Chapter 3 Plant Description

This chapter discusses the construction and operation of Fermi 3. Chapter 3 is written for single unit operation. The parameters associated with Fermi 3 appearance, water use, transmission facilities, and its relationship to the surrounding area are described in the following sections:

- External Appearance and Plant Layout (Section 3.1)
- Reactor Power Conversion System (Section 3.2)
- Plant Water Use (Section 3.3)
- Cooling System (Section 3.4)
- Radioactive Waste Management System (Section 3.5)
- Nonradioactive Waste Systems (Section 3.6)
- Power Transmission System (Section 3.7)
- Transportation of Radioactive Materials (Section 3.8)

For purposes of this section, the site, vicinity, and region are defined in Chapter 2.

3.1 External Appearance and Plant Layout

This subsection describes the planning, layout and appearance of Fermi 3 and the existing facility structures. Subsection 3.1.1 provides an overview of the existing site, including layout, location and a brief description of the surrounding areas. Subsection 3.1.2 describes the Fermi 3 arrangement, including visual impacts from areas adjacent to the site and general aesthetic principles that will be applied.

3.1.1 Existing Fermi Site Description

The 1260 acre Fermi site is located on the western shore of Lake Erie. The Fermi site grade is approximately 581.8 ft NAVD 88. The grade at the power block area where the Category I structures are located is approximately 589.3 ft NAVD 88. Lake Erie supplies the makeup water requirements for the site.

The existing site arrangement includes Fermi 1 and Fermi 2. Fermi 1 is no longer operational; the unit has been defueled and will be dismantled. Fermi 2 is in operation. During construction of Fermi 2, the initial plan was to also construct and operate a third unit. Unit 3 originally was to be located north of Fermi 2, between Fermi 2 and the two natural draft cooling towers. The plans for the original Unit 3 were halted prior to construction. A complete description of the existing site is provided in the Fermi 2 Updated Safety Analysis Report (Reference 3.1-1). The buildings for Fermi 2 have a natural concrete exterior, neutral gray in color, which tends to reduce visual impact (Reference 3.1-2).

Figure 2.1-4 shows the building layout and site property boundary. Figure 2.1-4 indicates the presence of Fermi 1; although, as discussed above, the plan is to remove this Unit. Figure 2.4-2 provides a topographical map of the site and vicinity with the site property boundary indicated.

Two concrete natural draft cooling towers are used for heat dissipation for Fermi 2. Each tower is approximately 450 ft in diameter at the base; the maximum elevation is 400 ft above the grade elevation. As shown on Figure 3.1-2 through Figure 3.1-8, the natural draft cooling towers for Fermi 2 are the predominant visible structures on the site and are visible from outside the site property boundaries. On Figure 3.1-2 through Figure 3.1-8, the cooling towers for Fermi 2 are the two towers that have a visible plume.

Security fences surround the immediate Fermi 2 area. In addition, the Owner Controlled Area (OCA) is fence-lined to the west and south sides of the property boundary. Visitor and employee parking are currently located inside the OCA fence-line, with access to the plant through a security gate house that is controlled on a 24-hour per day basis.

The site is located within the Detroit River International Wildlife Refuge (DRIWR) as shown on Figure 2.2-2. As shown on Figure 2.1-4, the northern and southern areas of the site feature large lagoons, while the western portion contains some forested areas and Quarry Lake. Quarry Lake served as the rock quarry for the construction activities for Fermi 2. The eastern portion of the site adjacent to Lake Erie contains the power plant structures. The grounds in the immediate vicinity of the plant buildings are attractively landscaped.

The site is accessible by Lake Erie, road, and rail. Personnel access to the site is via Fermi Drive. Fermi Drive provides access to the site from Dixie Highway. Dixie Highway runs, generally, parallel to the western side of the site boundary. The major highways and rail lines in the area are found mainly west of the site, and a number of smaller state and county roads serve the area. Dixie Highway provides access to the Fermi site from Interstate 75. Interstate 75 connects Detroit, Michigan, to the north with Toledo, Ohio, to the south. Figure 2.1-2 and Figure 2.1-3 show the major highways and rail lines in the vicinity of the site.

Figure 2.1-3 provides an overhead aerial photograph of regions in the vicinity of the Fermi site. Figure 2.2-2 also shows the immediate vicinity of the site. The land within five miles of the Fermi site is primarily agricultural with the exception of small beach communities and the small Newport-Oldport residential area to the northwest. As shown on Figure 2.2-2, Estral Beach, Stony Point, Detroit Beach, and Woodland Beach are small towns located along the Lake Erie shore within five miles of the Fermi site. These communities are blended summer resort and permanent residential areas. The nearest of these is Stony Point, about two miles south of the Fermi site.

3.1.2 New Facility Arrangement

Fermi 3 is an ESBWR, a light water-cooled reactor. Fermi 3 will be located southwest of the Fermi 2.

The ESBWR standard plant layout is shown in the ESBWR Design Control Document (DCD Figure 1.1-1) (Reference 3.1-3). The locations of the major structures of Fermi 3 on the Fermi site are shown on Figure 2.1-4. Figure 2.4-2 provides a topographical map of the site and vicinity with the site property boundary indicated. A discussion of radioactive and non-radioactive waste release locations are provided in Section 3.5 and Section 3.6, respectively. Chapter 4 discusses impacts due to construction, and provides an overview of the areas affected by the construction activities.

Figure 4.2-1 shows the construction affected areas, including areas that were impacted by previous construction activities. Figure 4.3-1, Figure 4.3-2, and Figure 4.3-3 show the impacts to undeveloped areas, including which impacts are considered to be temporary and which impacts are permanent. Also shown are the terrestrial communities within each of these areas.

Fermi 3 will share certain support structures such as office buildings, potable water supply and sanitary discharge offsite with Fermi 2. Paved site roadways will connect Fermi 3 to the remainder of the Fermi site, providing routine and non-routine access onsite with minimal disturbance of the area.

The normal power heat sink (NPHS) for Fermi 3 will be provided by a concrete natural draft cooling tower. Lake Erie will be used for makeup water for the Circulating Water System (CIRC), the Plant Service Water System (PSWS), and the Fire Protection System (FPS). The intake from Lake Erie for Fermi 3 will be adjacent to the intake for Fermi 2, i.e., located between the two groins that protrude into Lake Erie. The outfall from the Fermi 3 CIRC and PSWS will be off-shore via an underwater discharge line.

Existing infrastructure will be modified to integrate Fermi 3 with Fermi 2; however, none of the Fermi 2 structures or facilities that directly support power generation will be shared. The electrical switchyard for Fermi 3 is separate from the Fermi 2 switchyard. The transmission lines from the Fermi 3 and Fermi 2 switchyards share common transmission towers as the lines leave the site. The existing Fermi 2 protected area will be expanded to include Fermi 3. Existing administrative buildings, warehouses, and other minor support facilities will be used, expanded, or replaced, based on prudent economic and operational considerations.

Figure 3.1-1 provides a low, oblique aerial photograph view of the site with the Fermi 3 major features superimposed. As shown on Figure 3.1-1, Fermi 3 is located relatively close to Fermi 2. The major plant structures are located, for the most part, on areas that were environmentally altered for construction and operation of Fermi 1 and Fermi 2. Aesthetic principles and concepts used in the design and layout of Fermi 3 include the following:

- The overall plant arrangement for Fermi 3 is such that building configurations and structural designs minimize the building volumes and quantities of bulk materials consistent with safety, operational, maintenance, and structural needs to provide an aesthetically pleasing effect.
- Locating the major plant structures on areas that were previously environmentally altered.
- Locating the major plant structures at least 1000 ft from the shoreline.
- Placing the intake structure in the existing developed section of shoreline.

These considerations and the relative proximity of the Fermi 3 plant structures to the existing Fermi 2 plant structures provide an integrated design for the site.

The Fermi site environmental conditions are described in Chapter 2. The land within five miles of the Fermi site is primarily agricultural with the exception of the small beach communities discussed above and the small Newport-Oldport residential area to the northwest. Visual impacts from the site to these areas are limited to the immediate residents and traffic on the Dixie Highway and the smaller arterial roads. The site does not impact areas that have a high degree of visitor use or recreational areas.

As discussed previously, the site currently has two natural draft cooling towers of comparable size. Figure 3.1-2 through Figure 3.1-8 show the visual effects of the site from various offsite locations. These photographs are taken from near the site boundary, providing views of the site from all directions (looking north, east and south). These points of view would encompass the visual effects to any other facilities that are located farther away from the site. As can be clearly seen in these photographs, the visually predominant existing structures are the two natural draft cooling towers. The vegetation on the site helps to shield the power plant structures from public viewing. As Fermi 3 will be located in the same general vicinity as Fermi 2, this same vegetation will help to provide seclusion for Fermi 3. Similar to Fermi 2, the most visually obtrusive structure under consideration for the new facility is the natural draft cooling tower. The height of the new natural draft cooling tower is approximately 600 ft. For visual comparison, the relative location of Fermi 3 and the new natural draft cooling tower is super-imposed on the photographs on Figure 3.1-2 through Figure 3.1-8. These photographs, including the oblique aerials, provide comparison of the seasonal effects on the visual impact. That is, the photographs on Figure 3.1-2 through Figure 3.1-8 are taken during the time of year when the vegetation has the minimal shielding effect. Due to increased amounts of vegetation cover, visual impacts during other times of the year would be less than those shown in these figures.

Because the Fermi site is already aesthetically altered by the presence of an existing nuclear power plant and construction impacts would be temporary, significant adverse impacts to visual aesthetics of the site and vicinity are not expected from the construction or operation of Fermi 3.

3.1.3 **References**

3.1-1 Detroit Edison, “Fermi Unit 2 Updated Safety Analysis Report,” Revision 14, November 2006.

3.1-2 Detroit Edison, “Fermi Unit 2 Environmental Report,” Supplement 5, January 1979.

3.1-3 GE-Hitachi Nuclear Energy, “ESBWR Design Control Document – Tier 2,” Revision 6, August 2009.

Figure 3.1-1 Aerial View of Fermi Site Looking North - Fermi 3 Superimposed

Figure 3.1-2 View of Fermi Site from Dixie Highway Looking East

Figure 3.1-3 View of Fermi Site from Dixie Highway Looking Southeast

Figure 3.1-4 View of Fermi Site from Post Road Looking Southeast

Figure 3.1-5 View of Fermi Site from Swan Creek Road Looking Southeast

Figure 3.1-6 View of Fermi Site from Toll Road Looking East

Figure 3.1-7 View of Fermi Site from Pointe Aux Peaux Road Looking North

Figure 3.1-8 View of Fermi Site Taken from Pointe Mouille Marsh State Game Area Approximately 6 Miles from Site*

* Location of Pointe Mouille Marsh State Game Area is shown on Figure 2.2-2.

3.2 Reactor Power Conversion System

3.2.1 Reactor Description

Fermi 3 will consist of one ESBWR and auxiliaries. The design of the ESBWR is supplied by General Electric. The architect engineer, principal vendors and contractors have not been selected, but are to be determined consistent with the construction milestones outlined in Section 1.1.

A description of the turbines and condensers is provided in DCD Chapter 10. The design condenser/heat exchanger duty is 2896 MWt (9.883×10^9 Btu/hr) and the rated power is 4500 MWt (core design power (ECCS design basis) 4590 MWt). The gross electrical rating of the ESBWR is 1605 ± 50 MWe. Fermi 3 power consumption is approximately 70 MWe resulting in a net electrical output of approximately 1535 ± 50 MWe.

The ESBWR core and fuel assembly designs are described in DCD Table 1.3-1 (Reference 3.2-1). For reload cores, the uranium enrichment is approximately 4.6 percent U-235 (Reference 3.2-1). The expected assembly average burnup of discharged fuel is approximately 46,000 MWd/MTU (metric tons of uranium) (Reference 3.2-2). The total quantity of uranium in the initial core load and annual core reload quantities are approximately 167 MTU and 68.2 MTU, respectively (Reference 3.2-2). Section 3.8 describes the comparison of the reactor design and performance data with the criteria of 10 CFR 51.52(a), subparagraphs (1), (2), and (3).

3.2.2 Engineered Safety Features

Engineered Safety Features (ESFs) are provided to mitigate the consequences of design basis or loss-of-coolant accidents, even though the occurrence of these accidents is very unlikely. The ESFs of the ESBWR are described in DCD Chapter 6 and consist of (1) fission product containment and containment cooling systems; (2) Emergency Core Cooling Systems (ECCS), and (3) control room habitability systems. Instrumentation and controls for the ESFs are described in DCD Section 7.3. DCD Tables 6.2-1 and 6.2-10 outline the containment and containment cooling design parameters. ECCS design parameters are outlined in DCD Table 6.3-1. DCD Table 6.4-1 outlines the control room habitability area HVAC system.

3.2.3 Power Conversion Systems

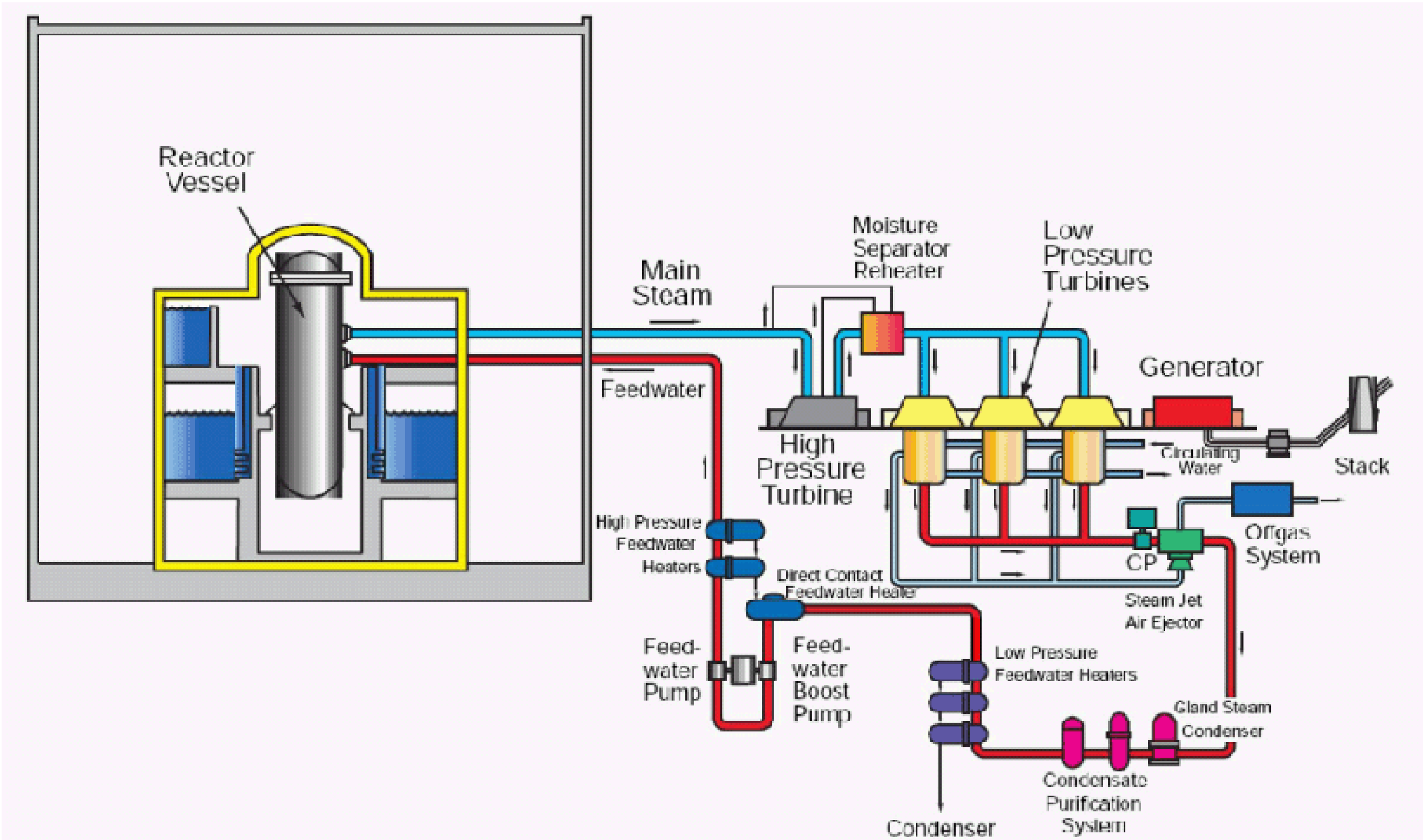
The ESBWR uses a steam turbine to convert heat energy to mechanical energy. Turbine exhaust is cooled through a condenser, and the waste heat is rejected to the atmosphere via a natural draft cooling tower. Fermi 3 will reject approximately 9.883×10^9 Btu/hr in waste heat. The tube material of the main condenser is selected based on circulating water chemistry. The material of the main condenser has not been selected at this time; however candidate materials are either stainless steel or titanium. The total surface area of the main condenser available for heat transfer is 1.61×10^6 ft^2. A complete description of the reactor power conversion system can be found in DCD Chapter 10. DCD Table 10.1-1 lists design features and performance characteristics for the major power conversion system components. The design data for the turbine generator are listed in DCD Table 10.3-1. Figure 3.2-1 provides a simplified depiction of the reactor power conversion system.

3.2.4 References

3.2-1 GE-Hitachi Nuclear Energy, “ESBWR Design Control Document – Tier 2,” Revision 6, August 2009.

3.2-2 GE Energy, “Response to RFI GE-0024 – Fuel Information,” GENS-SR4-2007-0051, June 8, 2007.

Figure 3.2-1 Simplified Flow Diagram of Reactor Power Conversion System



3.3 Plant Water Use

Fermi 3 requires water for cooling and operational uses. Lake Erie provides water for plant cooling, including the normal power heat sink (NPHS) and auxiliary heat sink (AHS).

Subsection 3.3.1 discusses water consumption and discharges by the various plant components and systems, including the NPHS, AHS, Ultimate Heat Sink (UHS), potable water and sanitary waste, demineralized water, and fire protection. Additionally, Figure 3.3-1 presents a water use diagram for Fermi 3 outlining normal plant power operating conditions as well as non-power/shutdown conditions.

Subsection 3.3.2 discusses methods of water treatment used in the plant and discharged back to the receiving water body (i.e., Lake Erie). Plant service water treatment is discussed in this subsection and also further discussed in FSAR Subsection 9.2.1. Makeup water is also discussed in this subsection, as well as in FSAR Subsection 9.2.3.

3.3.1 Water Consumption

Plant water systems discussed in this subsection include the CIRC, PSWS, Station Water System (SWS), Potable Water System (PWS), Sanitary Waste Discharge System (SWDS), demineralized system, and Fire Protection System (FPS). The CIRC, PSWS, SWS, and FPS share a common intake from Lake Erie. Potable water is being supplied for the demineralized system from the Frenchtown Township municipal water supply. The design of the intake structure is based on record low water levels for Lake Erie, thus even under these conditions plant operation is able to carry on normally. Under normal conditions, Lake Erie water levels remain relatively constant except during extreme seiche events. The intake structure is not designed for extreme seiche events. During extreme seiche events, the water supply to the SWS could be degraded and the unit operationally controlled to limit makeup requirements. The Ultimate Heat Sink (UHS) for Fermi 3, described in FSAR Subsection 9.2.5, contains a separate water supply for safety-related cooling. Lake Erie is not used for safety-related water withdrawal for Fermi 3. Therefore, a seiche event will not affect a safety-related water supply for Fermi 3. This is discussed further in Subsection 3.4.2.1. The SWS provides makeup water to the NPHS and AHS cooling tower basins, and the FPS. The SWS is further described in FSAR Subsection 9.2.10. Various drains in the plant produce effluent liquid radwaste. This flow can either be treated and discharged to Lake Erie, or recycled. Blowdown from several sources, including both NPHS and AHS cooling towers; optional treated liquid radwaste, including chemical waste is combined and shares a common discharge to Lake Erie. The demineralized water waste is discharged to the Fermi 3 SWDS.

3.3.1.1 Circulating Water System and Normal Power Heat Sink

The CIRC is used to remove the waste heat from the main condenser discharging to the NPHS. A more detailed description of the CIRC is presented in Subsection 3.4.1.1. During normal operation the NPHS may provide cooling to the AHS loads. Makeup water to the NPHS cooling tower replenishes water losses due to evaporation, drift, and blowdown. Figure 3.3-1 shows the water use (makeup, blowdown, evaporation, etc.) by the NPHS for Fermi 3. Figure 3.3-1 describes the flow rates for power and shutdown operations. Power operations are further subdivided into the maximum heat load (expected during summer months), minimum heat load (expected during the winter months), and the average heat load (expected during the spring and fall months). The maximum makeup water flow is approximately 34,000 gpm for the NPHS.

The maximum blowdown from the NPHS cooling tower is approximately 17,000 gpm, and the minimum blowdown is approximately 12,000 gpm. The annual average blowdown flow is approximately 14,000 gpm. The maximum blowdown value represents the design condition, at the warmest temperatures. The minimum value represents winter conditions under the coldest temperatures, which occur in the month of January. The average value represents the average of all monthly flows; this value would be representative of flows in the spring or fall months. Table 3.4-1 outlines the monthly variation in evaporation, blowdown and makeup flows. The blowdown is directed to an outfall that discharges into Lake Erie.

3.3.1.2 **Plant Service Water System and Auxiliary Heat Sink**

The PSWS provides nonsafety-related cooling to the Reactor Building and Turbine Building systems. During operation of Fermi 3, PSWS cooling is provided by either the NPHS cooling tower or the AHS cooling towers. While in shutdown condition, the PSWS is cooled by the AHS cooling towers. The AHS requires makeup water to replenish water losses due to evaporation, drift, and blowdown. Blowdown from the AHS is mixed with the NPHS cooling tower blowdown. The flow requirements for makeup flow for the PSWS are a maximum of approximately 1100 gpm. The makeup water requirements are included in the flow values stated in Subsection 3.3.1.1. A more detailed description of the PSWS is provided in Subsection 3.4.1.3.

3.3.1.3 **Ultimate Heat Sink**

The ESBWR design has no separate emergency water cooling system. The UHS function is provided by safety systems integral and interior to the reactor plant. These systems ultimately use the atmosphere as the eventual heat sink. These systems do not rely on cooling towers, basins, or cooling water intake/discharge structures external to the reactor plant. (Reference 3.3-1)

3.3.1.4 **Potable Water and Sanitary Waste Discharge System**

The PWS and SWDS are designed to provide potable water supply and sewage treatment necessary for normal plant operation and shutdown periods. The source of the potable water supply is the Frenchtown Township municipal water system. The PWS is designed to supply up to 200 gpm of potable water during peak demand period with a monthly average usage of 35 gpm, as outlined on Figure 3.3-1. The Demineralized water waste and the effluent from the auxiliary boiler are routed to the Fermi 3 SWDS. Sanitary waste is routed to the Frenchtown Township Sewage Treatment Facility.

3.3.1.5 **Demineralized Water**

The required flow for makeup water to the demineralization subsystem when using the option of discharging liquid radwaste to Lake Erie, is expected to be a monthly average of 160 gpm, with short term maximum flow expected to be 639 gpm during outages. The required flow for makeup water to the demineralization subsystem when using the option of recycling liquid radwaste is bounded by the makeup flow with liquid radwaste discharged to Lake Erie. The option to operate with liquid radwaste recycled supports zero discharge of liquid radwaste. The makeup water is supplied from the Frenchtown Township water line as depicted on Figure 3.3-1. Flows for various modes of operation, as well as liquid radwaste effluent are also outlined on this figure.

3.3.1.6 Fire Protection

Fire protection water is provided to the FPS from onsite storage tanks that have makeup supplied from the SWS. After the FPS is initially filled, maximum usage is about 30 gpm for activities such as maintaining the system filled and pressurized and periodic testing.

3.3.2 Water Treatment

As outlined in Subsection 3.3.1, plant makeup water is taken from a common intake from Lake Erie. This intake is treated with sodium hypochlorite, a biocide/algaecide, thus disseminating to the appropriate water use systems. Sodium hypochlorite is used to eradicate the presence of biologicals in the systems, both in the form of plant life such as algae and animals such as zebra mussels and corbicula. During select periods in spring and fall, sodium hypochlorite levels are elevated to ensure the absence of zebra mussels.

The SWS supplies makeup water to the PSWS, CIRC, and FPS. There are viable treatment options for mussel control in these systems, which include: chlorination and thermal shock treatment. The chlorination option will consist of isolation of the PSWS and elevation of chlorine levels within the PSWS for a specific duration of time. This will cause the eradication of any zebra mussel population within the system. Upon returning the PSWS to service, the chlorinated PSWS water will be combined with the much larger portion of blowdown from the NPHS, thus diluting the chlorine to acceptable discharge levels. The thermal shock treatment option would consist of raising the temperature of the CIRC to greater than 95°F for at least 60 minutes. This method is less practical for the PSWS due to system thermal limitations.

3.3.2.1 Station Water System

The SWS draws water from Lake Erie as the source of makeup to the plant. The SWS is described in FSAR Subsection 9.2.10. Makeup water to the plant is treated with a biocide, sodium hypochlorite, as it enters through the SWS pump house intake. Water treatment chemistry is provided in Table 3.3-1.

3.3.2.2 Circulating Water

The CIRC provides cooling water for removal of the power cycle heat from the main condensers and transfers this heat to the NPHS. The CIRC is described in FSAR Section 10.4. Chemical additions are made to both influent and effluent flows. System chemistry control is provided by the incorporation of an injection system at the inlet to the condenser that introduces a biocide, corrosion inhibitor, and scale inhibitor. The necessity of using a biocide is outlined in Subsection 3.4.2.2. The corrosion inhibitor is needed in order to reduce the effects of corrosion on the piping and condenser. The scale inhibitor is needed to reduce the build-up of scaling that could affect the efficiency of the condenser. Quantities and identification of these various chemicals are shown in Table 3.3-1. Discharge must also be treated before exiting to Lake Erie. Dehalogenation must occur in order to maintain oxidant within reasonable discharge limits. As discussed in Section 1.2, permits, e.g., National Pollution Discharge Elimination System (NPDES) permit and Section 401 Water Quality Certification, will be obtained for the discharge from Fermi 3. Additionally, Section 5.2 provides a discussion on effluent limitations and permit conditions.

3.3.2.3 **Plant Service Water System**

PSWS chemistry control is maintained in a similar fashion to that of the CIRC, i.e., with the addition of biocide, corrosion inhibitor, scale inhibitor, as well as dispersant chemicals to break up sedimentation when lake water is highly turbid. Water treatment chemistry is provided in Table 3.3-1. There are no expected changes to water treatment operating procedures based on seasonal variations. The PSWS is described in FSAR Subsection 9.2.1.

3.3.2.4 **Potable Water and Sanitary Waste**

The potable water for the Fermi site is supplied from the Frenchtown Township municipal water system. This water supply does not require any additional chemical treatment or additives. The sanitary waste system effluent is discharged to the Frenchtown Township Sewage Treatment Facility without addition of chemical treatments. FSAR Subsection 9.2.4 provides further description of the PWS and SWDS.

3.3.3 **References**

3.3-1 GE-Hitachi Nuclear Energy, “ESBWR Design Control Document – Tier 2,” Revision 6, August 2009.

Table 3.3-1 Chemical Additives for Water Treatment

System/Injection Point	Chemical	Approximate Usage	
Circulating Water System/ Cooling tower basin/ Station Water System	Biocide/Algaecide – Sodium Hypochlorite (15%)	1200 gal/week	Normal Power Operating Conditions/ Shutdown Conditions
Circulating Water System/ Makeup water line discharge	Corrosion Inhibitor - Sodium Silicate	400 gal/day	Normal Power Operating Conditions/ Shutdown Conditions
Circulating Water System / Makeup water line discharge	Scale Inhibitor/Dispersant	220 gal/day	Normal Power Operating Conditions/ Shutdown Conditions
Circulating Water System blowdown	Dehalogenation – Sodium Bisulfite	175 gal/day	Normal Power Operating Conditions/ Shutdown Conditions

Figure 3.3-1 Water Use Diagram (Sheet 1 of 3)

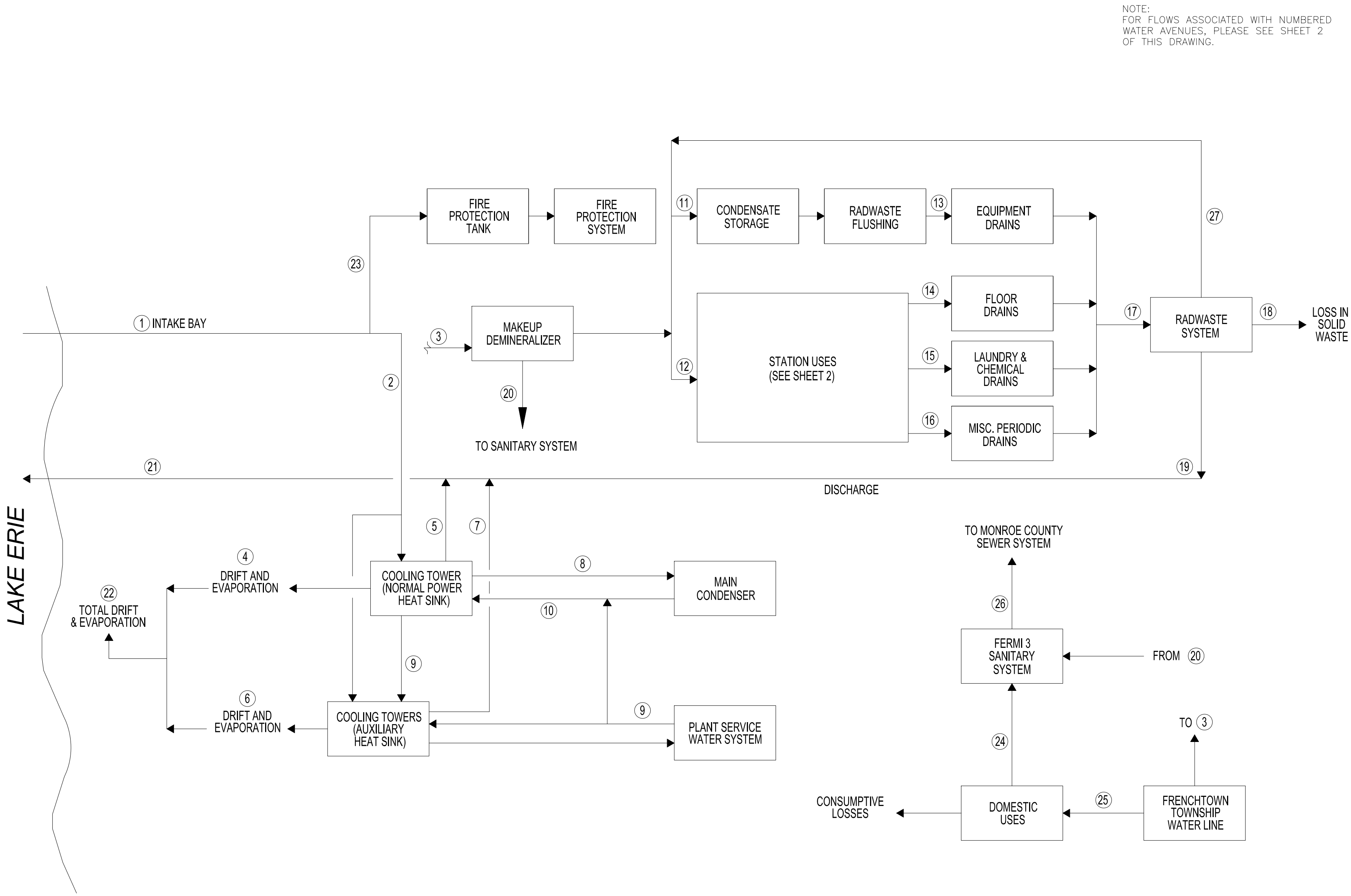


Figure 3.3-1 Water Use Diagram (Sheet 2 of 3)

Flow	Description	Value (gpm) Maximum Normal Power Operation[1] Discharged Radwaste	Value (gpm) Minimum Normal Power Operation[2] Discharged Radwaste	Value (gpm) Average Normal Power Operation[3] Discharged Radwaste	Value (gpm) Average Shutdown Operation Discharged Radwaste
1	Total Makeup Water Intake	34,264	23,780	28,993	1,166
2	Cooling Tower Makeup Water	34,234	23,750	28,963	1,136
3	Demineralizer Makeup Water	160	160	160	639
4	Normal Power Heat Sink Drift & Evaporation	17,124	11,882	14,488	0
5	Normal Power Heat Sink Discharge	17,110	11,868	14,474	0
6	Auxiliary Heat Sink Drift & Evaporation	0	0	0	569
7	Auxiliary Heat Sink Discharge	0	0	0	567
8	Inflow to Main Condenser	684,000	684,000	684,000	0
9	Total Plant Service Water System Flow	40,000	40,000	40,000	40,000
10	Total Circulating Water System Flow	724,000	724,000	724,000	0
11	Inflow to Condensate Storage	58	58	58	232
12	Inflow to Station Uses	49	49	49	196
13	Outflow to Equipment Drains	58	58	58	232
14	Outflow to Floor Drains	8	8	8	30
15	Outflow to Laundry & Chemical Drains	24	24	24	95
16	Outflow to Miscellaneous Periodic Drains	18	18	18	71
17	Inflow to the Radwaste System	107	107	107	428
18	Loss in Solid Radwaste	2	2	2	9
19	Radwaste Discharge (Liquid Radwaste Loss)	105	105	105	419
20	Makeup Demineralizer Blowdown	53	53	53	211
21	Total Discharge	17,215	11,973	14,579	987
22	Total Drift & Evaporation	17,124	11,882	14,488	569
23	Fire Protection Uses	30	30	30	30
24	Potable Water Discharge to Sewer	200	35	35	47
25	Domestic Uses	200	35	35	47
26	Total Discharge to Monroe County sewer system	253	88	88	258
27	Liquid Radwaste Recycled	0	0	0	0

Station Water Uses:

Standby Liquid Control System
Reactor Component Cooling Water System
Process Sampling System process use
HVAC system
Liquid Waste System chemical addition and line flushing
Turbine Component Cooling Water System
Auxiliary Boiler System
Isolation Condenser/Passive Containment Cooling Pool
Solid Waste System for line flushing
Chilled Water System
Post Accident Sampling station flushing

Figure 3.3-1 Water Use Diagram (Sheet 3 of 3)

Flow	Description	Value (gpm) Maximum Normal Power Operation[1] Recycled Radwaste	Value (gpm) Minimum Normal Power Operation[2] Recycled Radwaste	Value (gpm) Average Normal Power Operation[3] Recycled Radwaste	Value (gpm) Average Shutdown Operation Recycled Radwaste
1	Total Makeup Water Intake	34,264	23,780	28,993	1,166
2	Cooling Tower Makeup Water	34,234	23,750	28,963	1136
3	Demineralizer Makeup Water	3	3	3	13
4	Normal Power Heat Sink Drift & Evaporation	17,124	11,882	14,488	0
5	Normal Power Heat Sink Discharge	17,110	11,868	14,474	0
6	Auxiliary Heat Sink Drift & Evaporation	0	0	0	569
7	Auxiliary Heat Sink Discharge	0	0	0	567
8	Inflow to Main Condenser	684,000	684,000	684,000	0
9	Total Plant Service Water System Flow	40,000	40,000	40,000	40,000
10	Total Circulating Water System Flow	724,000	724,000	724,000	0
11	Inflow to Condensate Storage	58	58	58	232
12	Inflow to Station Uses	49	49	49	196
13	Outflow to Equipment Drains	58	58	58	232
14	Outflow to Floor Drains	8	8	8	30
15	Outflow to Laundry & Chemical Drains	24	24	24	95
16	Outflow to Miscellaneous Periodic Drains	18	18	18	71
17	Inflow to the Radwaste System	107	107	107	428
18	Loss in Solid Radwaste	2	2	2	9
19	Radwaste Discharge (Liquid Radwaste Loss)	0	0	0	0
20	Makeup Demineralizer Blowdown	1	1	1	4
21	Total Discharge	17,110	11,868	14,474	567
22	Total Drift & Evaporation	17,124	11,882	14,488	569
23	Fire Protection Uses	30	30	30	30
24	Potable Water Discharge to Sewer	200	35	35	47
25	Domestic Uses	200	35	35	47
26	Total Discharge to Monroe County sewer system	201	36	36	52
27	Liquid Radwaste Recycled	105	105	105	419

1. Summer months (Design/maximum)
2. Winter months (January/minimum)
3. Spring and fall months (Average)

3.4 Cooling System

Fermi 3 requires cooling water for the normal power heat sink in the CIRC and the auxiliary heat sink in the PSWS. Thermal energy is transferred via air or water through these heat sinks. Major system components include the intake and discharge portions.

Subsection 3.4.1 gives a description of the various cooling water systems and the operational modes for Fermi 3. The NPHS is discussed in this section, as well as in Section 3.3 and Subsection 5.3.2. Discharge to the air is also discussed in this section, as well as in Subsection 5.3.3.

Subsection 3.4.2 provides a description of the major components of the systems. Major components are contained within the intake structure and discharge piping. Further clarification of the intake structure is provided on Figure 3.4-1 and Figure 3.4-2. Additional discussion on the impacts of the discharge can be found in Subsection 5.3.2 and Subsection 5.3.3.

3.4.1 Description and Operational Modes

3.4.1.1 Circulating Water System

The CIRC provides cooling water during startup, normal plant operations, and hot shutdown for removal of power cycle heat from the main condensers and rejects this heat to the NPHS. The NPHS is comprised of a natural draft cooling tower. The main condensers contribute the majority of the heat to the NPHS with additional heat load introduced by the PSWS.

The main condenser rejects heat to the atmosphere at a rate of approximately 9.883×10^9 Btu/hr during normal full-power operation. Water from the NPHS basin is pumped through the main condenser and then back to the cooling tower where heat, transferred to the cooling water in the main condenser, is dissipated to the environment (the atmosphere) by evaporation.

As a result of the heat dissipation process, some water is evaporated. This results in an increase in the solids level in the NPHS cooling tower. To control solids levels or concentrations, a portion of the recirculated water is discharged. In addition to this blowdown from the CIRC, and evaporative losses, a small percentage of water in the form of droplets (drift) is lost from the cooling tower. Water pumped from Lake Erie via the intake structure is used to replace water lost by evaporation, drift and blowdown from the cooling tower. Blowdown water is returned to Lake Erie via an outfall into the lake (Subsection 3.4.2). A portion of the waste heat is thus dissipated to Lake Erie through the blowdown process.

The maximum, minimum and average Fermi 3 blowdown flow rates from the CIRC during normal full power operation are provided in Figure 3.3-1. Table 3.4-1 provides the monthly values for evaporation, blowdown, and makeup for the NPHS. The maximum temperature of the blowdown after passing through the NPHS is 86°F at the discharge to Lake Erie. The heat rejected to Lake Erie via blowdown is estimated based on these maximum blowdown flow and temperature conditions (Subsection 5.3.2). During other operating modes, heat dissipation to the environment is less than the bounding values for the normal full-power operational mode for the NPHS, except when the Turbine Bypass System (TBS) is in operation. In this condition, it is possible for the temperature of the discharge to rise to 96°F.

3.4.1.2 Station Water System

The SWS draws water from Lake Erie through an intake bay into the pump house located on the west shore of Lake Erie. The SWS provides makeup water to various plant systems. For example, the SWS provides makeup water to the NPHS cooling tower basin for the CIRC and to the AHS cooling tower basin for the PSWS. The pump configuration consists of three 50 percent capacity Plant Cooling Tower Makeup System (PCTMS) pumps that supply makeup to the cooling towers, and two 100 percent capacity Pretreated Water Supply System (PWSS) pumps. The PWSS pumps are capable of supplying makeup to the FPS as well as the AHS in shutdown conditions. The PCTMS pump configuration allows for one pump to be out of service and the other two maintaining design flow. This is also discussed in Subsection 3.4.2.1 and FSAR Subsection 9.2.10. The AHS can be used in conjunction with the NPHS during normal power operation. However during certain shutdown conditions, heat rejection is performed entirely with the AHS. The AHS operates during startup, hot shutdown, stable shutdown, cold shutdown, and refueling.

3.4.1.3 Plant Service Water System

The PSWS provides cooling water to the Turbine Component Cooling Water System (TCCWS) heat exchangers and the Reactor Component Cooling Water System (RCCWS) heat exchangers and rejects the heat back to the NPHS and/or the AHS during normal power operations. During shutdown conditions, the heat is rejected to the AHS. Further discussion of the PSWS can be found in FSAR Subsection 9.2.1. A simplified flow diagram is provided in FSAR Figure 9.2-205. Subsection 3.3.1.2 further discusses flows associated with PSWS, and Figure 3.3-1 outlines flow paths and values for maximum, minimum and average normal power conditions and average shutdown conditions. Chemical treatment of the PSWS is discussed in Subsection 3.3.2.3 and Table 3.3-1.

3.4.1.4 Ultimate Heat Sink

The Fermi 3 ESBWR design has no separate emergency water cooling system. The UHS function is provided by safety systems integral and interior to the reactor plant. This system ultimately uses the atmosphere as the eventual heat sink. These systems do not have cooling towers, basins, or cooling water intake/discharge structures external to the reactor plant.

3.4.1.5 Discharges to Lake Erie

Lake Erie is subject to liquid discharges during plant operation. Discharge from the heat dissipation system consists of blowdown from the CIRC and PSWS, as well as optional treated liquid radwaste. The thermal aspect of the discharge is covered in this subsection. Section 3.5 and Section 3.6 complete the description of the discharge characteristics.

The rate of discharge into Lake Erie is constant under normal full power operating conditions. The discharge is approximately 17,000 gpm (Figure 3.3-1), with a maximum temperature of 86°F. Table 3.4-1 contains a summary of the monthly discharge temperatures. A discussion of thermal plume predictions is contained in Subsection 5.3.2. The discharge pipe is fortified with riprap to reduce the effects of scouring; additional discussion of scouring can be found in Subsection 5.3.2.1.2. The current NPDES permit for Fermi 2 (Permit No. MI0037028) was renewed in 2005 with an expiration date in 2009. As discussed in Section 1.2, permits, e.g., NPDES permit and Section 401 Water Quality Certification, will be obtained for the discharge from Fermi 3. The discharge of chemicals that have been added to various systems as treatments such as biocide, corrosion inhibitor, and scale inhibitor are closely monitored in the NPDES permit, as well as the presence of metals and the temperature of effluent flow. Section 3.6 provides discussion and comparison to regulatory limitations on effluent flow from Fermi 3.

3.4.1.6 **Discharges to Air**

At the normal full-power design condition, the natural draft tower requires a maximum of 5.6 x 10^7 cfm of ambient air to dissipate about 10.72 x 10^9 Btu/hr of waste heat from the natural draft cooling tower at Fermi 3. Heat dissipated by the natural draft cooling tower includes contributions from the main condenser and the PSWS system. The heat load used for determining parameters associated with the natural draft cooling tower is conservative relative to the design heat loads (Reference 3.4-2).

The cooling tower used at Fermi 3 provides the only plant effluents with a potential for influencing local meteorology. The effluent types of concern are commonly described as visible plumes (fog) and cooling tower drift. Cooling tower drift is limited to no greater than 0.001 percent of the total tower water flow. Drift eliminators exist as a design feature of the natural draft cooling tower meant to reduce the volume of drift from the tower. These effluent types and their impacts on local weather are described in Subsection 5.3.3.

In addition to the heat discharged to the air, auditory discharges are considered. The noise from the NPHS is primarily the result of water splash. The sound level is estimated as being between 55 and 60 dBA at 1000 ft. Subsection 5.3.4 also discusses the estimated noise levels from the NPHS operation. The noise generated by the AHS is from water splash and fan motors. The sound level for the AHS is estimated at between 55 and 60 dBA at 1000 ft. (Reference 3.4-1)

3.4.1.7 **Operational Modes**

For the purposes of the design of the cooling systems, Fermi 3 is based on an estimated capacity factor of 96 percent (annualized). This considers a 24 month fuel cycle combined with an assumed 30-day refueling outage period. On a long term average, the heat load is 10.29 x 10^9 Btu/hr, which is 96 percent of the rated head load of 10.72 x 10^9 Btu/hr. There are six modes of plant operation; normal full-power operation, startup, hot shutdown, stable shutdown, cold shutdown and refueling. These can be generally grouped into two predominant modes, normal full power operation and shutdown operation. During normal full power operation, the NPHS, or a combination of the NPHS and the AHS, handle the heat dissipation to the atmosphere. Under normal full power operation, the heat load is rejected either entirely by the NPHS or by both the NPHS and the AHS. The AHS is capable of exchanging 2.98 x 10^8 Btu/hr. During shutdown operations, approximately 4 percent of plant operation annually, the AHS handles heat dissipation to the atmosphere.

3.4.2 Component Description

3.4.2.1 Intake System

The lake water intake and makeup water system is composed of two main parts: a wet pit pump house structure containing five vertical wet pit pumps, trash racks and traveling screens, and piping routed from the pump house structure to the cooling tower basin and the plant.

The SWS draws lake water via an intake bay (Figure 3.4-1 and Figure 3.4-2) from Lake Erie. This inlet bay is formed by two rock groins that extend 600 ft into Lake Erie. The intake bay is periodically dredged to maintain appropriate operating conditions.

At the inlet to the pump house structure a trash rack is positioned which is equipped with a trash rake. Trash collected from the trash racks is disposed of. There are three dual flow traveling screens arranged side by side to further prevent debris from entering the pump house. Aquatic organisms are first washed from the traveling screens using low pressure water spray. The remaining trash is then removed using high pressure wash sprays. Strainers are in place at the pump discharge and strainer backwash is directed back to Lake Erie. Strainer backwash is controlled to ensure that the limits of the applicable NPDES permit are adhered to.

The SWS pumps take suction from an intake bay through the makeup water pump house. The three PCTMS pumps supply makeup water to the cooling tower basins. Each pump has capacity to supply 50 percent of the total flow requirements. Two pumps are normally operated and the third is reserved for standby operation. This ensures makeup flow can be delivered in the event that one pump is out of service. The two operating pumps are capable of delivering the maximum cooling tower makeup water requirement of approximately 34,000 gpm, (Figure 3.3-1). The two PWSS pumps supply makeup water to the FPS under normal power operating conditions. They are 100 percent capacity pumps capable of supplying the necessary makeup water to the AHS and FPS in shutdown conditions.

The velocity of the water flowing through the dual flow intake traveling screens is approximately 0.5 fps at record low lake water levels, and no more than 0.5 fps under all operating conditions, as required by Section 316(b) of the Clean Water Act. The mesh size on each traveling screen is ⅜-inch. Each screen is capable of handling approximately 20,000 gpm of flow. The flow is designed to be sufficiently low that fish are not caught or trapped against the traveling screens. Fish which have entered the intake bay to this point are free to return to the lake in the same way they came. The pump house intake structure is sized such that the formation of vortices or other abnormal flow conditions that would interfere with the operation of the pumps is minimized. If fouling occurs, the screens are cleaned by backwashing. The formation of frazil ice on the screens is prevented by the low intake flow rate and by recirculating warmed water that has been rerouted from the discharge. A profile view of the intake screens and pumps suction is shown on Figure 3.4-2. This system is designed such that the intake structure has a minimal impact on the wildlife present in Lake Erie. This is consistent with good engineering design and environmental practices.

The addition of a biocide/algaecide, sodium hypochlorite, takes place as water enters the pump house structure. Once the water has passed through the trash rack and the traveling screens, a diffuser injects the biocide into the flow before the flow proceeds into the pump suction. Further chemical treatments are discussed in Subsection 3.3.2.

The elevation reference in use at Fermi is NAVD88. The elevation of the bottom of the intake bay at the entrance to the pump house is 559 ft. The record low level of Lake Erie water is 563’-11” and the record high level is 576’-6”. The elevation of the base of the bay at the location of the pump suction is 553 ft. This is more than 10 ft below the record low water level for Lake Erie, thus pump suction should not be a concern. Impacts to SWS pump suction due to seiche events are discussed in Subsection 3.3.1.

3.4.2.2 **Discharge System**

Dilution and dissipation of the discharge heat as well as other effluent constituents are affected by both the design of the discharge and the flow characteristics of the receiving water, in this case Lake Erie. Normal plant effluent flow from all sources (cooling tower blowdown, and optional treated liquid radwaste) is approximately 17,000 gpm. The NPHS cooling tower blowdown is the major contributor to the total flow, and its maximum return temperature is estimated at 86°F and the average temperature is 68°F. Table 3.4-1 contains the monthly discharge flow rates and the discharge temperatures (cold water temperature) to Lake Erie. Figure 3.4-4 and Figure 3.4-5 are used in the development of Table 3.4-1. The temperature rise across the main condenser is 31.2°F.

The 4-ft diameter discharge pipe is located approximately 1300 ft into Lake Erie to avoid recirculation. Another consideration in the length of the discharge pipe was to preclude the discharge plume from intruding on environmentally sensitive onsite areas (such as wetlands) during wind-driven rises in Lake Erie water level (seiche events). The pipe is buried in the bank as it is routed into Lake Erie where the discharge is located, below the water surface, see Figure 5.3-1. The pipe discharges through a diffuser, as described in Subsection 5.3.2.1.1.1. The analysis of the thermal plume that results from the discharge is discussed in Subsection 5.3.2.1. The analysis includes consideration of seiche events. As discussed in Subsection 3.3.1 and Subsection 5.3.2.1, due to potential for the water supply to the SWS to be degraded during extreme seiche events, the unit could be operationally controlled to limit makeup water requirements. These seiche events are relatively short-lived. As part of the operational controls in response to an extreme seiche event, the discharge could be reduced and or secured.

For a total discharge flow rate of approximately 17,000 gpm, the exit jet velocity is approximately 8.5 fps. The submerged jet mixes rapidly with the ambient lake water, accompanied by a reduction of momentum and kinetic energy through turbulent action. The environmental impact of discharged heat on Lake Erie is discussed in Subsection 5.3.2. The use of cooling towers for Fermi 3 provides good engineering design and represents the best technology available under Phase I of Section 316(a) of the Clean Water Act and also acts to greatly reduce the thermal loading to Lake Erie. Discharges from the AHS are directed to the CIRC basin. As shown in Figure 3.3-1, the discharge from the AHS is small in comparison to the NPHS discharge (less than 5 percent). When the

PSWS is operating without the CIRC operating, discharges from the AHS are controlled to ensure that the resultant thermal plume is bounded by the thermal plume from operating the NPHS.

3.4.2.3 **Heat Dissipation System**

The main source of heat dissipation is the NPHS. The NPHS is a natural draft cooling tower, as shown on Figure 3.4-3. The AHS consists of two mechanical draft cooling towers. The AHS is further discussed in FSAR Subsection 9.2.1.

Makeup flow to the NPHS cooling tower basin is supplied by the SWS through the intake structure located on Lake Erie. The NPHS is located approximately 2200 ft from the pump house intake structure. At the cooling tower basin, there are four CIRC pumps, each 25 percent capacity, which supply a total flow of 744,000 gpm. The flow is directed to the main condenser, and is then directed back to the cooling towers so that the heat can be rejected to the atmosphere. The cooling tower basin is located approximately 1100 ft from the main condenser.

The NPHS cooling tower discharges water to the basin, which receives makeup from Lake Erie. Intake water temperatures from Lake Erie can be seen in Subsection 2.3.1, and meteorological data can be found in Section 2.7. Cooling tower performance curves for wet bulb temperature and evaporation, as well as wet bulb and cold water temperature are seen on Figure 3.4-4 and Figure 3.4-5. The information in Table 3.4-1 is developed using these cooling tower performance curves. The design of the heat dissipation system does not present any major departures from acceptable cooling system design practices, nor does it contain any additional components for consideration, beyond the NPHS in the form of a natural draft cooling tower. This system is consistent with good engineering practices.

The PSWS and AHS are discussed in FSAR Section 9.2 and FSAR Table 9.2-201.

3.4.3 **References**

3.4-1 Edison Electric Institute, “Electric Power Plant Environmental Noise Guide,” New York, 1978.

3.4-2 GE-Hitachi Nuclear Energy, “ESBWR Design Control Document – Tier 2,” Revision 6, August 2009.

Table 3.4-1 Monthly Cooling Tower Temperatures and Flows

Month	Wet Bulb Temperature (˚F)	Cold Water Temperature (˚F) *	Evaporation Flow rate (gpm)	Drift Flow rate (gpm)	Blowdown Flow rate (gpm)	Makeup Flow rate (gpm)
January	23.7	53.8	11875	7.2	11867.8	23750
February	25.7	55.3	12200	7.2	12192.8	24400
March	32.3	59.4	13100	7.2	13092.8	26200
April	42.6	66	14300	7.2	14292.8	28600
May	52.7	72.7	15400	7.2	15392.8	30800
June	61.7	78.4	16300	7.2	16292.8	32600
July	65.9	81.5	16750	7.2	16742.8	33500
August	65	80.8	16700	7.2	16692.8	33400
September	58.1	76.3	16100	7.2	16092.8	32200
October	47	68.8	14800	7.2	14792.8	29600
November	37.5	62.7	13750	7.2	13742.8	27500
December	28	56.6	12500	7.2	12492.8	25000

* Cold Water temperatures are calculated based on ambient wet bulb temperatures, however the temperature of the discharge from the NPHS cooling tower basin will be maintained at 55˚F or above.

Figure 3.4-1 Station Water Intake Structure

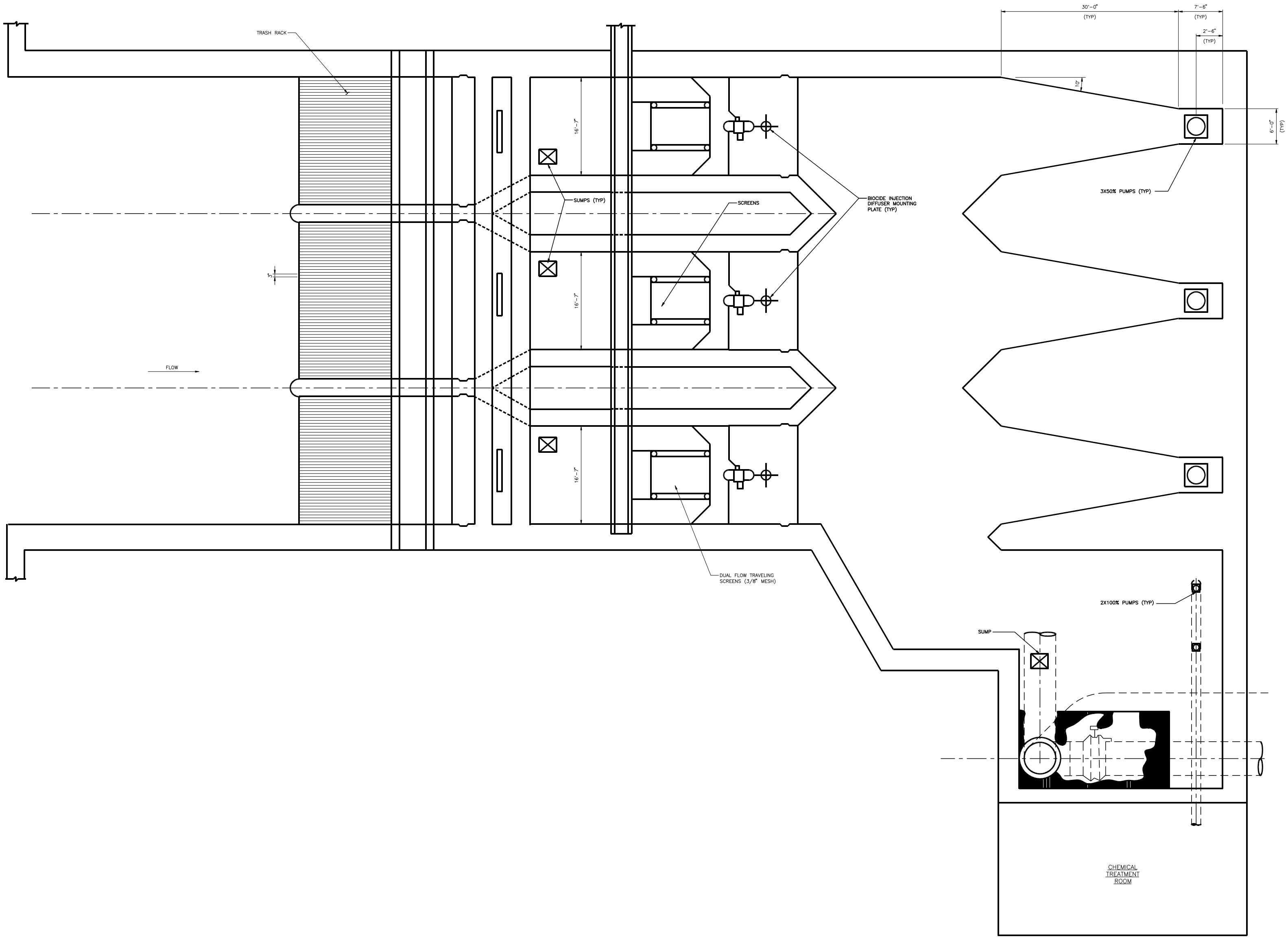


Figure 3.4-2 Station Water Intake Structure – Elevation View

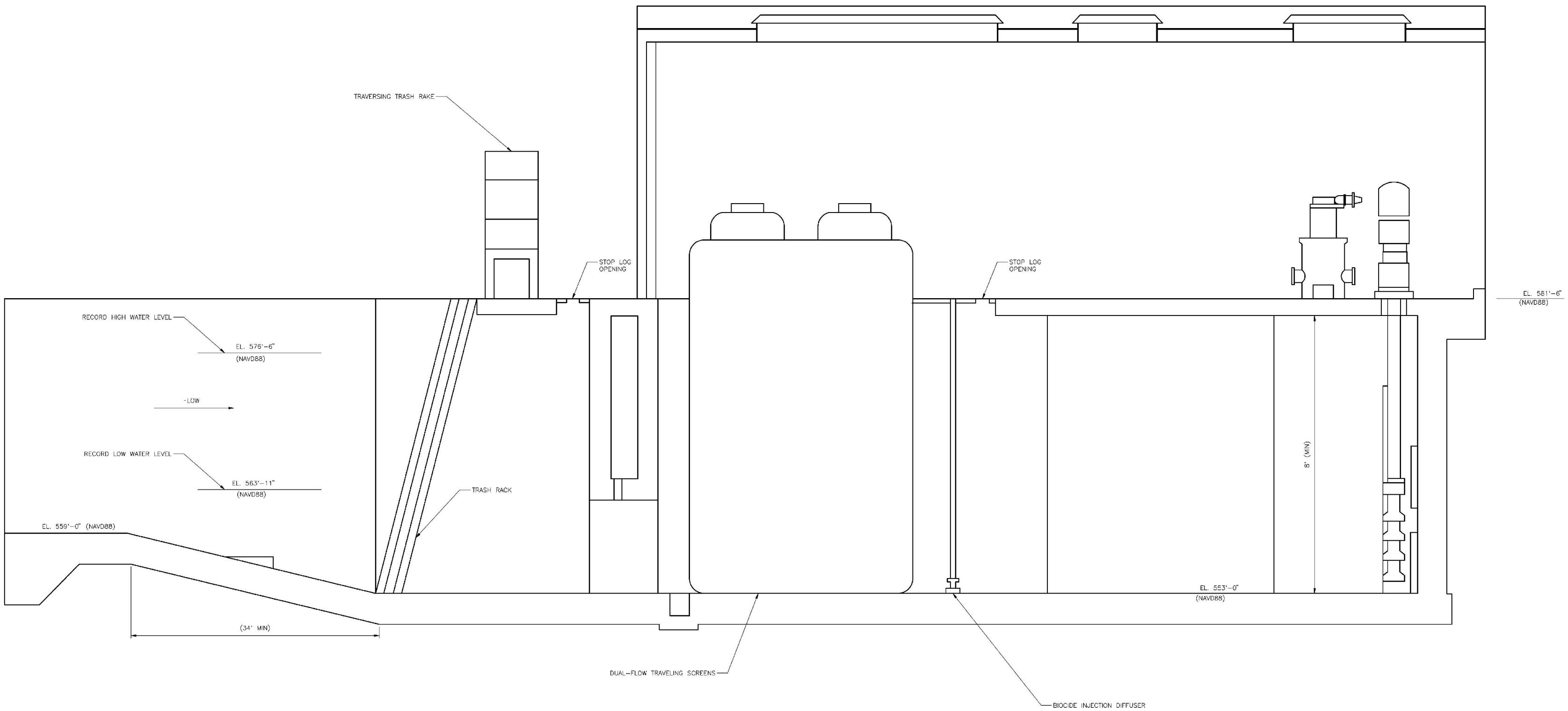


Figure 3.4-3 NPHS Cooling Tower

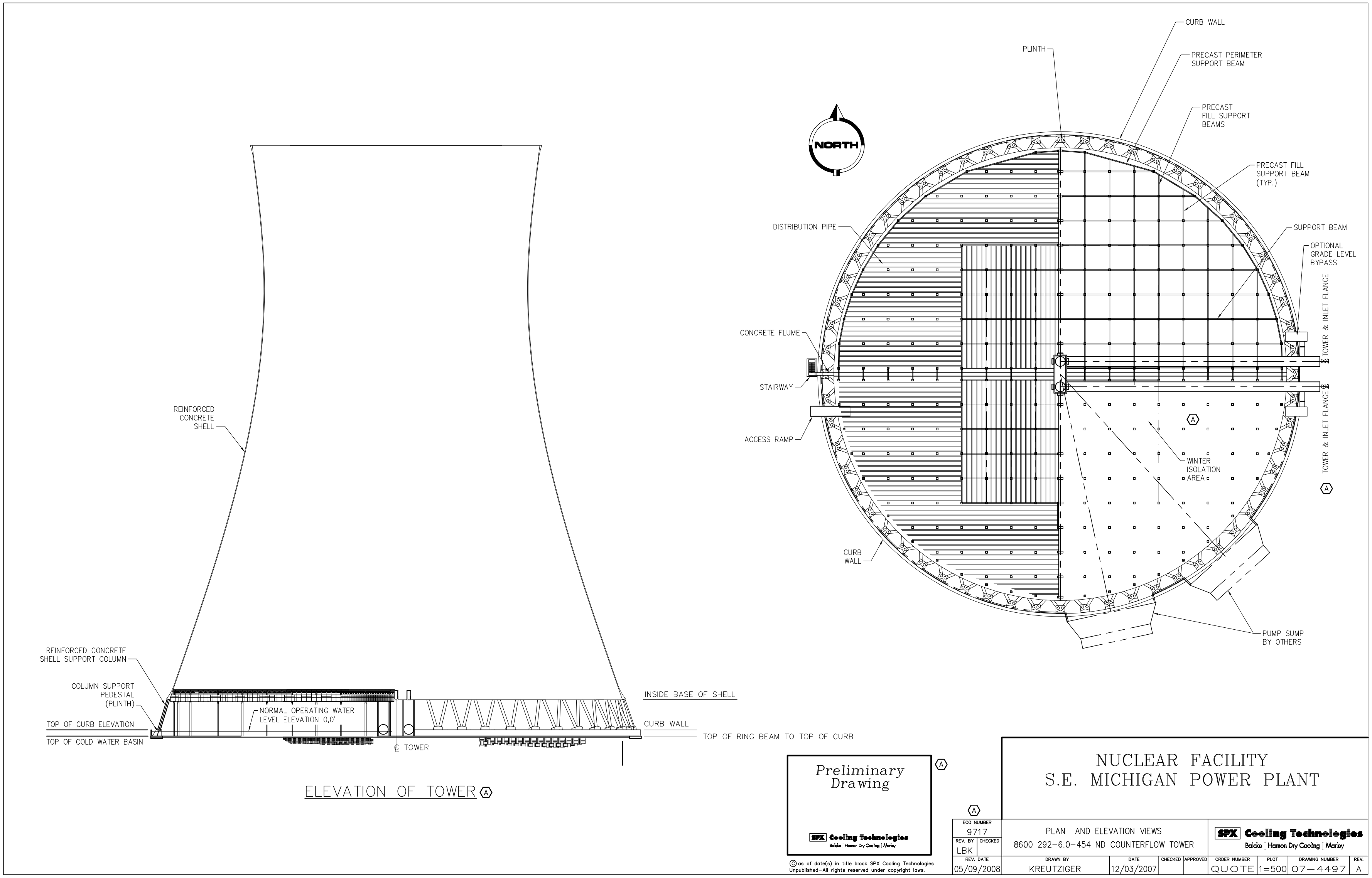


Figure 3.4-4 Cooling Tower Performance Curve

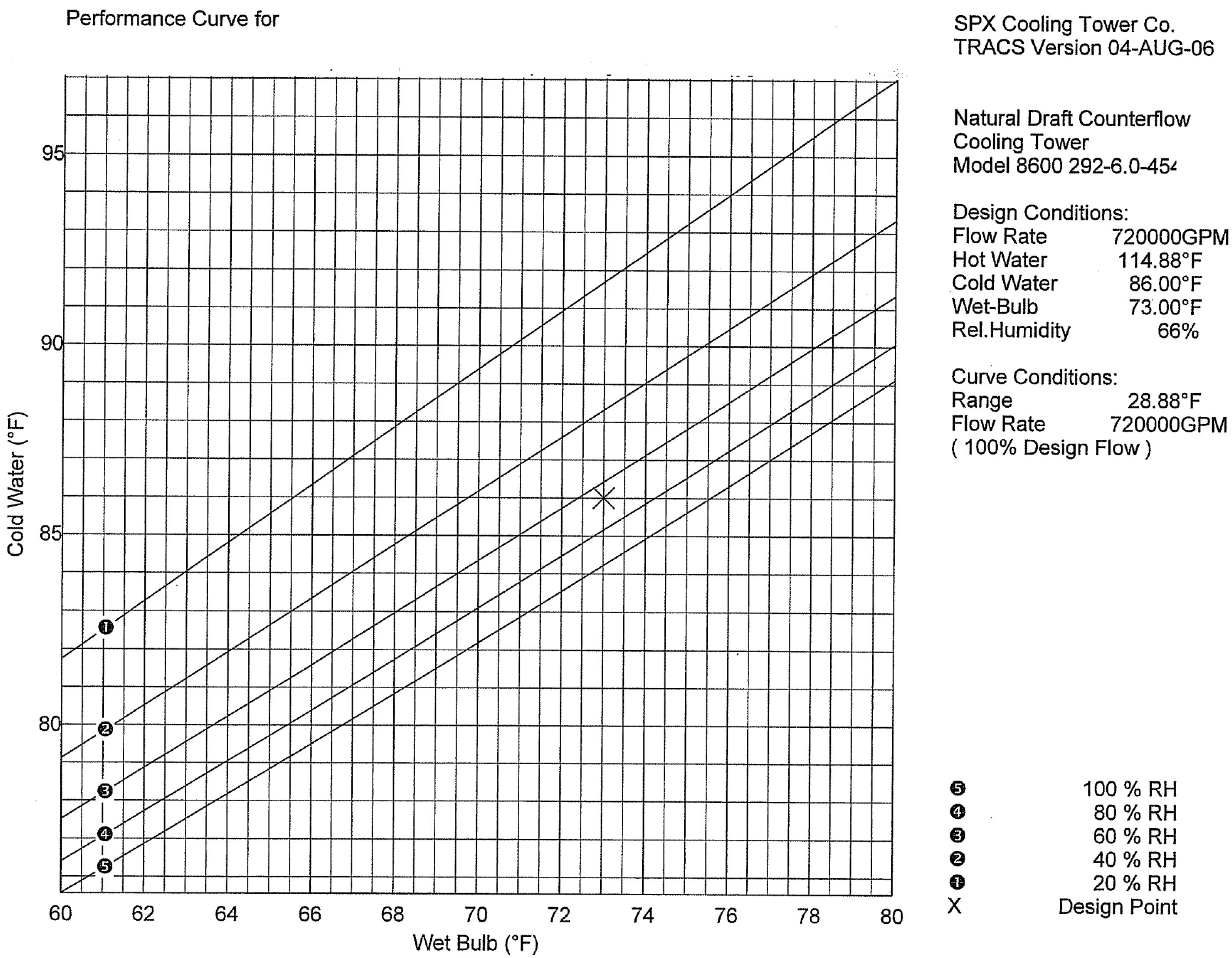


Figure 3.4-5 Cooling Tower Evaporation Curves

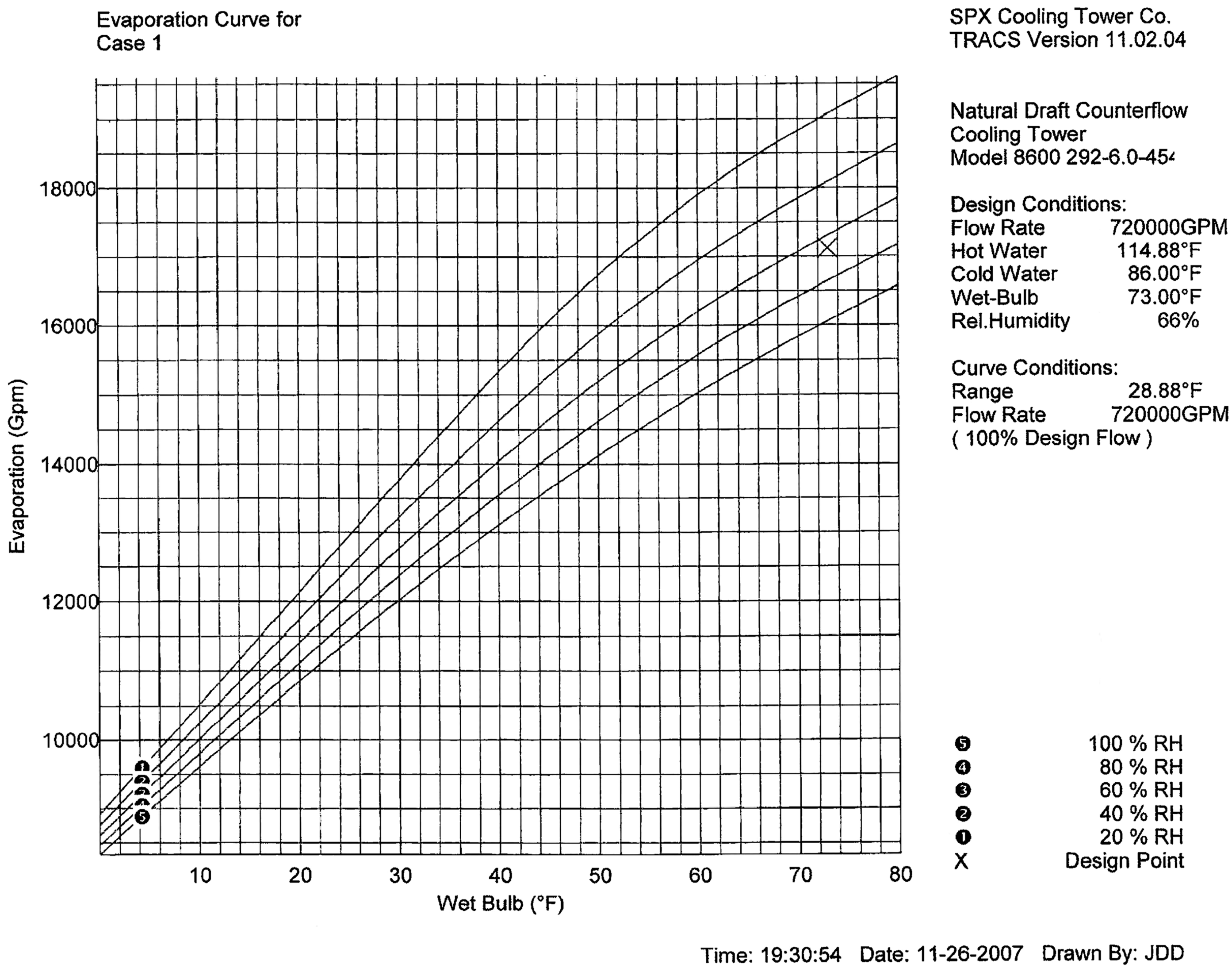
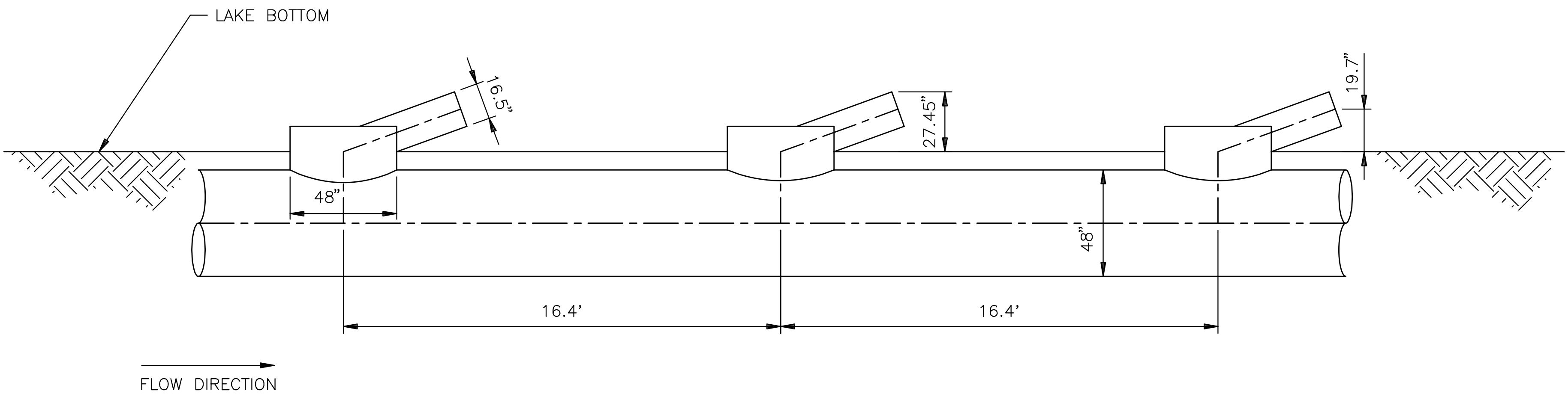


Figure 3.4-6 Outfall Diffuser Arrangement



3.5 Radioactive Waste Management System

This section describes the liquid, gaseous, and solid radioactive waste (radwaste) treatment systems and the instrumentation used to monitor the effluent release points. The information includes the origin, treatment, and disposal of all liquid, gaseous, and solid radioactive wastes generated by the station during normal operation including anticipated operational occurrences (e.g., refueling, purging, equipment downtime, maintenance). Low Level Mixed Waste is discussed in Subsection 3.6.3.4.

During normal operations of reactors, fission neutrons can activate nonradioactive materials normally present in the reactor coolant. Trace metals such as iron, cobalt, and manganese can become activated. Small amounts of fission-activated products within the fuel can enter the coolant by diffusing through the fuel cladding, or by escaping through fuel cladding leaks, if they occur. Thus, the reactor coolant normally carries materials with varying degrees of radioactivity. The sources of radioactivity and the source terms used for the design of the radioactive waste management systems are described in DCD Chapter 11 (Reference 3.5-1).

The radioactive waste management systems are designed to maintain releases of radioactive materials in effluents to “as low as reasonably achievable” levels in conformance with 10 CFR Parts 20 and 50, including the design objectives of 10 CFR 50 Appendix I. Brief descriptions of the radioactive waste management systems are provided in this section. More complete descriptions of the radioactive waste management systems design, including process flow diagrams, are included in DCD Sections 11.2, 11.3, and 11.4.

3.5.1 Source Terms

The sources of radioactivity that serve as input to the liquid, gaseous, and solid radioactive waste treatment systems for normal operation (including anticipated operational occurrences) are described in DCD Section 11.1. These sources include fission products (noble radiogas, radioiodines, and transuranic nuclides) and activation products (coolant, non-coolant, tritium, and Argon-41). FSAR Section 12.2 provides additional information on plant sources of radioactivity.

The calculation model used to determine the activity of each radionuclide in the primary containment is based on the ANSI/ANS 18.1 source terms (Reference 3.5-2) with appropriate adjustment factors applied. The details of the model, including the fission product noble gas release rate used, are provided in DCD Section 11.1.

Regulatory Guide 1.112, Appendix A, provides a listing of data needed for radioactive source term calculations for Boiling Water Reactors. General data needed for calculation of the radioactive source term is provided in DCD Sections 11.1, 11.2, and 11.3. Additional information on condensate demineralization and condensate and gland seal air removal systems is provided in DCD Sections 10.4.6 and 10.4.3, respectively. The ESBWR DCD concluded that the ESBWR conforms to Regulatory Guide 1.112 as shown in DCD Table 1.9-21 (Reference 3.5-1). There are no site-specific parameters that change that conclusion.

3.5.2 Radioactive Waste Management Systems

3.5.2.1 Liquid Waste Management System

Liquid radioactive wastes originate from minor leaks or drainage of equipment containing water contaminated with radioactivity. The Liquid Waste Management System (LWMS) collects, processes, and disposes of liquid radioactive wastes; and collects and transfers to the Solid Waste Management System (SWMS) certain solid wastes that are produced during shutdown, startup, and normal plant operation. Inputs to the LWMS from operational occurrences are listed in DCD Table 11.2-4 and are depicted in a block diagram on DCD Figure 11.2-2. This diagram also provides cross-reference to DCD sections which discuss the systems generating the influent streams. Decontamination factors for the various subsystems of the LWMS are provided in DCD Table 11.2-3. Tank, pump, and mobile systems capacities of the LWMS are provided in DCD Tables 11.2-2a, 11.2-2b, and 11.2-2c. A process diagram of the LWMS is provided on DCD Figure 11.2-1. Piping and instrumentation diagrams are provided for the LWMS drainage subsystems on DCD Figures 11.2-1a, 11.2-1b, 11.2-3, and 11.2-4.

Radioactive releases from the LWMS are discharged to the CIRC. Prior to discharging to the environment, the contents of the tank being released are sampled and analyzed to ensure that the activity concentration is consistent with the discharge criteria of 10 CFR 20 and the dose commitment in 10 CFR 50, Appendix I are met. A radiation monitor provides an automatic closure signal to the discharge line isolation valve. The effluent is eventually released to the environment through blowdown of the CIRC. The CIRC blowdown is discharged to Lake Erie through a single outfall monitored for radioactivity. FSAR Section 11.5 describes the Process Radiation Monitoring System (PRMS) in further detail.

The bounding annualized liquid effluent release for Fermi 3 is shown in DCD Table 12.2-19b. The parameters used for determining the release characteristics are shown in DCD Table 12.2-19a. The resulting bounding annualized release was used in determining the radiological impacts of operation. This analysis, resulting impact determinations, and evaluation showing conformance with 10 CFR 50, Appendix I design objectives are described in more detail in Section 5.4.

3.5.2.2 Gaseous Waste Management System

Radioactive waste products in the form of gases or airborne particles can be released to the environment by the ventilation systems or by other waste gas processing and handling systems. The Gaseous Waste Management System (GWMS) processes and controls the release of gaseous radioactive effluents to the environs. The GWMS is described in DCD Section 11.3.

The two main sources of plant gaseous radioactive effluents are building heating, ventilation, and air conditioning (HVAC) systems, described in DCD Section 9.4, and the Offgas System (OGS), described in DCD Section 11.3.2 and DCD Figure 11.3-1. The Fuel Building, Radwaste Building, Turbine Building, and Reactor Building HVAC systems are potential sources of radioactive gaseous effluents. The wastes discharged to the OGS during normal operation include radiolytic hydrogen and oxygen, power cycle injected gases and air in-leakage, and radioactive isotopes of krypton, xenon, iodine, nitrogen, and oxygen.

DCD Section 9.4 describes the building HVAC systems servicing the Fuel Building, Turbine Building, Radwaste Building, and Reactor Building, and includes process diagrams for each system. Detailed discussion of the potential sources of airborne activity to each of these systems is provided in DCD Section 12.2.3. This includes information on airborne sources from the fuel pool resulting from refueling activities.

During periods of high radioactivity, the Reactor Building and Fuel Building HVAC systems may direct exhaust to the Reactor Building HVAC purge exhaust filter unit. The Reactor Building purge exhaust filter units are equipped with prefilters, high efficiency particulate air (HEPA) filters and carbon filters for mitigating and controlling gaseous effluents from the Reactor Building or Fuel Building. DCD Table 9.4-11 provides design information for the Reactor Building purge exhaust filter units. The exhaust air is monitored for radiation prior to discharge to atmosphere through the RB/FB stack.

The Radwaste Building HVAC system directs exhaust air to exhaust filtration units. The system uses HEPA filtration of the exhaust air from the building prior to discharge to the atmosphere. The exhaust air is monitored for radiation prior to discharge to atmosphere through the RW stack. DCD Table 9.4-7 provides design information for the Radwaste Building HVAC system.

The Turbine Building HVAC system directs building exhaust air to filtration units. Exhaust air from low potential contamination areas is exhausted to the TB stack, where it is monitored for radioactive contamination. Exhaust air from high potential contamination areas is filtered using HEPA filters before being exhausted to the TB stack. Areas with high potential contamination have exhaust subsystems equipped with HEPA filtration units for localized air cleanup prior to mixing with the main ventilation exhaust. The Turbine Building combined ventilation exhaust is monitored for halogens, particulates and noble gas releases. Turbine Building exhaust air is directed to the TB stack where it is monitored for radiation prior to being discharged to the atmosphere.

Process radiation monitoring is provided for the systems described above. FSAR Section 11.5 describes the PRMS in further detail.

The bounding annualized airborne radioactivity source terms for Fermi 3 are shown in DCD Table 12.2-16 as supplemented by FSARTable 12.2-206. The parameters used for determining the release characteristics are shown in FSAR Table 12.2-15R. The resulting bounding annualized release was used in determining the radiological impacts of operation. This analysis, resulting impact determinations, and evaluation showing conformance with 10 CFR 50, Appendix I design objectives are described in more detail in Section 5.4.

3.5.2.3 **Solid Waste Management System**

Certain amounts of radioactive materials are generated in solid form. The Solid Waste Management System (SWMS) collects, processes, packages, and temporarily stores these solid radioactive wastes for offsite shipment and permanent disposal.

The SWMS controls, collects, handles, processes, packages, and temporarily stores solid waste generated by the plant prior to shipping the waste offsite. These wastes include filter backwash sludge, reverse-osmosis concentrates, and bead resins generated by the LWMS, reactor water cleanup/shutdown cooling system, fuel and auxiliary pools cooling system and the condensate purification system. Contaminated solids such as HEPA and cartridge filters, rags, plastic, paper, clothing, tools, and equipment are also disposed of in the SWMS. Liquids generated by the SWMS are processed through the LWMS described in Subsection 3.5.2.1.

The SWMS processes and components are described in FSAR Section 11.4. FSAR Table 11.4-1R provides SWMS component capacities. FSAR Table 11.4-2R provides estimates of annual waste generation and shipped volumes of dry active, wet solid and mixed wastes. FSAR Figure 11.4-1R and FSAR Figure 11.4-2R and DCD Figure 11.4-3 provide process and instrumentation diagrams for the SWMS.

The SWMS provides storage space sized to hold the total combined volume of 3 months of packaged Class A and 10 years of packaged Class B/C low-level radioactive waste estimated to be generated during plant operations. Such waste is normally promptly disposed of at licensed offsite processing and disposal facilities. The only operating disposal sites that presently accept Class B and C waste are in Richland, Washington, and Barnwell, South Carolina. However, neither of these facilities currently accepts Class B and C waste from outside the Northwest, Rocky Mountain and Atlantic LLRW compacts. A recently-licensed site in Andrews County, Texas, if opened, will, at least initially, only accept waste from Texas and Vermont, which are members of a prearranged compact. Michigan is not currently affiliated with any compact.

Additional waste minimization measures could be implemented to reduce or eliminate the generation of Class B and C waste, with the potential to greatly extend the planned 10 year storage capacity to the entire volume of Class B/C low-level radioactive waste. These measures could include reducing the service run length for resin beds, short loading media volumes in ion exchange vessels, and other techniques discussed in the EPRI Class B/C Waste Reduction Guide (Nov. 2007) and EPRI Operational Strategies to Reduce Class B/C Wastes (April 2007). As noted above, without crediting these waste minimization measures, the Radwaste Building provides 10 years capacity for storing Class B and C waste. This provides time for offsite disposal capability to be developed or additional onsite capacity to be added. Continued storage of Class B and C waste in the SWMS would be in accordance with procedures that will maintain occupational exposures within permissible limits and result in no additional environmental impacts.

If additional storage capacity for Class B and C LLRW is required, Fermi 3 could elect to construct a new temporary storage facility. The facility would meet applicable NRC guidance, including Appendix 11.4-A of the Standard Review Plan, "Design Guidance for Temporary Storage of Low-Level Waste." Such a facility would be located in a previously disturbed area in the vicinity of the power block, and in a location that would not affect wetlands. The environmental impacts of constructing such a facility would be minimal. The operation of a storage facility meeting the standards in Appendix 11.4-A would provide appropriate protection against releases, maintain exposures to workers and the public below applicable limits, and result in no significant environmental impact.

In lieu of onsite storage, Fermi 3 could enter into a commercial agreement with a third-party contractor that will process, store, own, and ultimately dispose of low-level waste generated as a result of Fermi 3 operations. Activities associated with the transportation, processing, and ultimate disposal of low level waste by the third-party contractor would necessarily comply with all applicable laws and regulations in order to assure public health and safety and protection of the environment. In particular, the third-party contractor would conduct its operations consistent with applicable Agreement State or NRC regulations (e.g., 10 CFR Part 20), which will assure that the radiological impacts from these activities would be small. Environmental impacts resulting from management of low-level wastes are expected to be bounded by the NRC's findings in 10 CFR 51.51(b) (Table S-3). Table S-3 assumes that solid, low-level waste from reactors will be disposed of through shallow land burial, and concludes that this kind of disposal will not result in the release of any significant effluent to the environment.

3.5.2.4 **Population Doses**

Population doses offsite were determined for airborne and liquid release pathways. A detailed discussion of the calculation methods and inputs is provided in Section 5.4.

Results of the analysis and conformance with 10 CFR 20 and 10 CFR 50, including the design objectives of 10 CFR 50, Appendix I are provided in Section 5.4.

3.5.3 **References**

3.5-1 GE-Hitachi Nuclear Energy, "ESBWR Design Control Document – Tier 2," Rev 7, March 2010.

3.5-2 ANSI/ANS 18.1, "Source Term Specification," 1976.

3.5-3 EPRI Class B/C Waste Reduction Guide (November 2007).

3.5-4 EPRI Operational Strategies to Reduce Class B/C Wastes (April 2007).

3.6 Nonradioactive Waste Systems

The nonradioactive waste from Fermi 3 is discussed in this section. Subsection 3.6.1 describes effluent wastes expected from the CIRC, PSWS, PWS, various drains within the plant, and other miscellaneous gaseous, liquid and solid effluents. The effluent from the SWDS is discussed in Subsection 3.6.2. Subsection 3.6.3 discusses other effluent streams from Fermi 3, including gaseous effluents, stormwater, various plant drains, and other waste.

3.6.1 Effluents Containing Chemicals or Biocides

This subsection discusses the CIRC, PSWS, PWS, and other chemically treated systems, and for completeness, the FPS. The flows associated with these systems are outlined on Figure 3.3-1. Effluent flow from the Fermi site must remain within the limits outlined by the NPDES permit, or other appropriate limits as specified by the Michigan Department of Environmental Quality. As discussed in Section 1.2, permits, e.g., NPDES permit and Section 401 Water Quality Certification, will be obtained for the discharge from Fermi 3.

There are four categories of water treatment chemicals: biocide, algaecide, corrosion inhibitor, and scale inhibitor. Specific chemicals anticipated to be used are determined by site specific water conditions, based on a conservative determination. The amount of chemicals added per year in pounds is outlined in Table 3.6-1. Effluent chemical constituents from Fermi 3 are shown in Table 3.6-2. Values specified in the Fermi 2 NPDES permit include Total Suspended Solids (TSS) and Total Residual Chlorine (TRC). The TSS specified in the permit is 100 ppm as a daily maximum; the maximum concentration discharged from Fermi 3 (Table 3.6-2) is 15.9 ppm, well within acceptable permitting limits. The TRC specified in the NPDES permit is 38 ppb or less, the amount discharged from Fermi 3 is zero. The addition of sodium hypochlorite does introduce chlorine into the water; however the addition of sodium bisulfite nullifies the presence of the chlorine. Regardless of the water systems' sources or constituents, each constituent discharged to the environment would be limited (i.e., volume and concentration) by the NPDES permit as discussed in Section 6.6.

The main body of water that receives effluent from Fermi 3 is Lake Erie. There is one discharge from Fermi 3 that includes the blowdown from the CIRC and PSWS, as well as optional treated liquid radwaste discharge. Effluent from these sources is in liquid form; no sludge disposal is necessary from these systems. The location and other details pertaining to this discharge into Lake Erie are discussed in Subsection 3.4.2.2.

In addition to the liquid discharge paths, discharge of some chemical constituents will be entrained in the fallout from the spray from the CIRC and PSWS Cooling Towers. This effect is discussed in Subsection 5.3.3.1.

The current status of the water quality in Lake Erie, as well as other water sources in proximity to the plant, is discussed in Subsection 2.3.3. The ecology of Fermi 3 is discussed in Section 2.4. Ecology is of particular importance due to the prevalence of zebra mussels in Lake Erie. They present an additional need for the use of biocides such as sodium hypochlorite.

3.6.1.1 Circulating Water System

The chemical treatment of the CIRC is discussed in Subsection 3.3.2.2 and Table 3.3-1. This system is treated with a biocide, algaecide, corrosion inhibitor, and scale inhibitor. The blowdown from the CIRC is also treated with dehalogenation. The effluent from the CIRC is discharged to Lake Erie, as described in Subsection 3.4.2.2.

The CIRC operates on two cycles of concentration under normal full power operating conditions; additional operating parameters of the CIRC are discussed in Subsection 3.4.1.1. Effluent chemical constituents discharged in the blowdown from the CIRC are shown in Table 3.6-2.

3.6.1.2 Plant Service Water System

The chemical treatment of the PSWS is discussed in Subsection 3.3.2.3 and Table 3.3-1. This system is treated with a biocide, algaecide, corrosion inhibitor, and scale inhibitor. The effluent from the PSWS is discharged to Lake Erie. Chemical constituents discharged in the effluent from the PSWS are shown in Table 3.6-2.

3.6.1.3 Potable Water System

The operation of the PWS is designed to supply water for domestic use and human consumption to Fermi 3. The source of the PWS is the Frenchtown Township Municipal Water System, and any chemicals present in the water are those added by the Frenchtown Township Water Treatment Facility. The water is treated to meet applicable drinking water standards; no additional onsite treatment is provided. The water is discharged to the SWDS which is routed offsite to the Frenchtown Township Sewage Treatment Facility.

3.6.1.4 Fire Protection System

The FPS receives no additional chemical treatment (makeup to the FPS is discussed in Subsection 3.3.1.6) and does not normally discharge any liquid effluent.

3.6.2 Sanitary System Effluents

This subsection discusses the sanitary waste systems effluent, including quantities and treatment of the waste products, during construction and operation of the plant.

Sanitary waste systems needed at Fermi 3 during construction activities include portable toilets supplied and serviced by an offsite vendor. There is no sanitary waste system discharge into the effluent stream.

Permanent SWDS components at Fermi 3 include waste basin, wet well, septic tank, settling tank, wet well pumps, sewage discharge pumps and associated valves, piping, and controls. The SWDS is discussed in FSAR Subsection 9.2.4. The system is designed to accommodate 60 gallons/day/person for up to 840 people during normal power operation and 1140 people during shutdown operation. This design condition drives the flow values that are outlined on Figure 3.3-1.

In addition to sanitary waste generated by domestic uses, the demineralized water waste and effluent from the auxiliary boiler are also routed to the SWDS.

The effluent of the SWDS is sewage that is pumped from the septic tank to the Frenchtown Township Sewage Treatment Facility for ultimate disposal. The SWDS does not come into contact with any systems that may contain radioactive waste; however measures are in place to ensure that no radioactive waste could be transmitted offsite. Since the effluent from the SWDS is routed to a waste treatment facility, and not discharged to the environment, it is not necessary for the effluent to meet NPDES permit requirements. It is, however, necessary to meet the limits outlined in the Industrial/Non-domestic User Discharge permit with the Frenchtown Township Sewage Treatment Facility. Chemical treatments applied to the waste are those within the Frenchtown Township Sewage Treatment Facility, in keeping with the municipal sewage treatment standards. Further discussion of the chemical treatment of the SWDS can be found in Subsection 3.3.2.4.

3.6.3 **Other Effluents**

This subsection discusses miscellaneous solid, liquid and gaseous effluents not addressed in Subsection 3.6.1 or Subsection 3.6.2. Gaseous effluents consist of exhaust from diesel generators, diesel-driven fire pumps, and the auxiliary boiler system (Aux Boiler). Stormwater, various plant drains, and other wastes are also discussed in the following subsections.

3.6.3.1 **Gaseous Effluents**

There are four main sources of gaseous nonradioactive effluent at Fermi 3, the standby diesel generators (SDG), ancillary diesel generators (ADG), Aux Boiler, and the diesel-driven fire pumps. The applicable regulations, permits, and consultation required by Federal, State, regional, and potentially affected Native American tribal agencies are addressed in Section 1.2. Proper maintenance and operating procedures, described in FSAR Section 13.5, assure that emissions are controlled consistent with system design to meet the standards from Section 1.2.

There are two 17.1 MW SDGs that are expected to operate approximately four hours per month for each engine. The proposed SDG for Fermi 3 will meet emission standards for owners and operators listed in 40 CFR 60.4205 at the time of purchase. Emission standards for stationary compression ignition internal combustion engines with a cylinder displacement greater than 30 liters per cylinder are displayed in Table 3.6-3. The non-road diesel fuel used to operate the two SDGs will also be required by 40 CFR 80.510 to meet sulfur content levels of 15 ppm effective June 1, 2010.

There are two 1650 kW ADGs that are expected to operate for approximately two hours every three months, for an annual total of 8 hours of operation for each engine. The manufacturers of the ADGs proposed for Fermi 3 will be required to meet emission standards listed in Table 1 of 40 CFR 1039.101 at the time of purchase. Tier 4 emission standards for compression ignition internal combustion engines manufactured after the model year 2014 with a rating greater than 560 kW are displayed in Table 3.6-4. The non-road diesel fuel used to operate the two ADGs will also be required by 40 CFR 80.510 to meet sulfur content levels of 15 ppm effective June 1, 2010.

Fermi 3 has one package Aux Boiler, rated at 50 tons of steam per hour (112 MBTU/hr or about 33 MW). The maximum expected operation on an annual basis is 30 days. Emissions are shown in Table 3.6-5, based on ASTM D-975 No. 2 fuel oil (Reference 3.6-1).

The fourth source of emissions at Fermi 3 are the two diesel-driven fire pumps. Each pump is approximately 200 kW and is expected to operate approximately 48 hours annually. The manufacturers of diesel-driven fire pumps proposed for Fermi 3 will be required to meet emission standards listed in Table 4 to Subpart IIII of Part 60.4202(d) at the time of purchase. Emission standards for stationary compression ignition internal combustion engines that are fire pumps with a maximum engine rating of 200 kW manufactured after 2009 are displayed in Table 3.6-6. The non-road diesel fuel used to operate the two fire pumps will also be required by 40 CFR 80.510 to meet sulfur content levels of 15 ppm effective on June 1, 2010.

In addition to the gaseous effluents emitted from the aforementioned combustion sources, a natural draft cooling tower (NDCT) and two 4-cell mechanical draft cooling towers (MDCT) will emit solid particulates. The emission estimates of particulate matter for particle sizes of 10 and 2.5 microns (PM_{10} and $PM_{2.5}$) from the operation of the proposed NDCT and 4-cell MDCTs are displayed in Table 3.6-7 along with design parameters that were used to derive the emission estimates. It is conservatively assumed that the $PM_{2.5}$ emissions are the same as the PM_{10} emissions from the cooling towers. The drift rates for the NDCT and 4-cell MDCTs are based on the values provided by the associated manufacturers of each cooling tower. The water flow rate to the NDCT, as specified in Figure 3.3-1, will be supplied at a maximum rate of 724,000 gallons per minute (gpm). The water from the basin of the NDCT will supply the makeup water to the 4-cell MDCTs at a maximum flow rate of 40,000 gpm. Section 5.3.3.1 states that the makeup water for the NDCT is expected to have a total dissolved solids (TDS) concentration of 420 parts per million (ppm) or 0.00042 grams of salt per gram of solution. The makeup water for the 4-cell MDCTs will be supplied from the NDCT basin; therefore, the TDS concentration for the 4-cell MDCTs is also expected to be 420 ppm. The emission rate (lb/hr) for particulates emitted from the cooling towers can be calculated by taking the product of the water flow rate, weight of one gallon of water, drift rate, and TDS concentration.

For the purpose of providing a maximum bounded value for the emissions of particulates from the cooling towers, the calculations in Table 3.6-7 were developed for the operation of both the NDCT and 4-cell MDCTs simultaneously for an entire year at the maximum water flow rate. While this likely overestimates the emissions of PM_{10} and $PM_{2.5}$ from the operation of the NDCT and 4-cell MDCTs, it provides a maximum value for the assessment of impacts from the operation of the cooling towers. Therefore, the maximum hourly and annual emissions of PM_{10} and $PM_{2.5}$ from the simultaneous operation of the NDCT and 4-cell MDCTs are expected to be 1.93 lb/hr and 8.47 tons/year, respectively.

Stationary combustion sources proposed for the operation of Fermi 3 will emit carbon dioxide (CO_2). The following provides the estimated CO_2 emissions and calculation methodology for the proposed standby diesel generators, ancillary diesel generators, diesel-driven fire pumps, and auxiliary boiler.

Standby and Ancillary Diesel Generators and Diesel-Driven Fire Pumps

In order to estimate the annual emissions of CO_2 for the proposed standby diesel generators, ancillary diesel generators, and diesel-driven fire pumps, emission factors were obtained from Tables 3.3-1 and Table 3.4-1 of Reference 3.6-2. The total annual emissions of CO_2 emitted from the standby diesel generators, ancillary diesel generators, and diesel-driven fire pumps is calculated by taking the product of the emission factor, number of units, annual operating hours, and engine power rating.

Auxiliary Boiler

The estimated annual emissions of CO_2 from the proposed auxiliary boiler is calculated by taking the product of the emission factor, heat input, and the annual operating hours. The CO_2 emission factor for the auxiliary boiler is 22,300 lb/10^3 gal as displayed in Table 1.3-12 of Reference 3.6-2. Dividing the emission factor (22,300 lb/10^3 gal) by the heating value of fuel oil (140 MBtu/10^3 gal), the emission factor becomes 159.29 lb/MBtu. The heat input of the boiler is 112 MBtu/hr.

Table 3.6-6-(A) provides the emission rates and estimated annual emissions of CO_2 for each stationary source proposed for Fermi 3. Therefore, the estimated annual emission of CO_2 from stationary sources during the operation of Fermi 3 is 7,734 tons per year.

3.6.3.2 **Stormwater**

Stormwater, specifically flood and probable maximum flood (PMF) are discussed in FSAR Subsection 2.4.2 and FSAR Subsection 2.4.3. Stormwater from the Fermi 3 site drains to the North and South Lagoons, which are located north and south of the site respectively. Stormwater construction and operational impacts are discussed in Chapter 4 and Chapter 5.

3.6.3.3 **Various Plant Drains**

There are several drains at Fermi 3 including: equipment drains, floor drains, laundry and chemical drains, and other miscellaneous periodic drains. These drains are treated and the treated effluent joins the discharge from the CIRC and PSWS to be discharged to Lake Erie. Waste from the various plant drains that cannot be treated for onsite discharge are routed for handling as hazardous waste.

3.6.3.4 **Other Waste**

Low level mixed waste (LLMW) contains hazardous waste and a low-level radioactive source, special nuclear, or byproduct material. Hazardous waste is not necessarily LLMW; LLMW only includes hazardous waste that has been exposed to radioactive contamination. Section 5.5 provides a more detailed discussion of the environmental impacts that could result from the operation of the non-radioactive waste systems and the storage and disposal of mixed wastes.

A summary of the hazardous waste generated at Fermi 2 for several years is shown in Table 3.6-8. Some examples of LLMW generated at Fermi 2 include:

- Industrial oils and laboratory waste
- Rags/wipes
- Lead products
- Mercury products

Federal regulations governing generation, management, handling, storage, treatment, disposal and protection requirements concerning LLMW are contained in 10 CFR 10 and 10 CFR 40. Additional discussion of guidelines and standards pertaining to waste disposal is found in Section 1.2. Treatment of LLMW from Fermi 3 is handled in a similar manner as that of Fermi 2, with eventual offsite transportation and disposal by properly licensed organizations. Fermi 2 is a Small Quantity Generator, as Fermi 3 will likely be. Further discussion of LLMW is provided in Section 5.5.

Universal waste is also disposed of properly at Fermi 3. Universal waste includes:

- Batteries
- Light bulbs
- Computer monitors and equipment

Handling of universal waste is done in accordance with State of Michigan regulations, with eventual offsite disposal by a properly permitted organization. Additional discussion of guidelines and standards pertaining to waste disposal is found in Section 1.2. When possible, materials are recycled with the proper facilities.

Fermi 2 practices recycling when possible; Fermi 3 also recycles. Examples of items recycled from the Fermi site include:

- Batteries
- Circuit Boards
- Recyclable lead

Used oil is also recycled. The used oil program in use at Fermi 2 will be similarly implemented with Fermi 3. In this program the used oil from site is sent to St. Clair power station for power generation.

In addition to mixed waste and universal waste, another form of waste that must be handled at Fermi 3 is the waste that is disposed of from trash racks and traveling water screens. The trash racks and traveling water screens of the SWS pumps are discussed in Subsection 3.4.2.1. Once the racks and screens are cleaned and the trash is present in the trash cart or trash basket, it is necessary to dispose of the waste. This waste is disposed of offsite.

3.6.4 **References**

3.6-1 "Standard Specification for Diesel Fuel Oils," ASTM D 975, American Society of Testing and Materials, Philadelphia, PA, 2007.

3.6-2 U.S. Environmental Protection Agency (USEPA), "Compilation of Air Pollutant Emission Factors (AP-42)," Fifth Edition, Vol. I., Tables 1.3-1, 1.3-12, 3.3-1, and 3.4-1, October 1996.

Table 3.6-1 Chemicals Added to Liquid Effluent Streams

System	Chemical	Maximum Amount	Average Amount	Frequency of Use	Concentration in Waste Streams
CIRC/ SWS	Biocide/Algaecide - Sodium Hypochlorite (15%)	620,000 lb/year	620,000 lb/year	Approximately 4.5 hour/week	Non-detectable, neutralized by sodium bisulfite TRC < 38ppb*
CIRC	Corrosion Inhibitor – Sodium Silicate	1,700,000 lb/year	1,400,000 lb/year	Continuous	Non-detectable, dissociates in system
CIRC	Scale Inhibitor/Dispersant	830,000 lb/year	700,000 lb/year	Continuous	Non-detectable, dissociates in system
CIRC	Dehalogenation – Sodium Bisulfite	650,000 lb/year	550,000 lb/year	Continuous	Non-detectable, neutralizes sodium hypochlorite

*Fermi 2 NPDES permit

Table 3.6-2 Effluent Chemical Constituents*

Ion/Chemical	As	Max Conc. (ppm)	Avg Conc. (ppm)
Sodium	Na	46.6	34.3
Calcium	Ca	71.9	71.9
Magnesium	Mg	17.4	17.4
Silica	SiO_2	19.9	19.5
Chloride	Cl	61.3	42.5
Sulphate	SO_4	38.5	38.5
Potassium	K	3.6	3.6
Scale Inhibitor/Dispersant	Chemical	11.6	11.6
Bicarbonate Alk.	$CaCO_3$	167.8	167.7
TDS	-	428.5	397.4
TSS	-	16.0	16.0

*Based on 2 cycles of concentration

Table 3.6-3 Standby Diesel Generators

	Emission per SDG* (g/kWh)	Annual Emissions per SDG (lb)
Particulates	0.15	271.4
Sulfur dioxide**		
Nitrogen oxides	1.6	2895.3

*Emission standards listed in 40 CFR60.4205

**Sulfur dioxide emissions will be controlled by the use of diesel fuel that meets CFR 80.510

Table 3.6-4 Ancillary Diesel Generators

	Emission per ADG* (g/kWh)	Annual Emissions per ADG (lb)
Particulates	0.03	0.87
Sulfur dioxide**		
Carbon monoxide	3.5	101.9
Hydrocarbons	0.19	5.5
Nitrogen oxides	0.67	19.5

*Emission standards listed in Table 1 of 40 CFR 1039.101

**Sulfur dioxide emissions will be controlled by the use of diesel fuel that meets 40 CFR 80.510

Table 3.6-5 Auxiliary Boiler System Emissions<

	Emission Factor (lb/MBtu)[A]	Annual Emissions (lb/year)
Particulates	0.014	1152
Sulfur Dioxide	0.002	136
Carbon Monoxide	0.036	2880
Hydrocarbons	0.002	145
Nitrogen Oxides	0.171	13824

Source A: Reference 3.6-2

Table 3.6-6 Diesel-Driven Fire Pump Emissions

	Emissions per Fire Pump* (g/kWh)	Annual Emissions per Fire Pump (lb)
Particulates	0.2	4.2
Sulfur Dioxide		
Carbon monoxide	3.5	74.1
Hydrocarbons+Nitrogen oxides	4.0	84.7

*Emission standards listed in Table 4 to Subpart IIII of Part 60 - Emission Standards for Stationary Fire Pump Engines referred in 40 CFR 60.4202(d)

**Sulfur dioxide emissions will be controlled by the use of diesel fuel that meets 40 CFR 80.510

Table 3.6-6-(A)Estimated Emissions of CO_2 from Operation of the Proposed Fermi 3 Stationary Sources

	Emission Factor Per Diesel Generator[(A)]	Annual Emissions (tons/year)
Standby Diesel Generators	705.28 g/kWh	1276.2
Ancillary Diesel Generators	705.28 g/kWh	20.5
Diesel Driven Fire Pumps	699.20 g/kWh	14.8
Auxiliary Boiler	159.29 lb/MBtu	6422.4
Total Estimated Emissions from Stationary Sources		7733.9

Source A: Reference 3.6-2

Table 3.6-7 Estimated Emissions of PM_{10} and $PM_{2.5}$ from Operation of the Proposed Femi 3 NDCT and 4-Cell MDCTs

	NDCT	4-Cell MDCTs
Drift Rate (%)	0.001	0.005
Water Flow Rate (gpm)	724,000	40,000
TDS Concentration (ppm)	420	420
Annual Hours of Operation	8760	8760
PM_{10}/$PM_{2.5}$ EmissionRate (lb/hr)	1.51	0.42
PM_{10}/$PM_{2.5}$ TotalAnnual Emissions (tons/year)	6.63	1.84

Table 3.6-8 Hazardous Waste Management (Fermi 2)

Hazardous Waste	2007 (lbs)	2006 (lbs)	2005 (lbs)
Paint Related Materials	43	1782	387
Oil /Solvent Waste	103	20	506
Fiber Wound Parts-Cleaner Filters	7	0	309
Vehicle Antifreeze - used	600	0	20
Munge-Blanchard & surface grinder/marble saw (B01-110)	180	0	210
Lead Paint/Contaminated Mat	0	80	120
Lead Contaminated rags/debris	45	0	405
Aerosol cans	692	70	1167
Leaking Lead-acid battery	0	75	0
Cutting Fluids	0	80	0
Sand Blast Grit	0	1222	0
Parts Cleaner Solvent	0	32	0
Total	**1670**	**3361**	**3136**

3.7 Power Transmission System

The Fermi 3 switchyard will be connected to the International Transmission Company (ITC*Transmission*) system by three 345 kV transmission lines. This new switchyard will be separate from the 345 kV and 120 kV switchyards feeding Fermi 2. The ITC*Transmission* system transfers power from power plants to local distribution systems. The ITC*Transmission* system also carries power resulting from transfers from power plants to loads across the Eastern Interconnection. (Reference 3.7-1) The 345 kV transmission system and associated corridors including the proposed route for Fermi 3 will be owned and operated by ITC*Transmission*. The applicant has no control over the construction or operation of the transmission system. The interconnection point is between Fermi 3 and the switchyard.

ITC*Transmission* operates within the Midwest Independent System Operator (Midwest ISO) regional reliability area, a Federal Energy Regulatory Commission (FERC) -approved regional transmission organization. As part of the Midwest ISO interconnection process, various studies and analyses are performed including feasibility and system impact studies. For the ITC*Transmission* service area, the Midwest ISO typically has ITC*Transmission* perform the studies and analyses. As part of these work activities, the Midwest ISO and ITC*Transmission* determine necessary upgrades to the transmission system. This process has been followed for the proposed connection of Fermi 3 to the ITC*Transmission* system.

ITC*Transmission* follows the applicable regulatory processes and approvals in order to implement changes to the transmission system. As discussed above, the interconnection studies are performed by ITC*Transmission*, including determining the routing for these new transmission lines. As part of this process, Detroit Edison is not involved in the evaluation or decision making for proposed changes to the transmission system or possible design. Accordingly, Detroit Edison cannot reasonably provide the transmission system detailed design information considered by ITC*Transmission*.

3.7.1 Power Transmission System Configuration

The output of Fermi 3 will be delivered to the switchyard through the unit main step-up transformers as described in FSAR Section 8.2 and Section 8.3. Fermi 3 will be connected to the switchyard by two overhead conductor circuits, one—the normal preferred power supply—feeds the unit's two unit auxiliary transformers (UAT) and the other—the alternate preferred power supply—feeds the unit's two reserve auxiliary transformers (RAT). The switchyard will be connected to ITC*Transmission* by three 345 kV transmission lines which are in turn connected to the Milan substation.

3.7.2 Design Parameters

Three new transmission lines and a separate switchyard will be needed for Fermi 3 per System Impact Study Report (MISO G867) performed by ITC*Transmission* (Reference 3.7-1). This study evaluated the connection of an additional 1563 MW to the system at the Fermi site. The new transmission lines and switchyard will be designed to prevent a common failure mode for all reasonable, postulated hazards. Without the new transmission lines, the study indicates that the full output of Fermi 3 contributes to post contingency overloads on the system, most notably at the points of interconnection on the 345 kV, 230 kV, and 120 kV portions of the system. The study also finds if Fermi 2 and Fermi 3 have switchyards tied together, that unstable conditions may arise. In addition to the new transmission lines and switchyard, upgrades to existing transmission (and possibly subtransmission) lines will be needed to facilitate the new generation on the system.

Transmission line and switchyard design will meet or exceed the requirements established in the National Electrical Safety Code (NESC) (Reference 3.7-2), which provides rules for electrical safety, electrical clearances, structural design loadings, and material strength factors. Modifications to the existing system will comply with relevant local, state, and industry standards including NESC and various American National Standards Institute/Institute of Electrical and Electronic Engineers, Inc. standards. The standards include the rules in Sections 23, 25, and 26 of the NESC.

3.7.3 Construction Methods

The Fermi 3 switchyard will be located approximately 3000 ft. to the west of the Fermi 3 reactor, and will be separate from the existing 345 kV and 120 kV switchyards utilized by Fermi 2.

The new transmission lines from the Fermi 3 switchyard will be 345 kV lines and will be located in existing corridors to the Milan substation.

The study performed by ITC*Transmission* indicated the use of towers, steel poles and/or combinations of these structures will be used in the construction of the new transmission lines. (Reference 3.7-1) The three 345 kV lines for Fermi 3 will run in a common corridor, with transmission lines for Fermi 2, to a point just east of I-75. From the intersection of this Fermi site corridor and I-75, the three Fermi-Milan lines will run west and north for approximately 12 miles in a corridor shared with other non-Fermi lines. From this point, all non-Fermi lines turn north and continue on to their respective destinations and the three Fermi-Milan lines will continue west for approximately 10 miles to the Milan substation.

3.7.4 Transmission Line Noise

There are two categories of electrical noise effects of power transmission lines: corona effect caused by electrical stresses at the conductor surface resulting in air ionization noise, and field effects caused by induction to objects in proximity to the conductors. The audible noise produced by corona effect and ground level electric field effect are the primary concerns.

Audible noise is typically at its maximum during or following rain or during fog. The maximum noise level is kept below the level which would result in a number of complaints (approximately 52.5 dB(A) per Reference 3.7-3) through the use of typical design standards to properly size conductors and specify corona-free hardware.

Ground level electric field effects of overhead power transmission lines relate to the possibility of exposure to electric discharges from objects in the line's field. The likely range of maximum vertical electric field is 4-6 kV/m (Reference 3.7-3) for a 345 kV transmission line.

3.7.5 References

3.7-1 ITC*Transmission*, “System Impact Study Report (MISO G867),” Generation Interconnection in Monroe County, MI, July 21, 2008.

3.7-2 National Electric Safety Code, Institute of Electrical and Electronic Engineers, Inc., 2007.

3.7-3 Fink, D.G., and H.W. Beaty, eds., “Standard Handbook for Electrical Engineers,” 13th ed., McGraw-Hill, New York, 1993.

3.8 Transportation of Radioactive Materials

This section addresses the transportation of radioactive materials associated with Fermi 3. Postulated accidents as a result of transporting radioactive materials are discussed in this section and in Section 7.4.

As required by 10 CFR 51.52, an environmental report prepared for the combined license stage of a light-water-cooled nuclear power reactor (LWR), and submitted after February 4, 1975, shall utilize Table S-4, “Environmental Impact of Transportation of Fuel and Waste To and From One Light-Water-Cooled Nuclear Power Reactor,” and contain a statement concerning transportation of fuel and radioactive wastes to and from the reactor.

Table S-4 (as provided in 10 CFR 51.52(c) and repeated herein as Table 3.8-1) is a summary impact statement concerning transportation of fuel and radioactive wastes to and from a reactor. The table is divided into two categories of environmental considerations: normal conditions of transport and accidents in transport. The normal conditions of transport considerations are further divided into environmental impact, exposed population, and range of doses to exposed individuals per reference-reactor year. These conditions describe the environmental impacts of the heat of the fuel cask in transit, weight, and traffic density. Also the number and range of radioactive doses to transport workers and the general public are described.

The accidents in transport consideration are concerned with environmental risk from radiological effects and common nonradiological causes such as fatal and nonfatal injuries.

To indicate that Table S-4 adequately describes the environmental effects of the transportation of fuel and waste to and from the reactor, the reactor licensee must state that the reactor and this transportation either meet all of the conditions in paragraph (a) of 10 CFR 51.52 or all of the conditions in paragraph (b) of 10 CFR 51.52. Subparagraphs 10 CFR 51.52(a)(1) through (5) delineate specific conditions the reactor must meet to use Table S-4 as part of its environmental report. These conditions are reactor core thermal power, fuel form, fuel enrichment, fuel encapsulation, average fuel irradiation, time after discharge of irradiated fuel before shipment, mode of transport of unirradiated fuel, mode of transport for irradiated fuel, and mode of transport for radioactive waste other than irradiated fuel. There are two other conditions in Table S-4 that require that radioactive waste, with the exception of irradiated fuel, be packaged and in solid form. Table 3.8-2 was prepared to succinctly show the reference conditions along with the bounding values for the ESBWR reactor technology. Subparagraph 10 CFR 51.52(a)(6) states, “The environmental impacts of transportation of fuel and waste to and from the reactor, with respect to normal conditions of transport and possible accidents in transport, are as set forth in Summary Table S-4 in paragraph (c) of this section; and the values in the table represent the contribution of the transportation to the environmental costs of licensing the reactor.”

Paragraph 10 CFR 51.52(b) states that reactors not meeting the conditions of 10 CFR 51.52(a) shall make a full description and detailed analysis of the environmental impacts for their reactor.

The ESBWR reactor design exceeds the conditions prescribed in 10 CFR 51.52 in three areas: 1) reactor power level; 2) fuel enrichment; and 3) average burnup.

3.8.1 Transportation of Unirradiated Fuel

In this subsection, the number and characteristics of shipments of unirradiated fuel to Fermi 3 are compared to the conditions described in 10 CFR 51.52. The details of the container designs, shipping procedures, and transportation routings would be in accordance with DOT (49 CFR 173 and 178) and NRC (10 CFR 71) regulations and depend on the requirements of the suppliers providing the fuel fabrication services.

The conditions specified in 10 CFR 51.52(a) that apply to unirradiated fuel include the following:

1. 1.The reactor has a core thermal power level not exceeding 3800 MWt;
2. The reactor fuel is in the form of sintered uranium dioxide pellets having a uranium 235 enrichment not exceeding 4 percent by weight, and the pellets are encapsulated in Zircaloy rods;
3. Unirradiated fuel is shipped to the reactor by truck.

Conditions (1) and (2) are not met by the ESBWR reactor design, while condition (3) is met since Fermi 3 plans to ship unirradiated fuel by truck. Since the ESBWR reactor design has a core thermal power of 4500 MWt and a fuel enrichment of 4.6 percent U-235, both exceeding the conditions specified in 10 CFR 51.52(a), a full description and detailed analysis is required.

Table 3.8-3 summarizes the number of truck shipments of unirradiated fuel. The table also normalizes the number of shipments to the electrical output for the reference reactor analyzed in WASH-1238. When normalized for electrical output, the number of truck shipments of unirradiated fuel for the ESBWR is less than the number of truck shipments estimated for the reference LWR.

In addition, 10 CFR 51.52(c) includes a condition that the truck shipments not exceed 73,000 lbs, as governed by Federal or State gross vehicle weight restrictions. All of the advanced reactor designs (including ESBWR) would meet this weight restriction for unirradiated fuel (Reference 3.8-2). Truck shipments from Fermi 3 will not exceed a gross vehicle weight of 73,000 lbs.

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. Radiological impacts of transportation of unirradiated fuel are discussed in Subsection 3.8.5.

3.8.2 Transportation of Irradiated Fuel

In this subsection, the impact of transporting irradiated fuel from Fermi 3 to a potential high-level waste repository at Yucca Mountain, Nevada is considered. Radiological impacts of transportation of irradiated fuel are discusssed in Section 3.8.6 and Section 3.8.7.

3.8.2.1 Core Thermal Power

Paragraph 10 CFR 51.52(a)(1) requires that the reactor have a core thermal power level not exceeding 3800 megawatts. The ESBWR reactor power level is 4500 MWt. The higher rated core power level would typically indicate the need for more fuel and therefore more fuel shipments. This is not the case for the ESBWR due to the higher unit capacity and higher burnup for the reactors with the increased power level.

3.8.2.2 Fuel Form

Paragraph 10 CFR 51.52(a)(2) requires that the reactor fuel be in the form of sintered uranium dioxide (UO_2) pellets. The ESBWR technology utilizes the sintered UO_2 pellet fuel form. See DCD (Reference 3.8-3) for a description of the ESBWR fuel assembly.

3.8.2.3 Fuel Enrichment

Paragraph 10 CFR 51.52(a)(2) requires that the reactor fuel have a uranium-235 enrichment not exceeding 4 percent by weight. The ESBWR reactor design has a fuel enrichment of 4.6 percent U-235, which exceeds this requirement.

3.8.2.4 Fuel Encapsulation

Paragraph 10 CFR 51.52(a)(2) requires that the reactor fuel pellets be encapsulated in Zircaloy rods. The fuel design utilized in the ESBWR technology uses Zircaloy rods.

3.8.2.5 Fuel Irradiation

Paragraph 10 CFR 51.52(a)(3) requires that the average burnup is not to exceed 33,000 MWd/MTU. The ESBWR reactor design has an expected average burnup of 46,000 MWd/MTU, exceeding this requirement.

3.8.2.6 Time after Discharge of Irradiated Fuel before Shipment

Paragraph 10 CFR 51.52(a)(3) requires that no irradiated fuel assembly be shipped until at least 90 days after it is discharged from the reactor. Table S-4 assumes 150 days of decay time prior to shipment of any irradiated fuel assemblies. Five years is the minimum decay time expected before shipment of irradiated fuel assemblies, supported by two current practices. One is per contract with DOE, who has ultimate responsibility for the spent fuel. Five years is the minimum cooling time specified in 10 CFR 961, Appendix E. The other practice is that the NRC specifies five years as the minimum cooling period when they issue certificates of compliance for casks used for shipment of power reactor fuel (NUREG-1437, Addendum 1, pp 26). The ESBWR Fuel Building spent fuel storage pool is designed for a maximum storage capacity to accommodate the total number of irradiated fuel assemblies resulting from 10 calendar years of plant operation plus one full core offload of fuel assemblies (Reference 3.8-3).

Detailed information for the specific cask to be used for transportation of spent fuel from Fermi 3 is not available at this time because a specific design has not been selected. The heat load expected can be estimated using general information available in the literature. The INEEL evaluation (INEEL 2003, Reference 3.8-4) provides a range of decay heat values from 18 to 22 kW / MTU. The upper bound of this range is selected for the analysis as a bounding value. The heat load per cask is 1.8 MTU based on information developed by DOE (DOE 2002) For comparison, the value used in WASH-1238 for spent fuel loading was 0.5 MTU.

The estimated heat load for a shipping cask is calculated to be

39.6 kW / cask = 135,155 BTU/hr / cask

The 10 CFR 51.52 Table S-4 value for heat per cask in transit is less than 250,000 BTU/hr. The expected cask heat load for the Fermi spent fuel transportation of 135,155 BTU/hr meets the Table S-4 limit.

3.8.2.7 **Shipment of Irradiated Fuel**

Paragraph 10 CFR 51.52(a)(5) allows for truck, rail, or barge transport of irradiated fuel. The ESBWR vendor states either rail or truck shipment will be used. Detroit Edison plans to ship irradiated fuel by either rail or truck. Packaging of the fuel for offsite shipment would comply with applicable DOT (49 CFR 173 and 178) and NRC (10 CFR 71) regulations for transportation of radioactive material. The newer spent fuel shipping cask capacities are up to 1.8 MTU/shipment (Reference 3.8-2).

Table 3.8-4 summarizes the number of truck shipments of irradiated fuel. The table also normalizes the number of shipments to the electrical output for the reference reactor analyzed in WASH-1238.

3.8.3 **Transportation of Radioactive Waste**

As described in Subsection 3.5.2.3, low-level radioactive waste will be packaged using the SWMS to meet transportation and disposal site acceptance requirements. Radwaste processing systems operation procedures, which includes packaging of solid radwaste, are developed as discussed in FSAR Subsection 13.5.2.2.5. Packaging of waste for offsite shipment will comply with applicable DOT (49 CFR 173 and 178) and NRC (10 CFR 71) regulations for transportation of radioactive material. As described in Subsection 3.5.2.3 and FSAR Section 11.4, the packaged waste will be stored onsite on an interim basis before being shipped offsite to a licensed volume reduction facility or disposal site. As stated in 10 CFR 51.52(a)(4), “with the exception of irradiated fuel, all radioactive waste shipped from the reactor is packaged and in a solid form.”

Paragraph 10 CFR 51.52(a)(5) requires that the mode of transport of low-level radioactive waste is either truck or rail. Detroit Edison plans to ship low-level radioactive waste by rail or truck.

Truck shipments of radwaste are evaluated with a capacity of approximately 2.34 cubic meters per shipment for consistency with the Reference LWR evaluation. Table 3.8-5 presents estimates of annual waste volumes and numbers of truck shipments. The values are normalized to the reference LWR analyzed in WASH-1238.

Radioactive waste shipments are subject to a weight limitation of 73,000 pounds per truck and 100 tons per cask per rail car. Radioactive waste will be shipped in compliance with federal or state weight restrictions.

3.8.4 Non-radiological Transportation Impacts

Nonradiological impacts are calculated using accident, injury, and fatality rates from published sources. The rates (that is, impacts per vehicle-km traveled) are then multiplied by estimated travel distances for workers and materials. The general formula for calculating nonradiological impacts is as follows:

Impacts = (unit rate) x (round-trip shipping distance) x (annual number of shipments)

In this formula, impacts are presented in units of the number of accidents, number of injuries, and number of fatalities per year. Corresponding unit rates (impacts per vehicle-km traveled) are used in the calculations.

The general approach used in this document to calculate nonradiological impacts of unirradiated and spent fuel shipments is based on state-level accident, injury, and fatality statistics developed by Saricks and Tompkins (1999, Reference 3.8-5). The round-trip distances between the proposed Fermi 3 site and the fuel fabrication facility (assumed to be located in Wilmington, NC) and Yucca Mountain, Nevada provided the data for the last part of the equation. State-by-state shipping distances were obtained from the Web-TRAGIS (Johnson 2003, Reference 3.8-6) output file and combined with the annual number of shipments and accident, injury, and fatality rates by state (Reference 3.8-5), to calculate nonradiological impacts. For radioactive waste (non-fuel) a round trip distance of 1600 km was used, consistent with WASH-1238, along with national median accident, injury, and fatality rates. The round trip distances and accident, injury, and fatality rates per shipment are shown in Table 3.8-6. The results on an annual basis are shown in Table 3.8-7. The values presented in Table 3.8-7 were calculated from the values reported in Table 3.8-6 multiplied by the applicable number of shipments for unirradiated and spent fuel and for radioactive waste. Table 3.8-7 values were then compared to those reported in Table S-4 of 10 CFR 51.52. As shown in Table 3.8-7 the impacts are less than those from 10 CFR 51.52 Table S-4.

3.8.5 Transportation of Unirradiated Fuel – Incident Free Radiological Impacts

Table S-4 of 10 CFR 51.52 includes conditions related to radiological doses to transport workers and members of the public along transport routes. These doses, based on calculations in WASH-1238, 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 of transit (including travel and stop times), and the number of shipments to which the individuals are exposed.

Calculation of worker and public doses associated with annual shipments of unirradiated fuel were performed using the RADTRAN 5 computer code (Sand 2008, Reference 3.8-7). One of the key assumptions in WASH-1238 for the reference LWR unirradiated fuel shipments is that the radiation dose rate at 1 meter from the transport vehicle is about 0.1 millirem/hr. This assumption is reasonable for the ESBWR because the fuel materials will be low-dose rate uranium radionuclides and will be packaged similarly (Reference 3.8-4). For unirradiated fuel shipments, highway routes were analyzed using the routing computer code TRAGIS Version 4.6.2 (Reference 3.8-6) and 2000 census data.

Routes were estimated by minimizing, as much as possible considering materials being transported, the total impedance of a route, which is a function of distance and driving time between the origin and destination. The TRAGIS computer code also can estimate routes that maximize the use of interstate highways. For unirradiated fuel the commercial route setting was used to generate highway routes generally used by commercial trucks. However, the routes chosen may not be the actual routes used in the future. The population summary module of the TRAGIS computer code was used to determine the exposed populations within 800 m (i.e., 0.5 mi, either side) of the route.

Unirradiated fuel was assumed to be shipped from Wilimington, NC. Summary data produced by the TRAGIS computer code are provided in Table 3.8-8 for unirradiated fuel. Other input parameters used in the radiation dose analysis for the ESBWR unirradiated fuel shipments are summarized in Table 3.8-8. The results for the unirradiated fuel shipment based on the RADTRAN 5 analyses are provided in Table 3.8-9.

Based on the parameters used in the analysis, these per-shipment doses are expected to conservatively estimate the impacts for fuel shipments. The per trip dose values were combined with the average annual number of shipments of unirradiated fuel to calculate annual doses to the public and workers for comparison to Table S-4 dose values.

The numbers of unirradiated fuel shipments were normalized to the reference reactor analyzed in WASH-1238. The numbers of shipments per year were obtained from Table 3.8-3. As shown in Table 3.8-9, the calculated radiation doses for transporting unirradiated fuel to the Fermi 3 site is bounded by Reference LWR dose values except for the crew annual dose. The radiological impacts from transportation of unirradiated fuel are less than the values in 10 CFR 51.52, Table S-4.

3.8.6 **Transportation of Spent Fuel – Incident Free Radiological Impacts**

This section provides the environmental impacts of transporting spent fuel from Fermi 3 (or alternative sites) to a spent fuel disposal facility using Yucca Mountain, Nevada as a possible location for a geologic repository. The impacts of the transportation of spent fuel to a possible repository in Nevada provides a reasonable bounding estimate of the transportation impacts to a monitored retrievable storage facility because of the distances involved and the representative exposure of members of the public in urban, suburban, and rural areas (NUREG-1817).

Incident-free transportation refers to transportation activities in which the shipments reach their destination without releasing any radioactive cargo to the environment. Impacts from these shipments will be from the low levels of radiation that penetrate the heavily shielded spent fuel shipping cask. Radiation doses will occur to (1) persons residing along the transportation corridors between Fermi 3 (or alternative sites) and the proposed repository; (2) persons in vehicles passing a spent fuel shipment; (3) persons at vehicle stops for refueling, rest, and vehicle inspections; and (4) transportation crew workers. The radiation doses are a function of many parameters, including vehicle speed, traffic count, dose rate at 1 m from the vehicle, packaging dimensions, number in the truck crew, stop time, and population density at stops.

This 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 on a modified trailer.

The transportation route selected for a shipment determines the total potentially exposed population and the expected frequency of transportation-related accidents. For truck transportation, the route characteristics most important to the risk assessment include the total shipping distance between each origin-destination pair of sites and the population density along the route.

Routing and population data used in RADTRAN 5 for truck shipments were obtained from the TRAGIS computer code routing module (Reference 3.8-6). The population data in the TRAGIS computer code were based on the 2000 census. All spent fuel shipments will be transported by legal weight trucks to the potential Yucca Mountain site over designated highway route-controlled quantity (HRCQ) routes.

Representative shipment routes for Fermi 3 (or alternative sites) were identified using the TRAGIS computer code routing model (Reference 3.8-6) for the truck shipments. The Highway data network in the TRAGIS computer code is a computerized road atlas that includes a complete description of the interstate highway system and of all U.S. highways.

Other input parameters used in the radiation dose analysis for the ESBWR spent nuclear fuel shipments are summarized in Table 3.8-10. The results for the incident free spent fuel shipments are presented in Table 3.8-11.

The normalized annual shipments values from Table 3.8-4 and corresponding population dose estimates per reactor-year are presented in Table 3.8-11. The population doses were calculated by multiplying the number of spent fuel shipments per year by the per-shipment doses. The population doses based on normalized annual shipments are compared to Table S-4 limits in Table 3.8-11.

As shown in Table 3.8-11, and similar to the evaluation in NUREG-1817, population doses to the crew and onlookers for the ESBWR exceed Table S-4 values. One of the key reasons for these higher population doses relative to Table S-4 is the shipping distances assumed for these analyses relative to the assumptions used in WASH-1238. The analyses in WASH-1238 used a "typical" distance for a spent fuel shipment of 1609 km (1000 mi). The shipping distance used in this assessment was 3614 km.

As noted in NUREG-1817, another key reason for the higher population doses relative to Table S-4 are the higher number of fuel shipments assumed based on a shipment capacity of 0.5 MTU based on shorter-cooled fuel assemblies. Newer cask designs are based on longer-cooled spent fuel (5 years out of the reactor) and have larger capacities than those used in this evaluation. DOE (Reference 3.8-2) spent fuel shipping-cask capacities were approximately 1.8 MTU per shipment. Use of the newer shipping-cask designs will reduce the number of spent fuel shipments and the associated impacts.

Similar to NUREG-1817, other conservative assumptions in the spent fuel transportation impacts calculation include:

- The shipping casks assumed in the Yucca Mountain EIS transportation analyses were designed for spent fuel that has cooled for 5 years (Reference 3.8-2). In reality, most spent fuel will have cooled for much longer than 5 years before it is shipped to a possible geologic repository. The NRC developed a probabilistic distribution of dose rates based on fuel cooling times that indicates that approximately three-fourths of the spent fuel to be transported to a possible geologic repository will have dose rates less than half of the regulatory limit (Reference 3.8-8). Consequently, the estimated doses in Table 3.8-11 could be divided in half if more realistic dose rate projections are used for spent fuel shipments from the Fermi 3.
- Use of 30 minutes as the average time at a truck stop in the calculations is conservative. Many stops made for actual spent fuel shipments are short duration stops (i.e., 10 minutes or less) for brief visual inspections of the cargo (checking the cask tie-downs). Based on data for actual truck stops, the NRC concluded that the assumption of a 30 minute stop for every 4 hours of driving time used to evaluate other potential ESP sites will overestimate public doses at stops by at least a factor of two (NUREG-1817).

If the population doses were adjusted for the longer shipping distance and larger shipping cask capacity, the population doses from incident-free spent fuel transportation from the Fermi 3 and the alternative sites will fall within Table S-4 requirements.

The impact of accident free transportation of unirradiated and spent fuel will be SMALL and does not warrant additional mitigation.

3.8.7 Transportation of Spent Fuel – Accident Radiological Impacts

The RADTRAN 5 (Sand 2008) computer code is used to estimate impacts of transportation accidents involving spent fuel shipments from Fermi 3. RADTRAN 5 considers a spectrum of potential transportation accidents, ranging from those with high frequencies and low consequences to those with low frequencies and high consequences (i.e., accidents in which the shipping container is exposed to severe mechanical and thermal conditions). This analysis utilized 19 severity categories and their associated severity fractions and release fractions from NUREG-1817, Table H-12.

The NRC conducted a screening analysis on the inventories reported in an Idaho National Engineering and Environmental Laboratory document entitled, "Early Site Permit ER Sections and Supporting Documentation," to select the dominant contributors to accident risks to simplify the RADTRAN 5 calculations (INEEL 2003). The screening identified the radionuclides that would contribute more than 99.999 percent of the dose from inhalation and the results are reported in NUREG-1817.

Radionuclide inventories are important parameters in the calculation of accident risks. The radionuclide inventories used in this analysis were provided by GEH and are represented in Table 3.8-12. The radionuclides selected for input to RADTRAN are consistent with those screened and used in NUREG-1817. Note that the values used in this analysis differ slightly than those used in NUREG-1817 but were provided in 2007 and are more recent than the INEEL 2003 information.

Transportation distances for spent fuel were developed using TRAGIS and are the same as those used for the evaluation of incident free transportation.

Massive shipping casks are used to transport spent fuel because of the radiation shielding and accident resistance required by 10 CFR 71. Spent fuel shipping casks must be certified Type B packaging systems. This requires that the cask be designed to withstand a series of severe hypothetical accident conditions with essentially no loss of containment or shielding capability.

According to Sprung et al. (NUREG/CR-6672), the probability of encountering accident conditions that would lead to shipping cask failure is less than 0.01 percent (i.e., more than 99.99 percent of all accidents would result in no release of radioactive material from the shipping cask). Shipping casks for advanced LWR spent fuel would provide equivalent mechanical and thermal protection of the spent fuel cargo as assumed in WASH-1238 because the shipping casks will be designed to meet the requirements of 10 CFR 71.

Consistent with NUREG-1817, using RADTRAN 5, the population dose from the released radioactive material was based on five possible exposure pathways:

1 External dose from exposure to the passing cloud of radioactive material.
2 External dose from the radionuclides deposited on the ground by the passing plume (this radiation exposure pathway is included even though the area surrounding a potential accidental release would be evacuated and decontaminated, thus preventing long-term exposures from this pathway).
3 Internal dose from inhalation of airborne radioactive contaminants.
4 Internal dose from resuspension of radioactive materials that were deposited on the ground (the radiation exposures from this pathway are included even though evacuation and decontamination of the area surrounding a potential accidental release would prevent long-term exposures).
5 Internal dose from ingestion of contaminated food (this pathway was not included because interdiction of foodstuffs and evacuation after an accident is assumed so no internal dose due to ingestion of contaminated foods was calculated).

A sixth pathway, external doses from increased radiation fields surrounding a shipping cask with damaged shielding, was considered but not included in the analysis. It is possible that shielding materials incorporated into the cask structures could become damaged as a result of an accident. However, the loss of shielding events is not included because this contribution to spent fuel transportation risk is much smaller than the dispersal accident risks from the pathways listed above.

The environmental consequences of transportation accidents due to shipping spent fuel from Fermi 3 to a spent fuel repository assumed to be at Yucca Mountain, Nevada were calculated. The shipping distances and population distribution information for the routes were the same as those used for the "incident-free" transportation impacts analysis.

Table 3.8-13 presents the accident risks associated with transportation of spent fuel from the proposed Fermi 3 site to the proposed Yucca Mountain repository. The accident risks are provided in the form of a unit collective population dose (i.e., person-rem per reactor year). The table also presents estimates of accident risk in terms of population dose per reactor year.

From NUREG-1817,

> 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 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, this 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 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 Publication 60 (ICRP 1991).

The population dose presented in Table 3.8-13 is less than 1 x 10-3 person-rem per reference reactor year. Therefore, the total detriment estimates associated would be less than 1 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.

3.8.8 **Alternate Sites**

The TRAGIS software was used to develop specific routes for the candidate sites identified in the Environmental Report, Section 9.3. Table 3.8-14 and Table 3.8-15 show the weighted population density and distances for each of the sites for unirradiated and irradiated fuel for comparison to the proposed site location.

The results show that the total population along the route for the alternative sites for unirradiated and spent fuel is greater for all of the alternative sites primarily due to the longer distances and the population around the Detroit metropolitan area. It is therefore reasonable to conclude that, given all other input parameters are the same, the radiological and accident impacts would be similar to the impacts identified for the selected Fermi-3 site or that impacts for alternate sites could be mitigated by avoiding the higher population areas around the Detroit metropolitan area.

3.8.9 **Conclusion**

The NRC evaluated the environmental impact and risk effects of transportation of fuel and waste for LWRs in WASH-1238, and in Supplement 1 of NUREG-75/038, Environmental Survey of

Transportation of Radioactive Materials to and from Nuclear Power Plants; and found the impacts to be small. These NRC analyses provided the basis for Table S-4 in 10 CFR 51.52.

The total truck traffic density for shipments of unirradiated fuel, irradiated fuel, and radioactive waste is the number of normalized annual shipments times two to account for incoming andoutgoing trucks. Based on the results presented in Table 3.8-3, Table 3.8-4, and Table 3.8-5, the annual normalized volume of trucks is expected to be 318 trucks annually (0.87 per day) and the traffic density is less than 1 truck per day. For comparison to the Reference LWR the Table S-4 traffic density is less than 1 truck per day.

The bounding cumulative doses to the exposed population, as given in Table S-4 of 10 CFR 51.52(c), are 0.04 person-Sv per reference-reactor year to transport workers, and 0.03 person-Sv per reference-reactor year to the general public (i.e., onlookers and persons along the route).

A site specific analysis was performed for the Fermi and alternate sites to evaluate the radiological and non-radiological impacts of transportation of radioactive materials. The overall transportation accident risks associated with unirradiated and spent fuel shipments are consistent with the transportation risks from current generation reactors presented in Table S-4 of 10 CFR 51.52. The conclusion given in Table S-4 that the radiological impacts associated with the transport of unirradiated fuel, irradiated fuel, and radioactive waste, is SMALL is also true for the transportation impacts from the Fermi 3 site or the alternative sites.

3.8.10 **References**

3.8-1 U.S. Nuclear Regulatory Commission, “Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants,” WASH-1238, December 1972.

3.8-2 U.S. Department of Energy, “Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada,” DOE/EIS-0250, Office of Civilian Radioactive Waste Management, Washington, D.C, 2002, http://www.ocrwm.doe.gov/ym_repository/seis/index.shtml, accessed 24 August 2008.

3.8-3 GE-Hitachi Nuclear Energy, “ESBWR Design Control Document – Tier 2,” Revision 6, August 2009.

3.8-4 Idaho National Engineering and Environmental Laboratory, “Early Site Permit ER Sections and Supporting Documentation,” INEEL Engineering Design File 3747, Revision 1, July 2003

3.8-5 Argonne National Laboratory Center for Transportation Research, “State-Level Accident Rates of Surface Freight Transportation: A Reexamination,” Saricks & Tompkins, ANL/ESD/TM-150, April 1999

3.8-6 Oak Ridge National Laboratories, “Transportation Routing Analysis Geographic Information System (TRAGIS) User’s Manual,” ORNL/NTRC-006, Revision 0, June 2003

3.8-7 Sandia National Laboratories, “RADCAT 2.3 User Guide,” SAND2006-6315, Revision 1, April 2008

3.8-8 U.S. Nuclear Regulatory Commission, “Reexamination of Spent Fuel Shipment Risk Estimates,” Sprung, et. al.,NUREG/CR-6672, 2000

Table 3.8-1 Summary Table S-4 – Environmental Impact of Transportation of Fuel and Waste To and From One Light-Water-Cooled Nuclear Power Reactor[1]

Normal Conditions of Transport

Condition	Value
Heat (per irradiated fuel cask in transit)	250,000 Btu/hr
Weight (governed by Federal or State restrictions)	73,000 lbs Per truck 100 tons per cask per rail car
Traffic density:	
Truck	Less than 1 per day
Rail	Less than 3 per month

Exposed Population	Estimated Number of Persons Exposed	Range of Doses to Exposed Individuals [2] (per reactor year)	Cumulative Dose to Exposed Population (per reactor year) [3]
Transport workers	200	0.01 to 300 millirem	4 man-rem
General public:			
Onlookers	1100	0.003 to 1.3 millirem	3 man-rem
Along Route	600,000	0.0001 to 0.06 millirem	

Accidents in Transport

Types of Effects	Environmental Risk
Radiological effects	Small [4]
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year

Notes:

1. Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," WASH-1238, December 1972, and Supp. 1 NUREG-75/038 April 1975.
2. The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5000 millirem per year for individuals as a result of occupational exposure and should be limited to 500 millirem per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirem per year.
3. Man-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirem) each, the total man-rem dose in each case would be 1 man-rem.

4. Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multi-reactor site.

Table 3.8-2 ESBWR Transportation Worksheet

Parameters	Table S-4 Condition (Reference Reactor) [1]	ESBWR (Single unit) (1500 MWe)
Reactor Characteristic:		
Reactor Power Level	Not exceeding 3800 MWt per reactor	4500 MWt
Fuel Form	Sintered UO_2 pellets	Sintered UO_2 pellets
U-235 Enrichment	Not exceeding 4%	Initial Core < 3.5%; Reload average < 4.6%
Fuel Rod Cladding	Zircaloy rods; 10 CFR 50.44 allows use of ZIRLO	Zircaloy
Average Burnup	Not exceeding 33,000 MWd	46,000 MWd/MTU
Unirradiated Fuel:		
Transport Mode	Truck	Truck
Irradiated Fuel:		
Transport Mode	Truck, rail or barge	Truck, rail
Decay Time Prior To Shipment	Not less than 90 days is a condition for use of Table S-4; 5 years is per contract with DOE	Five years
Radioactive Waste:		
Transport Mode	Truck or Rail	Truck
Waste Form	Solid	Solid
Packaged	Yes	Yes

Notes:

1. The Reference Reactor refers to a typical 1100 MWe light-water-cooled nuclear reactor as described in WASH-1238.

Table 3.8-3 Number of Truck Shipments of Unirradiated Fuel

Reactor Type	**Initial Core[(a)]**	**Annual reload**	**Total[(b)]**	**Unit electric Generation (MWe)[(c)]**	**Capacity Factor[(c)]**	**Normalized Shipments Total[(d)]**	**Normalized shipments Annual[(e)]**
Reference LWR	18[(f)]	6.0	252	1100	0.8	252	6.3
ESBWR	38[(g)]	7.91[(g)]	346	1594	0.93	205	5.1

Notes:

a. Shipments of the initial core have been rounded up to the next highest whole number.

b. Total shipments of unirradiated fuel over 40-year plant lifetime (initial core plus 39 years of average annual reload quantities).

c. Unit generating capacities from the ESBWR DCD and an assumed capacity factor consistent with ER 5.7.

d. Normalized to electric output for WASH-1238 reference plant (1100-MWe plant at 80 percent or an electrical output of 880 MWe).

e. Annual average for 40-year plant lifetime.

f. The initial core load for the reference boiling water reactor in WASH-1238 was 150 metric tons of uranium (MTU). The initial core load for the reference pressurized water reactor was 100 MTU. Both types result in 18 truck shipments of fresh fuel per reactor.

g. Initial core load of 1132 assemblies required and 474 assemblies per 2 years for refueling. Number of assemblies per shipment is 30.

Table 3.8-4 Number of Truck Shipments of Irradiated Fuel

Reactor Type	**Annual Reload MTU**	**Annual Shipments (b)**	**Unit Electric Generation (MWe)(c)**	**Capacity Factor(c)**	**Normalized Shipments Annual(d)**
Reference LWR	30	60	1100	0.8	60
ESBWR	34.1(a)	68.2	1594	0.93	39.5

Notes:

a. Based on reload of 68.197 MTU every two years.

b. Total shipments of irradiated fuel over 40-year plant lifetime (39 years of average annual reload quantities), 0.5 MTU per shipment.

c. Unit generating capacities from the ESBWR DCD and an assumed capacity factor consistent with ER 5.7.

d. Normalized to electric output for WASH-1238 reference plant (1100-MWe plant at 80 percent or an electrical output of 880 MWe).

Table 3.8-5 Number of Truck Shipments of Radioactive Waste

Reactor Type	**Annual Waste Shipped, m^3**	**Annual Shipments[(b)]**	**Unit Electric Generation (MWe)[(c)]**	**Capacity Factor[(c)]**	**Normalized Shipments Annual[(d)]**
Reference LWR	107.6	46	1100	0.8	46
ESBWR	448.8[(a)]	192	1594	0.93	114

Notes:

a. ESBWR DCD, Section 11.4, is 363 m^3 of dry active waste and 85.8 m^3 of wet solid waste.

b. WASH-1238, Table 8 reports 3800 ft^3/yr of solid wastes and a total of 46 shipments per year for solid waste. Amount per shipment is 82.61 ft^3 or 2.34 m^3.

c. Unit generating capacities from the DCD and an assumed capacity factor consistent with ER 5.7.

d. Normalized to electric output for WASH-1238 reference plant (1100-MWe plant at 80 percent or an electrical output of 880 MWe).

Table 3.8-6 Non-radiological Transportation Impacts - Accidents, Injuries, and Fatalities per Shipment, Round Trip

	Distance (km)	Accidents	Injuries	Fatalities
Unirradiated Fuel	2796	7.13E-04	6.07E-04	3.35E-05
Irradiated Fuel	7228	2.44E-03	1.50E-03	8.32E-05
Radioactive Waste	1600	5.34E-04	3.52E-04	2.08E-05

Table 3.8-7 Non-radiological Transportation Impacts - Accidents, Injuries, and Fatalities Annually

	Number of Trips (normalized)	Accidents/yr	Accident Cost/yr[(a)]	Injuries/yr	Fatalities/yr
Unirradiated Fuel	5.1	3.64E-03	$6.55	3.10E-03	1.71E-04
Irradiated Fuel	39.5	9.64E-02	$174	5.93E-02	3.29E-03
Radioactive Waste	114	6.09E-02	$110	4.01E-02	2.37E-03
Table S-4	-	-	$475	1.00E-01	1.00E-02

Notes:

a. Accident cost per year based on WASH-1238 cost per accident of $1800.

Table 3.8-8 RADTRAN 5 Input Parameters for Analysis of Unirradiated Fuel Shipments (Sheet 1 of 2)

Parameter	Parameter Value	Comments and Reference
Package		
Package Dimension – New Fuel Shipment	7.3 m	NUREG-1817, Table H-4
Radiation dose at 1 m from package	0.1 mrem/hr	WASH-1238
Fraction of emitted radiation that is gamma	1	Assumed the same as for spent nuclear fuel (conservative)
Crew		
Number of crew	2	WASH-1238 and DOE 2002
Crew Distance	2 m	Assumed minimum distance (Sand 2008)
Crew Shielding Factor	1	No shielding – analytical Assumption
Route-specific parameters		
Vehicle speed (rural, suburban, and urban)	88 km/hr	Conservative in-transit speed of 55 mph (88 km/hr) assumed (predominantly interstate highways used)
Number of persons per vehicle sharing route	2	The bureau of transportation services suggests a value of 1.2 persons per vehicle. 2 persons per vehicle chosen based on direction in RADTRAN manual (Reference 3.8-7)
Vehicle Density (vehicles/hr) Rural Suburban Urban	1155 2414 5490	National average from RADTRAN manual for interstate highways
Truck Stop Parameters		
Minimum and Maximum radius of annular area surrounding truck stop	10 m to 800 m	NUREG-1817, Table H-7
Population Density at truck stop	30,000 persons/km^2	NUREG-1817, Table H-7
Population Density Surrounding Truck Stop (outside of 800 m radius)	340 persons/km^2	NUREG-1817, Table H-7
Shielding Factor for Population at Truck stop (10 m to 800 m radius)	1	NUREG-1817, Table H-7
Shielding Factor for Population Surrounding Truck Stop (outside of 800 m radius)	0.2	NUREG-1817, Table H-7
Stop time	30 minutes per 4 hours of driving time	NUREG-1817
Distances (km)		
Rural Suburban Urban	795.7 554.5 47.9	WebTRAGIS generated values

Table 3.8-8 RADTRAN 5 Input Parameters for Analysis of Unirradiated Fuel Shipments (Sheet 2 of 2)

Parameter	Parameter Value	Comments and Reference
Population densities (persons per km^2)		
Rural Suburban Urban	17.9 336.5 2198.9	WebTRAGIS generated values using 2000 U.S. census data

Table 3.8-9 Annual Radiological Impacts of Transporting Unirradiated Fuel

	Number of Shipments[a]	Exposed Population	Dose Person-rem/ shipment	Cumulative Annual Dose, person-rem per reference reactor year	Table S-4 Limit per reference reactor year, person-rem
Fermi 3	5.1	Crew	4.05E-03	2.07E-02	4
		Onlookers	1.46E-03	7.46E-03	3
		Along route	6.39E-05	3.26E-04	3
Reference LWR[b]	6.3	Crew	-	1.10E-02	4
		Onlookers	-	4.20E-02	3
		Along route	-	1.00E-03	3

Notes:

a. Normalized to electric output for WASH-1238 reference plant (1100-MWe plant at 80 percent or an electrical output of 880 MWe).

b. NUREG-1817, Table 6-5

Table 3.8-10 RADTRAN 5 Input Parameters for Analysis of Spent Fuel Shipments (Sheet 1 of 2)

Parameter	Parameter Value	Comments and Reference
Package		
Package Dimension – Spent Fuel Shipment	5.2 m	DOE 2002 (Reference 3.8-2)
Radiation dose at 1 m from package	14 mrem/hr	RADTRAN input selected to limit dose rate to 10 mrem/hr limit at 2 meters (Reference 3.8-7)
Fraction of emitted radiation that is gamma	1.0	Escape probability is higher for gamma (conservative)
Crew		
Number of crew	2	WASH-1238 and DOE 2002 (Reference 3.8-2)
Crew Distance	3.1 m	DOE 2002 (Reference 3.8-2)
Dose rate to crew	2.0 mrem/hr	49 CFR 173.441
Route-specific parameters		
Vehicle speed (rural, suburban, and urban)	88 km/hr	Conservative in-transit speed of 55 mph (88 km/hr) assumed (predominantly interstate highways used)
Number of persons per vehicle sharing route	2	The bureau of transportation services suggests a value of 1.2 persons per vehicle. 2 persons per vehicle chosen based on direction in RADTRAN manual (Reference 3.8-7)
Vehicle Density (vehicles/hr) Rural Suburban Urban	 1155 2414 5490	National average from RADTRAN manual for interstate highways (Reference 3.8-7)
Truck Stop Parameters		
Minimum and Maximum radius of annular area surrounding truck stop	10 m to 800 m	NUREG-1817, Table H-7
Population Density at truck stop	30,000 persons/km^2	NUREG-1817, Table H-7
Population Density Surrounding Truck Stop (outside of 800 m radius)	340 persons/km^2	NUREG-1817, Table H-7
Shielding Factor for Population at Truck stop (10 m to 800 m radius)	1	NUREG-1817, Table H-7
Shielding Factor for Population Surrounding Truck Stop (outside of 800 m radius)	0.2	NUREG-1817, Table H-7
Stop time	30 minutes per 4 hours of driving time	NUREG-1817

Table 3.8-10 RADTRAN 5 Input Parameters for Analysis of Spent Fuel Shipments (Sheet 2 of 2)

Parameter	Parameter Value	Comments and Reference
Distances (km)		
Rural Suburban Urban	3064.3 488.1 61.2	WebTRAGIS generated values (Reference 3.8-6)
Population densities (persons per km^2)		
Rural Suburban Urban	8.5 309.6 2341.2	WebTRAGIS generated values using 2000 U.S. census data (Reference 3.8-6)

Table 3.8-11 Annual Radiological Impacts of Transporting Spent Fuel

	Number of Shipments[a]	Exposed Population	Dose Person-rem/ shipment	Cumulative Annual Dose, person-rem per reference reactor year	Table S-4 Limit per reference reactor year, person-rem
Fermi 3	39.5	Crew	1.66E-01	6.6	4
		Onlookers	3.75E-01	14.8	3
		Along route	5.48E-03	0.2	3
Reference LWR[b]	60	Crew	-	1.2	4
		Onlookers	-	0.8	3
		Along route	-	1.0	3

Notes:

a. Normalized to electric output for WASH-1238 reference plant (1100-MWe plant at 80 percent or an electrical output of 880 MWe).

b. NUREG-1817, Table 6-5

Table 3.8-12 Spent Fuel Radionuclides for ESBWR

Radionuclide	Ci/MTU
Am-241	1.30E+03
Am-242m	2.79E+01
Am-243	3.26E+01
Ce-144	1.35E+04
Cm-242	4.86E+01
Cm-243	3.47E+01
Cm-244	4.96E+03
Cm-245	6.75E-01
Co-60	2.86E+03
Cs-134	5.19E+04
Cs-137	1.27E+05
Eu-154	1.04E+04
Eu-155	5.40E+03
I-129	4.24E-02
Kr-85	9.27E+03
Pm-147	3.53E+04
Pu-238	6.15E+03
Pu-239	3.86E+02
Pu-240	6.22E+02
Pu-241	1.22E+05
Pu-242	2.24E+00
Ru-106	1.86E+04
Sb-125	4.81E+03
Sr-90	9.08E+04
Y-90	9.09E+04

Table 3.8-13 Annual Spent Fuel Transportation Accident Radiological Impacts

	Unit Population Dose (person-rem)[a]	Number of Shipments[b]	Population Dose person-rem per reference reactor year
Fermi 3	5.90E-08	39.5	2.33E-06
Table S-4	-	-	SMALL

Notes:

a. The RADTRAN output was adjusted for 0.5 MTU per shipment for the unit population dose.

b. Normalized to electric output for WASH-1238 reference plant (1100-MWe plant at 80 percent or an electrical output of 880 MWe).

Table 3.8-14 Distances and Population Densities for Transportation of Unirradiated Fuel to Alternate Sites

	Distance (km)			Population Density		
Site	**Rural**	**Suburban**	**Urban**	**Rural**	**Suburban**	**Urban**
Fermi Site	795.7	554.5	47.9	17.9	336.5	2198.9
Site A – Monroe County	805.4	557.5	50.6	18.0	337.3	2205.6
Site C – Lenawee County	805.4	557.5	50.6	18.0	337.3	2205.6
Site F – St. Clair County	837.1	645.8	83.2	18.1	351.2	2314.4
Site N – St. Clair County	812.9	609.1	75.9	18.0	348.3	2289.3
Site W1 – Huron County	960.0	717.3	80.1	17.6	352.6	2262.0
Site W2 – Huron County	960.0	717.3	80.1	17.6	352.6	2262.0
Site W3 – Huron County	960.0	717.3	80.1	17.6	352.6	2262.0

Table 3.8-15 Distances and Population Densities for Transportation of Irradiated Fuel to Alternate Sites

	Distance (km)			Population Density		
Site	Rural	Suburban	Urban	Rural	Suburban	Urban
Fermi Site	3064.3	488.1	61.2	8.5	309.6	2341.2
Site A – Monroe County	3074.1	493.2	63.9	8.6	310.8	2340.3
Site C – Lenawee County	3074.1	493.2	63.9	8.6	310.8	2340.3
Site F – St. Clair County	3082.3	561.5	56.6	8.8	304.1	2308.0
Site N – St. Clair County	3019.8	554.7	78.6	8.6	322.4	2345.6
Site W1 – Huron County	3145.0	577.8	59.2	8.7	313.2	2290.9
Site W2 – Huron County	3145.0	577.8	59.2	8.7	313.2	2290.9
Site W3 – Huron County	3145.0	577.8	59.2	8.7	313.2	2290.9