	0	108	108
W-NW							
2002	0	0	0	0	0	6	6
2030	0	0	0	0	0	6	6
2040	0	0	0	0	0	6	6
2050	0	0	0	0	0	6	6
2060	0	0	0	0	0	6	6
2070	0	0	0	0	0	6	6
NW							
2002	0	0	0	0	0	35	35
2030	0	0	0	0	0	35	35
2040	0	0	0	0	0	35	35
2050	0	0	0	0	0	35	35
2060	0	0	0	0	0	35	35
2070	0	0	0	0	0	35	35
N-NW							
2002	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0
2040	0	0	0	0	0	0	0
2050	0	0	0	0	0	0	0
2060	0	0	0	0	0	0	0
2070	0	0	0	0	0	0	0

Table H-1. (contd)

Sector/Year	0-2 km (0-1 mi)	2-3 km (1-2 mi)	3-5 km (2-3 mi)	5-6 km (3-4 mi)	6-8 km (4-5 mi)	8-16 km (5-10 mi)	Total
Totals							
2002	0	51	22	129	378	6671	7251
2030	0	54	23	139	406	7154	7776
2040	0	55	24	142	417	7327	7964
2050	0	56	25	146	427	7504	8157
2060	0	57	25	149	438	7686	8355
2070	0	58	26	153	449	7872	8557

Sources: SERI 2005a

Table H-2. Projected Resident Population within 80 Kilometers (50 Miles) of the Proposed Grand Gulf Early Site Permit Facility

Sector/Year	16-32 km (10-20 mi)	32-48 km (20-30 mi)	48-64 km (30-40 mi)	64-80 km (40-50 mi)	Subtotal	0-16 km (0-10 mi)	Total
North							
2002	726	470	653	392	2,241	13	2,254
2030	770	498	692	416	2,375	13	2,388
2040	785	508	706	424	2,423	13	2,436
2050	801	518	720	432	2,471	13	2,484
2060	817	529	735	441	2,521	13	2,534
2070	833	539	749	450	2,571	13	2,584
N-NE							
2002	20,890	17,721	6,377	200	45,188	14	45,202
2030	22,770	19,316	6,951	218	49,255	14	49,269
2040	23,453	19,895	7,159	225	50,733	14	50,747
2050	24,157	20,492	7,374	231	52,255	14	52,269
2060	24,882	21,107	7,595	238	53,822	14	53,836
2070	25,628	21,740	7,823	245	55,437	14	55,451
NE							
2002	6000	6,132	2,005	680	14,817	32	14,849
2030	6450	6,592	2,155	731	15,928	34	15,962
2040	6611	6,757	2,209	749	16,326	35	16,361
2050	6777	6,926	2,264	768	16,735	36	16,771
2060	6946	7,099	2,321	787	17,153	37	17,190
2070	7120	7,276	2,379	807	17,582	38	17,620

Table H-2. (contd)

Sector/Year	16-32 km (10-20 mi)	32-48 km (20-30 mi)	48-64 km (30-40 mi)	64-80 km (40-50 mi)	Subtotal	0-16 km (0-10 mi)	Total
E-NE							
2002	836	2,213	27,800	48,984	79,833	188	80,021
2030	901	2,386	29,968	52,805	86,060	202	86,262
2040	925	2,448	30,748	54,178	88,298	207	88,505
2050	949	2,511	31,547	55,586	90,593	212	90,805
2060	973	2,577	32,367	57,032	92,949	218	93,167
2070	999	2,644	33,209	58,514	95,365	223	95,588
East							
2002	1,238	1,456	10,900	8,039	21,633	342	21,975
2030	1,355	1,594	11,930	8,799	23,677	368	24,045
2040	1,398	1,644	12,306	9,076	24,423	377	24,800
2050	1,442	1,696	12,693	9,362	25,192	386	25,578
2060	1,487	1,749	13,093	9,657	25,986	396	26,382
2070	1,534	1,804	13,506	9,961	26,805	406	27,211
E-SE							
2002	995	1,160	7,000	8,020	17,175	851	18,026
2030	1,085	1,264	7,630	8,742	18,721	915	19,636
2040	1,117	1,302	7,859	9,004	19,282	938	20,220
2050	1,151	1,341	8,095	9,274	19,861	961	20,822
2060	1,185	1,382	8,338	9,552	20,457	985	21,442
2070	1,221	1,423	8,588	9,839	21,070	1,010	22,080
SE							
2002	1,200	1,613	4,151	18,987	25,951	3,534	29,485
2030	1,308	1,758	4,525	20,696	28,287	3,799	32,086
2040	1,347	1,811	4,660	21,317	29,135	3,894	33,029
2050	1,388	1,865	4,800	21,956	30,009	3,991	34,000
2060	1,429	1,921	4,944	22,615	30,910	4,091	35,001
2070	1,472	1,979	5,092	23,293	31,837	4,193	36,030
S-SE							
2002	700	483	1,764	4,226	7,173	569	7,742
2030	753	519	1,896	4,543	7,711	612	8,323
2040	771	532	1,944	4,657	7,904	627	8,531
2050	791	546	1,992	4,773	8,101	643	8,744
2060	810	559	2,042	4,892	8,304	659	8,963
2070	831	573	2,093	5,015	8,511	675	9,186

Table H-2. (contd)

Sector/Year	16-32 km (10-20 mi)	32-48 km (20-30 mi)	48-64 km (30-40 mi)	64-80 km (40-50 mi)	Subtotal	0-16 km (0-10 mi)	Total
				South			
2002	3,900	2,222	1,242	1,087	8,451	100	8,551
2030	4,017	2,289	1,279	1,120	8,705	103	8,808
2040	4,057	2,312	1,292	1,131	8,792	104	8,896
2050	4,098	2,335	1,305	1,142	8,879	105	8,984
2060	4,139	2,358	1,318	1,154	8,968	106	9,074
2070	4,180	2,382	1,331	1,165	9,058	107	9,165
				S-SW			
2002	1,069	8,026	16,095	10,600	35,790	1,362	37,152
2030	1,101	8,267	16,578	10,918	36,864	1,464	38,328
2040	1,112	8,349	16,744	11,027	37,232	1,501	38,733
2050	1,123	8,433	16,911	11,137	37,605	1,538	39,143
2060	1,134	8,517	17,080	11,249	37,981	1,577	39,558
2070	1,146	8,602	17,251	11,361	38,361	1,616	39,977
				SW			
2002	500	1,712	5,700	8,034	15,946	6	15,952
2030	530	1,815	6,042	8,516	16,903	6	16,909
2040	541	1,851	6,163	8,686	17,241	7	17,248
2050	551	1,888	6,286	8,860	17,586	7	17,593
2060	562	1,926	6,412	9,037	17,937	7	17,944
2070	574	1,964	6,540	9,218	18,296	7	18,303
				W-SW			
2002	1,230	1,400	2,122	1,196	5,948	98	6,046
2030	1,333	1,518	2,300	1,296	6,448	101	6,549
2040	1,371	1,560	2,365	1,333	6,628	102	6,730
2050	1,409	1,604	2,431	1,370	6,814	103	6,917
2060	1,448	1,649	2,499	1,408	7,005	104	7,109
2070	1,489	1,695	2,569	1,448	7,201	105	7,306
				West			
2002	300	698	3,463	3,098	7,559	101	7,660
2030	323	752	3,733	3,340	8,149	104	8,253
2040	332	772	3,830	3,426	8,360	105	8,465
2050	340	792	3,930	3,516	8,578	106	8,684
2060	349	813	4,032	3,607	8,801	107	8,908
2070	358	834	4,137	3,701	9,030	108	9,138

Table H-2. (contd)

Sector/Year	16-32 km (10-20 mi)	32-48 km (20-30 mi)	48-64 km (30-40 mi)	64-80 km (40-50 mi)	Subtotal	0-16 km (0-10 mi)	Total
W-NW							
2002	2,012	1,700	4,586	5,946	14,244	6	14,250
2030	2,169	1,833	4,944	6,410	15,355	6	15,361
2040	2,225	1,880	5,072	6,576	15,754	6	15,760
2050	2,283	1,929	5,204	6,747	16,164	6	16,170
2060	2,343	1,979	5,339	6,923	16,584	6	16,590
2070	2,403	2,031	5,478	7,103	17,015	6	17,021
NW							
2002	104	240	1,418	7,000	8,762	35	8,797
2030	113	262	1,546	7,630	9,551	35	9,586
2040	117	269	1,592	7,859	9,837	35	9,872
2050	120	278	1,640	8,095	10,132	35	10,167
2060	124	286	1,689	8,338	10,436	35	10,471
2070	128	294	1,740	8,588	10,749	35	10,784
N-NW							
2002	700	3,338	8,300	2,069	14,407	0	14,407
2030	768	3,663	9,109	2,271	15,812	0	15,812
2040	793	3,783	9,405	2,345	16,326	0	16,326
2050	819	3,905	9,711	2,421	16,856	0	16,856
2060	846	4,032	10,027	2,499	17,404	0	17,404
2070	873	4,163	10,352	2,581	17,970	0	17,970
Totals							
2002	42,400	50,584	103,576	128,558	325,118	7,251	332,369
2030	45,746	54,325	111,279	138,449	349,799	7,776	357,575
2040	46,955	55,673	114,054	142,012	358,694	7,964	366,658
2050	48,197	57,059	116,904	145,671	367,831	8,157	375,988
2060	49,475	58,482	119,831	149,429	377,217	8,355	385,572
2070	50,788	59,944	122,838	153,288	386,858	8,557	395,415

Sources: SERI 2005a

H.2 Environmental Impacts of Transportation

Section H.2 discusses the potential environmental impacts of transporting reactor fuel and radioactive waste to and from potential ESP sites including North Anna Power Station, Clinton Nuclear Power Station, Grand Gulf Nuclear Station, and their associated alternative sites. Section H.2.1 briefly discusses the effects of transporting unirradiated fuel to ESP sites, and Section H.2.2 discusses the effects of transporting spent fuel from ESP sites to a spent fuel disposal facility. Section H.2.3 discusses the environmental effects of radioactive waste shipments.

H.2.1 Unirradiated Fuel Shipping

This section addresses the number and characteristics of shipments of unirradiated fuel to ESP sites relative to the conditions in 10 CFR 51.52. Comparisons are also made against Table S–4 in 10 CFR 51.52(c) and WASH-1238 (AEC 1972), which provided the data that supports Table S–4. Section H.2.1.1 presents the basic unirradiated fuel shipping requirements for each advanced reactor design. These data were extracted from INEEL (2003). Section H.2.1.2 presents the comparisons to 10 CFR 51.52 conditions.

H.2.1.1 Advanced Reactor Unirradiated Fuel Shipping Data

In WASH-1238 (AEC 1972), a reference boiling water reactor (BWR) and pressurized water reactor (PWR) were used to formulate the basic numbers of unirradiated fuel shipments required for initial core loading and refueling. Both reference reactor types had a net electrical output of 1100 MW(e). The reference BWR assumed an initial core loading of 150 metric tons of uranium (MTU), and the reference PWR assumed a 100 MTU initial loading. Both reactor types resulted in 18 truck shipments of unirradiated fuel per reactor for initial core loading. Annual reload quantities were assumed to be 30 MTU/yr for both reactor types, which resulted in an additional six truck shipments per year per reactor. In total, about 252 truck shipments of unirradiated fuel would be required over a 40-year reactor life, including the initial core and 39 years of reloads, for both reactor types.

The initial fuel loading and annual reload quantities for the Advanced Boiling Water Reactor (ABWR), a 1500-MW(e) reactor, and the Economic Simplified Boiling Water Reactor (ESBWR) are approximately the same: 156.96 MTU per reactor initial core loading and 32.76 MTU/yr per reactor reload quantities (INEEL 2003). This equates to about 872 unirradiated fuel assemblies in the initial core and 213 assemblies per year for refueling. Truck shipment capacities were stated in INEEL (2003) to be 28 to 30 unirradiated fuel assemblies per truck shipment. Assuming 30 fuel assemblies per truck shipment, approximately 30 shipments of unirradiated fuel would be required to load the initial core and 6.1 truck shipments per year would be needed for refueling. If 28 fuel assemblies per truck shipment are used, the initial core load would require about 32 shipments of unirradiated fuel and annual refueling would require about 6.5 truck shipments per year.

The surrogate AP1000 is an 1150-MW(e) advanced PWR. The initial core load was estimated to be 84.5 MTU per reactor, and the annual reload requirement was estimated to be 24.4 MTU/yr per reactor. The data in INEEL (2003) also indicated that the average uranium mass in an unirradiated surrogate AP1000 fuel assembly would be 0.583 MTU and that 12 fuel assemblies per truck shipment would be transported. Therefore, about 14 truck shipments would be needed to supply the initial core and about 3.8 truck shipments per year would be needed to support refueling. For a site with two reactors, these estimates would be doubled.

The ACR-700 is an Advanced CANDU (CANada Deuterium Uranium) Reactor assumed to generate 731 MW(e). It was stated in INEEL (2003) that the initial core load for the ACR-700 is 61.3 MTU per reactor, and the annual refueling requirement is 33.1 MTU/yr per reactor. Each fuel assembly contains 18 kg of uranium (INEEL 2003). This corresponds to 3406 fuel assemblies in the initial core loading and 1839 fuel assemblies per year for refueling. The range of truck shipment capacities given by INEEL (2003) was 180 to 240 fuel assemblies per truck shipment. This equates to 15 to 19 truck shipments needed to supply the initial core load and from 7.7 to 10.2 annual refueling shipments. For a site with two reactors, these estimates would be doubled.

The International Reactor Innovative and Secure (IRIS) design is a 335-MW(e) advanced PWR. It requires an initial core load of 48.67 MTU or 89 fuel assemblies per unit (546.9 kg of uranium per fuel assembly) (INEEL 2003). For refueling, the IRIS reactor was assumed to require an additional 6.26 MTU/yr of unirradiated fuel per reactor or about 40 unirradiated fuel assemblies every 3.5 years. INEEL (2003) indicates that a “typical” site may contain three reactors. Assuming each truck shipment carries eight fuel assemblies, the initial core load would require 34 truck shipments per three-reactor site, and annual refueling would require an additional 4.3 truck shipments per year per three-reactor site.

The Gas Turbine–Modular Helium Reactor (GT-MHR) is a gas-cooled reactor that uses a substantially different fuel design than current and advanced LWRs. The reactor’s thermal power level is rated at 600 MW(t) per reactor, and the electric generation capacity is rated at 285 MW(e) per reactor. A standard GT-MHR site is assumed to be composed of four reactors. INEEL (2003) states that the initial core load for a single reactor would be about 1020 fuel assemblies. Annual average reload requirements would be 510 fuel assemblies per reactor. INEEL (2003) also indicates that each truck shipment could carry 80 fuel assemblies, so for all four reactors, about 51 truck shipments would be required to transport the initial core load and about 20 truck shipments per year would be required for the annual reload requirements.

The Pebble Bed Modular Reactor (PBMR) is a gas-cooled reactor that is rated at 400 MW(t) (165 MW(e)) per reactor. A typical PBMR site is assumed to consist of eight reactors. The PBMR uses a substantially different fuel design than a typical LWR. INEEL (2003) states that each reactor requires 260,000 fuel spheres for its initial core load; 120,000 fuel spheres per reactor are required for annual average reloads. A total of 48,000 fuel spheres is assumed to be transported in a typical truck shipment. As a result, it would take about 44 shipments of fuel spheres to transport the initial core load for all eight reactors and about 20 shipments per year to transport the annual reload quantity for all eight reactors.

To make comparisons to Table S–4, the environmental impacts were normalized to a reference reactor year. The reference reactor is an 1100 MW(e) reactor that has an 80 percent capacity factor, for a total electrical output of 880 MW(e) per year. The environmental impacts can be adjusted to calculate impacts per site by multiplying the normalized impacts by the ratio of the total electrical output for the advanced reactor sites to the electrical output of the reference reactor.

H.2.1.2 Analysis of the Environmental Impacts of Unirradiated Fuel Shipments

As required by 10 CFR 51.52, applicants for a construction permit are required to submit a statement that the reactor and the transportation of fuel and waste to and from the reactor meet all the conditions specified in 10 CFR 51.52(a) or 10 CFR 51.52(b). An ESP is a partial construction permit (10 CFR 52.21). The conditions specified in 10 CFR 51.52(a) that apply to unirradiated fuel include the following:

(1) The reactor core has a thermal loading less than 3800 MW. [51.52(a)(1)]

(2) The reactor fuel is in the form of sintered UO_2 pellets not exceeding 4 percent uranium-235 by weight, and the pellets are encapsulated in zircaloy rods. [51.52(a)(2)]

(3) Unirradiated fuel is shipped to the reactor by truck. [51.52(a)(5)]

(4) The environmental impacts of transportation of fuel and waste are as set forth in Summary Table S–4 in 10 CFR 51.52(c). [51.52(a)(6)]

If these conditions are not met, 10 CFR 51.52(b) requires the applicant to provide a full description and detailed analysis of the environmental impacts of transporting fuel and waste to and from the reactor, including values for the environmental impact under normal conditions of transport and the environmental risk from accidents in transport.

Unirradiated fuel shipment information for the advanced reactors is discussed below for each of these criteria.

Reactor Core Thermal Loading

The thermal output ratings of the seven advanced reactor types, as given in INEEL (2003), are as follows:

- ABWR – 4300 MW(t) (single reactor)
- ESBWR – 4000 MW(t) (single reactor)
- Surrogate AP1000 – 3400 MW(t) (single reactor)
- ACR-700 – 1982 MW(t) per reactor x two reactors per site = 3964 MW(t) per site
- IRIS – 1000 MW(t) per reactor x three reactors per site = 3000 MW(t) per site
- GT-MHR – 600 MW(t) per reactor x four reactors per site = 2400 MW(t) per site
- PBMR – 400 MW(t) per reactor x eight reactors per site = 3200 MW(t) per site.

As shown above, single-unit ABWR and ESBWR plants exceed the 3800-MW(t) condition in 10 CFR 51.52(a)(1). In addition, the twin-reactor ACR-700 site exceeds the core thermal power condition.

Reactor Fuel Form

All of the advanced LWRs (i.e., the ABWR, ESBWR, surrogate AP1000, IRIS, and ACR-700) use sintered UO_2 fuel pellets encapsulated in zircaloy rods. The average enrichment for the ACR-700 fuel is about 2 percent, which is well within the 10 CFR 51.52(a)(2) condition. The average enrichments for the other advanced LWR fuels exceed the 4 percent uranium-235 by weight condition in 10 CFR 51.52(a)(2).

The gas-cooled reactors (i.e., the GT-MHR and PBMR) have substantially different fuel forms than those described in 10 CFR 51.52(a)(2). The fuel forms for these reactors are coated uranium oxycarbide fuel kernels (GT-MHR) or coated uranium dioxide fuel kernels (PBMR). The fuel kernels are coated with layers of pyrolitic carbon and silicone carbide. Thus, these fuel forms are not the same as those specified in 10 CFR 51.52(a)(2). Furthermore, the equilibrium enrichments for these fuels are 12.9 percent (PBMR) and 19.8 percent (GT-MHR).

Shipping Mode

Trucks are used to ship unirradiated fuel to the various sites for all the reactor types (INEEL 2003).

WASH-1238 and Table S–4 of 10 CFR 51.52(c)

The condition specified in Table S–4 that applies to shipment of unirradiated fuel limits the number of shipments of fuel and waste to and from a commercial nuclear power plant to less than one per day. Table H-3 summarizes the number of truck shipments of unirradiated fuel required for each reactor type. The numbers of shipments are normalized to the net electrical generation output for the reference reactor in WASH-1238 (AEC 1972) or 880 MW(e) (1100-MW(e)) plant operating at 80-percent annual capacity factor.

As shown in Table H-3, the ACR-700, PBMR, and GT-MHR advanced reactor types exceed the number of truck shipments estimated for the reference LWR in WASH-1238 (AEC 1972). The largest number of shipments, in excess of 700 shipments over 40 years, is for the GT-MHR. However, the combined number of unirradiated fuel, spent fuel, and radioactive waste shipments per day equate to far less than one truck shipment per day for all reactor types. Consequently, the numbers of shipments for all the advanced reactor types are within the conditions specified in Table S–4 of 10 CFR 51.52. Table S–4 includes a condition that the truck shipments not

Table H-3. Numbers of Truck Shipments of Unirradiated Fuel for Each Advanced Reactor Type

	Number of Shipments per Unit					
Reactor Type	**Initial Core(a)**	**Annual Reload**	**Total(b)**	**Unit Electric Generation, MW(e)(c)**	**Capacity Factor(c)**	**Normalized, Shipments per 1100 MW(e)(d,e)**
Reference LWR (WASH-1238)	18	6	252	1100	0.8	252
ABWR/ESBWR(d,e)	30	6.1	267	1500(f)	0.95	165
Surrogate AP1000	14	3.8	161	1150(f)	0.95	130
ACR-700	30	15.4	628	1462(g)	0.9	420
IRIS	34	4.3	201	1005(h)	0.96	184
GT-MHR	51	20	831	1140(I)	0.88	729
PBMR	44	20	824	1320(j)	0.95	579

(a) Shipments of the initial core have been rounded up to the next highest whole number.
(b) Total shipments of unirradiated fuel over a 40-year plant lifetime (i.e., initial core load plus 39 years of average annual reload quantities).
(c) Unit capacities and capacity factors were taken from INEEL (2003).
(d) Normalized to net electric output for WASH-1238 reference LWR (i.e., 1100 MW(e) reactor at 80 percent or net electrical output of 880 MW(e)).
(e) Ranges of capacities are given in INEEL (2003) for these reactor unirradiated fuel shipments. The unirradiated fuel shipment data for these reactors were derived using the upper limits of the ranges.
(f) The ABWR/ESBWR unit includes one reactor at 1500 MW(e), and the surrogate AP1000 unit includes one reactor at 1150 MW(e).
(g) The ACR-700 unit includes two reactors at 731 MW(e) per reactor.
(h) The IRIS unit includes three reactors at 335 MW(e) per reactor.
(I) The GT-MHR unit includes four reactors at 285 MW(e) per reactor.
(j) The PBMR unit includes eight reactors at 165 MW(e) per reactor.
Note: The reference LWR shipment values have all been normalized to 880 MW(e) net electrical generation.

exceed 33,100 kg (73,000 lb) as governed by Federal or State gross vehicle weight restrictions. All of the advanced reactors were indicated in INEEL (2003) to be capable of meeting this restriction for unirradiated fuel shipments.

Finally, Table S–4 includes conditions related to radiological doses to transport workers and members of the public along transport routes. These doses are a function of the radiation dose rate emitted from the unirradiated fuel shipments, the number of exposed individuals and their locations relative to the shipment, the time in transit (including travel time and stop time), and the number of shipments to which the individuals are exposed. The radiological dose impacts of the transportation of unirradiated fuel were calculated using the RADTRAN 5 computer code (Neuhauser et al. 2003). The RADTRAN 5 calculations were performed to develop estimates of the worker and public doses associated with annual unirradiated fuel shipments to the ESP sites.

One of the key assumptions in WASH-1238 (AEC 1972) for the reference LWR unirradiated fuel shipments is that the radiation dose rate at 1 m (3 ft) from the transport vehicle is about

0.001 mSv/hr (0.1 mrem/hr). This assumption was also used in the analysis of advanced reactor unirradiated fuel shipments. This assumption is reasonable for all the advanced reactor fuel types because the fuel materials will be low-dose-rate uranium radionuclides and will be packaged similarly (i.e., inside a metal container that provides little radiation shielding). The numbers of shipments per year were obtained by dividing the normalized shipments in Table H-3 by 40 years of operation. Other key input parameters used in the radiation dose analysis for unirradiated fuel are shown in Table H-4.

Table H-4. RADTRAN 5 Input Parameters for Unirradiated Fuel Shipments

Parameter	RADTRAN 5 Input Value	Source
Shipping distance, km	3200	AEC (1972)[(a)]
Travel fraction – rural	0.90	NRC (1977a)
Travel fraction – suburban	0.05	
Travel fraction – urban	0.05	
Population density – rural, persons/km^2	10	DOE (2002a)
Population density – suburban, persons/km^2	349	
Population density – urban, persons/km^2	2260	
Vehicle speed – rural, km/hr	88.49	Based on average speed in rural areas given in DOE (2002a)
Vehicle speed – suburban, km/hr	88.49	
Vehicle speed – urban, km/hr	88.49	
Traffic count – rural, vehicles/hr	530	DOE (2002a)
Traffic count – suburban, vehicles/hr	760	
Traffic count – urban, vehicles/hr	2400	
Dose rate at 1 m from vehicle, mSv/hr	0.001	AEC (1972)
Packaging length, m	7.3	Approximate length of two LWR fuel element packages placed on end
Number of truck crew	2	AEC (1972), NRC (1977a), and DOE (2002a)
Stop time, hr/trip	4.5	Based on 0.0014-hour stop time per km (Hostick et al. 1992)
Population density at stops, persons/km^2	64,300	Based on 20 people in annular ring extending from 1 to 10 m (3.3 to 33 ft) from the vehicle

(a) AEC (1972) provides a range of shipping distances between 40 km (25 mi) and 4800 km (3000 mi) for unirradiated fuel shipments. A 3200-km (2000-mi) “average” shipping distance was assumed here.

The RADTRAN 5 results for this “generic” unirradiated fuel shipment are as follows:

- Worker dose: 1.71 x 10^{-5} person-Sv/shipment (1.71 x 10^{-3} person-rem/shipment)

- General public dose (onlookers/persons at stops and sharing the highway): 6.65 x 10^{-5} person-Sv/shipment (6.65 x 10^{-3} person-rem/shipment)

- General public dose (along route - persons living near a highway): 1.61 x 10^{-6} person-Sv/shipment (1.61 x 10^{-4} person-rem/shipment).

These values were combined with the average annual shipments of unirradiated fuel for each advanced reactor type (see Table H-3) normalized to the WASH-1238 (AEC 1972) reference LWR electric output (880 MW(e)) to calculate annual doses to the public and workers. The results are compared to Table S–4 conditions. The results are shown in Table H-5. As shown, the calculated radiation doses for shipping unirradiated fuel to advanced reactor sites are within the conditions shown in Table S–4.

Table H-5. Radiological Impacts of Transporting Unirradiated Fuel to ESP Sites

Plant Type	Normalized Average Annual Shipments	Cumulative Annual Dose, person-Sv/yr[(a)] per 1100 MW(e)		
		Workers	Public – Onlookers	Public – Along Route
Reference LWR (WASH-1238 (AEC 1972))	6.3	1.1×10^{-4}	4.2×10^{-4}	1.0×10^{-5}
ABWR/ESBWR	4.1	7.1×10^{-5}	2.7×10^{-4}	6.6×10^{-6}
Surrogate AP1000	3.3	5.6×10^{-5}	2.2×10^{-4}	5.2×10^{-6}
ACR-700	10.5	1.8×10^{-4}	7.0×10^{-4}	1.7×10^{-5}
IRIS	4.6	7.9×10^{-5}	3.1×10^{-4}	7.4×10^{-6}
GT-MHR	18.2	3.1×10^{-4}	1.2×10^{-3}	2.9×10^{-5}
PBMR	14.5	2.5×10^{-4}	9.6×10^{-4}	2.3×10^{-5}
10 CFR 51.52, Table S-4 Condition	<1 per day	4×10^{-2}	3.0×10^{-2}	3.0×10^{-2}

(a) Person-Sv = person-sievert; multiply person-Sv/yr times 100 to obtain dose in person-rem/yr.

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposures to low doses below about 100 mSv (10,000 mrem) and at low dose rates. However, radiation protection experts conservatively assume that any amount of radiation exposure may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response model is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the National Research Council (2006), the BEIR VII report, supports the linear, no-threshold dose response theory. Simply stated, any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably overestimates those risks.

Based on this model, the staff estimates the risk to the public from radiation exposure using the nominal probability coefficient for total detriment (730 fatal cancers, nonfatal cancers, and severe hereditary effects per 10,000 person-Sv (1,000,000 person-rem)) from International Commission on Radiological Protection (ICRP) Publication 60 (ICRP 1991). All the public doses presented in Table H-5 are less than or equal to 0.0012 person-Sv/yr (0.12 person-rem/yr); therefore, the total detriment estimates associated with these doses would all be less than 1×10^{-4} fatal cancers, nonfatal cancers, and severe hereditary effects per year. These risks are very small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that would be expected to occur annually to the same population from exposure to natural sources of radiation, based on the same risk model.

H.2.1.3 Transportation Accidents

Accidents involving unirradiated fuel shipments are also addressed in Table S–4. Accident risks are the product of accident frequency times consequence. Accident frequencies are likely to be lower than they were when WASH-1238 (AEC 1972) was published because traffic accident, injury, and fatality rates have fallen over the past 30 years. Consequences of accidents that are severe enough to result in a release of unirradiated fuel particles are not significantly different for advanced LWRs because the fuel form, cladding, and packaging are similar to those analyzed in WASH-1238. Consequently, the impacts of accidents during transport of unirradiated fuel to advanced LWR sites would be smaller than the WASH-1238 results that formed the basis for Table S–4.

With respect to the advanced gas-cooled reactors, accident rates (accidents per unit distance) and associated accident frequencies (accidents per year) would follow the same trends as for LWRs (i.e., overall reduction relative to the accident rates used in WASH-1238). The consequences of accidents involving gas-cooled reactor unirradiated fuel, however, are more uncertain. A literature search was conducted to identify publicly available documents that describe the effects of accidents (i.e., exposure of unirradiated gas-cooled reactor fuel to structural and thermal transients). No definitive references were found. Consequently, it was assumed that the gas-cooled reactor unirradiated fuel shipments would have the same abilities as LWR unirradiated fuel to maintain functional integrity following a traffic accident. This assumption is judged to be conservative because gas-cooled reactor fuel operates at significantly higher temperatures and thus maintains integrity under more severe thermal conditions than LWR fuel. Detailed information about the behavior of the gas-cooled reactor fuel under impact conditions was not available. However, packaging systems for unirradiated gas-cooled reactor fuel will be required to meet the same performance requirements as unirradiated LWR fuel packages including fissile material controls to prevent criticality under normal and accident conditions. Consequently, packaging systems for unirradiated gas-cooled reactor fuels are expected to provide protection equivalent to those designed for unirradiated LWR fuels. In addition, the fuel forms for the gas-cooled reactors are similar to those for LWRs (i.e., uranium oxide for the PBMR and uranium oxycarbide for the GT-MHR versus uranium oxide for LWRs); thus, the inherent failure resistance provided by unirradiated gas-cooled reactor fuels is expected to be similar to that provided by LWR fuels. Based on the assumption that unirradiated gas-cooled and LWR fuels and associated packaging systems provide similar resistance to various environmental conditions, the staff concluded that the impacts of accidents involving unirradiated gas-cooled reactor fuel are not expected to be significantly different than those for unirradiated LWR fuel.

H.2.2 Spent Fuel Shipping

This section discusses the impact of transporting irradiated or spent advanced reactor fuel from ESP sites to a potential high-level waste repository at Yucca Mountain, Nevada. The section is divided into two parts. The first part considers incident-free transportation, and the second part considers transportation accidents.

The analysis is based on shipment of spent fuel by legal-weight trucks in casks with characteristics similar to casks currently available (i.e., massive, heavily shielded, cylindrical metal pressure vessels). Each shipment is assumed to consist of a single shipping cask loaded onto a modified trailer. These assumptions are consistent with assumptions made in the evaluation of the environmental impacts of transportation of spent fuel presented in Addendum I to NUREG-1437 (NRC 1999). As discussed in Addendum I, these assumptions are conservative because the alternative assumptions involve rail transportation or heavy-haul trucks, which would reduce the number of spent-fuel shipments.

Environmental impacts of the transportation of spent fuel were calculated using the RADTRAN 5 computer code (Neuhauser et al. 2003). Routing and population data for input to RADTRAN 5 for shipment by truck were obtained from the TRAGIS routing code (Johnson and Michelhaugh 2000). The population data in the TRAGIS code is based on the 2000 U.S. Census.

H.2.2.1 Incident-Free Transportation of Spent Fuel

“Incident-free” transportation refers to transportation activities in which the shipments of radioactive material reach their destination without releasing any radioactive cargo to the environment. The vast majority of radioactive shipments are expected to reach their destination without experiencing an accident or incident or releasing any cargo. The “incident-free” impacts from these normal, routine shipments arise from the low levels of radiation that penetrate the heavily shielded spent fuel shipping cask. Although Federal regulations in 10 CFR Part 71 and 49 CFR Part 173 impose constraints on radioactive material shipments, some radiation penetrates the shipping container and exposes nearby persons to low levels of radiation.

Incident-free, legal-weight truck transportation of spent fuel has been evaluated by considering shipments from 11 representative reactor sites to the proposed high-level waste repository at Yucca Mountain, Nevada, (referred to here as the proposed Yucca Mountain repository) for disposal. This assumption is conservative because it tends to maximize the shipping distance from the East Coast and Midwest, where most of the reactors are assumed to be located. Therefore, shipment to one or more other potential sites, such as a monitored retrievable storage facility, would reduce the impacts.

Environmental impacts from these shipments will occur to persons residing along the transportation corridors between the potential advanced reactor sites and the proposed repository; to persons in vehicles passing the spent-fuel shipment; to persons at vehicle stops for refueling, rest, and vehicle inspections; and to transportation crew members. The impacts to these exposed population groups were quantified using the RADTRAN 5 computer code (Neuhauser et al. 2003).

This analysis assumes that all spent nuclear fuel will be transported to the proposed Yucca Mountain repository because Congress has directed (Nuclear Waste Policy Act of 1982, as amended) the U.S. Department of Energy to study only Yucca Mountain for the proposed repository.

The characteristics of specific shipping routes (e.g., population densities and shipping distances) influence the normal radiological exposures. To address the differences that arise from the specific reactor site from which the spent fuel shipment originates, each advanced reactor design was assumed to be located at all of the primary and alternative ESP sites. These sites are:

- Primary Sites
    - North Anna Power Station, Virginia
    - Clinton Nuclear Power Station, Illinois
    - Grand Gulf Nuclear Power Station, Mississippi

- Alternative Sites[a]
    - Savannah River Site (SRS), South Carolina
    - Portsmouth Gaseous Diffusion Plant (PGDP), Ohio
    - FitzPatrick Nuclear Power Plant, New York
    - Pilgrim Nuclear Power Station, Massachusetts
    - Zion Nuclear Power Station, Illinois
    - Quad Cities Nuclear Power Station, Iowa
    - Braidwood Nuclear Power Station, Illinois
    - Surry Power Station, Virginia

Input to RADTRAN 5 includes the total shipping distance between the origin and destination sites and the population distributions along the routes. This information was obtained by running the TRAGIS computer code (Johnson and Michelhaugh 2000) for the origin-destination combinations of interest for legal-weight trucks. The resulting route characteristics information is

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(a) Impacts were not calculated for the River Bend site because the analysis is bounded by the impacts calculated for Grand Gulf. Impacts were not calculated for the Dresden and LaSalle sites because they are bounded by the Braidwood analysis.

shown in Table H-6. Note that for truck shipments, all the spent fuel is assumed to be shipped to the proposed Yucca Mountain repository over designated controlled-quantity highway routes. The routes used here are the same as those used in the Yucca Mountain Environmental Impact Statement (DOE 2002b).

Table H-6. Transportation Route Information for Shipments from ESP Sites to the Proposed High-Level Waste Repository at Yucca Mountain

	One-Way Shipping Distance, km				Population Density, persons/km^2			Stop Time per Trip, hr
ESP Site	**Total**	**Rural**	**Suburban**	**Urban**	**Rural**	**Suburban**	**Urban**	
				Primary Site				
North Anna	4409.5	3498	812.4	99.1	11.3	319	2310.6	5
Clinton	3076.3	2626.3	398.3	51.7	9.4	306.1	2372.2	3.5
Grand Gulf(a)	3718.3	3030.4	581.3	106.6	9.2	339.4	2429.4	4
				Alternative Site				
Savannah River Site	4263	3260	881	122	11	331.5	2311.2	5
Portsmouth Gaseous Diffusion Plant	3902.2	3166.9	647.2	88.1	10.7	316.4	2339.7	4.5
FitzPatrick	4212.2	3228.6	875.4	108.2	11.4	312.4	2348.7	5
Pilgrim	4682.3	3469.3	1091.7	121.3	11.8	312.3	2377.2	5.5
Zion	3138.9	2629.6	441.3	68	9.5	323.8	2360.3	3.5
Quad Cities	2853.1	2451	352.6	49.5	9.1	310.2	2391.3	3
Braidwood(b)	3034.5	2604.4	378.7	51.4	9.4	308.9	2377.2	3.5
Surry	4555.4	3590.7	863.9	100.8	11.4	317.6	2301.6	5

(a) The River Bend alternative site can be assumed to be bounded by the Grand Gulf values because of the proximity of the sites.

(b) Dresden and LaSalle can be assumed to be bounded by the Braidwood values because of the proximity of the sites.

Shipping casks have not been designed for advanced reactor spent fuel. Although some of the advanced reactor fuel designs are similar to current LWR fuel, no attempt has been made to optimize the cargo capacities of shipping casks for advanced LWR fuels. For the non-LWR fuel types (i.e., the GT-MHR and PBMR), there is little information on even a conceptual basis that would provide a defensible technical basis for shipping-cask capacities. The shipping-cask capacity data in the *Early Site Permit Environmental Report Sections and Supporting Documentation* (INEEL 2003) is summarized as follows:

- ABWR – The ABWR fuel is not significantly different from existing LWR fuel designs; thus, the number of ABWR assemblies that can be transported in a legal-weight truck shipment (i.e., 23 MT [25-ton] shipping cask) is not expected to be different from current cargo capacities.

- ESBWR – The ESBWR fuel is similar to the ABWR fuel.

- Surrogate AP1000 – The surrogate AP1000 fuel assemblies are similar to current-generation PWR fuel. No information was provided in INEEL (2003) on shipping cask capacities for surrogate AP1000 spent nuclear fuel.

- ACR-700 – The ACR-700 fuel is somewhat different from the current and advanced LWR fuel designs. System Energy Resources, Inc. (SERI) estimated that an ACR-700 rail cask would hold about 10 MTU of spent fuel, similar to the current cask designs. This value is nearly identical to the cargo capacities of current rail cask designs; thus, it was assumed that the truck cask capacity for ACR-700 and current-generation LWRs would also be about the same (i.e., 1.8 MTU/shipment).

- IRIS – The IRIS fuel is similar to current-generation PWR fuel. No information was provided in INEEL (2003) on shipping-cask capacities for IRIS spent nuclear fuel.

- GT-MHR – The GT-MHR fuel is a spherical coated-particle fuel with a uranium oxycarbide fuel kernel loaded into graphite fuel assemblies. This fuel concept is significantly different from current and advanced LWR fuels (sintered UO_2 pellets loaded into zircaloy tubes). According to INEEL (2003), six spent fuel assemblies containing 0.023 MTU of spent fuel is assumed to be transported in a legal weight truck cask.

- PBMR – The PBMR fuel is also a spherical coated-particle fuel with uranium oxide fuel kernels. INEEL (2003) estimated that 0.495 MTU of spent PBMR fuel can be transported in a single legal-weight truck shipment.

These shipping cask capacities are approximations based on current shipping cask designs. Actual shipping cask capacities in the future may be significantly different. Applicants must account for changes in shipping cask capacities in applications at the construction permit or combined operating license stage.

Incident-free radiation doses are a function of many variables. The most important of these variables are presented in Table H-7. Most of these variables, which are extracted from the literature, are considered to be “standard” values used in many RADTRAN 5 applications, including environmental impact statements and regulatory analyses.

Table H-7. RADTRAN 5 Incident-Free Exposure Parameters

Parameter	RADTRAN 5 Input Value	Source
Vehicle speed – rural, km/hr	88.49	Based on average speed in rural areas given in DOE (2002a). Because most travel is on interstate highways, the same vehicle speed is assumed in rural, suburban, and urban areas. No speed reductions were assumed for travel at rush hour.
Vehicle speed – suburban, km/hr	88.49	
Vehicle speed – urban, km/hr	88.49	
Traffic count – rural, vehicles/hr	530	DOE (2002a)
Traffic count – suburban, vehicles/hr	760	
Traffic count – urban, vehicles/hr	2400	
Dose rate at 1 m from vehicle, mSv/hr	0.14	Approximate dose rate at 1 m (3 ft) that is equivalent to maximum dose rate allowed by the U.S. Department of Transportation and NRC regulations (i.e., 0.1 mSv/hr at 2 m (~7 ft) from the side of a transport vehicle) (DOE 2002b)
Packaging dimensions, m	Length – 5.2 Diameter – 1.0	DOE (2002b)
Number of truck crew	2	(AEC 1972; NRC 1977a; DOE 2002a)
Stop time, hr/trip	Route-specific	See Table H-6.
Population density at stops, persons/km^2	30,000	Sprung et al. (2000)
Min/max radii of annular area around vehicle at stops, m	1 to 10	Sprung et al. (2000)
Shielding factor applied to annular area surrounding vehicle at stops	1 (no shielding)	Sprung et al. (2000)
Population density surrounding truck stops, persons/km^2	340	Sprung et al. (2000)
Min/max radius of annular area surrounding truck stop, m	10 to 800	Sprung et al. (2000)
Shielding factor applied to annular area surrounding truck stop	0.2	Sprung et al. (2000)

For purposes of this Section H.2 analysis, the transportation crew for spent fuel shipments delivered by truck is assumed to consist of two drivers. Escorts were considered, but they were not included because their distance from the shipping cask would reduce the dose rates to levels well below the dose rates experienced by the drivers. Stop times were assumed to accrue at the rate of 30 minutes per 4-hour driving time. TRAGIS outputs were used to determine the number of stops for each origin-destination.

Doses to the public at truck stops have been significant contributors to the doses calculated in previous RADTRAN 5 analyses. For this Section H.2 analysis, stop doses are the sum of the doses to individuals located in two annular rings centered at the stopped vehicle, as illustrated in Figure H-1. The inner ring represents persons who may be at the truck stop at the same time as a spent fuel shipment and extends 1 to 10 m from the edge of the vehicle. The outer ring represents persons who reside near a truck stop and extends from 10 to 800 m from the vehicle. This scheme is the same as that used in Sprung et al. (2000).

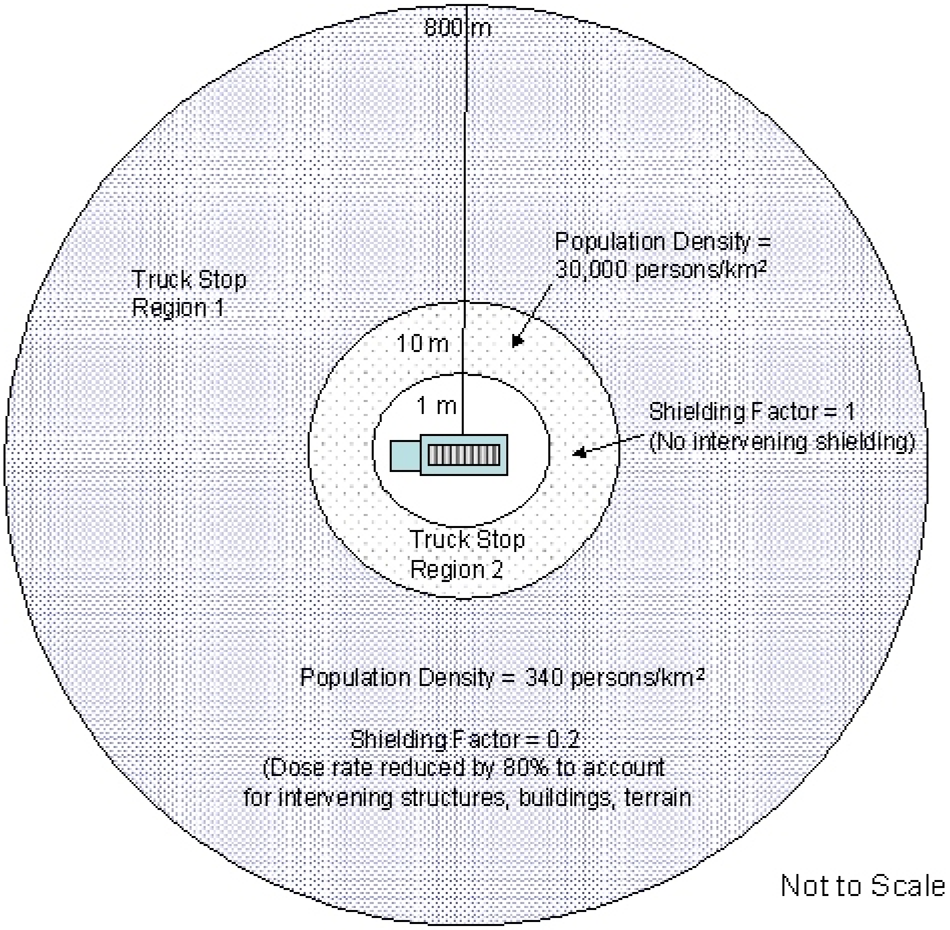

Figure H-1. Illustration of Truck Stop Model (Sprung et al. 2000)

Population densities and shielding factors were also taken from Sprung et al. (2000) and were based on the observations of Griego et al. (1996).

The results of these routine (incident-free) exposure calculations are shown in Table H-8 for spent fuel shipments from all 11 primary and alternative sites to the proposed Yucca Mountain repository. Population dose estimates are given for workers (i.e., truck crew members), onlookers (doses to persons at truck stops and persons and on highways exposed to the spent fuel shipments), and along the route (persons living near the highway).

Table H-8. Routine (Incident-Free) Radiation Doses to Transport Workers and the Public from Shipping Spent Fuel from Potential ESP Sites to the Proposed High-Level Waste Repository at Yucca Mountain

	Population Dose, person-Sv/shipment(a)		
Reactor Site	**Crew**	**Onlookers**	**Along Route**
Braidwood(b)	7.1×10^{-4}	2.4×10^{-3}	4.4×10^{-5}
Clinton	7.2×10^{-4}	2.5×10^{-3}	4.5×10^{-5}
FitzPatrick	9.8×10^{-4}	3.5×10^{-3}	9.5×10^{-5}
Grand Gulf(c)	8.7×10^{-4}	2.8×10^{-3}	7.0×10^{-5}
North Anna	1.0×10^{-3}	3.5×10^{-3}	9.2×10^{-5}
Pilgrim	1.1×10^{-3}	3.9×10^{-3}	1.2×10^{-4}
Portsmouth	9.1×10^{-4}	3.2×10^{-3}	7.3×10^{-5}
Quad Cities	6.7×10^{-4}	2.1×10^{-3}	4.1×10^{-5}
Savannah River	9.9×10^{-4}	3.5×10^{-3}	1.0×10^{-4}
Surry	1.1×10^{-3}	3.5×10^{-3}	9.7×10^{-5}
Zion	7.3×10^{-4}	2.5×10^{-3}	5.2×10^{-5}

(a) Multiply person-Sv/shipment by 100 to obtain doses in person-rem/shipment.
(b) The River Bend alternative site can be assumed to be bounded by the Grand Gulf values because of the proximity of the sites.
(c) Dresden and LaSalle can be assumed to be bounded by the Braidwood values because of the proximity of the sites.

This discussion addresses whether or not the environmental effects of incident-free advanced reactor spent fuel shipments are within the guidelines established in Table S–4. The bounding cumulative doses to the exposed population given in Table S–4 are:

• Transport workers	0.04 person-Sv (4 person-rem) per reference reactor year.
• General public (onlookers and along route)	0.03 person-Sv (3 person-rem) per reference reactor year.

Calculation of the cumulative doses entailed converting the per-shipment risks given in Table H-8 to estimates of environmental effects per reference reactor year of operation. The per-shipment results, which are independent of reactor type (i.e., the doses are dependent on the assumed external radiation dose rate emitted from the cask, which is fixed at the regulatory maximum limit for all of the advanced reactor types), are given in terms of the population dose per shipment of spent fuel. To develop estimates of the annual environmental impacts, the following assumptions were made:

- The basis for the annual number of shipments of spent fuel from the reference LWR in WASH-1238 (AEC 1972) will be used. In WASH-1238, it was assumed that 60 shipments per year would be made, each shipment carrying 0.5 MTU of spent fuel. This equates to shipping 30 MTU of spent fuel per year. This is equivalent to the annual refueling requirements for the reference LWR. It was assumed that the other reactor types would also ship spent fuel at a rate equal to their annual refueling requirements.

- Shipping cask capacities that were used to calculate annual spent fuel shipments for the advanced LWRs were assumed to be the same as for the reference LWR (i.e., approximately 0.5 MTU per truck shipment).

- The annual numbers of spent fuel shipments from the advanced gas-cooled reactors were taken directly from INEEL (2003). These estimates were 34 shipments per year from a GT-MHR site and 12 shipments per year from the PBMR site.

Table H-9 provides the estimated annual population doses from routine (incident-free) transportation of spent fuel from ESP sites to the proposed Yucca Mountain repository. The results in Table H-9 have been normalized to the WASH-1238 (AEC 1972) net electrical generation (i.e., 880 MW(e)). Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposure to low doses below about 100 mSv (10,000 mrem) and at low dose rates. However, radiation protection experts conservatively assume that any amount of radiation exposure may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response model is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report (National Research Council 2006), the BEIR VII report, supports the linear, no-threshold dose response theory. Simply put, the theory states that any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably over-estimates those risks.

Based on this model, the staff estimates the risk to the public from radiation exposure using the nominal probability coefficient for total detriment (730 fatal cancers, nonfatal cancers, and severe hereditary effects per 10,000 person-Sv [1,000,000 person-rem]) from International Commission on Radiological Protection (ICRP) Publication 60 (ICRP 1991). All the population doses presented in Table H-9 are less than one person-Sv/yr (100 person-rem/yr); therefore, the total detriment estimates associated with these population doses would all be less than 0.1 fatal cancers, nonfatal cancers, and severe hereditary effects per year. These risks are very small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that would occur annually in the same population from exposure to natural sources of radiation.

As shown in Table H-9, some of the estimated population doses are higher than the Table S–4 conditions. Two key reasons for the higher population doses relative to Table S–4 are the higher number of spent fuel shipments estimated for some of the reactor technologies and the longer shipping distances used in this assessment than were used in WASH-1238 (AEC 1972). WASH-1238 used a "typical" distance for a spent fuel shipment of 1600 km (1000 mi), whereas the shipping distances used in this assessment ranged from about 2900 km (1800 mi) to 4700 km (2900 mi). The higher numbers of shipments are based on spent fuel shipping-casks designed to transport short-cooled fuel (150 days out of the reactor). It was assumed in this analysis that the shipping-cask capacities are 0.5 MTU/shipment, roughly equivalent to one PWR or two BWR spent fuel assemblies per shipment. Newer designs are based on longer-cooled spent fuel (5 years out of reactor) and have larger capacities than those used in this assessment. DOE (2002b) spent fuel shipping-cask capacities were approximately 1.8 MTU/shipment, or up to four PWR or nine BWR fuel assemblies per shipment. Use of the newer shipping-cask designs will reduce the number of spent fuel shipments and the associated environmental impacts. If the population doses are adjusted for the shipping distance (a factor of 2 to 3) and shipping cask capacity (a factor of 4), the routine population doses from spent fuel shipments from all reactor types and all sites fall within the Table S–4 conditions.

Most of the stops made for actual spent fuel shipments are short duration stops (i.e., 10 minutes) for brief visual inspections of the cargo (e.g., checking the cask tie-downs). These stops typically occur in areas devoid of people, such as overpasses or freeway ramps in unpopulated areas. Therefore, doses to residents surrounding these types of stops are negligible. In DOE (2002b), close-proximity exposures (i.e., from 1 to 15.8 m from the cask) were not assumed to occur at the short-duration inspection stops. In this analysis, for the purpose of developing bounding estimates of environmental effects, close-proximity (1 to 10 m from cask) exposures at all truck stops were included in the RADTRAN 5 calculations. Because the numbers of stops in this analysis are effectively doubled relative to DOE (2002b), truck stop doses are also doubled. The doses to residents would also be lower; however, because doses to residents are two to three orders of magnitude (i.e., a factor of 100 to 1000) less than the calculated close-proximity doses, this reduction does not affect the total stop dose.

The number of exposed persons at stops is higher in this Section H.2 analysis by about a factor of 1.5 relative to DOE (2002b) assumptions (6.9 persons in DOE 2002b versus 10 persons assumed in this analysis). Thus, the bounding doses calculated in this analysis are also a factor of 1.5 (10 divided by 6.9) greater than those given in DOE (2002b). Furthermore, empirical data provided in Griego et al. (1996) indicate that a 30-minute stop is toward the high end of the stop time distribution. Average stop times for food and refueling observed by Griego et al. (1996) are on the order of 18 minutes. This amounts to another factor of 1.5 increase in stop doses calculated here relative to DOE (2002b).

Table H-9. Routine (Incident-Free) Population Doses from Spent Fuel Transportation, Normalized to Reference LWR Net Electrical Generation

Reactor Type	**Reference LWR (WASH-1238)**			**ABWR/ESBWR**			**Surrogate AP1000**			**ACR-700**		
No. Shipments per year	**60**			**41**			**40**			**90**		
	Environmental Effects, person-Sv per reference reactor year[(a)]											
Reactor Site	**Crew**	**Onlookers**	**Along Route**	**Crew**	**Onlookers**	**Along Route**	**Crew**	**Onlookers**	**Along Route**	**Crew**	**Onlookers**	**Along Route**
Braidwood[(b)]	4.2×10^{-2}	1.5×10^{-1}	2.6×10^{-3}	2.9×10^{-2}	1.0×10^{-1}	1.8×10^{-3}	2.8×10^{-2}	9.7×10^{-2}	1.7×10^{-3}	6.3×10^{-2}	2.2×10^{-1}	3.9×10^{-3}
Clinton	4.3×10^{-2}	1.5×10^{-1}	2.7×10^{-3}	2.9×10^{-2}	1.0×10^{-1}	1.8×10^{-3}	2.8×10^{-2}	9.7×10^{-2}	1.8×10^{-3}	6.4×10^{-2}	2.2×10^{-1}	4.1×10^{-3}
FitzPatrick	5.9×10^{-2}	2.1×10^{-1}	5.7×10^{-3}	4.0×10^{-2}	1.4×10^{-1}	3.9×10^{-3}	3.9×10^{-2}	1.4×10^{-1}	3.8×10^{-3}	8.8×10^{-2}	3.1×10^{-1}	8.5×10^{-3}
Grand Gulf[(c)]	5.2×10^{-2}	1.7×10^{-1}	4.2×10^{-3}	3.5×10^{-2}	1.2×10^{-1}	2.8×10^{-3}	3.4×10^{-2}	1.1×10^{-1}	2.7×10^{-3}	7.8×10^{-2}	2.5×10^{-1}	6.2×10^{-3}
North Anna	6.2×10^{-2}	2.1×10^{-1}	5.5×10^{-3}	4.2×10^{-2}	1.4×10^{-1}	3.7×10^{-3}	4.1×10^{-2}	1.4×10^{-1}	3.6×10^{-3}	9.2×10^{-2}	3.2×10^{-1}	8.2×10^{-3}
Pilgrim	6.5×10^{-2}	2.3×10^{-1}	7.0×10^{-3}	4.4×10^{-2}	1.6×10^{-1}	4.8×10^{-3}	4.3×10^{-2}	1.5×10^{-1}	4.6×10^{-3}	9.8×10^{-2}	3.5×10^{-1}	1.0×10^{-2}
Portsmouth	5.5×10^{-2}	1.9×10^{-1}	4.4×10^{-3}	3.7×10^{-2}	1.3×10^{-1}	3.0×10^{-3}	3.6×10^{-2}	1.2×10^{-1}	2.9×10^{-3}	8.1×10^{-2}	2.8×10^{-1}	6.6×10^{-3}
Quad Cities	4.0×10^{-2}	1.3×10^{-1}	2.4×10^{-3}	2.7×10^{-2}	8.6×10^{-2}	1.7×10^{-3}	2.6×10^{-2}	8.4×10^{-2}	1.6×10^{-3}	6.0×10^{-2}	1.9×10^{-1}	3.6×10^{-3}
Savannah River	6.0×10^{-2}	2.1×10^{-1}	6.0×10^{-3}	4.0×10^{-2}	1.4×10^{-1}	4.1×10^{-3}	3.9×10^{-2}	1.4×10^{-1}	4.0×10^{-3}	8.9×10^{-2}	3.2×10^{-1}	9.0×10^{-3}
Surry	6.4×10^{-2}	2.1×10^{-1}	5.8×10^{-3}	4.3×10^{-2}	1.4×10^{-1}	3.9×10^{-3}	4.2×10^{-2}	1.4×10^{-1}	3.8×10^{-3}	9.5×10^{-2}	3.2×10^{-1}	8.7×10^{-3}
Zion	4.4×10^{-2}	1.5×10^{-1}	3.1×10^{-3}	3.0×10^{-2}	1.0×10^{-1}	2.1×10^{-3}	2.9×10^{-2}	9.7×10^{-2}	2.0×10^{-3}	6.5×10^{-2}	2.2×10^{-1}	4.6×10^{-3}

Table H-9. (contd)

Reactor Type	IRIS			GT-MHR			PBMR		
No. Shipments per year	35			34			12		
	Environmental Effects, person-rem per reference reactor year[(a)]								
Reactor Site	**Crew**	**Onlookers**	**Along Route**	**Crew**	**Onlookers**	**Along Route**	**Crew**	**Onlookers**	**Along Route**
Braidwood	2.5×10^{-2}	8.5×10^{-2}	1.5×10^{-3}	2.4×10^{-2}	8.2×10^{-2}	1.5×10^{-3}	7.9×10^{-3}	2.7×10^{-2}	4.9×10^{-4}
Clinton	2.5×10^{-2}	8.5×10^{-2}	1.6×10^{-3}	2.4×10^{-2}	8.2×10^{-2}	1.5×10^{-3}	8.0×10^{-3}	2.8×10^{-2}	5.1×10^{-4}
FitzPatrick	3.4×10^{-2}	1.2×10^{-1}	3.3×10^{-3}	3.3×10^{-2}	1.2×10^{-1}	3.2×10^{-3}	1.1×10^{-2}	3.9×10^{-2}	1.1×10^{-3}
Grand Gulf	3.0×10^{-2}	9.8×10^{-2}	2.4×10^{-3}	2.9×10^{-2}	9.4×10^{-2}	2.3×10^{-3}	9.7×10^{-3}	3.2×10^{-2}	7.8×10^{-4}
North Anna	3.6×10^{-2}	1.2×10^{-1}	3.2×10^{-3}	3.4×10^{-2}	1.2×10^{-1}	3.1×10^{-3}	1.2×10^{-2}	4.0×10^{-2}	1.0×10^{-3}
Pilgrim	3.8×10^{-2}	1.3×10^{-1}	4.0×10^{-3}	3.6×10^{-2}	1.3×10^{-1}	3.9×10^{-3}	1.2×10^{-2}	4.3×10^{-2}	1.3×10^{-3}
Portsmouth	3.1×10^{-2}	1.1×10^{-1}	2.5×10^{-3}	3.0×10^{-2}	1.1×10^{-1}	2.4×10^{-3}	1.0×10^{-2}	3.6×10^{-2}	8.2×10^{-4}
Quad Cities	2.3×10^{-2}	7.4×10^{-2}	1.4×10^{-3}	2.2×10^{-2}	7.1×10^{-2}	1.4×10^{-3}	7.5×10^{-3}	2.4×10^{-2}	4.6×10^{-4}
Savannah River	3.4×10^{-2}	1.2×10^{-1}	3.5×10^{-3}	3.3×10^{-2}	1.2×10^{-1}	3.3×10^{-3}	1.1×10^{-2}	3.9×10^{-2}	1.1×10^{-3}
Surry	3.7×10^{-2}	1.2×10^{-1}	3.3×10^{-3}	3.5×10^{-2}	1.2×10^{-1}	3.2×10^{-3}	1.2×10^{-2}	4.0×10^{-2}	1.1×10^{-3}
Zion	2.5×10^{-2}	8.5×10^{-2}	1.8×10^{-3}	2.4×10^{-2}	8.2×10^{-2}	1.7×10^{-3}	8.2×10^{-3}	2.8×10^{-2}	5.8×10^{-4}

(a) Multiply person-Sv/yr by 100 to obtain doses in person-rem/yr.

(b) The River Bend alternative site can be assumed to be bounded by the Grand Gulf values because of the proximity of the sites.

(c) Dresden and LaSalle can be assumed to be bounded by the Braidwood values because of the proximity of the sites.

Based on these observations, the staff concluded that the stop model used in this study overestimates public doses at stops by approximately a factor of four (factor of two for close-proximity exposure time at stops, a factor of 1.5 for average stop time at food and refueling stops, and a factor of 1.5 for the number of people in proximity to the shipping cask). Coupled with the factor of two reduction in shipping cask dose rates that result from fuel aging, the doses to onlookers at stops could be reduced to about one-eighth of the doses shown in Table H-9 [$1/(2 \times 1.5 \times 1.5 \times 2) \approx 0.12$] to reflect more realistic truck shipping conditions. Based on the previous discussion, use of more realistic dose rates, shipping cask capacities, and truck stop model assumptions in the RADTRAN 5 calculations could substantially reduce the environmental effects presented in Table H-9.

Table H-10 provides a comparison between the radiological incident-free doses calculated in NUREG-0170 (NRC 1977a) and those calculated here. The table also summarizes the key incident-free input parameters used in NUREG-0170 and in this study. Comparisons are also made between the doses for spent fuel shipments in NUREG-0170 and doses calculated for a shipment from the Quad Cities, Iowa, to the proposed Yucca Mountain repository because the shipping distances are comparable (2530 km in NUREG-0170 versus 2853 km for Quad Cities to Yucca Mountain). As shown in the table, many parameters have changed over the years and the technical bases for them have improved. For example, the work of Griego et al. (1996) has improved the basis for assumptions about stop times and persons exposed at truck stops, and the TRAGIS computer code has improved the basis for shipping distances and population distributions along highway routes.

The incident-free impacts at truck stops shown in the table have been adjusted, as discussed above, to reflect more realistic conditions than assumed in the bounding analysis. Adjustments were not made to the onlookers, along route, and crew doses shown in Table H-9. As shown, the adjusted doses in Table H-10 for spent fuel shipments from the Quad Cities to the proposed Yucca Mountain repository are about a factor of two lower than the per-shipment doses from NUREG-0170 when the doses to and doses associated with in-transit storage from NUREG-0170 are excluded. Storage doses were excluded from this Section H.2 analysis because spent fuel shipments proceed directly from the reactor site to Yucca Mountain with no intermediate storage involved. Handler doses were excluded from this analysis because doses to workers who load the spent fuel cask at reactors and unload them at the proposed repository are treated as facility doses, not transportation doses.

Table H-10. Comparison of Incident-Free Doses from NUREG-0170 (NRC 1977a) Spent Fuel Shipments and Spent Fuel Shipment from Quad-Cities to the Proposed High-Level Waste Repository at Yucca Mountain

Incident-Free Exposure Parameter	NUREG-0170 (NRC 1977a)	This Study (Quad Cities to Yucca Mountain)$^{(a)}$
One-way shipping distance, km	2530	2853
Travel fraction		
Urban	0.05	0.02
Suburban	0.05	0.12
Rural	0.9	0.86
Population density along highway, persons per km^2		
Urban	3861	2391.3
Suburban	719	310.2
Rural	6	9.1
Speed, km/hr		
Urban	24	88
Suburban	40	88
Rural	88	88
Traffic count, vehicles/hr		
Urban	2800	2400
Suburban	780	760
Rural	470	530
Shipment dose Rate, mSv/hr at 2m	0.1	0.1
Crew dose rate, mSv/hr	0.02	Calculated (7.4 m from package)
Stop time, hr per trip		
Urban	2	3 hours per trip (30 minutes per 4 hours driving time)
Suburban	5	
Rural	1	
Population density at stops (per km^2)		
Urban	3861	Distribution: 1 to 10 m - 30,000; 10 to 800 m - 340 (see Figure G-1)
Suburban	719	
Rural	6	
Person-Sv/shipment		
Crew	1.2×10^{-3}	4.8×10^{-4}
Off-link	1.5×10^{-4}	3.1×10^{-4}
On-link	7.4×10^{-5}	1.7×10^{-4}
Stops	1.9×10^{-4}	$1.7 \times 10^{-4(b)}$
Total	1.6×10^{-3}	8.5×10^{-4}
Handlers + Storage	2.1×10^{-3}	Not calculated
Grand Total	**3.7×10^{-3}**	**8.5×10^{-4}**

(a) Tables H-7 and H-9 provide the basis for these input parameters.

(b) Stop doses have been adjusted as described in the text to reflect more realistic assumptions than were used in the bounding analysis (Table H-9).

H.2.2.2 Transportation Accident Impacts

RADTRAN 5 assesses accident risk by calculating a risk value, which is the product of probabilities and the consequences of accidents. RADTRAN 5 considers a spectrum of potential transportation accidents, ranging from those with high frequencies and low consequences (e.g., “fender-benders”) to those with low frequencies and high consequences (e.g., accidents in which the shipping container is exposed to severe mechanical and thermal conditions).

Radionuclide inventories are important parameters in the calculation of accident risks. The radionuclide inventories used in this analysis were taken directly from the *Early Site Permit Environmental Report Sections and Supporting Documentation* (INEEL 2003). The report included hundreds of radionuclides for each advanced reactor type. A screening analysis was conducted to select the dominant contributors to accident risks to simplify the RADTRAN 5 calculations. The screening identifies the radionuclides that will contribute more than 99.999 percent of the dose from inhalation.

A sum-of-fractions approach was used for this screening. First, the inventory of each radionuclide was multiplied by its respective inhalation dose conversion factor, taken from Federal Guidance Report 13 (EPA 2002). These values were then summed. Then, each inventory-conversion factor product was divided by the sum of the products to obtain the fraction of the total inhalation dose for each radionuclide. The resulting fractions were then sorted from largest to smallest, their cumulative contributions were calculated, and those that contributed to 99.999 percent of the inhalation-dose potential were selected. Two gases, krypton-85 and iodine-129, were added to the list because they are more easily released than the solid and semi-volatile species contained in the fuel.

The inventories of radionuclides used in this study are shown in Table H-11. Note that the list of radionuclides provided in the table includes all of the radionuclides that were included in the analysis conducted by Sprung et al. (2000), which validates the screening process used in this EIS. Also note that INEEL (2003) did not provide radionuclide source terms for radioactive material deposited on the external surfaces of LWR spent fuel rods, which is commonly referred to as “crud.” In addition, data on activation products was provided for only the ABWR. The ABWR spent fuel transportation risks were calculated assuming the entire Co-60 inventory is in the form of crud. This is very conservative as the source term used here is about two orders of magnitude greater than that given in Sprung et al. (2000). Because crud is deposited from corrosion products generated elsewhere in the reactor cooling system and the complete reactor design and operating parameters are uncertain, the quantities and characteristics of crud deposited on advanced reactor spent fuel are unknown at this time. Consequently, the impacts of crud and activation products on spent fuel transportation accident risks will need to be examined at the construction permit or combined operating license stage.

Table H-11 shows that the dominant radionuclides are approximately the same regardless of fuel type. The table does not show radionuclide inventory data for the ACR-700 and IRIS advanced reactors, as those were not given in INEEL (2003). Nor were they provided in WASH-1238 (AEC 1972) for the reference LWR. Consequently, accident risks were not quantified for these reactor types.

Table H-11. Radionuclide Inventories Used in the Transportation Accident Risk Calculations for Each Advanced Reactor Type

Radionuclide	ABWR and ESBWR Inventory, Bq/MTU(a)	Surrogate AP1000 Inventory, Bq/MTU	GT-MHR Inventory, Bq/MTU	PBMR Inventory, Bq/MTU
Am-241	4.96×10^{13}	2.69×10^{13}	8.18×10^{13}	7.55×10^{13}
Am-242m	1.24×10^{12}	4.85×10^{11}	5.03×10^{11}	8.51×10^{11}
Am-243	1.20×10^{12}	1.24×10^{12}	5.14×10^{11}	4.77×10^{12}
Ce-144	4.22×10^{14}	3.28×10^{14}	2.15×10^{15}	1.19×10^{15}
Cm-242	2.04×10^{12}	1.05×10^{12}	1.51×10^{12}	2.78×10^{12}
Cm-243	1.37×10^{12}	1.14×10^{12}	2.02×10^{11}	1.96×10^{12}
Cm-244	1.80×10^{14}	2.87×10^{14}	2.83×10^{13}	5.48×10^{14}
Cm-245	2.43×10^{10}	4.48×10^{10}	1.65×10^{8}	5.29×10^{10}
Co-60	1.01×10^{14}	--(b)	--(b)	--(b)
Cs-134	1.78×10^{15}	1.78×10^{15}	2.21×10^{15}	4.03×10^{15}
Cs-137	4.59×10^{15}	3.44×10^{15}	1.08×10^{16}	1.41×10^{16}
Eu-154	3.81×10^{14}	3.38×10^{14}	3.23×10^{14}	3.74×10^{14}
Eu-155	1.93×10^{14}	1.71×10^{14}	8.77×10^{13}	1.08×10^{14}
I-129	1.55×10^{9}	1.55×10^{9}	1.55×10^{9}	1.55×10^{9}
Kr-85	3.29×10^{14}	3.29×10^{14}	3.29×10^{14}	3.29×10^{14}
Pm-147	1.25×10^{15}	6.51×10^{14}	6.92×10^{15}	5.07×10^{15}
Pu-238	2.27×10^{14}	2.25×10^{14}	1.17×10^{14}	4.55×10^{14}
Pu-239	1.43×10^{13}	9.44×10^{12}	2.25×10^{13}	1.11×10^{13}
Pu-240	2.28×10^{13}	2.01×10^{13}	3.96×10^{13}	3.32×10^{13}
Pu-241	4.51×10^{15}	2.58×10^{15}	8.33×10^{15}	7.18×10^{15}
Pu-242	8.29×10^{10}	6.73×10^{10}	1.56×10^{11}	4.51×10^{11}
Ru-106	6.07×10^{14}	5.74×10^{14}	1.48×10^{15}	1.68×10^{15}
Sb-125	1.99×10^{14}	1.42×10^{14}	2.21×10^{14}	2.51×10^{14}
Sr-90	3.27×10^{15}	2.29×10^{15}	8.95×10^{15}	1.08×10^{16}
Y-90	3.27×10^{15}	2.29×10^{15}	8.95×10^{15}	1.08×10^{16}

(a) To convert Bq/MTU to Ci/MTU, divide the value by 3.7×10^{10}.

(b) Co-60 is an activation product. Only the ABWR/ESBWR submittal in INEEL (2003) provided inventory data for activation products.

Robust shipping casks are used to transport spent fuel because of the heavy radiation shielding and accident resistance required by 10 CFR Part 71. Spent fuel shipping casks must be certified Type B packaging systems, which means they must withstand a series of severe hypothetical accident conditions with essentially no loss of containment or shielding capability. These casks are also designed with fissile material controls to ensure that the spent fuel remains subcritical under both normal and accident conditions. The tests include a 9-m (30-ft) free drop onto an unyielding surface, a drop onto a puncture probe, an exposure to an engulfing 800°C fire for 30 minutes, and an underwater immersion. According to Sprung et al. (2000), the probability of encountering accident conditions more severe than these tests that could lead to shipping cask failure are less than 0.01 percent of all accidents (i.e., more than 99.99 percent of all accidents would not result in a release of radioactive material from the shipping cask). It was assumed that shipping casks for advanced reactor spent fuels will provide equivalent mechanical and thermal protection of the spent fuel cargo.

The RADTRAN 5 accident risk calculations were performed using unit radionuclide inventories (Bq/MTU) for the spent fuel shipments from the various reactor types. The resulting risk estimates were then multiplied by assumed annual spent fuel shipments (MTU/yr) to derive estimates of the annual accident risks associated with spent fuel shipments from each potential ESP site. As was done for routine exposures, it was assumed that the numbers of shipments of spent fuel per year are equivalent to the annual discharge quantities: 32.76 MTU/yr for the ABWR and ESBWR; 24.4 MTU/yr for a single-reactor surrogate AP1000 site; 6.8 MTU/yr for the four-reactor GT MHR site; and 8.3 MTU/yr for the eight-reactor PBMR site. These data were taken from INEEL (2003) and have not been normalized to the reference LWR net electrical generation.

Route-specific accident rates (accidents per km) were derived for the RADTRAN 5 accident risk analysis. The approach used to develop accident rates for spent fuel shipments is as follows. The TRAGIS data provide estimates of the distance traveled in each state along a route and the type of highway (interstate, state highway, or other). Saricks and Tompkins (1999) provide accident rates for each state that are a function of highway type. The approach taken to estimate route-specific accident rates was to multiply the state-level accident or fatality rates by the distances traveled in each state on the corresponding highway type and then sum over all the states on each route. For example, for interstate highways, the interstate distances and interstate accident rates were used. For non-interstate highway travel, either the “Primary” or “Other” accident rates given by Saricks and Tompkins (1999) were used. This approach allowed computation of route-specific accident rates.

Transportation accident risk analysis in RADTRAN 5 is performed using an accident severity and package release model. The user can define up to 30 severity categories, with each category increasing in magnitude. Severity categories are related to fire, puncture, crush, and immersion environments created in vehicular accidents. For this analysis, the 19 severity categories defined by Sprung et al. (2000) were adopted.

Each severity category has an assigned conditional probability (or the probability, given an accident occurs, that it will be of the specified severity). The accident scenarios are further defined by allowing the user to input release fractions and aerosol and respirable fractions for each severity category. These fractions are a function of the physical-chemical properties of the materials being transported as well as the mechanical and thermal accident conditions that define the severity categories. The severity and release fractions used here are presented in Table H-12.

Table H-12. Severity and Release Fractions Used to Model Spent Fuel Transportation Accidents (Sprung et al. 2000)

		Release Fractions[(a)]				
Severity Category	**Severity Fraction[(b)]**	**Gas**	**Cesium**	**Ruthenium**	**Particulates**	**Corrosion Products**
1	1.53×10^{-8}	0.8	2.4×10^{-8}	6.0×10^{-7}	6.0×10^{-7}	2.0×10^{-3}
2	5.88×10^{-5}	0.14	4.1×10^{-9}	1.0×10^{-7}	1.0×10^{-7}	1.4×10^{-3}
3	1.81×10^{-6}	0.18	5.4×10^{-9}	1.3×10^{-7}	1.3×10^{-7}	1.8×10^{-3}
4	7.49×10^{-8}	0.84	3.6×10^{-5}	3.8×10^{-6}	3.8×10^{-6}	3.2×10^{-3}
5	4.65×10^{-7}	0.43	1.3×10^{-8}	3.2×10^{-7}	3.2×10^{-7}	1.8×10^{-3}
6	3.31×10^{-9}	0.49	1.5×10^{-8}	3.7×10^{-7}	3.7×10^{-7}	2.1×10^{-3}
7	0	0.85	2.7×10^{-5}	2.1×10^{-6}	2.1×10^{-6}	3.1×10^{-3}
8	1.13×10^{-8}	0.82	2.4×10^{-8}	6.1×10^{-7}	6.1×10^{-7}	2.0×10^{-2}
9	8.03×10^{-11}	0.89	2.7×10^{-8}	6.7×10^{-7}	6.7×10^{-7}	2.2×10^{-3}
10	0	0.91	5.9×10^{-6}	6.8×10^{-7}	6.8×10^{-7}	2.5×10^{-3}
11	1.44×10^{-10}	0.82	2.4×10^{-8}	6.1×10^{-7}	6.1×10^{-7}	2.0×10^{-3}
12	1.02×10^{-12}	0.89	2.7×10^{-8}	6.7×10^{-7}	6.7×10^{-7}	2.2×10^{-3}
13	0	0.91	5.9×10^{-6}	6.8×10^{-7}	6.8×10^{-7}	2.5×10^{-3}
14	7.49×10^{-11}	0.84	9.6×10^{-5}	8.4×10^{-5}	1.8×10^{-5}	6.4×10^{-3}
15	0	0.85	5.5×10^{-5}	5.0×10^{-5}	9.0×10^{-6}	5.9×10^{-3}
16	0	0.91	5.9×10^{-6}	6.4×10^{-6}	6.8×10^{-7}	3.3×10^{-3}
17	0	0.91	5.9×10^{-6}	6.4×10^{-6}	6.8×10^{-7}	3.3×10^{-3}
18	5.86×10^{-6}	0.84	1.7×10^{-5}	6.7×10^{-8}	6.7×10^{-8}	2.5×10^{-3}
19	0.99993	0	0	0	0	0

(a) RADTRAN 5 also models the fraction of the released particulate material that is small enough to be dispersible in prevailing wind conditions and the fraction that is respirable. For this analysis, these parameters were set to 1.0 (i.e., 100 percent dispersible and 100 percent respirable).

(b) Severity fractions are the conditional probabilities, given the occurrence of an accident, that the mechanical and thermal conditions experienced by a spent fuel shipping cask are within the conditions defined by the Severity Category. See Sprung et al. (2000) for detailed information about the derivation of these data. Generic steel-depleted uranium-steel cask designs were assumed for the severity fractions.

The severity categories and release fractions published by Sprung et al. (2000) were designed specifically to address accidents involving current generation LWR fuel and the current generation of spent fuel shipping casks. While some of the advanced reactor fuel designs are similar to current-generation reactor fuel designs (e.g., the ABWR, ESBWR, Surrogate AP1000, ACR-700, and IRIS), others are significantly different, including the GT-MHR and PBMR.

Extrapolating the current generation of LWR fuel and shipping casks to advanced LWR fuels and shipping casks is expected to be relatively straightforward because the fuel form, cladding, and physical and mechanical properties are similar. Furthermore, substantial experimental data exist to develop technically defensible release fractions for various radionuclide groups (e.g., gases, semi-volatiles such as cesium and ruthenium, and particulates). However, because detailed experimental studies of releases from GT-MHR and PBMR fuels have not been this approach is bounding. However, gas-cooled reactors operate at much higher temperatures than LWRs; thus, high-temperature conditions anticipated in transportation accident fires are expected to have less effect on radionuclide releases than they would for LWR fuels. Consequently, smaller release fractions are anticipated for advanced gas-cooled reactor fuels than for LWR fuels subjected to thermal transients.

For accidents that result in a release of radioactive material, RADTRAN 5 assumes the material is dispersed into the environment according to standard Gaussian diffusion models. The code allows the user to choose two different methods for modeling the atmospheric transport of radionuclides after a potential accident. The user can input either Pasquill atmospheric-stability category data or averaged time-integrated concentrations. In this Section H.2 analysis, the default standard cloud option (using time-integrated concentrations) was used.

RADTRAN 5 was used to calculate the population dose from the released radioactive material for four of five[a] possible exposure pathways:

- External dose from exposure to the passing cloud of radioactive material (cloudshine).

- External dose from radionuclides deposited on the ground by the passing plume (groundshine). The Section H.2 analysis included the radiation exposures from this pathway even though the area surrounding a potential accidental release would be evacuated and decontaminated, thus preventing long-term exposures from this pathway.

- Internal dose from inhalation of airborne radioactive contaminants (inhalation).

- Internal dose from radioactive materials that were deposited on the ground and then resuspended (resuspension). The Section H.2 analysis included the radiation exposures from this pathway even though evacuation and decontamination of the area surrounding a potential accidental release would prevent long-term exposures.

A sixth pathway, external doses arising from increased radiation fields surrounding a shipping cask with damaged shielding, was considered but not included in the analysis. It is possible that

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(a) The internal dose from ingestion of contaminated food was not considered, as the staff assumed evacuation and subsequent interdiction of foodstuffs following a potential transportation accident.

shielding materials incorporated into the cask structures could become damaged as a result of an accident. For example, casks with lead shielding could undergo a slumping phenomenon in which impact or fire causes gaps to form in the lead. Radiation would penetrate through the gaps in the shielding at higher intensities, leading to higher radiation dose rates. These events, which are commonly referred to as “loss of shielding events,” were not included in this assessment because their contribution to spent fuel transportation risks is much smaller than the dispersal accident risks.

Standard radionuclide uptake and dosimetry models are incorporated into RADTRAN 5. The computer code combines the accident consequences and frequencies of each severity category, sums up the severity categories, and then integrates across all the shipments. Accident-risk impacts are provided in the form of a collective population dose (person-rem over the entire shipping campaign).

The shipping distances and population distribution information for the routes used for the evaluation of the impacts of incident-free transportation (see Table H-6) were also used to calculate transportation impacts. Representative shipping casks described above were assumed.

Table H-13 presents unit (per MTU) accident risks associated with transportation of spent fuel from each potential ESP site to the proposed Yucca Mountain repository.

Projected annual accident risks, normalized to the WASH-1238 (AEC 1972) reference LWR net electrical generation (i.e., 880 MW(e)) are presented in Table H-13. As expected, accident risks are highest for the longest shipments. Also, consistent with past spent fuel transportation risk assessments, the routine impacts are several orders of magnitude greater than accident impacts.

Considering the small magnitude of the risks presented in Table H-12 and the conservative computational methods and data used to address uncertainties, the overall transportation accident risks associated with ABWR, ESBWR, Surrogate AP1000, GT-MHR, and PBMR spent fuel shipments are judged to be small. Although likely to also be small, accident risks associated with IRIS and ACR-700 spent fuel shipments could not be analyzed because of the lack of radionuclide source-term data. Additional analyses are necessary to quantify the impacts of IRIS and ACR-700 spent fuel shipments.

Table H-13. Unit Spent Fuel Transportation Accident Risks for Advanced Reactors

Site	ABWR/ ESBWR	Surrogate AP1000	GT-MHR	PBMR
	Advanced Reactor Type			
Population Dose, person-Sv/MTU[(a)]				
Braidwood[(b)]	1.0 x 10^{-7}	1.0 x 10^{-8}	1.5 x 10^{-8}	2.5 x 10^{-8}
Clinton	1.1 x 10^{-7}	1.0 x 10^{-8}	1.5 x 10^{-8}	2.6 x 10^{-8}
FitzPatrick	1.9 x 10^{-7}	1.7 x 10^{-8}	2.5 x 10^{-8}	4.3 x 10^{-8}
Grand Gulf[(c)]	2.0 x 10^{-7}	1.9 x 10^{-8}	2.8 x 10^{-8}	4.7 x 10^{-8}
North Anna	2.3 x 10^{-7}	2.1 x 10^{-8}	3.2 x 10^{-8}	5.4 x 10^{-8}
Pilgrim	4.0 x 10^{-7}	3.7 x 10^{-8}	5.5 x 10^{-8}	9.3 x 10^{-8}
Portsmouth	2.3 x 10^{-7}	2.1 x 10^{-8}	3.1 x 10^{-8}	5.2 x 10^{-8}
Quad Cities	1.0 x 10^{-7}	9.4 x 10^{-9}	1.4 x 10^{-8}	1.4 x 10^{-8}
Savannah River	2.3 x 10^{-7}	2.4 x 10^{-8}	3.6 x 10^{-8}	6.1 x 10^{-8}
Surry	2.4 x 10^{-7}	2.2 x 10^{-8}	3.3 x 10^{-8}	5.6 x 10^{-8}
Zion	1.5 x 10^{-7}	1.4 x 10^{-8}	2.1 x 10^{-8}	3.5 x 10^{-8}

(a) To convert to person-rem, multiply person-Sv by 100.
(b) Dresden and LaSalle can be assumed to be bounded by the Braidwood values because of the proximity of the sites.
(c) The River Bend alternative site can be assumed to bounded by the Grand Gulf values because of the proximity of the sites.

Table H-14 presents the environmental consequences of transportation accidents when shipping spent fuel from the proposed ESP sites and alternative sites to the proposed Yucca Mountain repository. The shipping distances and population distribution information for the routes were the same as those used for the normal “incident-free” conditions. The table presents estimates of population dose (person-Sv/reference reactor year) for several of the advanced reactor designs. These values are normalized to the WASH-1238 reference reactor (880-MW(e)) net electrical generation, 1100-MW(e) reactor operating at 80 percent capacity).

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposure to low doses below about 100 mSv (10,000 mrem) and low dose rates. However, radiation protection experts conservatively assume that any amount of radiation exposure may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response model is used to describe the relationship

Table H-14. Annual Spent Fuel Transportation Accident Impacts for Advanced Reactors, Normalized to Reference LWR Net Electrical Generation

	Advanced Reactor Type			
	ABWR/ESBWR	**Surrogate AP1000**	**GT-MHR**	**PBMR**
MTU/reference reactor year	**20.3**	**19.7**	**6.0**	**5.8**
Population Dose, person-Sv per reference reactor year[a]				
Braidwood[b]	2.1 x 10^{-6}	2.0 x 10^{-7}	8.9 x 10^{-8}	1.5 x 10^{-7}
Clinton	2.3 x 10^{-5}	2.0 x 10^{-7}	9.1 x 10^{-8}	1.5 x 10^{-7}
FitzPatrick	3.8 x 10^{-6}	3.3 x 10^{-7}	1.5 x 10^{-7}	2.5 x 10^{-7}
Grand Gulf[c]	4.1 x 10^{-6}	3.7 x 10^{-7}	1.7 x 10^{-7}	2.7 x 10^{-7}
North Anna	4.7 x 10^{-6}	4.2 x 10^{-7}	1.9 x 10^{-7}	3.1 x 10^{-7}
Pilgrim	8.1 x 10^{-6}	7.2 x 10^{-7}	3.3 x 10^{-7}	5.4 x 10^{-7}
Portsmouth	4.6 x 10^{-6}	4.0 x 10^{-7}	1.8 x 10^{-7}	3.0 x 10^{-7}
Quad Cities	2.1 x 10^{-6}	1.8 x 10^{-7}	8.4 x 10^{-8}	8.1 x 10^{-8}
Savannah River	5.3 x 10^{-6}	4.7 x 10^{-7}	2.2 x 10^{-7}	3.5 x 10^{-7}
Surry	4.9 x 10^{-6}	4.3 x 10^{-7}	2.0 x 10^{-7}	3.2 x 10^{-7}
Zion	3.0 x 10^{-6}	2.7 x 10^{-7}	1.2 x 10^{-7}	2.0 x 10^{-7}

(a) Multiply person-Sv/reference reactor year by 100 to obtain doses in person-rem/reference reactor year.
(b) Dresden and LaSalle can be assumed to be bounded by the Braidwood values because of the proximity of the sites.
(c) The River Bend alternative site can be assumed to be bounded by the Grand Gulf values because of the proximity of the sites.

between radiation dose and detriments such as cancer induction. A recent report (National Research Council 2006), the BEIR VII report, supports the linear, no-threshold dose response theory. Simply put, the theory states that any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably over-estimates those risks.

Based on this model, the staff estimates the risk to the public from radiation exposure using the nominal probability coefficient for total detriment (730 fatal cancers, nonfatal cancers, and severe hereditary effects per 10,000 person-Sv [1,000,000 person-rem]) from ICRP Publication 60 (ICRP 1991). All the population doses presented in Table H-14 are less than 1.0 x 10^{-5} person-Sv (1.0 x 10^{-3} person-rem) per reference reactor year; therefore, the total detriment estimates associated with these population doses would all be less than 1.0 x 10^{-6} fatal cancers, nonfatal cancers, and severe hereditary effects per reference reactor year. These risks are quite small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that would be expected to occur annually in the same population from exposure to natural sources of radiation using the same risk model.

H.2.3 Shipment of Radioactive Waste

This section discusses the environmental effects of transporting radioactive waste from advanced reactor sites. The environmental conditions listed in 10 CFR 51.52 that apply to shipments of radioactive waste are as follows:

- Radioactive waste (except spent fuel) is packaged and in a solid form [51.52(a)(4)]

- Radioactive waste (except spent fuel) is shipped from the reactor by truck or rail [51.52(a)(5)].

INEEL (2003) indicates that all of the advanced reactors will transport their radioactive waste by truck. Furthermore, INEEL (2003) indicates that all of the advanced reactors plan to solidify and package their radioactive waste. In addition, all of the advanced reactors will be subject to NRC (10 CFR Part 71) and U.S. Department of Transportation regulations for the shipment of radioactive material (49 CFR Parts 171, 172, 173, 178).

Table S–4 also specifies the following conditions that apply to shipments of radioactive waste:

- Weight – less than 33,100 kg (73,000 lb) per truck or 100 tons per cask per rail car

- Traffic density – less than one truck shipment per day or three rail cars per month.

The advanced reactors are assumed to be capable of shipping their radioactive wastes in compliance with Federal or State weight restrictions. With respect to the traffic density, all of the advanced reactor vendors provided radioactive waste generation estimates. Table H-15 provides these estimates, in addition to the radioactive waste generation estimates for the reference LWR in WASH-1238 (AEC 1972).

As shown in the table, only the PBMR generates a larger volume of radioactive waste than the reference LWR in WASH-1238. However, the GT-MHR and PBMR information in INEEL (2003) assumed these advanced reactors would ship wastes using two different packaging systems: one that hauls 28 m^3/shipment (1000 ft^3 per shipment) and one that hauls 5.7 m^3/shipment (200 ft^3/per shipment). Under those conditions, the number of shipments of radioactive waste per year, normalized to 1100 MW(e) electric generation capacity, would be about six shipments/year per 1100 MW(e) (880 net MW(e)) for the GT-MHR and seven shipments/year per 1100 MW(e) for the PBMR. These estimates are well below the reference LWR (42 shipments per 1100 MW(e)). In any event, all the estimates are well below the one truck shipment per day condition given in 10 CFR 51.52, Table S–4. Doubling the shipment estimates to account for empty return shipments is still well below the one shipment per day condition.

Table H-15. Summary of Radioactive Waste Shipments for Advanced Reactors

Reactor Type	INEEL (2003) Waste Generation Information	Annual Waste Volume, m^3/yr per Unit	Electrical Output, MW(e) per Unit	Normalized Rate, m^3/1100 MW(e) Reactor (880 MW(e) Net)[a]	Shipments/ 1100 MW(e) (880 MW(e) Net) Electrical Output[b]
Reference LWR (WASH-1238)	100 m^3/yr per unit	108	1100	108	46
ABWR	100 m^3/yr per unit	100	1500[c]	62	27
ESBWR	100 m^3/yr per unit	100	1500[c]	62	27
Surrogate AP1000	55 m^3/yr per unit	56	1150[c]	45	20
ACR-700	47.5 m^3/yr per unit	95	1462[d]	64	28
IRIS	25 m^3/yr per unit	74 (3 units)	1005[e]	67	29
GT-MHR	98 m^3/yr (4-unit plant)	98 (4 units)	1140[f]	86	37[h]
PBMR	100 drums/yr per unit	168 (8 units)	1320[g]	118	51[h]

(a) Capacity factors used to normalize the waste generation rates to an equivalent electrical generation output are given in Table 6-3 for each reactor type. All are normalized to 880 MW(e) net electrical output (1100-MW(e) plant with an 80 percent capacity factor).
(b) The number of shipments per 1100 MW(e) was calculated assuming the WASH-1238 average waste shipment capacity of 2.34 m^3 per shipment (108 m^3/yr divided by 46 shipments).
(c) The ABWR and ESBWR units include one reactor at 1500 MW(e) and the surrogate AP1000 site includes one reactor at 1150 MW(e).
(d) The ACR-700 unit includes two reactors at 731 MW(e) per reactor.
(e) The IRIS unit includes three reactors at 335 MW(e) per reactor.
(f) The GT-MHR unit includes four reactors at 285 MW(e) per reactor.
(g) The PBMR unit includes eight reactors at 165 MW(e) per reactor.
(h) INEEL (2003) states that 90 percent of the waste could be shipped on trucks carrying 28 m^3 (1000 ft^3) of waste and the remaining 10 percent in shipments carrying 5.7 m^3 (200 ft^3) of radioactive waste. This would result in five to six shipments per year after normalization to the reference LWR electrical output.

Conversions: 1 m^3 = 35.31 ft^3. Drum volume = 210 liters (0.21 m^3).

H.3 Support Information for Radiological Dose Assessment

The staff performed an independent assessment of the radiological impacts of normal operation for a new nuclear unit at the Grand Gulf ESP site. Results of this assessment are presented in this appendix and are compared to SERI's results in Section 5.9, "Radiological Impacts of Normal Operation," of Revision 2 of the Environmental Review in SERI's application

(SERI 2005a). This section contains information on (1) dose estimates to the public from liquid effluents, (2) dose estimates to the public from gaseous effluents, and (3) dose estimates to the biota from both liquid and gaseous effluents.

For comparative purposes with SERI's estimates, all doses and amounts of radioactive material are reported in millirem (mrem) and curies (Ci), respectively.

H.3.1 Dose Estimates to the Public from Liquid Effluents

The staff used the LADTAP II code (Strenge et al. 1986) and input parameters supplied by SERI in its environmental report, Revision 2 (SERI 2005a) to estimate doses to the general population and the maximally exposed individual(a) from the liquid effluent pathway

H.3.1.1 Scope

The important pathways for determining the dose to the population and to the maximally exposed individual from liquid effluents include:

- Eating fish or invertebrates that are caught in the Mississippi River near the point of discharge. The population doses are based on the commercial fish and invertebrate catches taken from the Grand Gulf environmental report (MP&L 1973). The annual consumption rate of fish and shellfish by the maximally exposed individual is taken from estimates provided in Regulatory Guide 1.109 (NRC 1977b)

- External exposure from the surface of contaminated water or from shoreline sediment as a result of using the shoreline for activities such as sunbathing or fishing

There are only three public water supply systems in the state of Mississippi that use surface water as a source, and none of these are located within 80 km (50 mi) of the Grand Gulf ESP site. There are no downstream intakes that use the Mississippi River as a potable water supply within 160 km (100 mi) of the Grand Gulf ESP site. For this reason, ingestion of water is not considered as a pathway.

Swimming and recreational boating in the Mississippi River near the GGNS site is very limited, and it was assumed for this analysis that no swimming or recreational boating occurs.

(a) The maximally exposed individual probably does not really exist. It is an imaginary person used to ensure that the dose criterial set forth in NRC regulations are met by nuclear power facilities. At this facility, the maximally exposed individual is assumed to eat fish and shellfish caught near the point of discharge and use the shoreline for activities such as sunbathing or fishing.

Doses to the maximally exposed individual were calculated for the following:

- Total body - Dose was the total for all pathways (i.e., fish and invertebrate consumption and shoreline usage) with the highest value for either the adult, teen, child, or infant compared to the design objective of 0.03 mSv/yr (3 mrem/yr) per reactor in Title 10 of the Code of Federal Regulations (CFR), Part 50, Appendix I.

- Organ dose - Dose was the total for each organ for all pathways (i.e., fish and invertebrate consumption and shoreline usage) with the highest value for either the adult, teen, child, or infant compared to the design objective of 0.1 mSv/yr (10 mrem/yr) per reactor in 10 CFR Part 50, Appendix I.

The NRC staff reviewed the input parameters used by SERI for appropriateness. Default values for input parameters from Regulatory Guide 1.109 were used when site-specific parameters were not available.

H.3.1.2 Resources Used

The staff used a personal computer version of the LADTAP II code entitled NRCDOSE Version 2.3.5 (Bland 2000), obtained through the Oak Ridge Radiation Safety Information Computational Center (RSICC) to calculate doses to the public from liquid effluents.

H.3.1.3 Input Parameters

Table H-16 provides a listing of the major parameters used in calculating dose to the public from liquid effluent releases during normal operation. The values used by SERI and the staff for each parameter are listed along with comments regarding the appropriateness of the value. All of the input parameters were similar and appropriate.

Table H-16. Parameters Used in Calculating Dose to the Public from Liquid Effluents

Parameter	SERI Value		Staff Value		Comments (Appropriateness of Value)
Source term (Ci/yr)	Table 3.0-8 of SERI (2005a), modified as discussed in “Comments” column		Table 3.0-8 of SERI (2005a), modified as discussed in “Comments” column		
	Iodine-131	2.826×10^{-2}	Iodine-131	2.83×10^{-2}	The staff’s values were rounded to three significant digits. Rhodium-106 (1.47×10^{-1} curies), Rhodium-103m (9.86×10^{-3} curies), Silver-110 (2.80×10^{-4} curies), Barium-137m (2.49×10^{-2} curies), were not included in the calculation because they are not accepted by the LADTAP II code. Their contribution to the dose is relatively small.
	Iodine-132	5.200×10^{-3}	Iodine-132	5.20×10^{-3}	
	Iodine-133	2.000×10^{-2}	Iodine-133	2.00×10^{-2}	
	Iodine-134	3.400×10^{-3}	Iodine-134	3.40×10^{-3}	
	Iodine-135	1.503×10^{-2}	Iodine-135	1.50×10^{-2}	
	Tritium	$6.200 \times 10^{+3}$	Tritium	$6.20 \times 10^{+3}$	
	Carbon-14	8.800×10^{-4}	Carbon-14	8.80×10^{-4}	
	Sodium-24	5.622×10^{-3}	Sodium-24	5.62×10^{-3}	
	Phosphorus-32	3.600×10^{-4}	Phosphorus-32	3.60×10^{-4}	
	Chromium-51	1.541×10^{-2}	Chromium-51	1.54×10^{-2}	
	Manganese-54	5.200×10^{-3}	Manganese-54	5.20×10^{-3}	
	Manganese-56	7.622×10^{-3}	Manganese-56	7.62×10^{-3}	
	Cobalt-57	1.438×10^{-4}	Cobalt-57	1.44×10^{-4}	
	Cobalt-58	6.720×10^{-3}	Cobalt-58	6.72×10^{-3}	
	Cobalt-60	1.822×10^{-2}	Cobalt-60	1.82×10^{-2}	
	Iron-55	1.162×10^{-2}	Iron-55	1.16×10^{-2}	
	Iron-59	4.000×10^{-4}	Iron-59	4.00×10^{-4}	
	Nickel-63	2.800×10^{-4}	Nickel-63	2.80×10^{-4}	
	Copper-64	1.503×10^{-2}	Copper-64	1.50×10^{-2}	
	Zinc-65	8.200×10^{-4}	Zinc-65	8.20×10^{-4}	
	Bromine-84	4.000×10^{-5}	Bromine-84	4.00×10^{-5}	
	Rubidium-88	5.400×10^{-4}	Rubidium-88	5.40×10^{-4}	
	Rubidium-89	8.811×10^{-5}	Rubidium-89	8.81×10^{-5}	
	Strontium-89	2.200×10^{-4}	Strontium-89	2.20×10^{-4}	
	Strontium-90	7.027×10^{-5}	Strontium-90	7.03×10^{-5}	
	Yttrium-90	6.216×10^{-6}	Yttrium-90	6.22×10^{-6}	
	Strontium-91	1.800×10^{-3}	Srtrontium91	1.80×10^{-3}	
	Yttrium-91	2.200×10^{-4}	Yttrium-91	2.20×10^{-4}	
	Yttrium-91m	2.000×10^{-5}	Yttrium-91m	2.00×10^{-5}	
	Strontium-92	1.600×10^{-3}	Strontium-92	1.60×10^{-3}	
	Yttrium-92	1.200×10^{-3}	Yttrium-92	1.20×10^{-3}	
	Yttrium-93	1.800×10^{-3}	Yttrium-93	1.80×10^{-3}	
	Zirconium-95	2.080×10^{-3}	Zirconium-95	2.08×10^{-3}	
	Niobium-95	3.820×10^{-3}	Niobium-95	3.82×10^{-3}	
	Molybdenum-99	1.659×10^{-3}	Molybdenum-99	1.66×10^{-3}	
	Technetium-99m	1.600×10^{-3}	Technetium-99m	1.60×10^{-3}	
	Ruthenium-103	9.860×10^{-3}	Ruthenium-103	9.86×10^{-3}	
	Ruthenium-106	1.470×10^{-1}	Ruthenium-106	1.47×10^{-1}	
	Silver-110m	2.100×10^{-3}	Silver-110m	2.10×10^{-3}	

Table H-16. (contd)

Parameter	SERI Value		Staff Value		Comments (Appropriateness of Value)
	Antimony-124	1.358×10^{-3}	Antimony-124	1.35×10^{-3}	
	Tellurium-129	3.000×10^{-4}	Tellurium-129	3.00×10^{-4}	
	Tellurium-129m	2.400×10^{-4}	Tellurium-129m	2.40×10^{-4}	
	Tellurium-131	6.000×10^{-5}	Tellurium-131	6.00×10^{-5}	
	Tellurium-131m	1.800×10^{-4}	Tellurium-131m	1.80×10^{-4}	
	Tellurium-132	4.800×10^{-4}	Tellurium-132	4.80×10^{-4}	
	Cesium-134	1.986×10^{-2}	Cesium-134	1.99×10^{-2}	
	Cesium-136	1.260×10^{-3}	Cesium-136	1.26×10^{-3}	
	Cesium-137	2.664×10^{-2}	Cesium-137	2.66×10^{-2}	
	Cesium-138	3.800×10^{-4}	Cesium-138	3.80×10^{-4}	
	Barium-140	1.104×10^{-2}	Barium-140	1.10×10^{-2}	
	Lanthanum-140	1.486×10^{-2}	Barium-140	1.49×10^{-2}	
	Cerium-141	2.400×10^{-4}	Cerium-141	2.40×10^{-4}	
	Cerium-143	3.800×10^{-4}	Cerium-143	3.80×10^{-4}	
	Cerium-144	6.320×10^{-3}	Cerium-144	6.32×10^{-3}	
	Praseodymium-143	2.600×10^{-4}	Praseodymium-143	2.60×10^{-4}	
	Praseodymium-144	6.320×10^{-3}	Praseodymium-144	6.32×10^{-3}	
	Tungsten-187	2.600×10^{-4}	Tungsten-187	2.60×10^{-4}	
	Neptunium-239	6.216×10^{-3}	Neptumium-239	6.22×10^{-3}	
Discharge flow rate cfs (gpm)	0.078 (35)		0.078 (35)		Site-specific value from Table 3.0-1 (SERI 2005a)
Source term multiplier	1		1		Site specific value from SERI (2005b)
Site type	Fresh water		Fresh water		Site specific value from SERI (2005b)
Reconcentration model	No internal reconcentration model employed		No internal reconcentration model employed		
80-kilometer (50-mile) population	$3.95 \times 10^{+5}$		$3.95 \times 10^{+5}$		Value from Tables 2.5-1 and 2.5-6 (SERI 2005a)
Shore width factor	0.2		0.2		Site-specific value based on Regulatory Guide 1.109 (NRC 1977b)

Table H-16. (contd)

Parameter	SERI Value	Staff Value	Comments (Appropriateness of Value)
Dilution factors for aquatic food and shoreline	730	730	Based on a cooling tower blowdown rate of 808 L/s (12,800 gpm) (Table 5.4-1 of SERI 2005a) and a dilution factor of 2 in the Mississippi River (SERI 2006).
Consumption and usage factors for adults, teens, children, and infants	Values from Table 5.4-2 of environmental report (SERI 2005a)	Values from Table 5.4-2 of environmental report (SERI 2005a)	Default values from Regulatory Guide 1.109

H.3.1.4 Comparison of Results

Table H-17 compares the results obtained by SERI for the maximum individual and total population dose with those obtained by calculations performed by the staff. The dose results are essentially the same.

Table H-17. Comparison of Dose Estimates to the Public from Liquid Effluent Release per Unit

Type of Dose	SERI's Environmental Report (SERI 2005a)	Staff's Calculation	Percent Difference
	Maximum Individual Dose (mrem/yr)[(a)]		
Total Body (mrem/yr)[(b)]	2.17	2.17	0
Organ Dose (bone)[(c)] (mrem/yr)	4.10	4.09	<1
	Total Population Dose (person-rem/yr)[(d)]		
Total Body	2.06	2.06	0
Maximum Organ (liver)	3.32	3.32	0

(a) mrem = millirem; divide mrem/yr by 100 to obtain millisievert/yr
(b) An adult was found to receive the maximum individual total body dose.
(c) A child was found to receive the maximum individual organ dose.
(d) Divide man-rem/yr by 100 to obtain person-sievert/yr.

H.3.2 Dose Estimates to the Public from Gaseous Effluents

The staff used the GASPAR II code (Strenge et al. 1987) and input parameters supplied by SERI in its environmental report, Revision 2 (SERI 2005a) to estimate doses to the general population within an 80-km (50-mi) radius of the Grand Gulf ESP site and to the maximally exposed individual from the gaseous effluent pathways.

H.3.2.1 Scope

The staff and SERI calculated annual radiation exposures for the population within a 80-km (50-mi) radius of the site and for hypothetical individuals of various ages using the GASPAR II code and assuming the following pathways:

- Direct radiation from immersion in the gaseous effluent cloud and from particulates deposited on the ground
- Inhalation of gases and particulates
- Ingestion of milk contaminated through the grass-cow-milk pathway
- Ingestion of vegetables contaminated by particulates
- Ingestion of meat from animals grazing on contaminated pasture.

Three types of doses were calculated by the staff and compared with SERI's calculations.

- Doses to an individual located at the exclusion area boundary of 0.93 km (0.58 mi) north of the site as a result of gamma air dose, beta air dose, total body dose and skin dose
- Doses to hypothetical individuals (maximally exposed individual) of various ages that are exposed to gaseous radioactive effluents via the pathways listed above
- Doses to the population residing within an 80-km (50-mi) radius of the site.

The NRC staff reviewed the input parameters used by SERI for appropriateness. Default values for input parameters from Regulatory Guide 1.109 (NRC1977b) were used when site-specific input parameters were not available. The staff concluded that all the input parameters used by SERI were appropriate. These parameters were used by the staff in its independent calculations.

H.3.2.2 Resources Used

The staff used a personal computer version of GASPAR II code entitled NRCDOSE, Version 2.3.5 (Bland 2000), obtained through the Oak Ridge RSICC to calculate doses to the public from gaseous effluents.

H.3.2.3 Input Parameters

Table H-18 provides a list of the major parameters used in calculating dose to the public from gaseous effluent releases during normal operation. The values used by SERI and the staff for each parameter are listed along with comments regarding the appropriateness of the value.

Table H-18. Parameters Used in Calculating Dose to the Public from Gaseous Effluent Releases

Parameter	SERI Value (Table 3.0-7 in SERI 2005a)		Staff Value		Comments (Appropriateness of Value)
Source term for calculating dose to the maximally exposed individual (curies/year) and population within 50-mile radius	Krypton-83m	1.68×10^{-3}	Krypton-83m	1.68×10^{-3}	The source term is the bounding plant paramenter envelope. The values are appropriate.
	Krypton-85m	$7.20 \times 10^{+1}$	Krypton-85m	$7.20 \times 10^{+1}$	
	Krypton-85	$8.20 \times 10^{+3}$	Krypton-85	$8.20 \times 10^{+3}$	
	Krypton-87	$5.03 \times 10^{+1}$	Krypton-87	$5.03 \times 10^{+1}$	
	Krypton-88	$9.20 \times 10^{+1}$	Krypton-88	$9.20 \times 10^{+1}$	
	Krypton-89	$4.81 \times 10^{+2}$	Krypton-89	$4.81 \times 10^{+2}$	
	Xenon-131m	$3.60 \times 10^{+3}$	Xenon-131m	$3.60 \times 10^{+3}$	Krypton-90 (6.49×10^{-4} curies), Xenon-139 (8.11×10^{-4} curies), Ruthenium-103m (2.22×10^{-4} curies) Rhodium-106 (3.78×10^{-5} curies), were not included in the calculation because they are not accepted by the GASPAR code. Their contribution to the total dose is small.
	Xenon-133m	$1.74 \times 10^{+2}$	Xenon-133m	$1.74 \times 10^{+2}$	
	Xenon-133	$9.20 \times 10^{+3}$	Xenon-133	$9.20 \times 10^{+3}$	
	Xenon-135m	$8.11 \times 10^{+2}$	Xenon-135m	$8.11 \times 10^{+2}$	
	Xenon-135	$9.19 \times 10^{+2}$	Xenon-135	$9.19 \times 10^{+2}$	
	Xenon-137	$1.03 \times 10^{+3}$	Xenon-137	$1.03 \times 10^{+3}$	
	Xenon-138	$8.65 \times 10^{+2}$	Xenon-138	$8.65 \times 10^{+2}$	
	Iodine-131	5.19×10^{-1}	Iodine-131	5.19×10^{-1}	
	Iodine-132	$4.38 \times 10^{+0}$	Iodine-132	$4.38 \times 10^{+0}$	
	Iodine-133	$3.41 \times 10^{+0}$	Iodine-133	$3.41 \times 10^{+0}$	
	Iodine-134	$7.57 \times 10^{+0}$	Iodine-134	$7.57 \times 10^{+0}$	
	Iodine-135	$4.81 \times 10^{+0}$	Iodine-135	$4.81 \times 10^{+0}$	
	Carbon-14	$2.19 \times 10^{+1}$	Carbon-14	$2.19 \times 10^{+1}$	
	Tritium	$7.06 \times 10^{+3}$	Tritium	$7.06 \times 10^{+3}$	
	Sodium-24	8.11×10^{-3}	Sodium-24	8.11×10^{-3}	
	Phosphorus-32	1.84×10^{-3}	Phosphorus-32	1.84×10^{-3}	
	Argon-41	$1.02 \times 10^{+2}$	Argon-41	$1.02 \times 10^{+2}$	
	Chromium-51	7.03×10^{-2}	Chromium-51	7.03×10^{-2}	
	Manganese-54	1.08×10^{-2}	Manganese-54	1.08×10^{-2}	
	Manganese-56	7.03×10^{-3}	Manganese-56	7.03×10^{-3}	

Table H-18. (contd)

Parameter	SERI Value (Table 3.0-7 in SERI 2005a)		Staff Value		Comments (Appropriateness of Value)
	Iron-55	1.30×10^{-2}	Iron-55	1.30×10^{-2}	
	Cobalt-57	2.46×10^{-5}	Cobalt-57	2.46×10^{-5}	
	Cobalt-58	6.90×10^{-2}	Cobalt-58	6.90×10^{-2}	
	Iron-59	1.62×10^{-3}	Iron-59	1.62×10^{-3}	
	Cobalt-60	2.61×10^{-2}	Cobalt-60	2.61×10^{-2}	
	Nickel-63	1.30×10^{-5}	Nickel-63	1.30×10^{-5}	
	Copper-64	2.00×10^{-2}	Copper-64	2.00×10^{-2}	
	Zinc-65	2.22×10^{-2}	Zinc-65	2.22×10^{-2}	
	Rubidium-89	8.65×10^{-5}	Rubidium-89	8.65×10^{-5}	
	Strontium-89	1.14×10^{-2}	Strontium-89	1.14×10^{-2}	
	Strontium-90	3.60×10^{-3}	Strontium-90	3.60×10^{-3}	
	Yttrium-90	9.19×10^{-5}	Yttrium-90	9.19×10^{-5}	
	Strontium-91	2.00×10^{-3}	Strontium-91	2.00×10^{-3}	
	Strontium-92	1.57×10^{-3}	Strontium-92	1.57×10^{-3}	
	Yttrium-91	4.81×10^{-4}	Yttrium-91	4.81×10^{-4}	
	Yttrium-92	1.24×10^{-3}	Yttrium-92	1.24×10^{-3}	
	Yttrium-93	2.22×10^{-3}	Yttrium-93	2.22×10^{-3}	
	Zirconium-95	3.19×10^{-3}	Zirconium-95	3.19×10^{-3}	
	Niobium-95	1.68×10^{-2}	Niobium-95	1.68×10^{-2}	
	Molybdenum-99	1.19×10^{-1}	Molybdenum-99	1.19×10^{-1}	
	Technetium-99m	5.95×10^{-4}	Technetium-99m	5.95×10^{-4}	
	Ruthenium-103	7.03×10^{-3}	Ruthenium-103	7.03×10^{-3}	
	Ruthenium-106	2.34×10^{-4}	Ruthenium-106	2.34×10^{-4}	
	Silver-110m	4.00×10^{-6}	Silver-110m	4.00×10^{-6}	
	Antimony-124	3.62×10^{-4}	Antimony-124	3.62×10^{-4}	
	Antimony-125	1.83×10^{-4}	Antimony-125	1.83×10^{-4}	
	Tellurium-129m	4.38×10^{-4}	Tellurium-129m	4.38×10^{-4}	
	Tellurium-131m	1.51×10^{-4}	Tellurium-131m	1.51×10^{-4}	
	Tellurium-132	3.78×10^{-5}	Tellurium-132	3.78×10^{-5}	
	Cesium-134	1.24×10^{-2}	Cesium-134	1.24×10^{-2}	
	Cesium-136	1.19×10^{-3}	Cesium-136	1.19×10^{-3}	
	Cesium-137	1.89×10^{-2}	Cesium-137	1.89×10^{-2}	
	Cesium-138	3.41×10^{-4}	Cesium-138	3.41×10^{-4}	
	Barium-140	5.41×10^{-2}	Barium-140	5.41×10^{-2}	
	Lanthanum-140	3.62×10^{-3}	Lanthanum-140	3.62×10^{-3}	
	Cerium-141	1.84×10^{-2}	Cerium-141	1.84×10^{-2}	
	Cerium-144	3.78×10^{-5}	Cerium-144	3.78×10^{-5}	
	Praseodymium-144	3.78×10^{-5}	Praseodymium-144	3.78×10^{-5}	
	Tungsten-187	3.78×10^{-4}	Tungsten-187	3.78×10^{-4}	
	Neptunium-239	2.38×10^{-2}	Neptunium-239	2.38×10^{-2}	
Population Distribution	Used data from SERI's supporting documentation (equivalent to data found in Tables 2.5-1 and 2.5-6 of SERI (2005a) for the year 2070)		Used data from SERI's supporting documentation (equivalent to data found in Tables 2.5-1 and 2.5-6 of SERI (2005a) for the year 2070)		Site-specific data - appropriate for use
Atmospheric dispersion factors	Used data from SERI's supporting documentation (equivalent to		Used data from SERI's supporting documentation (equivalent to		Site-specific data - appropriate for use

Table H-18. (contd)

Parameter	SERI Value (Table 3.0-7 in SERI 2005a)	Staff Value	Comments (Appropriateness of Value)
(sec/m^3)	Table 2.7-118 of SERI (2005a))	Table 2.7-118 of SERI (2005a))	
Ground deposition factors (m^{-2})	Used data from SERI's supporting documentation (equivalent to Table 2.7-120 of SERI (2005a))	Used data from SERI's supporting documentation (equivalent to Table 2.7-120 of SERI (2005a))	Site-specific data - appropriate for use
Milk production rate within 80 km (50 mi) (L/yr)	Used data from SERI's supporting documentation (equivalent to Table 5.4-5 of SERI (2005a))	Used data from SERI's supporting documentation (equivalent to Table 5.4-5 of SERI (2005a))	Site-specific data - appropriate for use
Meat production rate within 80 km (50 mi) (kg/yr)	Used data from SERI's supporting documentation (equivalent to Table 5.4-6 of SERI (2005a))	Used data from SERI's supporting documentation (equivalent to Table 5.4-6 of SERI (2005a))	Site-specific data - appropriate for use
Vegetable production rate within 80 km (50 mi) (kg/yr)	Used data from SERI's supporting documentation (equivalent to Table 5.4-7 of SERI (2005a))	Used data from SERI's supporting documentation (equivalent to Table 5.4-7 of SERI (2005a))	Site-specific data - appropriate for use
Pathway receptor locations (direction, distance and atmospheric dispersion factors) Nearest site boundary Nearest vegetable garden Nearest home Nearest milk cow Nearest meat cow	Used data from SERI's supporting documentation (equivalent to Table 2.7-117 of SERI (2005a))	Used data from SERI's supporting documentation (equivalent to Table 2.7-117 of SERI (2005a))	Site-specific data - appropriate for use
Consumption factors for leafy vegetables, meat, milk, and vegetable/fruit	Table 5.4-4 of SERI (2005a)	Table 5.4-4 of SERI (2005a)	Appropriate for use - NRC 1977b
Fraction of year that leafy green vegetables are grown	1	1	Appropriate for use
Fraction of year that cows are on pasture	1	1	Appropriate for use
Fraction of the max individual's vegetable intake from their own garden	0.76	0.76	Appropriate for use

Table H-18. (contd)

Parameter	SERI Value (Table 3.0-7 in SERI 2005a)	Staff Value	Comments (Appropriateness of Value)
Fraction of milk cow intake that is from pasture while on pasture	1	1	Appropriate for use
Average absolute humidity over the growing season	8	8	Appropriate for use - Default value of GASPAR II code - appropriate for use
Fraction of year goats are on pasture	1	1	Site-specific data - appropriate for use
Fraction of goat intake that is from pasture while on pasture	1	1	Site-specific data - appropriate for use
Fraction of year beef-cattle are on pasture	1	1	Site-specific data - appropriate for use
Fraction of beef-cattle intake that is from pasture while on pasture	1	1	Site-specific data - appropriate for use

H.3.2.4 Comparison of Dose Estimates to the Public from Gaseous Effluent Releases

Table H-19 compares results obtained by SERI with those performed by the staff for doses to the maximally exposed individual, primarily at the exclusion area boundary. Doses calculated were similar.

Table H-19. Comparison of Dose Estimates to the Maximally Exposed Individual from Gaseous Pathway Releases

Type of Dose	SERI's Environmental Report (SERI 2005a)	Staff's Calculation	Percent Difference
Gamma air dose at exclusion area boundary (mrad)(a)	1.80	1.80	0
Beta air dose at exclusion area boundary (mrad)(a)	3.48	3.48	0
Total body dose at exclusion area boundary (plume, ground, and inhalation) - (Teen) (mrem)(b)	1.62	1.69	4.3
Skin dose at exclusion area boundary - (Teen) (mrem)(b)	4.42	4.42	0
Vegetable consumption at nearest garden (Child, thyroid) (mrem)(b)	6.70	6.70	0

(a) mrad = millirad; divide mrad by 100 to obtain milligray/yr.
(b) mrem = millirem; divide mrem by 100 to obtain millisievert/yr.

Table H-20 provides the doses to the maximally exposed individual calculated by SERI and the staff. Doses to the maximally exposed individual were calculated at the nearest residence, nearest garden, nearest site boundary, nearest meat cow, and nearest milk cow. The doses calculated by the NRC staff were the same as those calculated by SERI. Thus, only one number is given for each entry in the table.

Table H-20. SERI (2005a) and Staff Dose Estimates to the Maximally Exposed Individual from Gaseous Effluent Releases from Operation of One New Nuclear Unit

Location	Pathway	Total Body Dose (mrem/yr)[(a)]	Skin Dose (mrem/yr)[(a)(b)]	Thyroid Dose (mrem/yr)[(a)]
Nearest Residence[(c)] (NNE, 1.02 km (0.64 mi))	Plume Exposure	0.63	2.09	0.63
	Inhalation			
	Adult	0.171	-	0.69
	Teen	0.173	-	0.85
	Child	0.153	-	0.995
	Infant	0.088	-	0.855
Nearest Garden[(c)] (ENE, 1.01 km (0.63 mi))	Vegetable Consumption			
	Adult	0.387	-	2.87
	Teen	0.491	-	0.36
	Child	0.901	-	0.67
Nearest Site Boundary[(d)] (N, 0.93 km (0.58 mi))	Plume Exposure	1.18	3.88	1.18
	Inhalation		-	
	Adult	0.318	-	1.28
	Teen	0.321	-	1.58
	Child	0.285	-	1.84
	Infant	0.164	-	1.58
Nearest Milk Cow[(c)] (S SW 16 km (10 mi))	Cow Milk		-	
	Adult	0.00565	-	0.055
	Teen	0.00833	-	0.0865
	Child	0.0159	-	0.172
	Infant	0.0287	-	0.409

Table H-20. (contd)

Location	Pathway	Total Body Dose (mrem/yr)[a]	Skin Dose (mrem/yr)[a][b]	Thyroid Dose (mrem/yr)[a]
Nearest Meat Cow[c] (S, 6.4 km (4.0 mi))	Meat Consumption			
	Adult	0.00653	-	0.0144
	Teen	0.00472	-	0.0104
	Child	0.00758	-	0.0163

(a) mrem = milirem; divide mrem/yr by 100 to obtain millisievert/yr.
(b) Skin dose is only applicable to plume exposure.
(c) "Nearest" refers to the location at which the highest radiation dose to an individual from the applicable pathways has been estimated.
(d) "Nearest" refers to that site boundary location at which the highest radiation doses from gaseous emissions have been estimated to occur.

H.3.2.5 Comparison of Results - Population Doses

Table H-21 compares the SERI population dose estimates taken from Table 5.4-13 of SERI (2005a) with the staff's estimate. Calculated doses are the same.

Table H-21. Comparison of Population Doses from Gaseous Effluent Releases

Pathway	SERI's Environmental Report (SERI 2005a)	Staff's Calculation	Percent Difference
	Total Body (person-rem/yr)[a]		
Plume	0.157	0.157	0
Ground	0.0546	0.0546	0
Inhalation	0.418	0.418	0
Vegetable ingestion	0.152	0.152	0
Cow-milk ingestion	0.215	0.215	0
Meat ingestion	0.184	0.184	0
Total	1.18	1.18	0
	Thyroid (Worst Case Organ) (person-rem/yr)[a]		
Plume	0.157	0.157	0
Ground	0.0546	0.0546	0
Inhalation	1.23	1.23	0
Vegetable ingestion	0.154	0.154	0
Cow-milk ingestion	0.89	0.890	0
Meat ingestion	0.248	0.248	0
Total	2.73	2.73	0

(a) Divide person-rem/yr by 100 to obtain person-sievert/yr.

H.3.3 Dose Estimates to the Biota from Liquid and Gaseous Effluents

To estimate doses to the biota from the liquid and gaseous effluent pathways, the staff used the LADTAP II code (Strenge et al. 1986) and the GASPAR II code (Strenge et al. 1987) and input parameters supplied by SERI as part of its environmental report (SERI 2005a).

H.3.3.1 Scope

Doses from the liquid pathways to both terrestrial and aquatic biota were calculated using the LADTAP II code. Aquatic biota include fish, invertebrates, and algae. Terrestrial biota include muskrat, raccoon, heron, and duck. The LADTAP II code calculates the biota dose from the liquid effluent pathway by calculating an internal dose component and an external dose component and summing them for a total dose. The NRC staff reviewed the input parameters used by SERI for appropriateness. Default values from Regulatory Guide 1.109 (NRC 1977b) were used when input parameters were not available. The staff used the same parameters in its independent calculations using LADTAP.

Terrestrial biota could also be exposed via the gaseous effluent pathway. An estimate of these values was made by using the dose from exposure to the ground and multiplying it by a factor that adjusts for the size of the animal and their distance from the ground. This is added to the dose from the plume to obtain the external dose. Internal dose to terrestrial biota is based on the total body inhalation dose for the maximally exposed individual (infant) at the site boundary calculated by GASPAR II. The total body inhalation dose (rather than organ specific doses) is used since the biota doses are assessed on a total body basis.

H.3.3.2 Resources Used

To calculate the doses to the public from liquid releases, the staff used a computer code entitled, NRCDOSE, version 2.3.5 (Bland 2000) which is a version of the LADTAP II code and the GASPAR II code, obtained through the Oak Ridge RSICC.

H.3.3.3 Input Parameters

The LADTAP II parameters are specified in Table H-16 and include the source term, discharge flow rate, reconcentration model, effluent discharge rate to the Mississippi River, impoundment total volume, and shore width factor. Parameters unique to the biota dose calculation were taken from Table 5.4-14 (terrestrial biota parameters including food intake, body mass and effective body radius) and Table 5.4-15 of the environmental report (SERI 2005a) (shoreline exposure and swimming exposure estimates). These parameters were default values used in the LADTAP II code (Strenge et al. 1986) and are appropriate values to use in calculating biota dose.

H.3.3.4 Comparison of Results

Table H-22 compares the dose results obtained by SERI (2005a, Table 5.4-16) with those performed by the staff for liquid effluents. The dose estimates were the same.

Table H-22. Comparison of Dose Estimates to Biota from Liquid Effluents

Biota	Type of Dose	SERI's Environmental Report (SERI 2005a) (mrad/yr)[(a)]	Staff's Calculation (mrad/yr)[(a)]	Percent Difference
Fish	Internal	14.2	14.2	0
	External	11.2	11.2	0
Invertebrates	Internal	143	143	0
	External	22.3	22.3	0
Algae	Internal	148	148	0
	External	0.05	0.05	0
Muskrat	Internal	73.8	73.8	0
	External	7.45	7.45	0
Raccoon	Internal	13.4	13.4	0
	External	5.57	5.57	0
Heron	Internal	186	186	0
	External	7.44	7.44	0
Duck	Internal	69.9	69.9	0
	External	11.2	11.2	0

(a) mrad = millirad; divide mrad/yr by 100 to obtain milligray/yr.

Table H-23 compares the dose results obtained by SERI (2005a, Table 5.4-16) with those performed by the staff for gaseous effluents. These dose estimates were similar.

Table H-23. Comparison of Dose Estimates to Biota from Gaseous Effluents

Biota	Type of Dose	SERI's Environmental Report (SERI 2005a) (mrad/yr)[(a)]	Staff's Calculation (mrad/yr)[(a)]	Percent Difference
Muskrat	Internal	0.164	0.164	0
	External	2.03	2.02	< 1
Raccoon	Internal	0.164	0.164	0
	External	1.82	1.81	< 1
Heron	Internal	0.164	0.164	0
	External	1.69	1.68	<1
Duck	Internal	0.164	0.164	0
	External	2.14	2.13	< 1

(a) mrad = millirad; divide mrad/yr by 100 to obtain milligray/yr.

H.4 References

10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy*, Part 50, "Domestic Licensing of Production and Utilization Facilities."

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy,* Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 52. Code of Federal Regulations, Title 10, *Energy*, Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

10 CFR Part 71. Code of Federal Regulations,. Title 10, *Energy*, "Packaging and Transportation of Radioactive Material."

49 CFR Part 171. Code of Federal Regulations, Title 49, *Transportation*, Part 171, "General Information, Regulations, and Definitions."

49 CFR Part 172. Code of Federal Regulations, Title 49, *Transportation*, Part 172, "Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements."

49 CFR Part 173. Code of Federal Regulations, Title 49, *Transportation,* Part 173, "Shippers - General Requirements for Shipments and Packagings."

49 CFR Part 178. Code of Federal Regulations, Title 49, *Transportation,* Part 178, "Specifications for Packagings."

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Appendix I

Plant Parameter Envelope Values

Appendix I

Plant Parameter Envelope Values

This appendix contains the System Energy Resources, Inc. plant parameter envelope for the proposed Grand Gulf early site permit site as submitted in System Energy Resources, Inc. environmental report (SERI 2005) as Tables 3.0-1 to 3.0-9 and reproduced here as Table I-1.

Table I-1. PPE for the Grand Gulf Early Site Permit Facility

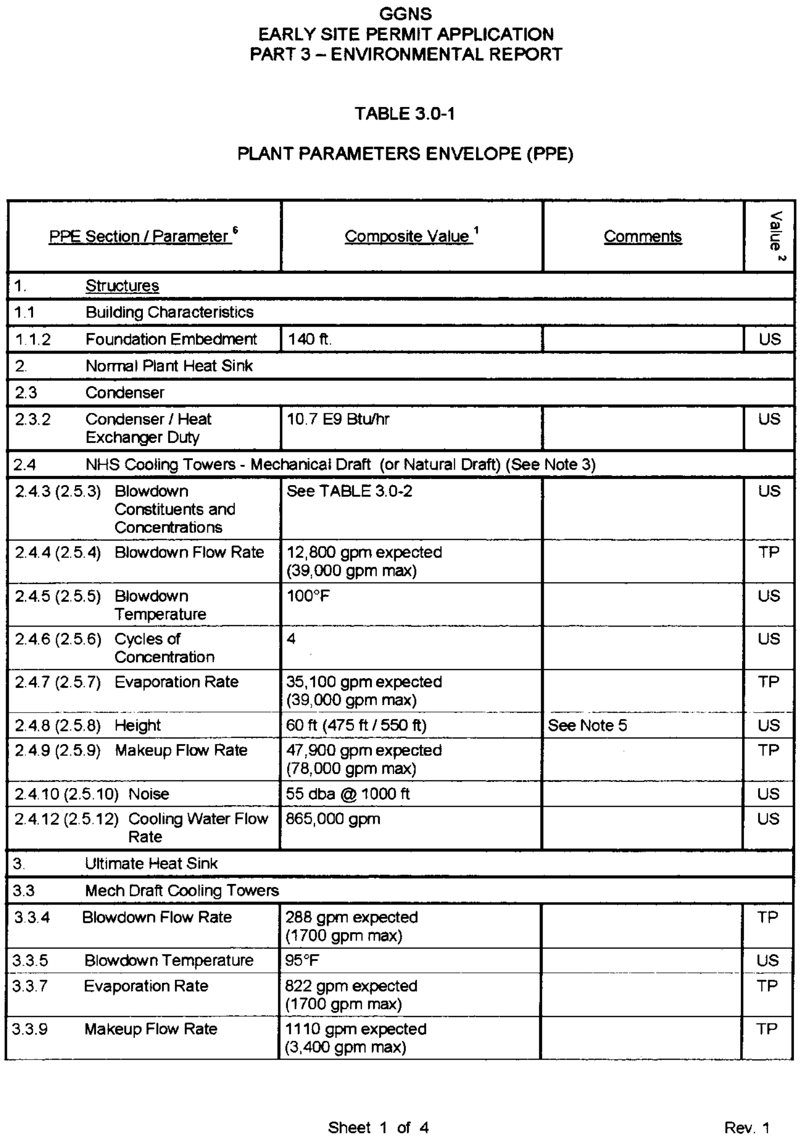

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TABLE 3.0-1

PLANT PARAMETERS ENVELOPE (PPE)

PPE Section / Parameter [6]		Composite Value [1]	Comments	Value [2]
1.	Structures			
1.1	Building Characteristics			
1.1.2	Foundation Embedment	140 ft.		US
2.	Normal Plant Heat Sink			
2.3	Condenser			
2.3.2	Condenser / Heat Exchanger Duty	10.7 E9 Btu/hr		US
2.4	NHS Cooling Towers - Mechanical Draft (or Natural Draft) (See Note 3)			
2.4.3 (2.5.3)	Blowdown Constituents and Concentrations	See TABLE 3.0-2		US
2.4.4 (2.5.4)	Blowdown Flow Rate	12,800 gpm expected (39,000 gpm max)		TP
2.4.5 (2.5.5)	Blowdown Temperature	100°F		US
2.4.6 (2.5.6)	Cycles of Concentration	4		US
2.4.7 (2.5.7)	Evaporation Rate	35,100 gpm expected (39,000 gpm max)		TP
2.4.8 (2.5.8)	Height	60 ft (475 ft / 550 ft)	See Note 5	US
2.4.9 (2.5.9)	Makeup Flow Rate	47,900 gpm expected (78,000 gpm max)		TP
2.4.10 (2.5.10)	Noise	55 dba @ 1000 ft		US
2.4.12 (2.5.12)	Cooling Water Flow Rate	865,000 gpm		US
3.	Ultimate Heat Sink			
3.3	Mech Draft Cooling Towers			
3.3.4	Blowdown Flow Rate	288 gpm expected (1700 gpm max)		TP
3.3.5	Blowdown Temperature	95°F		US
3.3.7	Evaporation Rate	822 gpm expected (1700 gpm max)		TP
3.3.9	Makeup Flow Rate	1110 gpm expected (3,400 gpm max)		TP

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TABLE 3.0-1 (Continued)

PPE Section / Parameter [6]	Composite Value [1]	Comments	Value [2]
3.3.12 Cooling Water Flow Rate	26,125 gpm (normal) 52,250 gpm (shutdown / accident)		US
5. Potable Water/Sanitary Waste System			
5.1 Discharge to Site Water Bodies			
5.1.1 Flow Rate	120 gpm expected (210 gpm max)		TP
5.2 Raw Water Requirements			
5.2.1 Maximum Use	240 gpm		TP
5.2.2 Monthly Average Use	180 gpm		TP
6. Demineralized Water System			
6.1 Discharge to Site Water Bodies			
6.1.1 Flow Rate	220 gpm expected (290 gpm max)		TP
6.2 Raw Water Requirements			
6.2.1 Maximum Use	1440 gpm		TP
6.2.2 Monthly Average Use	1100 gpm		TP
7. Fire Protection System			
7.1 Raw Water Requirements			
7.1.1 Maximum Use	1890 gpm		TP
7.1.2 Monthly Average Use	(30 gpm)		TP
8. Miscellaneous Drain			
8.1 Discharge to Site Water Bodies			
8.1.1 Flow Rate	200 gpm expected (300 gpm max)		TP
9. Unit Vent/Airborne Effluent Release Point			
9.4 Release Point			
9.4.2 Elevation (Normal)	Ground level		US
9.4.3 Elevation (Post Accident)	Ground level		US
9.4.4 Minimum Distance to Site Boundary	0.52 mi (841 m) exclusion area		US
9.5 Source Term			
9.5.1 Airborne Effluents (Normal)	32,699 Ci/yr	See TABLE 3.0-7	US

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TABLE 3.0-1 (Continued)

PPE Section / Parameter [6]		Composite Value [1]	Comments	Value [2]
9.5.2	Airborne Effluents (Post-Accident)	Based on limiting DBAs.	See Note 4	US
9.5.3	Tritium Airborne Effluent Normal)	7060 Ci/yr		TP
10.	Liquid Radwaste System			
10.2	Release Point			
10.2.1	Flow Rate	35 gpm		US
10.3	Source Term			
10.3.1	Liquid	0.694 Ci/yr	See TABLE 3.0-8	US
10.3.2	Tritium	6,200 Ci/yr	See TABLE 3.0-8	US
11.	Solid Radwaste System			
11.2.1	Activity	5400 Ci/yr		TP
11.2.2	Principal Radionuclides	See TABLE 3.0-3		US
11.2.3	Volume	18,646 ft^3/yr		TP
13.	Auxiliary Boiler System			
13.2	Flue Gas Effluents	See TABLE 3.0-4		US
16.	Standby Power System			
16.1	Diesels			
16.1.3	Diesel Flue Gas Effluents	See TABLE 3.0-5		US
16.2	Gas Turbines			
16.2.3	Gas-Turbine Flue Gas Effluents	See TABLE 3.0-6		US
17.	Plant Characteristics			
17.3	Megawatts Thermal	4300 MWt	Includes allowance for ~10% uprate from design core power of 3,926 MWt.	US
17.4	Plant Design Life	60 years		US
17.5	Plant Population			
17.5.1	Operation	1160		TP
18.	Construction			
18.3.1	Noise	76-101 db @ 50 ft		US
18.4	Plant Population			
18.4.1	Construction	3150 people max		US

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TABLE 3.0-1 (Continued)

NOTES:

1. The "Composite Value" provides an envelope (bounding values) for design parameters for the various plant designs considered for the site. See Site Safety Analysis Report Section 1.3 for a discussion of the basis for parameter values.
2. "Value" pertains to the "Composite Value" for each parameter listed. In this table, a value designated "US" represents a "unit specific" value, meaning that it is applied per unit, or group of units or modules. A designation of "TP" is given to a value that represents total facility requirements. See Site Safety Analysis Report Section 1.3 for a discussion of the basis for parameter values.
3. Several main condenser cooling system alternatives were considered (i.e., mechanical and natural draft cooling towers, cooling ponds, and once-through cooling). The most restrictive value for each cooling system PPE section has been used in this table (e.g., 550 ft cooling tower height selected since both mechanical and natural draft towers were considered).
    - The once through cooling option was eliminated due to significant environmental impact.
    - The cooling pond option was eliminated due to insufficient GGNS site acreage to accommodate pond.
4. In general, source terms for any given accident are those used by the Vendors in their safety analyses. The methodologies used by the Vendors for establishing source terms include those established in TID-14844 and Regulatory Guide 1.183. See SSAR Sections 3.3.2 and 3.3.3 for additional detail on accident selection and source term methods.
5. For the purposes of environmental (aesthetic) impact, a natural draft cooling tower with a height of 550 ft is considered. The cooling tower plume model discussed in Section 5.3.3.1 of the ER was done assuming a natural draft cooling tower height of 475 ft., and a mechanical draft cooling tower height of 60 ft.
6. A definition for each parameter is provided in Table 3.0-9.

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TABLE 3.0-2

BLOWDOWN CONSTITUENTS AND CONCENTRATIONS[1]

Constituent	Concentration (ppm)[2, 3] River Source	Well / Treated Water	Envelope
Chlorine demand	10.1	--	10.1
Free available chlorine	0.5	--	0.5
Chromium	--	--	--
Copper	--	6	6
Iron	0.9	3.5	3.5
Zinc	--	0.6	0.6
Phosphate	--	7.2	7.2
Sulfate	600	3,500	3,500
Oil and grease	--	--	--
Total dissolved solids	--	17,000	17,000
Total suspended solids	50	150	150
BOD, 5-day	--	--	--

NOTES:

1. See PPE Table 3.0-1 Sections 2.4.3 and 2.5.3.
2. Assumed cycles of concentration equals 4.
3. Concentrations are per unit/group of units, as applicable.

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TABLE 3.0-3

PRINCIPAL RADIONUCLIDES IN SOLID RADWASTE [1]

Radionuclide [3]	Quantity (Ci/yr)
Fe-55	1761.37
Fe-59	1.35
Co-60	395.92
Mn-54	347.22
Cr-51	97.138
C0-58	93.6
NI-63	279
H-3	1.5
C-14	0.3
Nb-95	162
Ag-110m	9
Zr-95	76.45
Ba-140	0.528
Pu-241	0.09
La-140	0.607
Other	72.858
Cs-134	605
Cs-137	507
Sr-90	1.24
I-131	81.91
Ba-137m	507
Na-24	0.44
Ru-103	2.18
Ru-106	1.37
Sb-124	11.29
I-133	4.55
Ce-141	0.14
Ce-144	0.11
Gd-153	3.09
CS-136	0.0287
Zn-65	25.7
Sr-89	0.886
Y-90	1.24
Y-91	4.43 E-4
Rh-103m	1.22 E-3
Rh-106	0.0592
Te-129m	2.31 E-5
Te-129	1.51 E-5
Total (rounded to nearest hundred) [2]	5400

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TABLE 3.0-3 (Continued)

NOTES:

1. See PPE Table 3.0-1 Section 11.2.2.
2. This is the bounding total for twice the single unit or group of units, not the total of the bounding quantities above.
3. Individual Radionuclide quantities must be doubled since they represent data for a single unit or group of units.

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TABLE 3.0-4

YEARLY EMISSIONS AUXILIARY BOILERS[1]

Pollutant Discharged[2, 3]	Quantity (lbs)
Particulates	17,250
Sulfur oxides	51,750
Carbon monoxide	1749
Hydrocarbons	50,100
Nitrogen oxides	19,022

NOTES:

1. See PPE Table 3.0-1 Section 13.2.
2. Emissions are based on 30 days/yr operation.
3. Individual quantities must be doubled since they represent data for a single unit or group of units.

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TABLE 3.0-5

YEARLY EMISSIONS FROM STANDBY DIESEL GENERATORS [1]

Pollutant Discharged [2]	Quantity (lbs)
	Total All DGs [3]
Particulates	1230
Sulfur oxides	4,608
Carbon monoxide	4,600
Hydro-carbons	3,070
Nitrogen oxides	28,968

NOTES:

1. See PPE Table 3.0-1 Section 16.1.3.
2. Emissions are based on 4 hrs/month operation for each of the diesel generators.
3. Individual quantities must be doubled since they represent data for a single unit or group of units.

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TABLE 3.0-6

YEARLY STANDBY POWER SYSTEM GAS TURBINE FLUE GAS EFFLUENTS[1]

Gas Turbine Capacity (MWe)	20 MWe
Distillate 20°F Ambient BTU/KWH (LHV) [3]	9,890
BTU/KWH (HHV)	10,480
Fuel Consumption Rate (lbs/hr) [3]	121,200
Effluent	**Quantity [2, 3] (lbs or PPMVD)**
NOX (PPMVD @ 15% O2	42
NOX as NO2 (lbs)	2016
CO (PPMVD)	31
CO (lbs)	912
UHC (PPMVD)	3
UHC (lbs)	48
VOC (PPMVD)	N/A
VOC (lbs)	10
SO2 (PPMVD)	N/A
SO2 (lbs)	1882
SO3 (PPMVD)	N/A
SO3 (lbs)	30
SULFUR MIST (lbs)	50
PARTICULATES (lbs)	22
Exhaust Analysis (% Vol)	(% Vol)
ARGON	0.87
NITROGEN	72.56
OXYGEN	12.52
CARBON DIOXIDE	5.19
WATER	9.87

NOTES:

1. See PPE Table 3.0-1 Section 16.2.3.
2. Emissions are based on 4 hrs/month operation for each of the gas turbines.
3. Individual quantities must be doubled since they represent data for a single unit or group of units.

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TABLE 3.0-7

NORMAL OPERATIONS GASEOUS RELEASE SOURCE TERM[1]

Radionuclide	Composite Normal Release[2] (Ci/yr)	Radionuclide	Composite Normal Release[2] (Ci/yr)
Kr-83m	1.68E-03	Rb-89	8.65E-05
Kr-85m	7.20E+01	Sr-89	1.14E-02
Kr-85	8.20E+03	Sr-90	3.60E-03
Kr-87	5.03E+01	Y-90	9.19E-05
Kr-88	9.20E+01	Sr-91	2.00E-03
Kr-89	4.81E+02	Sr-92	1.57E-03
Kr-90	6.49E-04	Y-91	4.81E-04
Xe-131m	3.60E+03	Y-92	1.24E-03
Xe-133m	1.74E+02	Y-93	2.22E-03
Xe-133	9.20E+03	Zr-95	3.19E-03
Xe-135m	8.11E+02	Nb-95	1.68E-02
Xe-135	9.19E+02	Mo-99	1.19E-01
Xe-137	1.03E+03	Tc-99m	5.95E-04
Xe-138	8.65E+02	Ru-103	7.03E-03
Xe-139	8.11E-04	Rh-103m	2.22E-04
I-131	5.19E-01	Ru-106	2.34E-04
I-132	4.38E+00	Rh-106	3.78E-05
I-133	3.41E+00	Ag-110m	4.00E-06
I-134	7.57E+00	Sb-124	3.62E-04
I-135	4.81E+00	Sb-125	1.83E-04
C-14	2.19E+01	Te-129m	4.38E-04
Na-24	8.11E-03	Te-131m	1.51E-04
P-32	1.84E-03	Te-132	3.78E-05
Ar-41	1.02E+02	Cs-134	1.24E-02
Cr-51	7.03E-02	Cs-136	1.19E-03
Mn-54	1.08E-02	Cs-137	1.89E-02
Mn-56	7.03E-03	Cs-138	3.41E-04
Fe-55	1.30E-02	Ba-140	5.41E-02
Co-57	2.46E-05	La-140	3.62E-03
Co-58	6.90E-02	Ce-141	1.84E-02
Fe-59	1.62E-03	Ce-144	3.78E-05
Co-60	2.61E-02	Pr-144	3.78E-05
Ni-63	1.30E-05	W-187	3.78E-04
Cu-64	2.00E-02	Np-239	2.38E-02
Zn-65	2.22E-02		
		Total without Tritium	25,639
		Tritium (H-3)	7.06E+03
		Total with Tritium	32,699

NOTES:

1. See PPE Table 3.0-1, Section 9.5.1 and 9.5.3.
2. Composite source term based on highest Radionuclide release for all plant types considered.

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TABLE 3.0-8

NORMAL OPERATIONS LIQUID RELEASE SOURCE TERM [1]

Radionuclide	Composite Normal Release [2] (Ci/yr)	Radionuclide	Composite Normal Release [2] (Ci/yr)
I-131	2.826E-02	Zr-95	2.080E-03
I-132	5.200E-03	Nb-95	3.820E-03
I-133	2.000E-02	Mo-99	1.659E-03
I-134	3.400E-03	Tc-99m	1.600E-03
I-135	1.503E-02	Ru-103	9.860E-03
H-3	6.200E+03	Rh-103m	9.860E-03
C-14	8.800E-04	Ru-106	1.470E-01
Na-24	5.622E-03	Rh-106	1.470E-01
P-32	3.600E-04	Ag-110	2.800E-04
Cr-51	1.541E-02	Ag-110m	2.100E-03
Mn-54	5.200E-03		
Mn-56	7.622E-03	Sb-124	1.358E-03
Co-57	1.438E-04	Te-129	3.000E-04
Co-58	6.720E-03	Te-129m	2.400E-04
Co-60	1.822E-02	Te-131	6.000E-05
Fe-55	1.162E-02	Te-131m	1.800E-04
Fe-59	4.000E-04	Te-132	4.800E-04
Ni-63	2.800E-04	Cs-134	1.986E-02
Cu-64	1.503E-02	Cs-136	1.260E-03
Zn-65	8.200E-04	Cs-137	2.664E-02
Br-84	4.000E-05	Ba-137m	2.490E-02
Rb-88	5.400E-04	Cs-138	3.800E-04
Rb-89	8.811E-05	Ba-140	1.104E-02
Sr-89	2.200E-04	La-140	1.486E-02
Sr-90	7.027E-05	Ce-141	2.400E-04
Y-90	6.216E-06	Ce-143	3.800E-04
Sr-91	1.800E-03	Ce-144	6.320E-03
Y-91	2.200E-04	Pr-143	2.600E-04
Y-91m	2.000E-05	Pr-144	6.320E-03
Sr-92	1.600E-03	W-187	2.600E-04
Y-92	1.200E-03	Np-239	6.216E-03
Y-93	1.800E-03	All Others	4.000E-05
		Total All w/o Tritium	6.941E-01
		Total Tritium	6.200E+03

NOTES:

1. See PPE Table 3.0-1, Section 10.3.
2. Composite source term based on highest Radionuclide release for all plant types considered.

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TABLE 3.0-9

PLANT PARAMETERS DEFINITIONS

Parameter	Units	Definition	Bounding Value (Footnotes)
1.1 Building Characteristics			
1.1.2 Foundation Embedment	Feet	The depth from finished grade to the bottom of the basemat for the most deeply embedded power block structure.	1
2. Normal Plant Heat Sink			
2.3 Condenser			
2.3.2 Condenser / Heat Exchanger Duty	BTU per hour	Design value for the waste heat rejected to the circulating water system across the normal heat sink condensers.	2
2.4 (2.5) NHS Cooling Towers (Mechanical Draft or Natural Draft)			
2.4.3 (2.5.3) Blowdown Constituents and Concentrations	Ppm	The maximum expected concentrations for anticipated constituents in the cooling water systems blowdown to the receiving water body.	2
2.4.4 (2.5.4) Blowdown Flow Rate	Gallons per minute	The normal (and maximum) flow rate of the blowdown stream from the cooling water systems to the receiving water body for closed system designs.	2
2.4.5 (2.5.5) Blowdown Temperature	°F	The maximum expected blowdown temperature at the point of discharge to the receiving water body.	1
2.4.6 (2.5.6) Cycles of Concentration	Number of cycles	The ratio of total dissolved solids in the cooling water blowdown streams to the total dissolved solids in the makeup water streams.	1
2.4.7 (2.5.7) Evaporation Rate	Gallons per minute	The expected (and maximum) rate at which water is lost by evaporation from the cooling water systems.	2
2.4.8 (2.5.8) Height	Feet	The vertical height above finished grade of either natural draft or mechanical draft cooling towers associated with the cooling water systems.	1
2.4.9 (2.5.9) Makeup Flow Rate	Gallons per minute	The expected (and maximum) rate of removal of water from a natural source to replace water losses from closed cooling water systems.	2
2.4.10 (2.5.10) Noise	Decibels	The maximum expected sound level produced by operation of a cooling tower, measured at 1000 feet from the noise source.	1
2.4.12 (2.5.12) Cooling Water Flow Rate	Gallons per minute	The total cooling water flow rate through the normal heat sink condensers/heat exchangers.	1
3. Ultimate Heat Sink			
3.3 Mechanical Draft Cooling Towers			
3.3.4 Blowdown Flow Rate	Gallons per minute	The normal (and maximum) flow rate of the blowdown stream from the UHS system to receiving water body for closed system designs.	2
3.3.5 Blowdown Temperature	°F	The maximum expected UHS blowdown temperature at the point of discharge to the receiving water body.	1

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TABLE 3.0-9 (Continued)

Parameter	Units	Definition	Bounding Value (Footnotes)
3.3.7 Evaporation Rate	Gallons per minute	The expected (and maximum) rate at which water is lost by evaporation from the UHS system.	2
3.3.9 Makeup Flow Rate	Gallons per minute	The expected (and maximum) rate of removal of water from a natural source to replace water losses from the UHS system.	2
3.3.12 Cooling Water Flow Rate	Gallons per minute	The total cooling water flow rate through the UHS system.	1
5. Potable Water/Sanitary Waste System			
5.1 Discharge to Site Water Bodies			
5.1.1 Flow Rate	Gallons per minute	The expected (and maximum) effluent flow rate from the potable and sanitary waste water systems to the receiving water body.	3
5.2 Raw Water Requirements			
5.2.1 Maximum Use	Gallons per minute	The maximum short-term rate of withdrawal from the water source for the potable and sanitary waste water systems.	2
5.2.2 Monthly Average Use	Gallons per minute	The average rate of withdrawal from the water source for the potable and sanitary waste water systems.	2
6. Demineralized Water System			
6.1 Discharge to Site Water Bodies			
6.1.1 Flow Rate	Gallons per minute	The expected (and maximum) effluent flow rate from the demineralized water processing system to the receiving water body.	3
6.2 Raw Water Requirements			
6.2.1 Maximum Use	Gallons per minute	The maximum short-term rate of withdrawal from the water source for the demineralized water system.	2
6.2.2 Monthly Average Use	Gallons per minute	The average rate of withdrawal from the water source for the demineralized water system.	2
7. Fire Protection System			
7.1 Raw Water Requirements			
7.1.1 Maximum Use	Gallons per minute	The maximum short-term rate of withdrawal from the water source for the fire protection water system.	2
7.1.2 Monthly Average Use	Gallons per minute	The average rate of withdrawal from the water source for the fire protection water system.	2
8. Miscellaneous Drain			
8.1 Discharge to Site Water Bodies			
8.1.1 Flow Rate	Gallons per minute	The expected (and maximum) effluent flow rate from miscellaneous drains to the receiving water body.	2

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TABLE 3.0-9 (Continued)

Parameter	Units	Definition	Bounding Value (Footnotes)
9. Unit Vent/Airborne Effluent Release Point			
9.4 Release Point			
9.4.2 Elevation (Normal Operation)	Feet	The elevation above finished grade of the release point for routine operational releases.	3
9.4.3 Elevation (Post Accident)	Feet	The elevation above finished grade of the release point for accident sequence releases.	3
9.4.4 Minimum Distance to Site Boundary	Feet	The minimum lateral distance from the release point to the site boundary.	3
9.5 Source Term			
9.5.1 Airborne Effluents (Normal)	Curies per year	The annual activity, by isotope, contained in routine (normal) plant airborne effluent streams.	2
9.5.2 Airborne Effluents (Post-Accident)	Curies	The activity, by isotope, activity contained in post-accident airborne effluents.	1
9.5.3 Tritium Airborne Effluents (Normal)	Curies per year	The annual activity of tritium contained in routine (normal) plant airborne effluent streams.	2
10. Liquid Radwaste System			
10.2 Release Point			
10.2.1 Flow Rate	Gallons per minute	The flow rate of liquid potentially radioactive effluent streams from plant systems to the receiving water body.	2
10.3 Source Term			
10.3.1 Liquid	Curies per year	The annual activity, by isotope, contained in routine plant liquid effluent streams.	2
10.3.2 Tritium	Curies per year	The annual activity of tritium contained in routine plant airborne effluent streams.	2
11. Solid Radwaste System			
11.2.1 Activity	Curies per year	The annual activity, by isotope, contained in solid radioactive wastes generated during routine plant operations.	2
11.2.2 Principal Radionuclides	Curies per year	The principal radionuclides contained in solid radioactive wastes generated during routine plant operations.	2
11.2.3 Volume	Cubic feet per year	The expected volume of solid radioactive wastes generated during routine plant operations.	2
13. Auxiliary Boiler System			
13.2 Flue Gas Effluents	Pounds per year	The expected combustion products and anticipated quantities released to the environment due to operation of auxiliary boilers.	2
16. Standby Power System			
16.1 Diesel			
16.1.3 Diesel Flue Gas Effluents	Pounds per year	The expected combustion products and anticipated quantities released to the environment due to operation of the emergency standby diesel generators.	1

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TABLE 3.0-9 (Continued)

Parameter	Units	Definition	Bounding Value (Footnotes)
16.2 Gas-Turbine			
16.2.3 Gas-Turbine Flue Gas Effluents	Pounds per year	The expected combustion products and anticipated quantities released to the environment due to operation of the emergency standby gas-turbine generators.	1
17. Plant Characteristics			
17.3 Megawatts Thermal	Mega-watts	The maximum thermal power generated by a single unit or group of units/modules of a specific reactor plant type.	2
17.4 Plant Design Life	Years	The life for which the plant is designed to operate.	1
17.5 Plant Population			
17.5.1 Operation	Persons	The number of people required to operate and maintain the plant.	2
17.6 Station Capacity Factor	Percent	The percentage of time that a plant is capable of providing power to the grid.	1
18. Construction			
18.4 Plant Population			
18.4.1 Construction	Persons	The number of people required to construct the plant.	2

NOTES:

1. The Bounding Value is the maximum value for any of the plant designs being considered for the site.
2. The Bounding Value is the maximum value for any of the plant design/number of unit combinations being considered for the site.
3. The Bounding Value is the minimum value for any of the plant designs being considered for the site.

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Appendix J

System Energy Resources, Inc. Commitments and NRC Staff Assumptions Relevant to the Analysis of Impact

Appendix J

System Energy Resources, Inc. Commitments and NRC Staff Assumptions Relevant to the Analysis of Impact

Throughout the environmental report supporting the Grand Gulf Early Site Permit (ESP) application (SERI 2005), System Energy Resources, Inc. (SERI) provides:

(1) Commitments to address certain issues in the design, construction, and operation of the facility

(2) Statements of planned compliance with current laws, regulations, and requirements

(3) Commitments to future activities and actions that it will take should it be granted an ESP and decide to apply for a construction permit (CP) or combined license (COL)

(4) Descriptions of SERI's estimate of the environmental impacts resulting from the construction and operation of a new nuclear unit or units on the Grand Gulf ESP site

(5) Descriptions of SERI's estimates of future activities and actions of others and the likely environmental impacts of those activities and actions that would be expected should it be granted an ESP and decide to apply for a CP or COL.

Those statements are discussed throughout this environmental impact statement (EIS) and are listed in this Appendix.(a) Some of those statements considered by the staff in determining the level of impacts to a resource are related to matters that are within SERI's control. Table J-1 lists those matters that were considered in the staff's evaluation of the environmental impacts related to the construction and operation of a new nuclear unit or units at the Grand Gulf ESP site. The table shows the technical area where the matter is addressed in the EIS, and SERI's statement that addresses the matter. Table J-2 lists assumptions related to likely activities and actions of others that were considered by the staff.

In some cases, the same statement or similar statements are made in more than one place in the environmental report. Where statements contain essentially the same information, the location of the more comprehensive statements are listed first in the table, and the text provided is the text from that location.

(a) The listings are not intended to be a complete list of the commitments described in the SERI environmental report.

Table J-1. Statements Made in the SERI Environmental Report and in Response to NRC Staff Requests for Additional Information Related to Future Actions and Activities by SERI and the Impacts of Those Activities Considered in the Staff's Analysis

Technical Area	Environmental Report or RAI Statement
Land Use	The Universal Transverse Mercator Grid Coordinates for the location of the new reactor(s) on the site are approximately N3,543,261 meters and E684,018 meters.
Land Use	There is no rail service in the vicinity of the Grand Gulf Nuclear Station (GGNS) site and there are no active railroad tracks that traverse the GGNS site or the vicinity surrounding the site.
Land Use	Entergy Operations allows access to parts of the plant site property for recreational purposes. The site is posted to ensure awareness of access restrictions by individuals.
Land Use	There is no activity at the GGNS plant site to explore for, drill for, or otherwise extract minerals. Past unsuccessful exploratory activities on or near the GGNS plant site and the geological character of the subsurface structure in the vicinity of the GGNS plant site indicate that commercial mineral production appears unlikely in the foreseeable future.
Land Use	Information from the Claiborne County Extension office at the present time indicated that there are approximately 300 to 400 head of cattle within a 6 mile radius of the site, and most of the cattle are located southwest of the plant. There are no milk cows or swine within Claiborne County.
Land Use	Dredging would be required to form the embayment. The embayment bottom would be at approximately elevation 15 ft msl.
Land Use	There are three transmission lines associated with GGNS: (1) the Baxter-Wilson line, a 22-mile single-circuit 500 kV transmission line connecting GGNS to the Baxter-Wilson EHV Substation near Vicksburg, Mississippi; (2) the Franklin line, a 43.6-mile single-circuit 500 kV transmission line connecting the GGNS switchyard to the Franklin EHV Substation; and, (3) the Port Gibson line, a 5.5-mile single-circuit 115 kV transmission line connecting the GGNS switchyard to the Port Gibson Substation. The electrical power generated by GGNS Unit 1 is transmitted by interconnection with 500 kV transmission facilities that were in existence when Unit 1 was constructed.

Table J-1. (contd)

Technical Area	Environmental Report or RAI Statement
Land Use	The power transmission and distribution (T&D) system existing at the time of the new facility startup and operation will be relied upon to distribute the electricity generated by a new facility at Grand Gulf. In support of site selection evaluation work (environmental report, Section 9.3), a sensitivity analysis of the T&D system was performed to assess transmission injection capability for the new potential electrical power generation at GGNS. This study concluded that the existing T&D system is adequate for at least an additional 1311 MW(e) of generating capacity, provided that certain modifications were accomplished.
Land Use	When the specific facility design, the expected electrical output, the need for power, and primary market location(s) are established, the adequacy of the existing (at that time) T&D system to support the new facility will be determined. If, at that time, additional changes to the T&D system were warranted, the associated environmental impacts would be evaluated.
Land Use	An estimated 400 acres of the 2100-acre GGNS site would be affected by construction of a new facility.
Land Use	Of the approximately 400 acres estimated for the construction of a new facility, approximately 120 acres overlap currently developed or previously altered areas. It is estimated that approximately 125 acres would contain permanent structures (primarily a power block area, cooling tower area, and bottom land pipeline and intake areas.
Land Use	The barge slip constructed for GGNS Unit 1 would be used to offload large equipment and materials for the construction of a new facility transported by river.
Land Use	There would be some impact from excavation and construction of the intake structure along the river bank in the flood plain areas, but the impact is expected to be small and temporary. Additionally, trenching from the intake to the proposed power block location on the bluffs east of the river would be required to lay supply and discharge piping from the new facility. Most of the floodplain areas are also classified as wetlands.

Table J-1. (contd)

Technical Area	Environmental Report or RAI Statement
Land Use	Makeup water (cooling tower makeup and other raw water needs) for a new facility would be supplied primarily from the Mississippi River via an embayment, and associated intake structure, located on the east bank of the river and on the north side of the existing barge slip. Dredging would be required to form the embayment on the Mississippi River... Riprap, or other appropriate means, would be used to stabilize the banks of the embayment and the river shoreline around the embayment during and following construction. These construction activities would be done in compliance with Corps of Engineer requirements...
Land Use	The proposed outfall, located above normal river water level, would include a concrete drainage course to the river similar to that for the GGNS Unit 1 discharge structure.
Land Use	It is anticipated that the existing road system would be adequate for construction of a new facility, and new road construction would not be necessary.
Land Use	Use of Hamilton and Gin Lakes for recreational fishing may be temporarily restricted during construction as a safety measure to protect members of the public from hazards related to the use of heavy construction equipment. Therefore, the impact to recreational users of these lakes would be minimal.
Land Use	Approximately 145 acres of upland forest and approximately 105 acres of upland fields would be affected by the construction of a new facility (Figure 2.4-3). This represents approximately 35% and 66% of these habitat types within the GGNS site, respectively... Approximately 100 acres of the upland area of the GGNS site would be permanently altered (i.e., for structures, parking lots, etc.) for a new facility. The remaining acreage disturbed by construction would be revegetated or reseeded and allowed to develop back into a stable ecological community.
Land Use	Approximately 30 acres of bottomland palustrine, forested, seasonally flooded wetland would be disturbed during the construction of a new facility (Figure 2.4-3). This is approximately 3% of this habitat type within the GGNS site property. The remainder of the area required for construction would be in areas previously disturbed for the construction of GGNS Unit 1 (e.g., heavy haul road, barge slip area).
Land Use	Additional re-routing of onsite drainages and construction of additional sediment retention basins would likely be required to support construction of a new facility. A buffer zone of native vegetation could be maintained between the construction areas and the lakes.

Table J-1. (contd)

Technical Area	Environmental Report or RAI Statement
Land Use	Operation of a new facility is not expected to produce any additional significant impacts to land use on the site nor in the vicinity of the GGNS site… These recreational areas may experience increased visitation due to the operational work force at a new facility. No other impacts to these recreational facilities would be expected.
Land Use	The bounding estimate of salt deposition from the operation of cooling towers would be approximately 8 lbm/100-acre-month … This amount of deposition would not be expected to cause damage to vegetation in the vicinity of the GGNS site. Therefore, no significant impact to land use from cooling tower drift is expected on the site. And, based on proposed cooling tower(s) distance from the site boundary, and the prevailing wind direction, none is expected beyond the site boundaries.
Land Use	The rail line, which extended from Vicksburg to the site and beyond, and the spur constructed to the site to support GGNS Unit 1 construction, have since been abandoned. To support transport of heavy materials and equipment to the site, new rail service will likely be required. This may involve reconstruction of rail tracks along the former rights of way, or construction of new rail lines.
Land Use (response to RAI 4.1-1)	The statement quoted from the Environmental Report is intended to identify that the precise methods of construction material transportation to the site have not been determined or projected and that rail service is not immediately available at the site. The Environmental Report does not propose, project or evaluate possible changes to rail service. Many variables could affect potential future construction material transportation modes, including the degree to which modular construction methods are to be used. Although not evaluated for the ESP, the Environmental Report does not preclude future consideration and evaluation of rail service.
Land Use (response to RAI 2.5.3-1)	NRC staff considered the aerial photos of the GGNS construction in the evaluation of ESP facility construction impacts.
Land Use	Additional analysis would be necessary to confirm whether, beyond the addition of 1311 MW(e), any supporting T&D system upgrades or changes would be required, and what the associated operational environmental impacts would be. This additional analysis was not pursued at ESP.

Table J-1. (contd)

Technical Area	Environmental Report or RAI Statement
Land Use	The occurrence of icing conditions even in the vicinity of the linear mechanical draft cooling towers (LMDCTs) is expected to be rare since the water deposition rate is small and prolonged periods with below freezing temperatures are infrequent. Because any icing would be confined within the site property boundary, no adverse impact on surrounding public lands or roadways would occur.
Land Use	Based on the results of the evaluation performed for this application, the guidance provided in NUREG-1555, and the results of the Cooling Tower Drift Program performed for the existing GGNS facility, no adverse impact on the surrounding vegetation from salt deposition due to the operation of the NHS cooling towers for the new facility is anticipated.
Land Use	The majority of in-migrants and their families would be expected to settle in developed, more populous areas, or their suburbs, such as Vicksburg (Warren County), Natchez (Adams County), and Clinton/Jackson (Hinds County), which have a combined year 2000 population of over 300,000 people.
Land Use	The temporary outage staff typically stays in area hotels or recreational vehicle courts dispersed throughout the region; therefore, no single community would be overburdened by the influx of temporary workers. It is expected that the increased frequency of the temporary outage staff would not significantly impact the region.
Land Use	Empirical case studies of seven operating nuclear power plants indicated in all instances that the in-migration of plant personnel had small impacts on housing. In addition, the workers would not move exclusively to one community but rather would be expected to make residences in the relatively large area formed by surrounding communities.
Land Use	It is possible that the influx of site workers would increase demand for and stimulate the development of some commercial businesses (e.g., gasoline and automotive service stations, restaurants, etc). However, these services would likely be confined to existing commuter routes, and would not represent a major land use change for the region.
Meteorology and Air Quality	The normal plant heat sink (NHS) that will be used to dissipate heat from the turbine cycle for the new facility will utilize cooling towers to dissipate the heat directly to the atmosphere.
Meteorology and Air Quality	The cycles of concentration for the NHS circulating water is expected to be a maximum of 4, which will result in the concentrations in the circulating water being 4 times that of river water.

Table J-1. (contd)

Technical Area	Environmental Report or RAI Statement
Meteorology and Air Quality	Seasonal and Annual Cooling Tower Impact (SACTI) model predicts that the majority of the fogging due to the operation of the LMDCTs will be confined to within about ½ mile (800 m) to the south to southeast of the towers with occasional fogging (approximately 2 hrs/yr) up to about ¾ mile (1200 m) to the south to southeast of the towers (this area is entirely within the property boundary of the site). Therefore, it is predicted that the operation of the LMDCTs will result in limited increased fogging at the site.
Meteorology and Air Quality	The towers will use drift eliminators to minimize the amount of water lost from the towers via drift.
Meteorology and Air Quality	Gaseous emissions will be within regulatory guidelines set by Federal and State agencies.
Meteorology and Air Quality	The meteorological monitoring program will be the same throughout the pre-construction and operational phases of the project. The monitoring program will simply be a continuation of the ongoing meteorological monitoring program for the GGNS Unit 1 facility.
Ecology	It will be required to coordinate with the Corps of Engineers and/or other appropriate regulatory agencies and obtain permits for construction of the embayment and intake structure when the final design of the intake structure and its exact location are defined. The design and placement of the embayment and intake structure will be in accordance with the Corps guidance, MDEQ and EPA requirements, and good engineering practice.
Ecology	The normal heat sink circulating water system for the new facility will be a closed-cycle type system using either hyperbolic natural draft cooling towers or mechanical draft cooling towers.
Ecology	The design and placement of the embayment and intake structure will be in accordance with the Corps of Engineers guidance, MDEQ and EPA requirements, and good engineering practice.
Ecology	The Corps of Engineers has completed revetments along the east and west river banks... It is expected that these measures will stabilize the Mississippi River shoreline near the site.
Ecology	This portion of the switchyard would be used, with modifications.
Ecology	Plant makeup (cooling tower makeup and other raw water needs) for a new facility would be supplied from the Mississippi River via an intake structure located on the east bank of the river.

Table J-1. (contd)

Technical Area	Environmental Report or RAI Statement
Ecology	The Corps of Engineers continues to evaluate the need for additional shoreline work, and would be expected to make improvements as considered appropriate. However, those actions would not be expected to impact site suitability.
Ecology	Makeup to the normal heat sink cooling towers, balance of plant cooling systems (e.g., plant service water), and other raw water makeup needs for a new facility would be supplied by an intake structure located on the east bank of the Mississippi River.
Ecology	The new facility owner would be required to coordinate with the Corps of Engineers and obtain permits from appropriate regulatory agencies for construction of the embayment and intake structure when the final design of the embayment and intake structure and its exact location are defined.
Ecology	Eagles nesting on site would be largely protected from shooting, development and habitat alteration, and other human disturbance that usually accounts for mortality and reduced breeding success elsewhere.
Ecology	Other than the installation of additional revetments along the east bank, no significant changes to the river channel or banks which would be expected to alter the ecological characteristics of this riparian habitat have occurred.
Ecology	Makeup water to the cooling tower(s) and supply or makeup water for the SWS will be withdrawn directly from the Mississippi River through an intake structure on the river shore.
Ecology	The power transmission and distribution (T&D) system existing at the time of the new facility startup and operation will be relied upon to distribute the electricity generated by a new facility at Grand Gulf.
Ecology	When the specific facility design, the expected electrical output, the need for power, and primary market location(s) are established, the adequacy of the existing (at that time) T&D system to support the new facility will be determined.
Ecology	Construction activities to be conducted within a floodplain on the site would be the water intake structure and embayment along with other items that are a part of that water intake facility. This water intake will be located at or near the existing barge slip area.
Ecology	Once the facility design is finalized, appropriate analyses of transmission and distribution system adequacy will be made.

Table J-1. (contd)

Technical Area	Environmental Report or RAI Statement
Ecology	Traffic on Grand Gulf Road will increase substantially during the peak construction period, and will be at its peak during the morning and evening shift changes. Noise in the general area will increase from this increased traffic but the increases will be temporary, and will only occur as indicated twice per day, during the week.
Ecology	The new facility will require a small amount of water withdrawal relative to normal river flow; makeup flow requirements are estimated at approximately 85,000 gpm.
Ecology	There is little potential that operation of the cooling system intake for a new facility at the Grand Gulf ESP site will impact any such areas (wildlife).
Ecology	The Normal Plant Heat Sink (NHS) that will be used to dissipate heat from the turbine cycle for the new facility will utilize cooling towers to dissipate the heat directly to the atmosphere.
Ecology	The heat dissipation system for the NHS for the new facility will use either natural draft cooling towers or linear mechanical draft cooling towers.
Ecology	Two types of cooling systems will be considered for a new facility at the Grand Gulf ESP site: natural draft cooling towers and mechanical draft cooling towers.
Ecology	Environmental measurements and monitoring of terrestrial and aquatic ecology at the GGNS site will be divided into four phases: • Pre-application (CP or COL) Monitoring • Site Preparation and Construction Monitoring • Pre-operational Monitoring • Operational Monitoring
Ecology	The Grand Gulf ESP site will not be substantially different from the acceptable environmental impacts identified for the previously analyzed sites.
Ecology	(Coal) Additional ecological impact will occur due to land use related to mining of coal and limestone. Substantially greater impacts expected, relative to that required for uranium mining and reprocessing.
Ecology	(Combined Cycle Natural Gas) Additional ecological impact will occur due to land use related to gas wells and collection stations; expected to be proportionally higher than that related to uranium mining and reprocessing.
Water Use and Quality	Plant makeup (cooling tower makeup and other raw water needs) for a new facility would be supplied from the Mississippi River via an intake structure located on the east bank of the river.

Table J-1. (contd)

Technical Area	Environmental Report or RAI Statement
Water Use and Quality	Emergency cooling water (ultimate heat sink) for a new facility would be provided from closed-cooling systems which utilizes enclosed basins with mechanical draft cooling towers, or similar heat removal mechanisms, and would not be reliant on the source of water from the river intake, with the possible exception of normal make-up.
Socioeconomics	Emergency planning responsibilities are assigned to a number of departments and agencies. Federal, state and local officials will implement appropriate protective actions in case of an emergency.
Socioeconomics	A highway construction plan to extend the present path of Highway 18 is in the early planning stages. This proposed extension will connect Highway 18 to Grand Gulf Road, providing additional access to the GGNS site.
Socioeconomics	Depending on the type of plant (merchant plant which would be unregulated, or a regulated – by the Public Service Commissions of Mississippi and Louisiana plant), the tax structure may be similar to the GGNS Unit 1 (for a regulated plant), or be some mutually agreeable amount for an unregulated merchant plant.
Socioeconomics	The actual mode of shipment [of irradiated fuel] will be determined by DOE and may include either rail or truck shipments.
Socioeconomics	Construction of the cooling towers will have minimal impact on the surroundings. Construction noise levels during construction of a new facility at the Grand Gulf ESP site will have minimal impacts on the surrounding populace.
Socioeconomics	Complying with applicable OSHA noise regulations will ensure that the impact on construction workers is considered to be small.
Socioeconomics	A construction noise abatement and protection program will provide required mitigative measures for noise which may, on a short term basis, exceed guidance [65dB(A)]. Excessively loud construction activities would be done during daylight hours if necessary.
Socioeconomics	Traffic on Grand Gulf Road will increase substantially during the peak construction period, and will be at its peak during the morning and evening shift changes. Noise in the general area will increase from this increased traffic but the increases will be temporary, and will only occur as indicated twice per day, during the week.
Socioeconomics	Many of the short-term employees will likely travel to the area unaccompanied by family members.

Table J-1. (contd)

Technical Area	Environmental Report or RAI Statement
Socioeconomics	Rural setting of the site and the premise that the majority of the work force will emanate from the surrounding more populated areas and communities away from the site, it is likely a large portion of these new business and jobs would be temporary.
Socioeconomics	U.S. 61 S is two-lane improved roadway - will be 4-lane, divided freeway within 2 years like U.S. 61 N from Port Gibson
Socioeconomics	SACTI model predicts that the majority of the fogging due to the operation of the LMDCTs will be confined to within about ½ mile (800 m) to the south to southeast of the towers with occasional fogging (approximately 2 hrs/yr) up to about ¾ mile (1200 m) to occasional fogging (approximately 2 hrs/yr) up to about ¾ mile (1200 m) to the south to southeast of the towers (this area is entirely within the property boundary of the site). Therefore, it is predicted that the operation of the LMDCTs will result in limited increased fogging at the site.
Socioeconomics	While the proposed project's workforce and construction time period are greater than that of the gas plant, the impacts will be short term and mitigated by dispersion over several relatively populous counties and improved transportation routes.
Socioeconomics	Facility workforce will add to road network traffic load with an associated increase in traffic accidents. Road improvements and flexible work schedules will mitigate this impact to a certain extent.
Socioeconomics	Several road improvement and construction projects have been accomplished or planned for GGNS area. These projects will help ameliorate traffic problems associated with the proposed new facility.
Human Health	Liquid radwaste system design will be such that water which is discharged to the environment shall result in radioactive releases which conform to the "as low as reasonably achievable" requirements of 10 CFR 50.34a.
Human Health	Gaseous radwaste system design, including ventilation systems exhaust systems, will be such that radioactive gases which are discharged to the environment from these systems shall result in radioactive releases which conform to the "as low as reasonably achievable" requirements of 10 CFR 50.34a.
Human Health	The LWR technologies being considered will solidify and package their radioactive waste.
Human Health	In all likelihood, the decay time will be at least ten years and probably even longer.

Table J-1. (contd)

Technical Area	Environmental Report or RAI Statement
Human Health	The actual mode of shipment of spent fuel will be determined by DOE and may include either rail or truck shipments.
Human Health	The gas-cooled technologies being considered will solidify and package their radioactive waste.
Human Health	The gas-cooled reactor technologies will make far fewer shipments. The GT-MHR will need only 6 shipments while the PBMR will require 9 shipments annually.
Human Health	In the case of decay heat, both of the gas-cooled reactor technologies will generate fewer watts per MTU at time of shipment, and fewer kW per truck cask at time of shipment. The fuel inventory will be discussed as part of the remaining two characteristics that were exceeded: actinide inventory and krypton-85 inventory.
Human Health	Location of a new facility will be several hundred feet or more away from the protected area boundary, and about 1000 feet from the Unit 1 Turbine Building, the radiation levels due to nitrogen-16 skyshine are expected to be essentially background levels, similar skyshine are expected to be essentially background levels, similar to those readings obtained at TLDs located on the west/northwest side of the plant protected area boundary.
Human Health	These areas are several hundred feet from the protected area boundary, which will result in a substantial reduction in the dose rate due to distance from the source of the radiation.
Human Health	It is expected that the dose rates in these two constructions areas will be at or very near background levels.
Human Health	The doses they receive from background radiation will be more significant than nitrogen-16 skyshine doses.
Human Health	Implementation of a radiation environmental monitoring program for the new facility, compliance with requirements for maintaining dose ALARA, and attention to design of plant shielding to ensure dose is ALARA, will result in doses to the public and to construction workers due to direct radiation being minimal.

Table J-2. Key Assumptions Used by the NRC Staff in Assessing Environmental Impacts at the Grand Gulf Early Site Permit Site

Technical Area	Assumption	EIS Section
Land Use	The Grand Gulf ESP site will be wholly contained within the Grand Gulf site.	5.1
Land Use	The construction footprint will align with environmental report Figure 2.1-2.	5.1.1
Land Use	Land-use impacts of any potential transmission line right-of-way upgrade or expansion request will be assessed by the appropriate authority. State or local agency citing procedures will be followed once right-of-way routing is determined.	5.1.2
Land Use	Existing transmission line rights-of-way are 61 m (200 ft) in width.	5.1.2
Land Use	Transmission line upgrades would utilize only existing 500-kV transmission lines and rights-of-way. The 115-kV line is used to supply power to the site from offsite.	5.1.2
Land Use	No significant agriculture, crops, or dairy production are or will be located at or immediately near the Grand Gulf site.	5.1.1
Land Use	No third-party mining activities would be possible at the ESP site.	5.1.1
Land Use	Planned maintenance and refueling outages would be staggered such that only the GGNS Unit 1 or the proposed Grand Gulf ESP facility would be in outage at one time.	5.1.1
Land Use	Salt drift from any cooling tower design would be localized and well below NRC guidance thresholds.	5.1.1
Land Use	Induced housing effects of construction and operations would be dispersed across urbanized areas of southwestern and central Mississippi.	5.1.1
Land Use	The applicant would follow best management practices and would abide by all relevant regulations pertaining to ground-disturbing activities, such as forest and wetlands protection.	5.1.1, 5.1.2

Table J-2. (contd)

Technical Area	Assumption	EIS Section
Meteorology and Air Quality	Meteorological data from the site presented in various tables in the environmental report and request for additional information responses are reasonably representative of the site (except for wind data). Only the wind data for 2001 to 2003 are assumed to be representative.	2.3.3
Meteorology and Air Quality	Air emissions from the Grand Gulf ESP facility would be bounded by those listed in the environmental report .	5.2.2
Meteorology and Air Quality	The applicant would use dust control measures during construction and operation.	4.2.1
Meteorology and Air Quality	If air quality impacts related to transportation occur during construction, the applicant would implement best management practices to minimize the impacts.	4.2.2
Meteorology and Air Quality	Various measures outlined in the environmental report would be followed to limit air quality impacts of construction.	4.2.1
Meteorology and Air Quality	Cooling towers would have drift eliminators that are comparable in effectiveness to the drift eliminators in current generation cooling towers.	5.2.1
Ecology	Upland and bottomland areas of the proposed Grand Gulf ESP site that would be disturbed by construction would undergo a botanical survey prior to initiating such activities.	4.4.1.4
Ecology	A recent description will be provided of the aquatic biota that are in the vicinity of the ESP site and the transmission line rights-of-way prior to or during the CP or COL stage. The description will be consistent with NUREG 1555, Environmental Standard Review Plan, Chapter 2.4.2.	4.4.2, 4.4.3,1, 5.4.2, 5.4.3.1, 7.4
Ecology	The proposed intake system will have screens with a size such that the average intake velocity through the screen would be less than or equal to 0.15 m/s (0.5 ft/s).	5.4.2.1

Table J-2. (contd)

Technical Area	Assumption	EIS Section
Socioeconomics	Per the discussion in the environmental report, the staff assumed that 50 percent of the workforce at the Grand Gulf ESP site would come from the 80-km zone surrounding the plant, with almost all immigrating personnel and families living in Vicksburg, suburban Jackson, and Natchez. The staff also did the impact analysis under the alternative assumption that personnel and families would be distributed the same as the current plant-related population for GGNS.	4.5.2, 4.5.3.1, 4.5.4.3, 4.5.4.4, 5.5.2, 5.5.3.1, 5.5.4.1, 5.5.4.3, 5.5.4.4, 5.5.4.5
Socioeconomics	For the Grand Gulf ESP site, the staff identified two ways in which a new nuclear plant might be treated for property tax purposes under Mississippi tax law, which was assumed to remain the same in the future. If the plant were a merchant plant, it might be taxed as an ordinary taxable business asset, taxable by Claiborne County. The other possibility is that the state of Mississippi might decide to tax the asset instead, and provide some share of the funds back to the county and to the city of Port Gibson. The staff did the analysis both ways.	4.5.3.2, 5.5.3.2, 2.8.2.3
Socioeconomics	The staff relied on SERI's statement in a reply to a request for additional information that it had no plans to restore the former rail spur to the Grand Gulf ESP site. This implies that large items and bulk materials would come in by barge or truck. SERI also said that a rail spur could not be precluded.	2.2.1, 2.8.2.2, 4.5.4.1
Socioeconomics	The staff assumed that if very large groups of families with school-age children moved into Claiborne County, the state of Mississippi would provide some impact assistance to the local school system.	4.5.4.5, 5.5.4.5
Environmental Justice	There are no unidentified and significant pre-existing health conditions or resource dependencies among minority and low-income populations in the region of the Grand Gulf ESP site.	4.7, 5.7
Environmental Justice	The relative geographical locations of concentrations of minority and low-income individuals in the region of the Grand Gulf ESP site as shown in the 2000 U.S. Census are valid at time of CP or COL application.	4.7, 5.7

Table J-2. (contd)

Technical Area	Assumption	EIS Section
Cultural Resources	Cultural resource surveys will be conducted if areas identified in Figure 4-1 in the EIS are selected for construction.	4.6
Cultural Resources	Appropriate cultural resource surveys would be conducted prior to construction of new transmission lines.	4.6
Cultural Resources	Cultural resource-specific written directions will be included in SERI's Excavation and Backfill Work Procedures prior to construction and operation.	4.6, 5.6
Human Health	New transmission lines would be built to current industry and regulatory standards.	5.8.3
Human Health	Appropriate State and local requirements would be considered when assessing the occupational hazard and health risks associated with construction.	4.8.1
Human Health	The staff assumed adherence to NRC, Occupational Safety and Health Administration, and State safety standards, practices, and procedures for operation of new nuclear units.	5.8.5
Human Health	New unit or units are constructed at the location identified in the ER.	4.9
Human Health	Assumptions listed on pages 6-41 and 6-42.	6.2.4
Accidents	Population growth in the vicinity of the site would not alter the population distribution in the region.	5.10.2