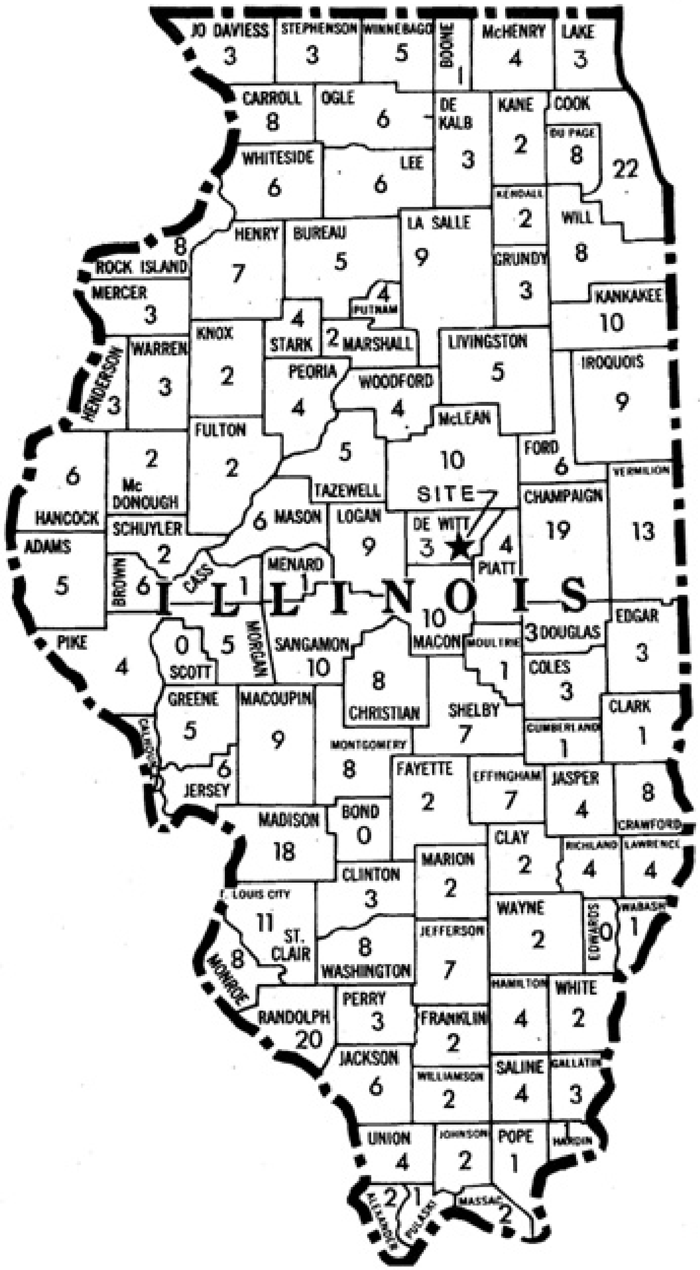
Environmental Report for the EGC Early Site Permit

Figure 2.7-1
Number of Tornadoes per County (1916-1969) 54 Year Period



Legend

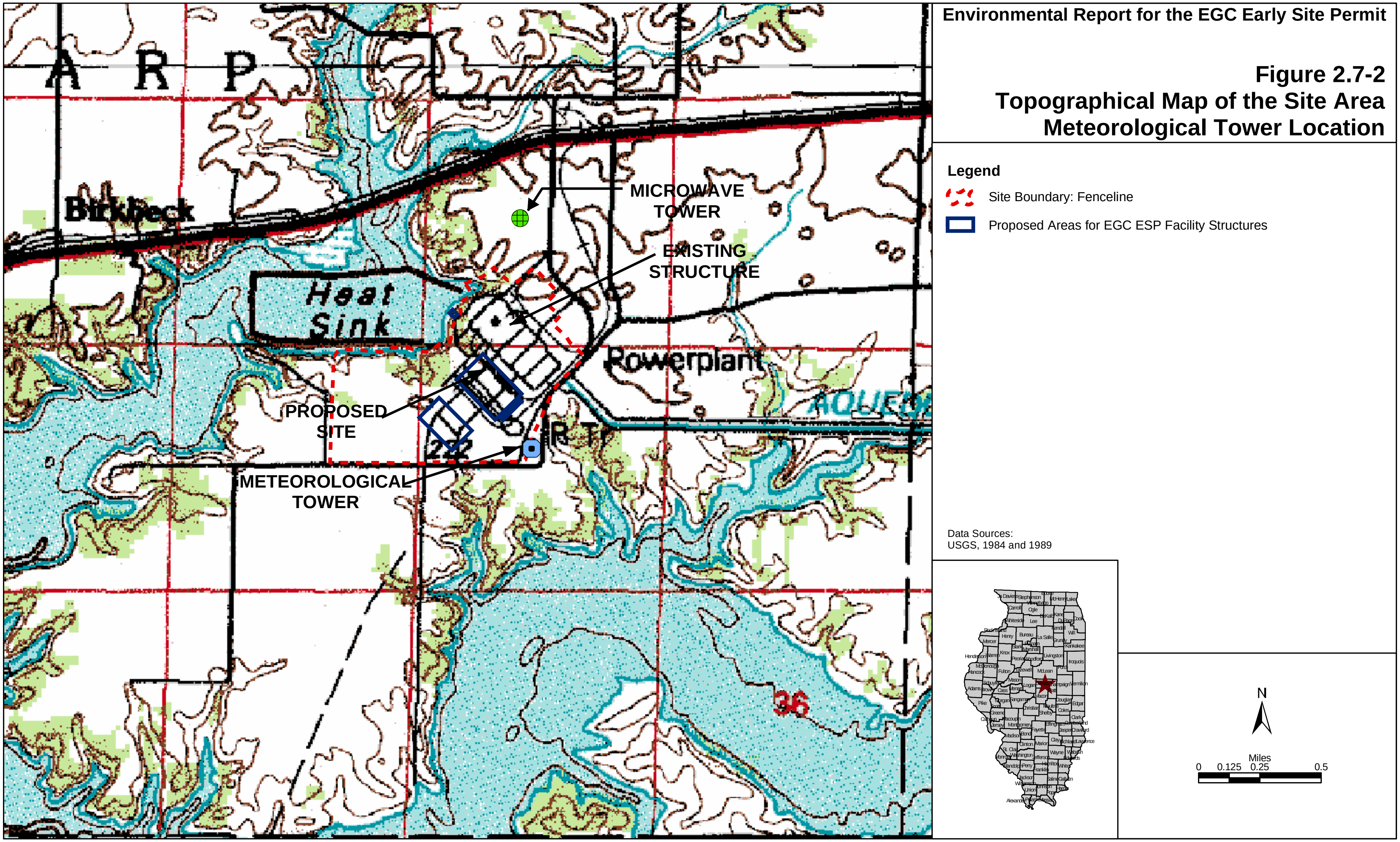
9 denotes the number of tornadoes reported in Iroquois County during the period 1916-1969

Data Source:
CPS, 2002

N

Not to Scale

Figure 2.7-2
Topographical Map of the Site Area
Meteorological Tower Location



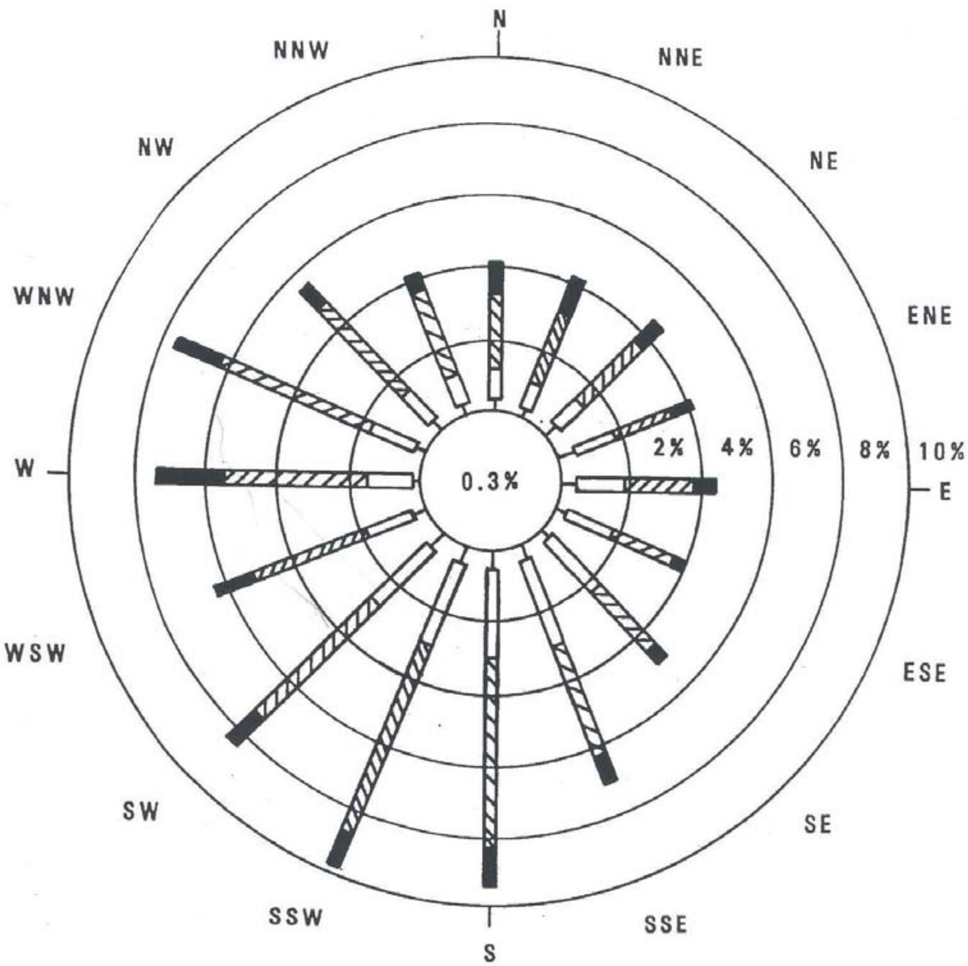
Legend

- Site Boundary: Fenceline
- Proposed Areas for EGC ESP Facility Structures

Data Sources:
USGS, 1984 and 1989

Environmental Report for the EGC Early Site Permit

Figure 2.7-3
Wind Rose, 10-Meter Level, Clinton Power Station Site, Period of Record: 4/14/72-4/30/77



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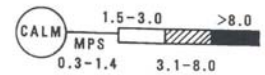
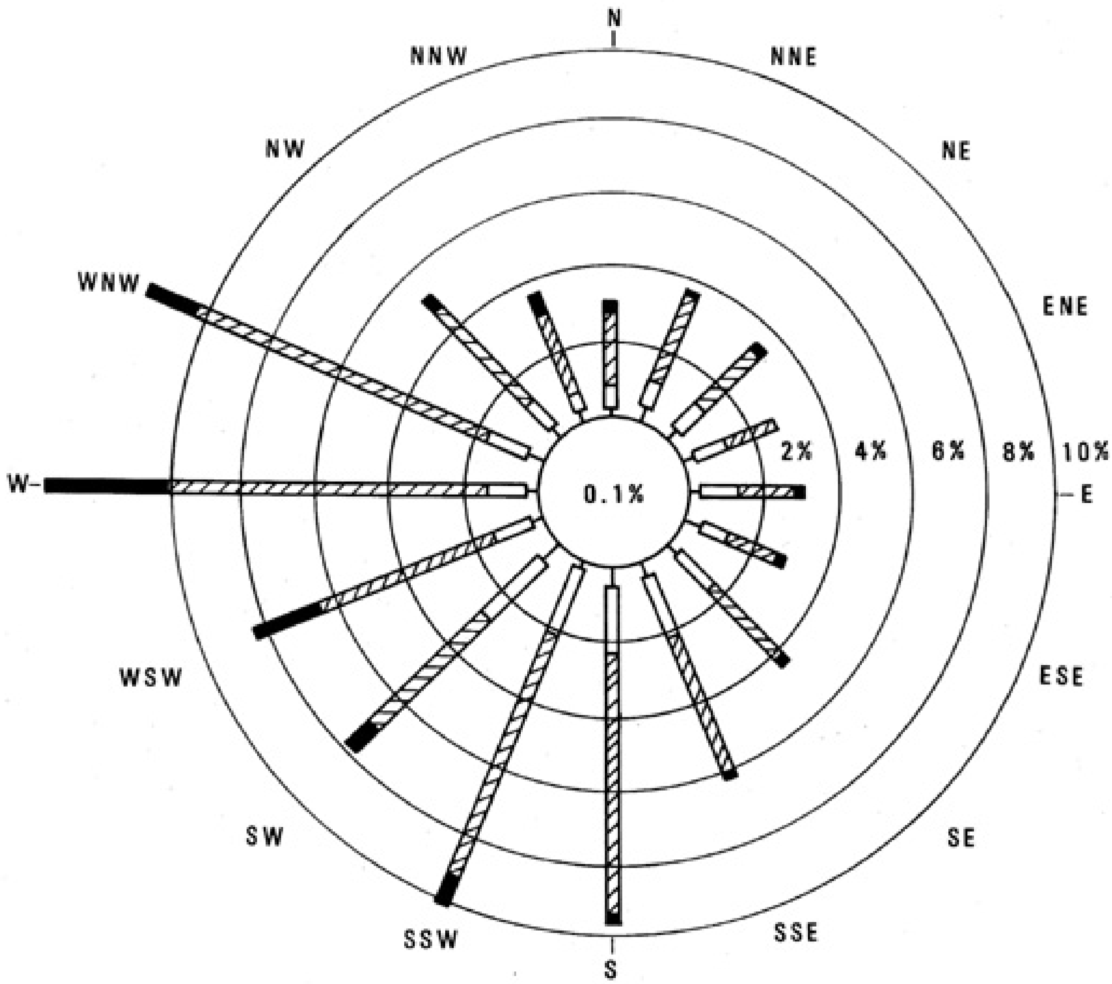


Data Source:
CPS, 2002

Not to Scale

Environmental Report for the EGC Early Site Permit

Figure 2.7-4
Wind Rose, 10-Meter Level, Clinton Power Station Site, Composite January
Period of Record: 4/14/72-4/30/77



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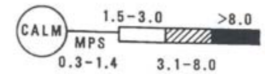
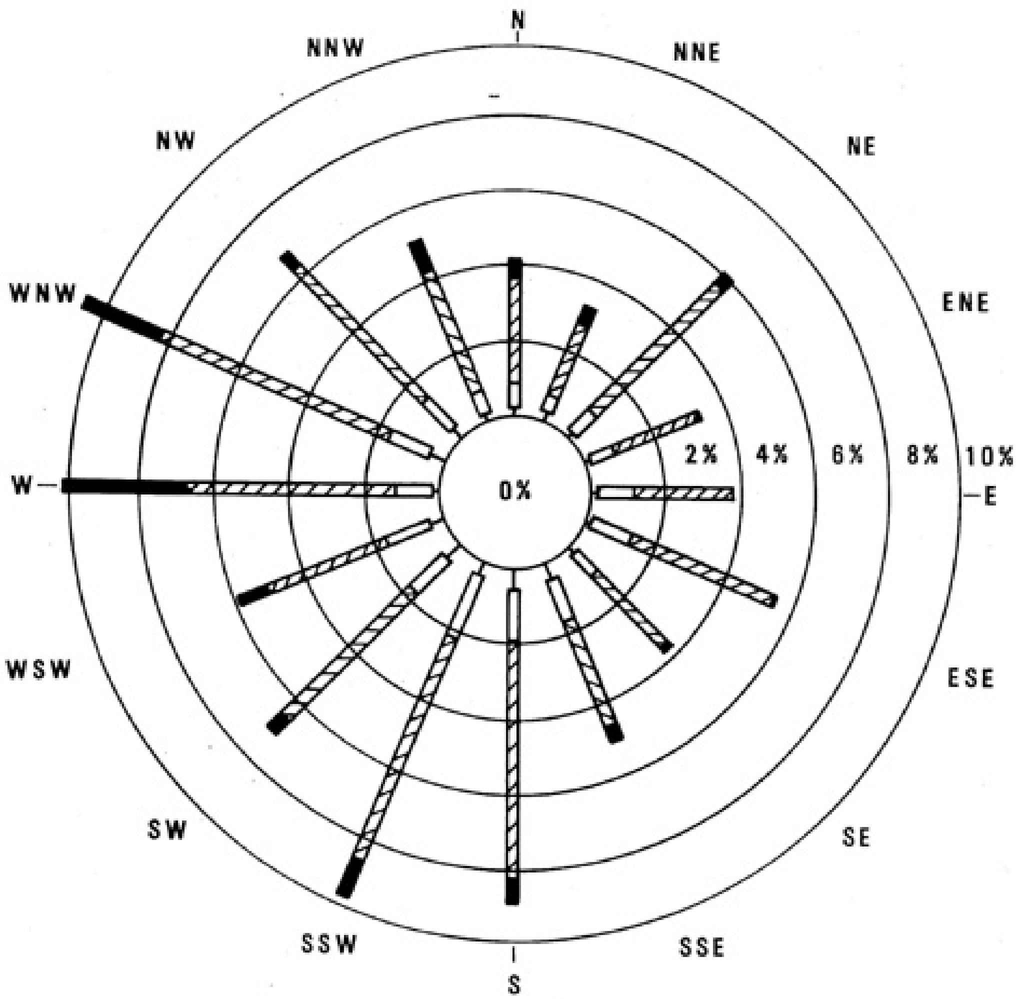


Data Source:
CPS, 2002

Not to Scale

Environmental Report for the EGC Early Site Permit

Figure 2.7-5
Wind Rose, 10-Meter Level, Clinton Power Station Site, Composite February
Period of Record: 4/14/72-4/30/77



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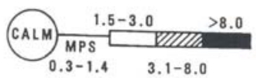
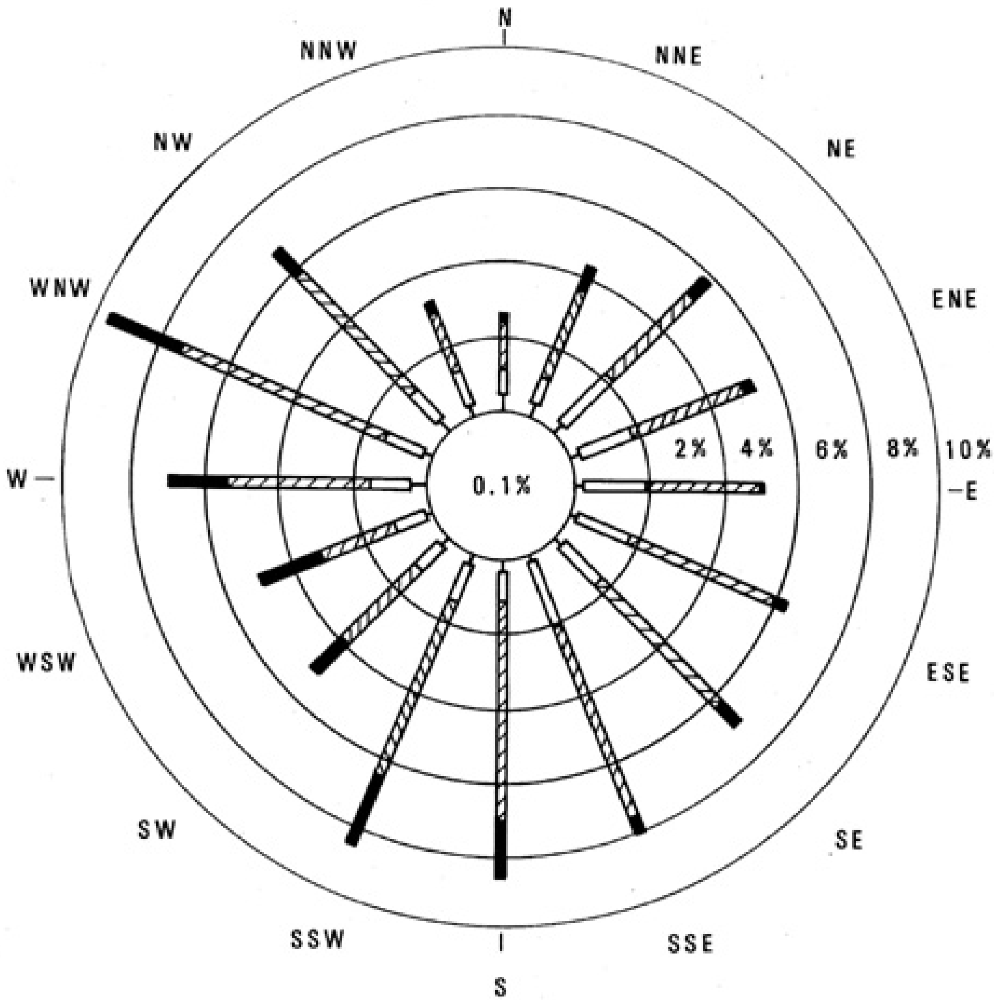


Data Source:
CPS, 2002

Not to Scale

Environmental Report for the EGC Early Site Permit

Figure 2.7-6
Wind Rose, 10-Meter Level, Clinton Power Station Site, Composite March
Period of Record: 4/14/72-4/30/77



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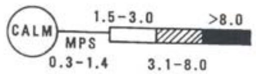
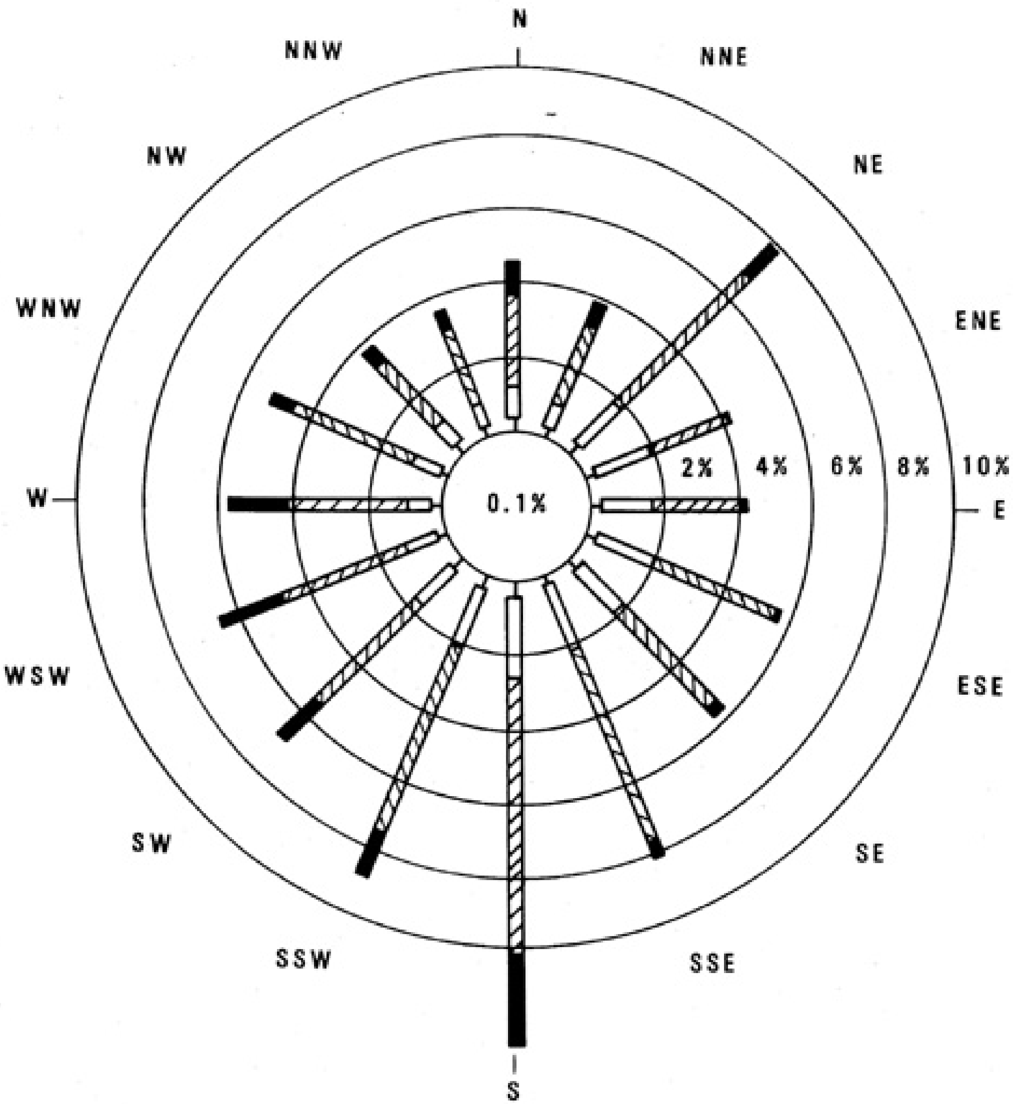


Data Source:
CPS, 2002

Not to Scale

Environmental Report for the EGC Early Site Permit

Figure 2.7-7
Wind Rose, 10-Meter Level, Clinton Power Station Site, Composite April
Period of Record: 4/14/72-4/30/77



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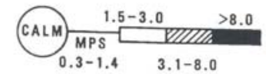
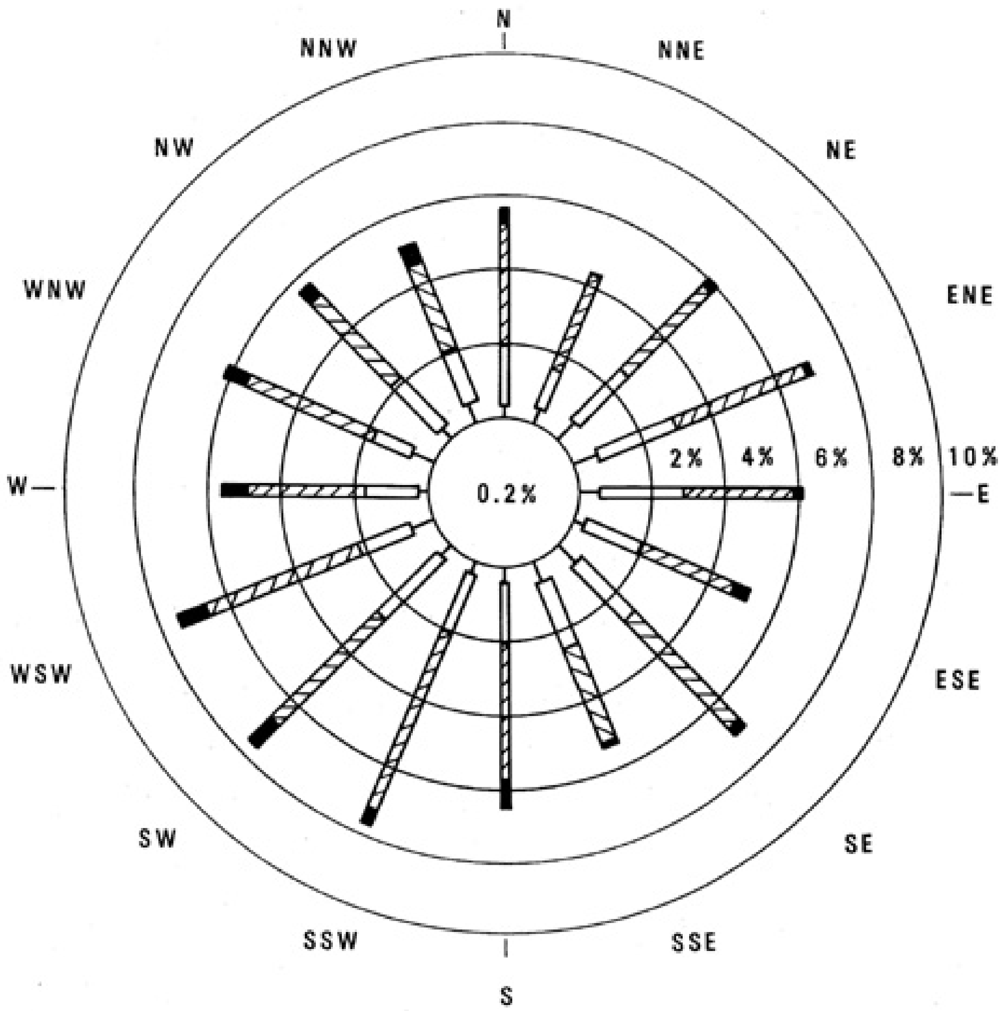


Data Source:
CPS, 2002

Not to Scale

Environmental Report for the EGC Early Site Permit

Figure 2.7-8
Wind Rose, 10-Meter Level, Clinton Power Station Site, Composite May
Period of Record: 4/14/72-4/30/77



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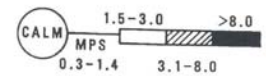
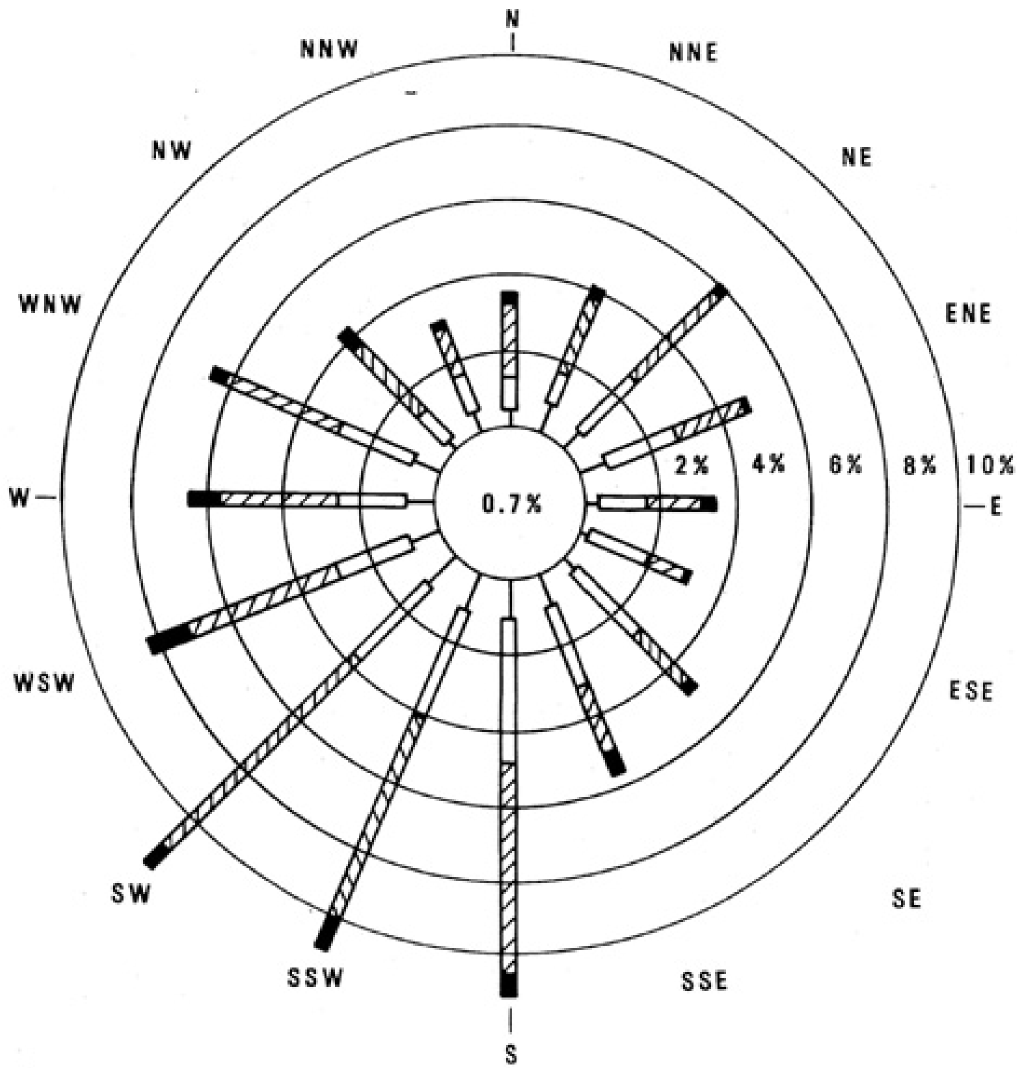


Data Source:
CPS, 2002

Not to Scale

Environmental Report for the EGC Early Site Permit

Figure 2.7-9
Wind Rose, 10-Meter Level, Clinton Power Station Site, Composite June
Period of Record: 4/14/72-4/30/77



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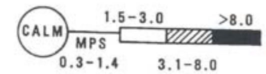


Data Source:
CPS, 2002

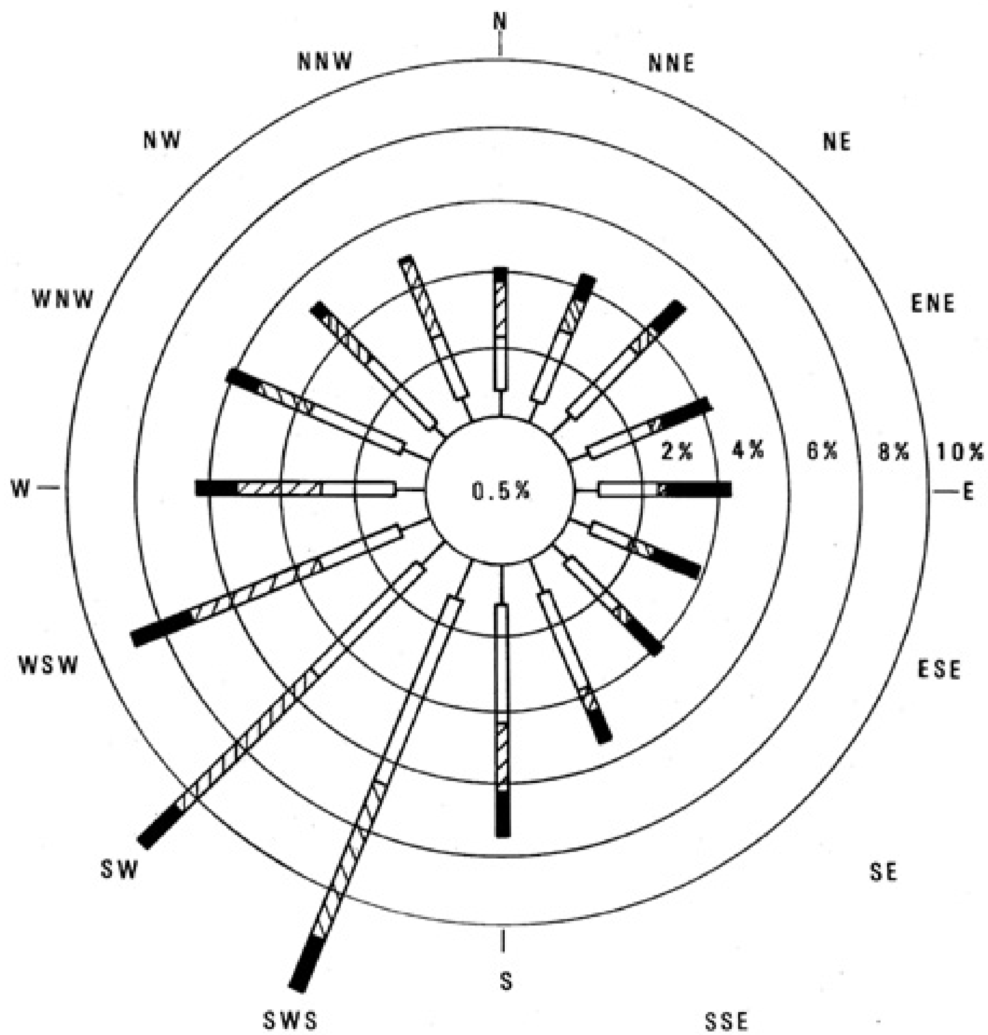
Not to Scale

Environmental Report for the EGC Early Site Permit

Figure 2.7-10

Wind Rose, 10-Meter Level, Clinton Power Station Site, Composite July

Period of Record: 4/14/72-4/30/77



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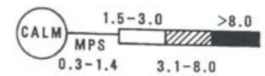
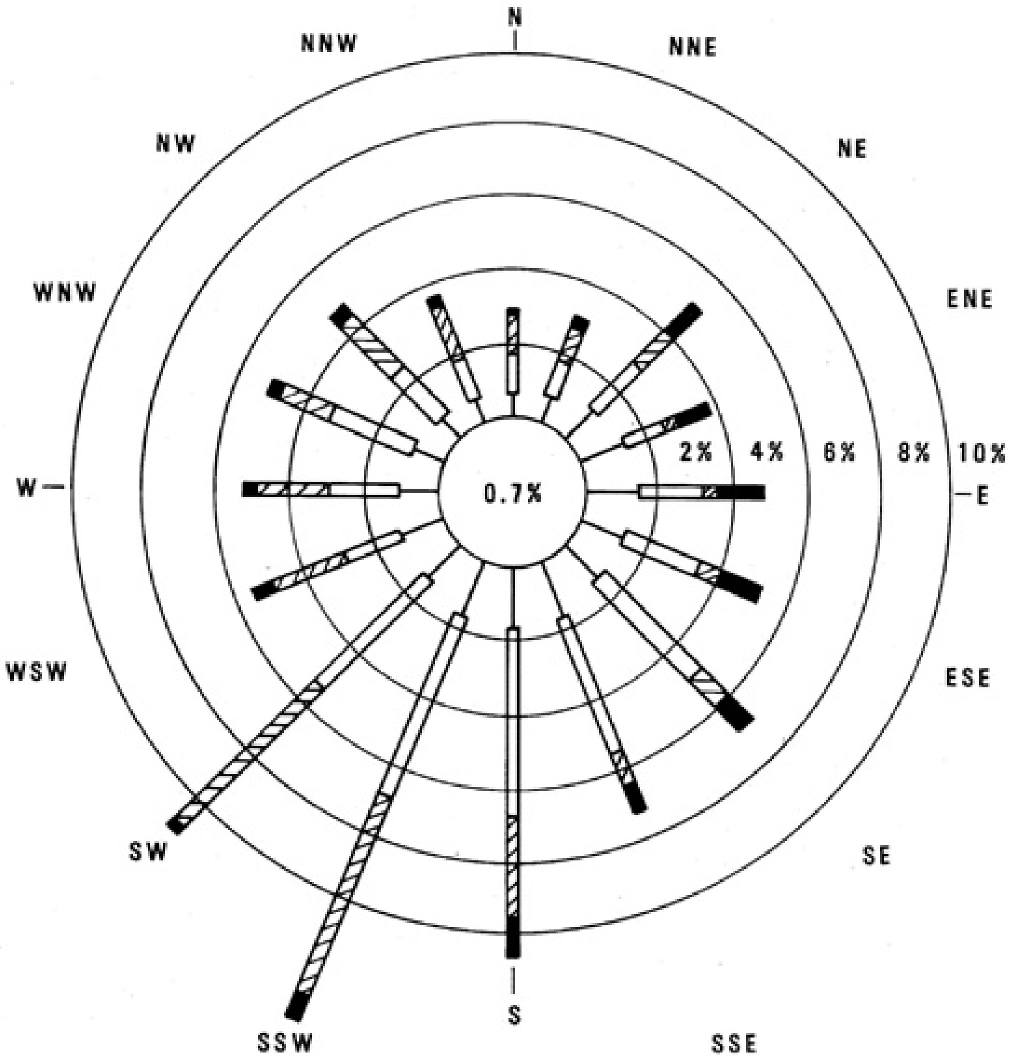


Data Source:
CPS, 2002

Not to Scale

Environmental Report for the EGC Early Site Permit

Figure 2.7-11
Wind Rose, 10-Meter Level,
Clinton Power Station Site,
Composite August
Period of Record: 4/14/72-4/30/77



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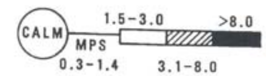
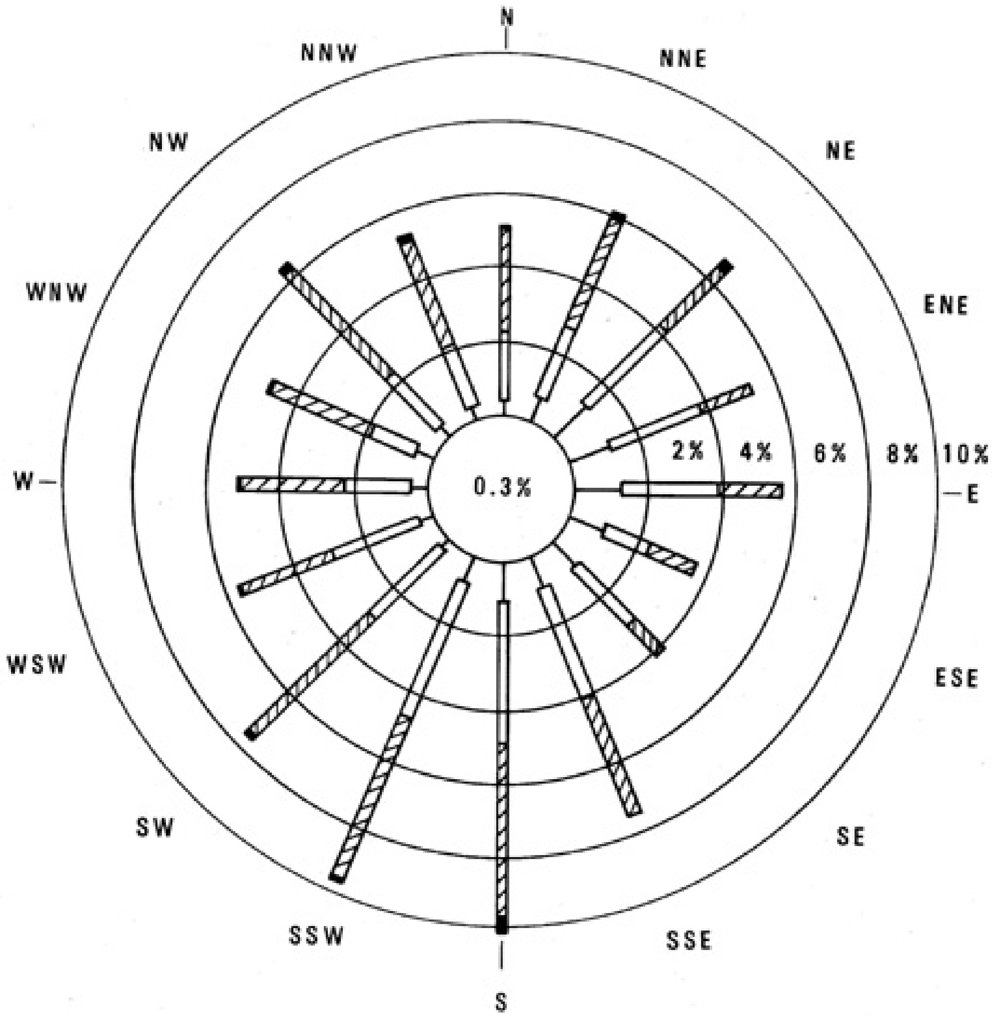


Data Source:
CPS, 2002

Not to Scale

Environmental Report for the EGC Early Site Permit

Figure 2.7-12
Wind Rose, 10-Meter Level, Clinton Power Station Site, Composite September
Period of Record: 4/14/72-4/30/77



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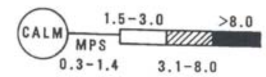
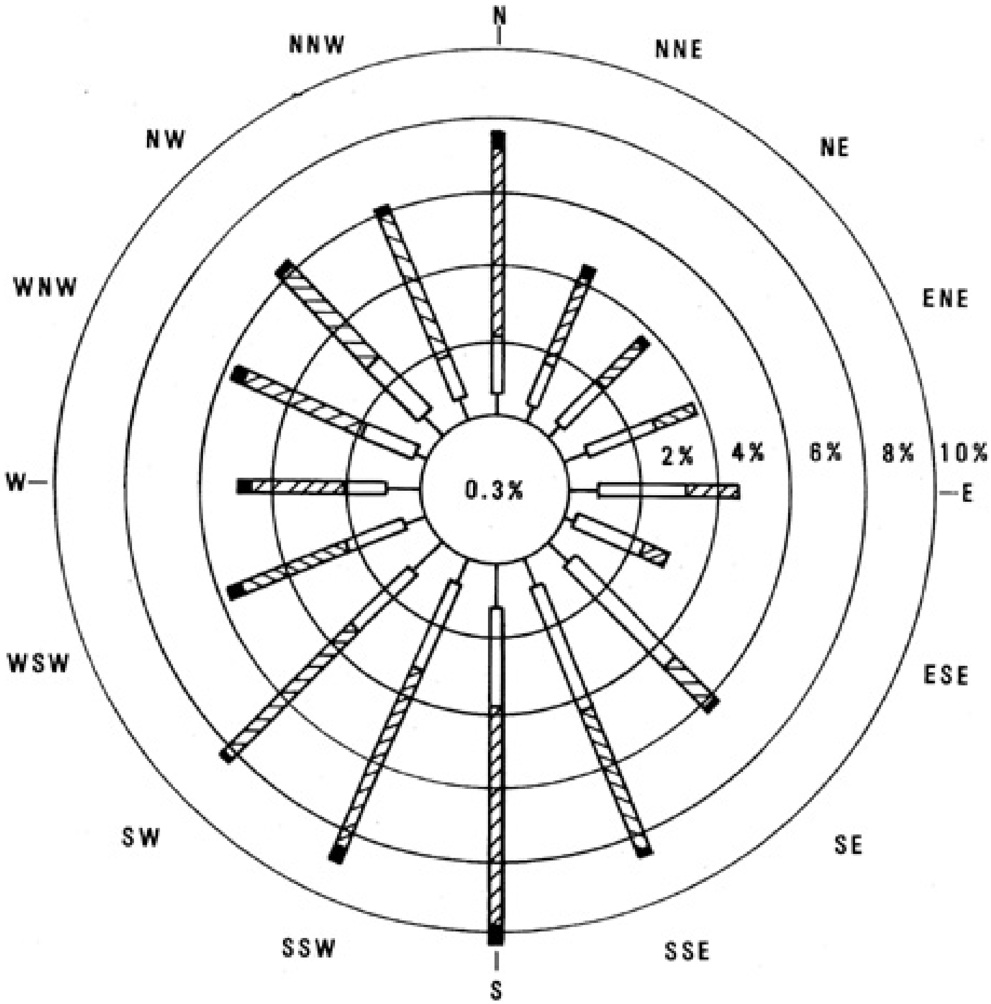


Data Source:
CPS, 2002

Not to Scale

Environmental Report for the EGC Early Site Permit

Figure 2.7-13
Wind Rose, 10-Meter Level, Clinton Power Station Site, Composite October
Period of Record: 4/14/72-4/30/77



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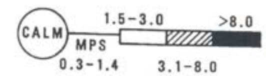
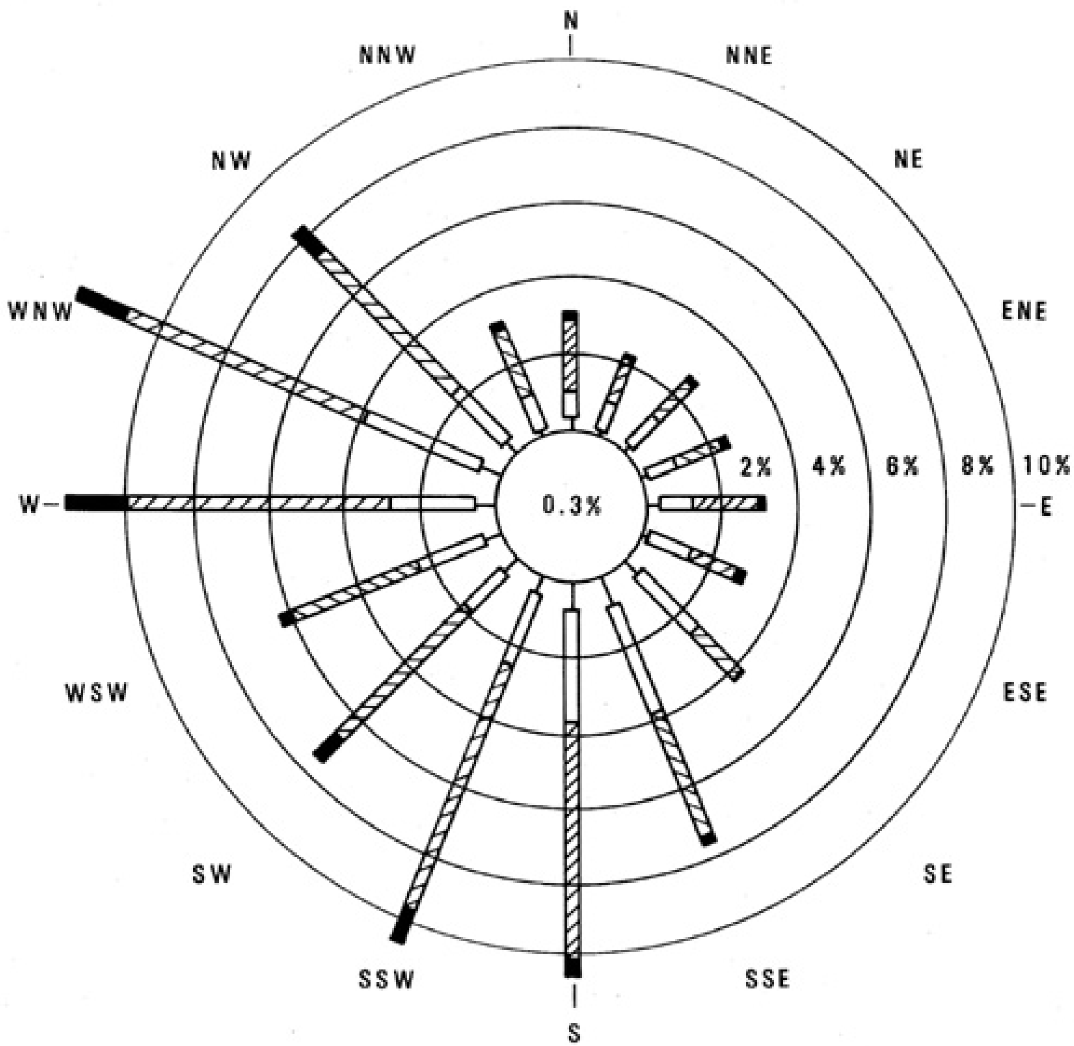


Data Source:
CPS, 2002

Not to Scale

Environmental Report for the EGC Early Site Permit

Figure 2.7-14
Wind Rose, 10-Meter Level,
Clinton Power Station Site,
Composite November
Period of Record: 4/14/72-4/30/77



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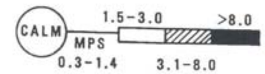
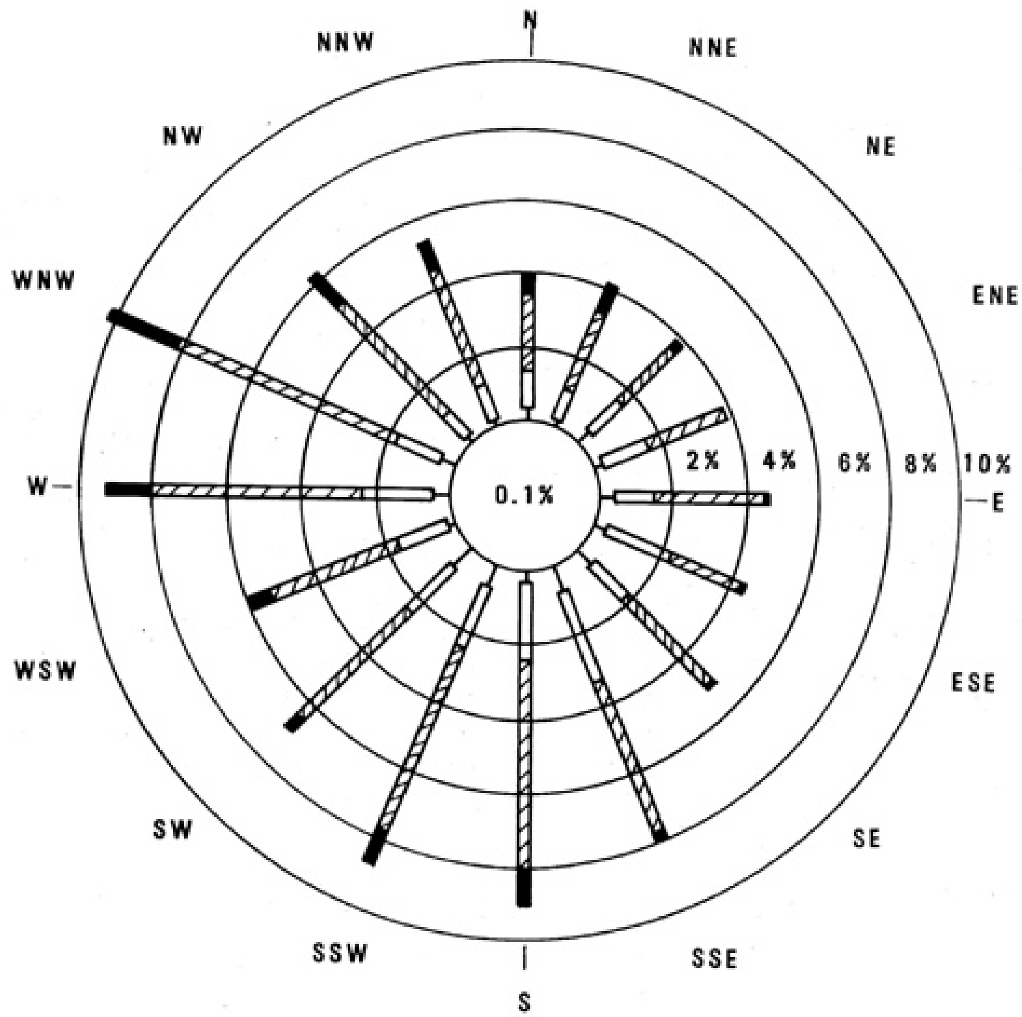


Data Source:
CPS, 2002

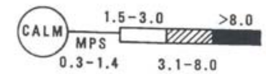
Not to Scale

Environmental Report for the EGC Early Site Permit

Figure 2.7-15
Wind Rose, 10-Meter Level, Clinton Power Station Site, Composite December
Period of Record: 4/14/72-4/30/77



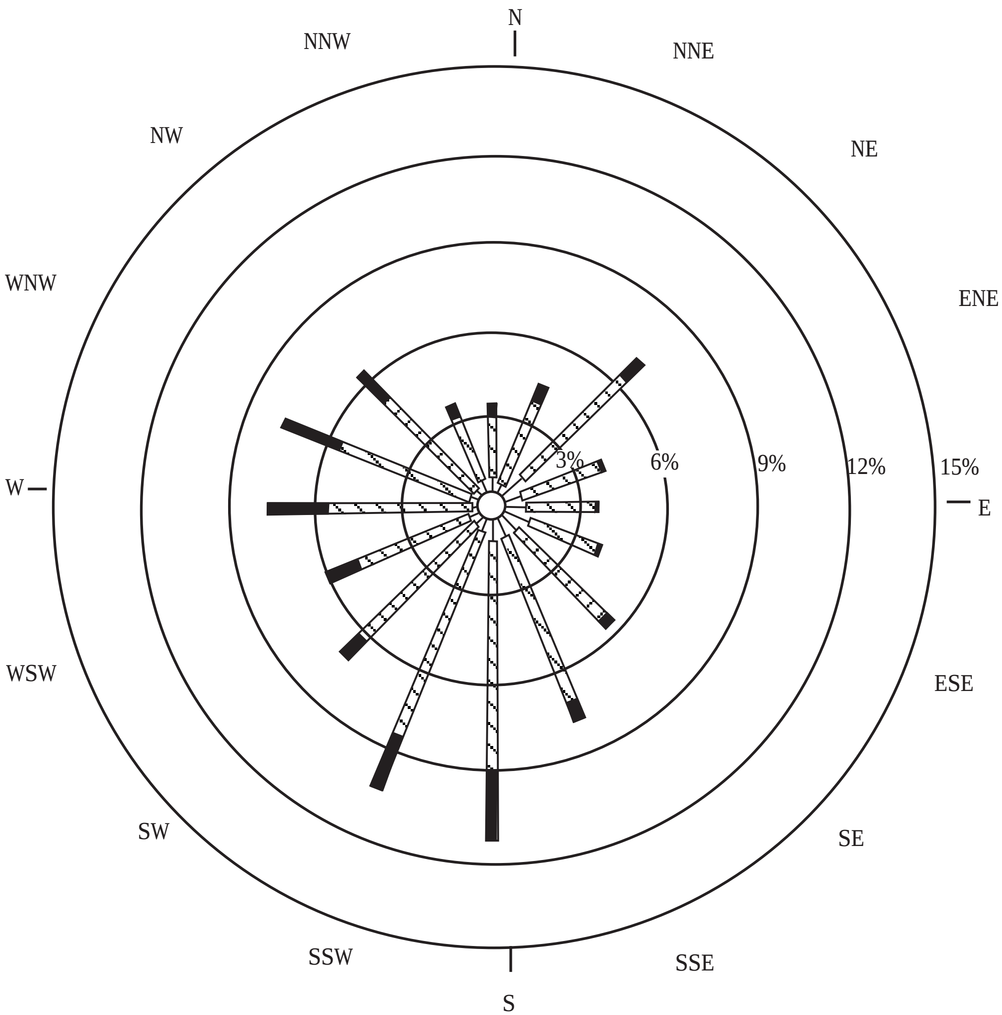
Legend



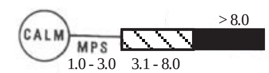
Data Source:
CPS, 2002

Not to Scale

Figure 2.7-16
Wind Rose, 10-Meter Level, Clinton Power Station Site, Period of Record: 1/1/00-8/31/02



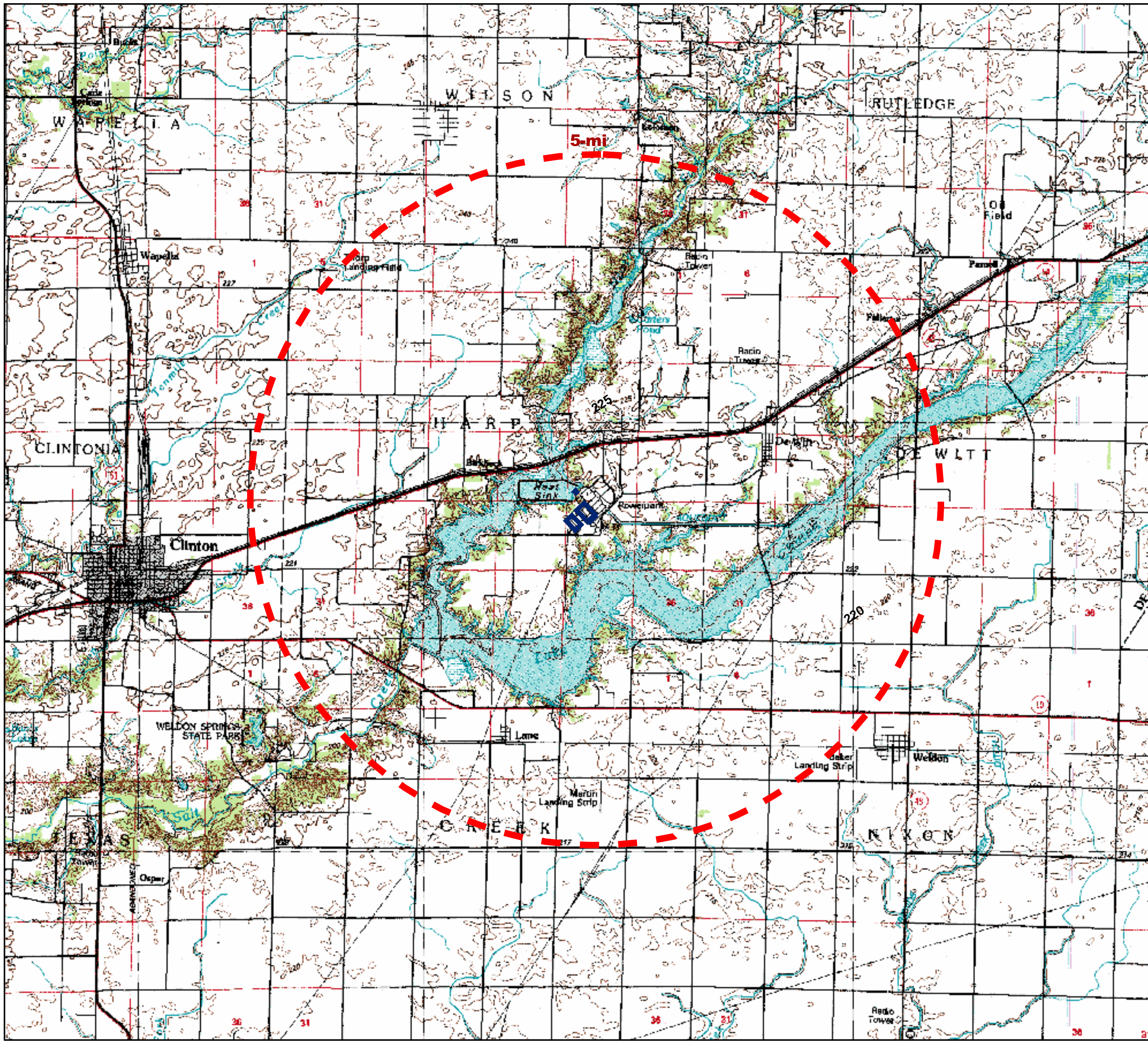
Legend



Data Source:
CPS, 2002

Not to Scale

Figure 2.7-17
Topographic Map Within 5 mi of the EGC ESP Site



Legend

Vicinity: 5-mi Radius Around Site

Proposed Areas for EGC ESP Facility Structures

Data Sources:
USGS, 1984 and 1989

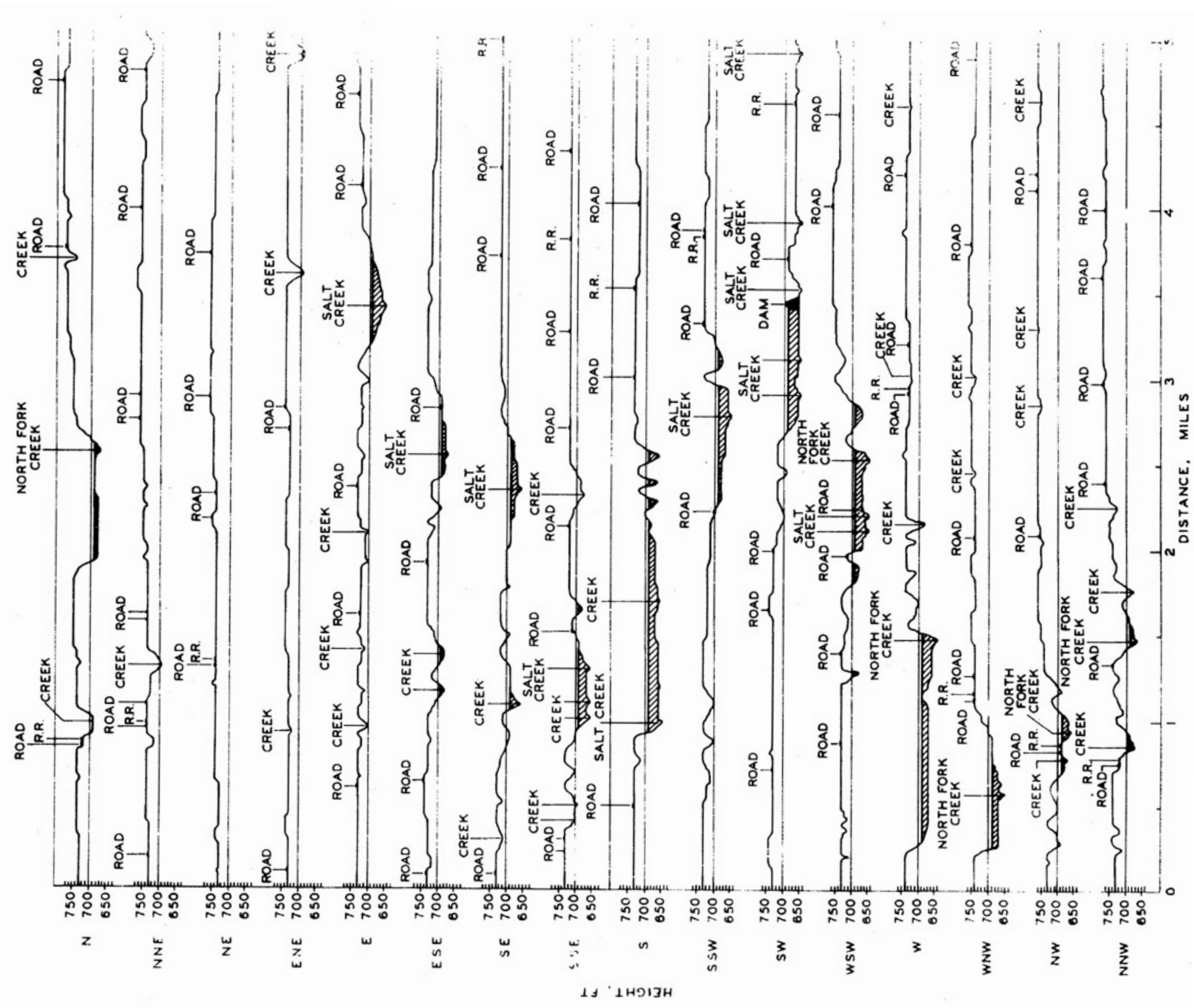
N

Miles

0 1 2 4

Environmental Report for the EGC Early Site Permit

Figure 2.7-18
Topographical Cross Section as a Function of the Distance From the Exelon ESP Site



Data Source:
CPS, 2002

Not to Scale

CHAPTER 3

Plant Description

This chapter describes potential impacts from possible plant designs on the selected EGC ESP Site. The specific reactor type for the EGC ESP Site has not been selected; however, sufficient information from a range of possible facilities is available to characterize the proposed development to support the application for an ESP. The bounding parameters outlined in this chapter and in Table 1.4-1 of the SSAR help ensure proper decisions about potential facilities and impacts at the site.

The EGC ESP Facility will be essentially independent of the CPS. With the exception of using the CPS UHS as a source of makeup water, no CPS safety-related systems or equipment will be shared or cross-connected. Raw water for cooling water makeup and other facility services will be provided from a new intake structure located on Clinton Lake adjacent to the CPS intake structure. Facility discharges will use the CPS discharge flume as a discharge path to Clinton Lake. Some structures, such as a warehouse, training buildings, and parking lots, may be shared. Some support facilities, such as domestic water supply and sewage treatment, may also be shared. The existing switchyard will be expanded to accommodate the output of the new facility and to provide the necessary off-site power. Detailed information about the EGC ESP Facility is presented in the sections that follow.

This chapter is organized into 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 Systems (Section 3.5);
- Nonradioactive Waste Management Systems (Section 3.6);
- Power Transmission System (Section 3.7); and
- Transportation of Radioactive Materials (Section 3.8).

For purposes of this ER, the site is defined as the property within the CPS fenceline (see Figure 2.1-3). The vicinity is the area within a 6-mi radius from the centerpoint of the site. The region of the site is the area between a 6-mi radius and a 50-mi radius from the centerpoint of the site.

3.1 External Appearance and Plant Layout

The specific technology and design for the proposed reactor(s) have not been selected. Sufficient information from a range of possible plants is available to characterize the proposed development to support the application for an ESP. An architectural rendering of the plant including landscaping will be provided at the COL phase because a specific plant design has not been selected.

The following description is based on generic plant characteristics associated with the various nuclear reactor technologies.

Seven advanced nuclear reactor design alternatives were used to develop bounding information necessary to support this application. The proposed development at the EGC ESP Site may be any one of the following advanced reactor designs, or a new design that falls within the range of surrogate plant parameter information developed to characterize the proposed development:

- PBMR – 8 modules;
- ABWR – 1 unit;
- AP1000 – 2 units;
- ESBWR – 1 unit
- IRIS – 3 units;
- GT-MHR – 4 modules; and
- ACR-700 – 2 units.

The gas reactors are of a low profile design and consist of modular arrangements of four and eight units for the GT-MHR and PBMR, respectively. The water reactors (i.e., the three-unit IRIS, dual-unit AP1000 and ACR-700, and the single-unit BWRs) are similar in appearance to the facility at the CPS.

A set of composite (or bounding) plant parameter values was developed to consider the values for the selected plant designs. Engineering judgment was applied so that the EGC ESP Facility is properly characterized. These PPEs values were used in the following sections of this document and were obtained from Table 1.4-1 of the SSAR.

3.1.1 Plant Location

The site chosen by the Applicant for an ESP is colocated on the CPS Site. This site is located in Harp Township, DeWitt County, approximately 6-mi east of the City of Clinton in Illinois. The EGC ESP Facility will be located approximately 700-ft south of the CPS. Detailed information regarding the proposed EGC ESP Site is provided in Chapter 2.

3.1.2 Planned Physical Activities

If the ESP is granted, and at EGC's discretion, EGC may perform the activities listed below:

- Preparation of the site for construction of the facility (such as clearing, grading, and construction of temporary access roads and borrow areas).
- Installation of temporary construction support facilities (such as warehouse and shop facilities, utilities, concrete mixing facilities, docking and unloading facilities, and construction support buildings).
- Excavation for facility structures.
- Construction of service facilities (such as roadways, paving, RR spurs, fencing, exterior utility and lighting systems, transmission lines, and sanitary sewage treatment facilities).
- Construction of structures, systems, and components, which do not prevent or mitigate the consequences of postulated accidents that could cause undue risk to the health and safety of the public.
- Drilling of sample/monitoring wells or additional geophysical borings.
- Construction of facility cooling tower structure(s) that are not safety-related.
- Construction of facility intake structures that are not safety-related.
- Installation of non-safety-related fire detection and protection equipment.
- Expansion of the CPS switchyard to accommodate the construction of the proposed EGC ESP Facility.
- Expansion of the CPS transmission system and substation (will not be performed by EGC).
- Modification of the CPS discharge flume to accommodate the EGC ESP Facility outflow (will not be performed by EGC and modification to the CPS NPDES permit may be required).

3.1.3 Station Layout and Appearance

The EGC ESP Facility will be a large industrial facility similar in general appearance to the CPS. The EGC ESP Facility may consist of a single reactor (unit) or multiple reactors (modules). As stated in the introduction, the EGC ESP Facility will be essentially independent of the CPS. With the exception of using the CPS UHS as a source of makeup water, no CPS safety-related systems or equipment will be shared or cross-connected. Clinton Lake will be used as a source of makeup water for the cooling water system. The CPS discharge flume will also be used for the EGC ESP Facility. Additional facilities, such as offices, a water intake structure, non-safety-related cooling tower structure(s), a security building, and miscellaneous storage buildings will also be constructed (see Figure 2.1-4). The structures will be made of concrete, wood, and wood with metal siding. In addition, it will be made at a maximum height of approximately 234-ft above grade. Some structures, such as warehouse and training buildings and parking lots, may be shared with the CPS. Some support facilities, such as domestic water supply and sewage treatment, may also be shared.

Full wet or dry/wet cooling systems may not be feasible options during severe drought conditions, but were assumed for most purposes throughout this chapter because they require the most significant water usage. As such, if required by reactor design, UHS cooling towers of the mechanical draft type will be located adjacent to the plot plan area on the southeast side, and will encompass 0.5 ac of land. The estimated height of these cooling towers is 60 ft (see SSAR Table 1.4-1).

Normal heat sink (NHS) cooling towers, either mechanical draft or natural draft hyperbolic types, for the normal (non-safety) plant cooling services will be located southeast of the major facility structures and will require a maximum siting area of approximately 50 ac. The estimated dimensions of the natural draft towers are 550-ft high and 550 ft in diameter (see SSAR Table 1.4-1).

Raw water for cooling water makeup and other facility services will be provided from a new intake structure located on Clinton Lake adjacent to the CPS intake structure. Cooling tower blowdown and other facility discharges will use the CPS discharge flume as a discharge path to Clinton Lake.

The existing switchyard will be expanded to accommodate the output of the new facility and to provide the necessary off-site power. The switchyard area intended for the planned CPS Unit 2 will be utilized for this purpose. Existing transmission right-of-way will be used. Detailed information regarding this subject area is presented in Section 4.1.2.

The EGC ESP Facility footprint and layout is presented in Figure 2.1-4 and Figure 2.1-5. The figures depict the location of the new power block structure, the new intake structure, safety- and non-safety-related cooling towers, and the discharge flume to Clinton Lake.

3.1.4 Aesthetic Appearance

The EGC ESP Site will have a power block structure that could be up to 234-ft tall. The heat dissipation system could have a height of up to 550 ft, as mentioned above, and would slightly alter the visual aesthetics of the site. The CPS Site already exhibits an industrial environment; therefore, the EGC ESP Site will not substantially alter an already visually disturbed site. Any visual impacts from the visible plumes from the EGC ESP Facility will be similar to those associated with the CPS. There is the potential that an additional visible plume will result from the heat dissipation system.

The viewshed of the EGC ESP Facility is limited to a few residences and recreational users in the vicinity. Based on the fact that the EGC ESP Site will have similar visual impacts as the CPS (with the exception of the new plume from the heat dissipation system assumed for the EGC ESP Facility), the EGC ESP Site will have a minor impact on aesthetic quality for nearby residences and recreational users of Clinton Lake. Therefore, no mitigation will be provided.

3.2 Reactor Power Conversion System

Although the specific technology and design for the proposed reactor(s) have not been selected, bounding information for the reactors including the number of units, core thermal power, gross and net electrical output, and engineered safety features are provided in Table 1.4-1 of the SSAR. Provided in the following section is a generic description of the power conversion systems for the advanced reactors under consideration.

The bounding parameters indicate that the proposed reactor(s) could generate up to 6,800-MW core thermal power. In general, the ABWR (one unit) is rated at 3,926 MWt, the AP1000 (two units) is rated at 6,800 MWt, the IRIS (three units) is rated at 3,000 MWt, the GT-MHR (four modules) is rated at 2,400 MWt, the PMBR (eight modules) is rated at 3,200 MWt, the ESBWR (one unit) is rated at 4,000 MWt, and the ACR-700 (two units) is rated at 3,966 MWt.

The power conversion system utilized by the advanced reactors under consideration would include the following:

- Water cooled reactor plants, which use a steam-turbine to generate power from the reactor heat; and
- Gas cooled reactor plants, which use a gas-turbine to generate power from the reactor heat.

Both types of turbines reject exhaust heat to the normal plant cooling system.

3.3 Plant Water Use

The following paragraphs provide the anticipated and maximum plant water usage for the range of advanced reactors being considered. The design parameters presented were obtained from Table 1.4-1 of the SSAR. A water balance diagram (see Figure 3.3-1) and water balance table (see Table 3.3-1) are provided for convenience.

As described in more detail in Section 5.2, a drawdown analysis was completed to determine the capacity of the cooling water supply during dry periods. The results of the drawdown analysis, in terms of total water available or water available for new plant withdrawal, are presented in Table 5.2-3. Water requirements for the bounding plant and various cooling options is presented in Table 5.2-2. The results indicate the consumptive use limitations for the 50- and 100-yr droughts would not maintain the required minimum lake level and discharge to Salt Creek for the wet cooling system designs unless there is a short-term reduction in the plant load factor that would maintain minimum lake levels during these drought conditions. Cooling system designs that would maintain the minimum lake level and discharges to Salt Creek during the 50- and 100-yr droughts without limiting plant operations are the dry/wet cooling process (barely exceeds bounding parameter for the 100-yr drought) and the dry cooling process.

Full wet or dry/wet cooling systems may not be feasible options during severe drought conditions, but were assumed for most purposes because they require the most significant water usage.

Some cooling designs proposed may require the use of UHS cooling towers while others may utilize once-through cooling. A backup supply of emergency makeup water for the proposed UHS cooling will be provided from the submerged pond located at the bottom of Clinton Lake, which also serves as the UHS for the CPS with a failure of the dam on Clinton Lake. The CPS submerged UHS contains sufficient water inventory to provide shutdown cooling makeup water for the EGC ESP Facility for 30 days, and simultaneously provide shutdown cooling for the CPS following an accident.

Wastewater discharges from the proposed facility will be in strict compliance with an approved NPDES permit issued by the IEPA. This permit will make certain that discharges are controlled from systems (such as flumes, sewage treatment facilities, radwaste treatment systems, activated carbon treatment systems, water treatment waste systems, facility service water, stormwater runoff, etc.) to Clinton Lake. The effect on water quality in Clinton Lake due to the operation of the proposed facility will be carefully monitored in full compliance with the NPDES permit.

Additional information describing the NHS and UHS facility and emergency cooling systems is provided in Section 3.4.

3.3.1 Water Consumption

Most of the water that will be withdrawn from Clinton Lake and utilized for cooling is not consumptive as most will be returned after use as cooling tower blowdown. Values for water consumption and water supply were obtained from Table 1.4-1 of the SSAR.

3.3.1.1 Water Supply

The makeup water supply for the NHS and the UHS cooling will be taken from Clinton Lake. Pumps for the makeup water will be located in a new intake structure positioned approximately 65 feet south of the CPS intake structure.

Wet/dry cooling towers may be used to reduce makeup water consumption, if required, to match water demand with the available water supply.

3.3.1.2 Water Requirements

The raw water requirements for the EGC ESP Facility are presented in Table 3.3-2. This is the total of the water usage for potable/sanitary water supply, demineralized water production, filtered water production, and the cooling system makeup. This quantity includes the water required from Clinton Lake for the cooling tower makeup. The cooling tower makeup value presented is based on a conventional wet tower and represents the maximum expected value required during startup or adjustments to the blowdown in order to control water chemistry. Normal values presented in Table 3.3-2 are the continuous water usage requirements. The maximum values are intermittent demands that may occur during system-upset conditions or startup.

3.3.1.3 Cooling Water Discharges

The cooling water thermal discharges into Clinton Lake from the operation of the EGC ESP Facility are presented in Table 3.3-3. This is the summation of the cooling system blowdown discharges from towers.

Normal values were used to determine continuous water discharge quantities to Clinton Lake. The maximum values are intermittent flow rates that may occur during system-upset conditions, shutdown, or startup. The loss of water from Clinton Lake is the water supply requirement minus the discharges, since the discharges are returned to Clinton Lake.

The UHS for CPS is the volume of water retained by a submerged dam if Clinton Lake's main dam fails and drains. The volume of water retained in the UHS must provide shutdown cooling for the CPS. In addition, it is also the source of safety-related makeup water for the EGC ESP Facility safety-related cooling towers.

3.3.2 Water Treatment

The materials in the primary system of most of the proposed reactors will be primarily composed of austenitic stainless steel and Zircaloy cladding. For those reactors that use water as the primary coolant, reactor water chemistry limits will be established to provide an environment favorable to these materials. Design limits will be placed on conductivity and chloride concentrations. Operationally, the conductivity will be limited because it can be continuously and reliably measured, and it will give an indication of abnormal conditions and the presence of unusual materials in the coolant. Chloride limits will be specified to prevent stress corrosion cracking of stainless steel. During normal operation, condensate water will be processed through a condensate treatment system. This process consists of softening/filtration (probably some type of reverse osmosis filtration system to remove suspended particles and to purify) and demineralization (mixed resin beds or electro demineralization). The cleanup system will be provided for removal of impurities

resulting from fission products and corrosion products formed in the primary system. The cleanup process will serve to maintain a high level of water purity in the reactor coolant and to reduce contamination levels and minimize corrosion. A specific design has not been selected and the above paragraph only generically addresses the specifics of the cooling, filtration, and purification systems. Once a design is selected, more detailed information will be provided.

It is expected that chemical treatment of the cooling water and water processed through the reactor coolant cleanup system will be required on a periodic basis. This may entail the use of scale inhibitors, corrosion inhibitors (chloride), and sulfuric acid for pH adjustment.

Biological defouling of the cooling towers and the shell side of the primary heat exchangers with biocides, dispersants, and molluskicides may also be required on a periodic basis. During colder months, it may be necessary to incorporate a deicing compound into the cooling water if a wet cooling system is selected for the proposed EGC ESP Facility.

Potable water used throughout the plant will also be processed through the reverse osmosis filtration system and, if necessary, be treated with an anti-bacterial inhibitor (such as chlorine), and sampled on a monthly basis.

The chemicals used will be subject to review and approval for use by the IEPA. The total residual chemical concentrations in the discharges to Clinton Lake will be subject to discharge permit limits established by the IEPA. More detailed information regarding the specific types, quantities, and frequency of chemical addition will be provided after a specific reactor type is selected.

Estimated bounding blowdown constituents and concentrations are presented in Table 3.6-1 for the proposed EGC ESP Facility.

3.4 Cooling System

Details regarding the design of intake and discharge structures and cooling system comparison tables for the proposed reactor cooling systems will be presented at the COL phase. The design parameters presented in the following sections were obtained from Table 1.4-1 of the SSAR. The following section presents generic descriptions of the cooling system operational modes, component descriptions, NHS, UHS, and cooling system instrumentation. These design parameters help determine the environmental impacts on the EGC ESP Site and the suitability of the site for a nuclear facility. Additionally, even though the exact design for the ultimate reactor has not yet been selected, the information presented in this section is nevertheless sufficient to evaluate the impacts of the facility represented by the PPE information contained in the SSAR.

Based on the results of the drawdown analysis summarized in Section 3.3, full wet or dry/wet cooling systems may not be feasible options during severe drought conditions, but were assumed for most purposes because they require the most significant water usage.

3.4.1 Description and Operational Modes

3.4.1.1 Normal Heat Sink

The NHS provides cooling water for condensing turbine exhaust steam and cooling the turbine auxiliaries in a light water reactor plant, helium cooling in a gas cooled reactor plant, and the cooling water for other non-safety plant components.

The operation of the EGC ESP Facility will result in a significant amount of heat dissipation to the atmosphere. The cooling system options that have been conceptualized and could be incorporated into the facility design will transfer waste heat from plant components to the atmosphere, surface water, or the earth.

Described below are some of the options that are being proposed.

Proposed wet cooling systems that will utilize mechanical or natural draft cooling towers will use evaporative cooling to transfer heat from closed loop process water systems to the atmosphere. Within a wet cooling tower, hot process water will be piped through the cooling tower where non-contact cooling water is sprayed in at the top of the tower, cooling the process water. Significant amounts of cooling water can be lost by evaporation.

Proposed dry cooling systems will transfer heat to the atmosphere by pumping hot process water through a large heat exchanger or radiator, over which ambient air is passed to transfer heat from the process water to the air. This is a closed non-contact process, thus, no water is lost to evaporation, and there is no visible water vapor. The temperature of the ambient air will be elevated through the cooling process. The warm air rises naturally and dissipates into the local atmosphere, typically with no visible effects. Dry cooling is less efficient than wet cooling; therefore, dry cooling systems tend to be much larger and more costly than wet cooling systems. It is assumed that the dry cooling system would fit within the same footprint as wet cooling system and associated plant facilities.

Proposed hybrid wet/dry cooling systems will use a combination of the wet and dry cooling methods.

Proposed surface water cooling systems will include the use of cooling ponds, lakes, and streams. Lake cooling is the primary cooling process used by the CPS. Heated non-contact cooling water is cooled by contact with the soil and air as the water passes down the discharge flume and around the Clinton Lake cooling loop, back to the plant intake. Evaporation also occurs at an elevated rate due to the increased lake water temperature.

As stated above, full wet or wet/dry cooling processes have been assumed for most purposes because, out of the options proposed, they have the greatest consumptive water usage. As such, the NHS will provide the cooling water required for the non-safety-related facility components during normal operation and normal shutdown. The cooling water source for the NHS will be from cooling towers. Circulating water and service water pumps will take suction from the cooling tower basins and supply water to the components for cooling. The heated water from the components will be returned to the cooling towers for rejection of the heat to the atmosphere. The cooling systems that use water from the NHS are described in the reactor manufacturers' standard design documentation and the SSAR.

Blowdown, from the circulating water and service water system pumps, will be used to control the concentration of impurities in the water due to evaporation in the cooling towers.

3.4.1.2 Ultimate Heat Sink

The UHS will provide safety-related cooling water to the various reactor plant cooling water systems and components that are used for accident mitigation, safe shutdown, and maintenance of the units in a safe shutdown condition. It is assumed that safety-related cooling towers will provide the UHS function for the EGC ESP Facility; however, other options are being considered as mentioned above. Normal makeup water for the UHS cooling towers will be obtained from Clinton Lake and emergency makeup water will be supplied from the submerged pond located at the bottom of Clinton Lake. The submerged pond was constructed for the CPS in order to provide the UHS function if the Clinton Lake Dam fails.

3.4.2 Component Descriptions

Safety-related cooling towers of the mechanical draft type will be located adjacent to the EGC ESP Facility and will provide the cooling water required for the safety-related facility components during normal operation. Natural draft type or mechanical draft cooling towers will be provided for the normal (non-safety) facility cooling services. A new intake structure will be added to the Clinton Lake shoreline for use by the EGC ESP Facility while the CPS discharge flume will be modified to accommodate the new facility discharges.

3.4.2.1 EGC ESP Intake Structure

A new intake structure will be constructed to accommodate both the NHS and UHS functions for the EGC ESP Facility. The amount of shoreline and bottom that would be disturbed is an insignificant percentage of the total for Clinton Lake. The approximate

intake dimension of 100-ft wide by 150-ft deep (shore to lake dimension) has been estimated based on intake velocity and flow rate.

3.4.2.2 Clinton Power Station Discharge Flume

The CPS discharge flume will have to be modified to accommodate discharges from the EGC ESP Facility. The only modification to the discharge flume will be to connect discharge pipes from the EGC ESP Facility to the discharge flume. Discharge pipe connections will be in the portion of the existing flume discharge structure that was originally provided for the circulating water discharge from the cancelled CPS Unit 2.

3.4.2.3 Normal Heat Sink

The cooling systems that use water from the NHS are either described in the reactor manufacturers, standard design documentation, or do not presently exist. Information that is available is limited to a description of the supply and discharge of the cooling water external to the standard plant package. Once the specific reactor design is selected, information will be summarized in this section.

The NHS provides the cooling water required for the non-safety-related station components during normal operation. The cooling water source for the NHS is from cooling towers. Circulating water and service water pumps take suction from the cooling tower basins and supply water to the components for cooling. The heated water from the components is returned to the cooling towers for rejection of the heat to the atmosphere.

The makeup water supply for the NHS cooling towers will be taken from Clinton Lake. Pumps for the makeup water will be located in a new intake structure, which will be maintained at a nominal distance (approximately 65 feet) between the structures to facilitate construction and maintain the independence of the structures. The intake water for the facility will pass through bar racks or similar devices in order to remove large debris. In addition, it will also pass through traveling screens in order to remove smaller debris before entering the pump suction chamber. The approach velocity to the intake will be limited to a maximum velocity of 0.50 fps at the normal lake level elevation of 690 ft above msl. Trash collection baskets will be provided to collect trash from the screen washwater, for approved disposal, before the washwater is discharged to Clinton Lake. Strainers will be provided on the makeup pump discharges and when the strainer backwash water is returned to Clinton Lake. Several plant cooling options are being considered that may be used to reduce makeup water consumption, if required, to match water demand with the available water supply. However, for conservatism in determining impacts, either full wet or a combination wet/dry system will be used, as stated previously.

The maximum discharge flow to the NHS cooling towers is estimated to be 1,200,000 gpm during normal operation. The maximum heat load on the NHS cooling system is anticipated to be 15.08E+09 British thermal units per hour (Btu/hr) during normal operation.

As noted above, the CPS discharge flume will be modified to accommodate the EGC ESP Facility outflow. Engineering evaluations have not been performed to estimate the extent of the modifications but will be performed at the COL phase. The discharge from cooling tower blowdown will normally be 12,000 gpm with a maximum flow of 49,000 gpm (see

Table 1.4-1 of the SSAR). The temperature of the blowdown discharge to the CPS discharge flume is estimated to be a maximum of 101°F. The blowdown temperature is dependent on the wet bulb temperature and will decrease with wet bulb temperatures less than 85°F.

3.4.2.4 Ultimate Heat Sink

The UHS system will pump water from the safety-related (essential service water) cooling tower basins through the components cooled by the system. The water will then be returned to the cooling towers for heat rejection to the atmosphere. Normal makeup water for the UHS cooling tower basins will be supplied from Clinton Lake. Emergency makeup water will be supplied from the submerged pond below Clinton Lake in the event that Clinton Lake dam fails. Pumps for the normal and emergency UHS makeup water will be located in a new intake structure, the same one used for the NHS cooling towers, and positioned approximately 65 feet south of the CPS intake structure. Detailed design information regarding the new intake structure is not presently available but will be provided at the COL phase. Blowdown, from the discharge of the UHS system pumps, will be used to control the concentration of impurities in the water due to evaporation in the cooling tower.

The cooling systems that use water from the UHS are either described in the reactor manufacturer's standard design documentation or the information does not presently exist. Information that is available is limited to a description of the supply and discharge of the cooling water external to the standard plant package. Once the specific reactor design is selected, information will be summarized in this section. However, it is assumed that the UHS system will consist of a minimum of two redundant cooling divisions (trains), such that adequate cooling is provided with a single failure including a failure that renders one cooling tower inoperable. The quantity of pumps in each division (train) and the number of divisions of safety-related cooling water pumps, heat exchangers and piping, will be provided to satisfy the requirements of the reactor manufacturer's standard plant design.

The maximum discharge flow from the UHS cooling system to the UHS cooling towers is 26,125 gpm during normal operation and 52,250 gpm during shutdown (see Table 1.4-1 of the SSAR). The maximum heat load on the UHS cooling system is 2.25E+08 Btu/hr during normal operation and 4.11E+08 Btu/hr during shutdown. The discharge from UHS cooling tower blowdown is normally 144 gpm with a maximum blowdown of 700 gpm. The maximum temperature of the UHS blowdown discharge is 95°F.

3.4.2.5 Instrumentation

Temperature monitoring instrumentation will be provided in the blowdown discharge pipe to monitor the discharge temperature.

3.5 Radioactive Waste Management Systems

Detailed information regarding the description of the liquid and gaseous radioactive waste management and effluent control systems; process/instrumentation diagrams; system process flow diagrams of the liquid and gaseous radioactive waste management and effluent control systems; identification of principal release points; identification of sources of radioactive liquid and gaseous waste materials to the environment; and identification of direct radiation sources stored on site as solid waste will be provided at the COL phase.

This section provides a list of the bounding quantity of radioactive wastes that are projected to be generated, processed, and stored or released annually in liquid and gaseous effluents, and in the form of solid waste from the EGC ESP Facility. Radioactive waste management and effluent control systems will be designed to minimize releases from active reactor operations to values as low as reasonably achievable (ALARA). The EGC ESP Facility radioactive waste systems have been evaluated against the requirements of 10 CFR 20 and 10 CFR 50, Appendix I. The systems are capable of meeting the design objectives of 10 CFR 20 and 10 CFR 50, Appendix I, and will be maintained in accordance with ALARA principles, be protective of the environment, and will minimize radiological doses to the public. Maximum individual and population doses during normal plant operations are provided in Section 5.4.

3.5.1 Liquid Radioactive Waste Management System

Radioactive isotopes are produced as a normal by-product of reactor operations. A small quantity of these radionuclides can contribute to the normal radioactive liquid effluents from the plant. The liquid radioactive waste management system supplied with any of the alternative advanced reactor concepts is designed to control, collect, process, store, and dispose of potentially radioactive liquids during the phases of plant operation. This includes startup, normal operation, shutdown, refueling, and anticipated operational occurrences. Radioactive liquid effluents can be released from the plant to the environment via waste liquid processing systems. The process systems will be designed to minimize the releases to, and impact on, the aquatic environment. Discharges will be via the existing discharge plume of the CPS.

The release of radioactive liquid effluents from the plant will be controlled in such a manner as to not exceed the average annual effluent concentration limits (ECLs) specified in 10 CFR 20.

The proposed EGC ESP Facility will be operated such that releases of radioactive liquid effluent to Clinton Lake are expected to be negligible. To provide for a bounding assessment, the maximum quantities in Table 3.5-1 for releases of radioactive liquid wastes from the proposed reactor designs were used in the evaluation of the EGC ESP Facility. The discharge quantity is taken from the bounding isotopic releases presented in the SSAR Table 1.4-4 for all isotopes except tritium, which is provided in SSAR Table 1.4-1. The liquid waste effluent concentrations are determined based on a composite of the highest activity content of the individual isotopes from the AP1000 (two units), IRIS (three units), ABWR (one unit), ESBWR (one unit), ACR-700 (two units), GT-MHR (four modules) and the PBMR (eight

modules). The discharge flow is conservatively taken as the minimum dilution value (2,400 gpm for the GT-MHR) from SSAR Table 1.4-1.

In order to provide for operating flexibility, a bounding assessment was performed to demonstrate the capability of complying with the 10 CFR 20 and 10 CFR 50, Appendix I, regulatory requirements at the EGC ESP Site. Compliance with the 10 CFR 20 criteria is based on demonstrating that average annual concentrations of radioactive material released in the liquid effluents at the boundary of the restricted area do not exceed the values specified in 10 CFR 20.

The fraction of ECL is determined by ratioing the resulting concentrations by the 10 CFR 20 ECL limits. Table 3.5-2 was obtained from Table 3.1-5 of the SSAR, which compares the releases for those radionuclides identified in Table 3.5-1 with the 10 CFR 20 ECLs and shows compliance to 10 CFR 20 requirements.

3.5.2 Gaseous Radioactive Waste Management System

Radioactive isotopes are produced as a normal by-product of reactor operation. A small portion of these radionuclides contribute to the normal radioactive gaseous effluents from the plant. The gaseous radioactive waste processing system will be designed to control, collect, process, store, and dispose of potentially radioactive gases during the phases of plant operation. The normal gaseous effluents will be released from the plant to the environment via waste gas processing systems that are designed to minimize the releases to, and the impact on, the environment. Potentially radioactive gases will also be present in the station buildings as a result of process system leakage. These gases will be released to the environment via the building ventilation systems.

The release of radioactive gaseous effluents from the plant will be controlled and monitored so that the regulatory limits specified in 10 CFR 20 and 10 CFR 50, Appendix I, are maintained.

The maximum postulated quantity of radioactive gases released from the gaseous waste processing systems and the building ventilation systems used in the evaluation of the EGC ESP Facility is shown on Table 3.5-3. Discharge quantities are taken from the bounding isotopic releases given in SSAR Table 1.4-3 for all isotopes except tritium, which is provided in SSAR Table 1.4-1. The gaseous effluent concentrations were determined based on the projected release of a composite of the highest activity content of the individual isotopes in combination with the highest sector average annual site dispersion factor at the effluent control boundary presented in Table 3.1-2 of the SSAR.

Compliance with the isotopic limits of 10 CFR 20 was based on demonstrating that the annual average concentrations of radioactive material, which would be released in the gaseous effluents at the boundary of the restricted area, would not exceed the values specified in 10 CFR 20.

Table 3.5-4 compares the releases identified in Table 3.5-3 with the 10 CFR 20 ECLs and shows compliance with the 10 CFR 20 requirements (comparison tables were obtained from Table 3.1-1 of the SSAR).

3.5.3 Solid Radioactive Waste Management System

The solid radioactive waste management system will receive, collect, and store any solid radioactive wastes received prior to their processing and packaging for shipment off site. In addition, the solid waste management system will provide storage of operations waste prior to processing or shipment. The system will be designed to collect and store radioactive wastes in a manner that will maintain radiation exposures ALARA and perform the following objectives:

- Collect, hold for decay, monitor, package, and temporarily store the wet and dry solid radioactive wastes produced by the plant during operation and maintenance prior to off-site shipment.
- Provide a means for segregating trash by radioactivity level and temporarily store the wastes.
- Minimize exposure to solid radioactive waste materials that could conceivably be hazardous to either operating personnel or the public, in accordance with 10 CFR 20 and 10 CFR 50, Appendix I.
- Minimize the volume of solidified waste requiring shipment off site.
- Take due account (through equipment selection, arrangement, remote handling, and shielding) of the necessity to keep radiation exposure of in-station personnel ALARA.

For the alternative reactor designs considered, the average total annual volume of solid radioactive waste treated within the system is not expected to exceed 15,087 ft^3/yr (see Table 1.4-1 of the SSAR). Maximum anticipated annual activity is not expected to exceed 5,900 curies per year (Ci/yr) (see Table 3.5-5). A bounding list of the principal radionuclides expected in solid radioactive wastes is presented in Table 3.5-5. The waste will be packaged and shipped in accordance with the applicable regulatory requirements.

3.6 Nonradioactive Waste Management Systems

This section generically describes the nonradioactive waste management systems and the chemical and biocidal characteristics of the nonradioactive waste stream that will be discharged from the plant.

Nonradioactive wastes from nuclear power plants may include, but are not limited to, boiler blowdown (continual or periodic purging of impurities from auxiliary boilers), water and sanitary treatment wastes, floor and equipment drains, and stormwater runoff.

If applicable, nonradioactive wastes will be collected in the wastewater treatment system. The system will be designed to stop the discharge of wastewater upon detection of high radiation in the stream to the CPS discharge flume.

Detailed information regarding the description of the nonradioactive waste management and effluent control systems, process/instrumentation diagrams, and system process flow diagrams will be provided at the COL phase.

3.6.1 Effluents Containing Biocides or Chemicals

Principal chemical, biocide, and pollutant sources that may be used or produced during the operation of the EGC ESP Facility may include, but are not limited to, the following:

- Sodium hydroxide and sulfuric acid, which are used to regenerate resins (depending on plant design);
- Phosphate in cleaning solutions;
- Biocides used for condenser defouling;
- Boiler blowdown chemicals;
- Oil and grease from plant floor drains;
- Chloride;
- Sulphates;
- Copper;
- Iron; and
- Zinc.

The estimated concentrations of impurities in the blowdown water are presented in Table 3.6-1 (values obtained from reactor vendors and values are not site specific), and were obtained from Table 1.4-2 of the SSAR.

Other small volumes of wastewater, which may be released from other station systems, are described in the SSAR. These will be discharged from sources, such as the service water and auxiliary cooling systems, water treatment, laboratory and sampling wastes, floor drains, and stormwater runoff. These waste streams will be discharged as separate point sources or will be combined with the cooling water discharges.

The chemical waste effluents may consist of the nonradioactive wastes produced from the regeneration of demineralizers, waste discharges from reverse osmosis units, filter backwash water, and wastes from laboratory and sampling processes. Drains from radioactive sources or potentially radioactive sources will not be connected to the chemical waste drain system.

Chemical waste discharges will be collected in a tank for sampling and pH adjustment before being discharged as neutralized wastes to Clinton Lake. The chemical wastes will be routed to the discharge flume of the CPS, which flows to Clinton Lake.

It is expected that chemical treatment of the cooling water systems with biocides, dispersants, molluskicides, and scale inhibitors will be required on a periodic basis. The chemicals used will be subject to review and approval for use by the IEPA and releases will be in compliance with an approved NPDES permit. The total residual chemical concentrations in the discharges to Clinton Lake will be subject to limits that will be established by the IEPA.

As discussed in Section 5.2.2.2, the water quality of Clinton Lake is presently classified as an impaired water body by the IEPA. The causes of impairment include a Confidence Level 3 (high) Excess Algal Growth, and a Confidence Level 2 (moderate) Metals. The power plant operation is not uniquely related to either of the impairments. Algal growth is related to nutrient levels in the water column that originate from the dominant agricultural land use in the vicinity. Metals concentrations in the water column and sediment have a number of sources including natural geologic formations, agricultural practices, and industrial sources. For both impairments stormwater management and erosion control practices for sediment control are the best control option. Nutrients and metals attach to sediment and are effectively controlled with control of sediment in stormwater. Industrial pollution control practices and strategic materials selection and corrosion control are also expected to be effective in reducing metals contributions from industrial sources.

3.6.2 Sanitary System Effluents

Sanitary systems installed for preconstruction and construction activities will include the use of portable toilets, which are supplied and serviced by an off-site vendor.

Sanitary system wastes that are anticipated to be discharged to Clinton Lake during actual station operations include discharges from the potable and sanitary water treatment system. The CPS sanitary sewage treatment plant will, in all likelihood, be shared and, if necessary, be upgraded to accommodate the additional sanitary waste supplied by the EGC ESP Facility. As with the CPS, these discharges will be controlled in compliance with an approved NPDES permit for the EGC ESP Facility, to be issued by IEPA. The normal and maximum amount of sanitary discharges to Clinton Lake for the selected composite reactor are presented in Table 3.6-2 and were obtained from Table 1.4-1 of the SSAR.

3.6.3 Other Effluents

3.6.3.1 Liquid Effluents

Other effluent discharges to Clinton Lake will include discharges from the chemical waste treatment system, plant drains, and storm drainage.

The total amount of anticipated discharges from the chemical waste treatment system and plant drains to Clinton Lake is presented in Table 3.6-3 and was obtained from Table 1.4-1 of the SSAR.

Plant stormwater drainage control systems will be presented at the COL phase. Erosion and sedimentation controls for preconstruction and construction activities are discussed in Section 4.6.

3.6.3.2 Gaseous Effluents

Bounding estimates of other gaseous effluents and the total quantity of sulfur oxides (SO_x), nitrogen oxides (NO_x), hydrocarbons, and suspended particulates to be discharged annually during station operations (e.g., from diesel engines, gas-turbines, heating facilities), and elevation of the release points are provided in Table 3.6-4 and Table 3.6-5. These estimates were obtained from Tables 1.4-1, 1.4-6, 1.4-7, and 1.4-8 of the SSAR.

3.7 Power Transmission System

This section generally discusses the electric transmission system construction, which would be required in conjunction with construction of the EGC ESP Facility. Detailed information regarding the impacts from construction are presented in Section 4.1.2. The proposed facility is located in the service territory of Illinois Power Company, the regional electrical transmission system owner/operator, and adjacent to the CPS, which is owned and operated by AmerGen. Discussions with service providers have furnished the general information used to determine the amount and type of new construction required. An RTO or the owner, both regulated by Federal Energy Regulatory Commission (FERC), will bear the ultimate responsibility for defining the nature and extent of system improvements, and the design and routing of connecting transmission and the impacts of such improvements. Therefore, the construction described in this section is based on the existing infrastructure, Illinois Power Company system design preferences, and best transmission practices. The guiding assumption for transmission route design is that the new construction will follow in parallel with some of the existing transmission serving the CPS, and that it is only required to reach the nearest substation providing connection to the greater area grid. Impacts to the grid will be addressed by the system owner after submission of an interconnect request. Any such request would be premature during site selection, since the design and operating capacity of the proposed facility have not yet been determined.

The system description in this chapter assumes that construction and operation of transmission lines necessary to connect a new facility to the grid will be the responsibility of the transmission system owner, and that new studies will be performed by the RTO or the owner, under FERC regulations. The assumptions developed in this section are further based on the CPS ER, which provides the most recent data available on transmission lines and corridors in the vicinity.

3.7.1 Background

3.7.1.1 Open Transmission Requirements

EGC plans to develop a merchant generator facility at the site; the proposed site will be set aside for a unit that generates power for sale on the open wholesale market. The facility owner will not be responsible for building transmission lines. Rather, it will interconnect with the transmission system owner. Under FERC regulations, an electric transmission system provider engaged in bulk power system operations must allow new generation to interconnect to its system and request transmission services across the transmission system. Illinois Power Company’s Open Access Transmission Tariff identifies processes for making an interconnection request and for requesting transmission services. Once a request is received, the transmission system owner will conduct studies to determine the impacts of the generation or transmission service on the existing system, and then identify the system improvement needed. The system improvement needs are generally based on power flow studies in order to determine the thermal capacity necessary to accommodate the power flows and system stability studies in order to determine the effects the generation will have on system stability under steady state and transient conditions given various system contingencies. These studies and additional impact studies are prepared by the transmission system owner/operator under FERC regulations and guidance.

The CPS interconnects to the Illinois Power Company transmission system. The EGC ESP Facility will rely on an interconnection with Illinois Power Company, and anticipates that the configuration of the transmission system and corridor will be similar to the existing system. The construction assumptions developed in this chapter, Chapter 4, and Chapter 5, are therefore based on the existing system, described below.

3.7.1.2 Illinois Power Company Transmission System

The existing Illinois Power Company electrical transmission system in central Illinois consists of a backbone 345-kV system and an underlying 138-kV system. The Illinois Power Company system is interconnected with the systems of other utilities at numerous locations.

The CPS interconnects to the Illinois Power Company system through a 345-kV switch station. From this switch station, there are 345-kV interconnections to the following Illinois Power Company substations:

- Brokaw, about 15 mi to the north;
- Oreana, about 23 mi to the south;
- Rising, about 25 mi to the east; and
- Latham, about 25 mi to the southwest.

Based on the information available, there is no 345-kV transmission out of the Rising substation. To the extent new transmission lines are needed, they would be interconnected to the Brokaw, Oreana, or Latham substations, or to a future substation on the Latham-Rising line. Reinforcements to the 138-kV or lower voltage systems are not anticipated.

3.7.1.3 Comparative Loads

An April 2002 report by the Illinois Commerce Commission, *Assessment of Retail and Wholesale Market Competition in the Illinois Electric Industry in 2001*, indicated that the noncoincident peak demand for Illinois' investor owned electric utilities was 29,465 MW (Illinois Commerce Commission, 2002). A May 2002 Illinois Power Company report to the Commission estimated the Illinois Power Company transmission system summer 2002 peak load at 4,276 MWe. The CPS has a rated capacity of 1,138.5 MWe (CPS, 2002).

From the above data, the addition of approximately 2,180 MWe in the area would be a significant increase in the power to be carried by the system, 50 percent of the estimated 2002 Illinois Power Company transmission system's peak load.

3.7.2 Transmission System Description

The existing transmission system was sized for a larger capacity than currently used and would be able to carry some new generation. However, in order to accommodate the bounding case of an output of 2,180 MWe, new lines will be required, as there is insufficient capacity on the existing system to carry the load, and the existing structures were not designed for additional circuits. Parallel lines are required in each direction because a single line can not carry the full output of both the EGC ESP Facility and CPS. Four new transmission lines will be required to connect the EGC ESP Facility to the existing transmission grid in southern Illinois. Two parallel, double circuit transmission lines will

depart the station north to an interconnect point at the Brokaw substation near Bloomington, Illinois, approximately 15 mi from the site (see Figure 2.2-4). A second pair of parallel double circuit lines will depart the station south to an interconnect point on Illinois Power Company's Latham-Rising 345-kV line (Number 4571), approximately 9 mi from the site (see Figure 2.2-4). As discussed above, it is assumed that any new transmission lines related to this project would be 345 kV.

Illinois Power Company has not constructed new 345-kV transmission lines for 15 to 20 yrs. However, Illinois Power Company has an engineering standard and preferred design that consists of wood pole H-Frame support structures (see Figure 3.7-1). Pole heights are typically 80 to 100 ft with 600- to 700-ft spans between poles. The right-of-way is about 130-ft wide but varies depending on the specific location. In this case, the total required right-of-way width would be 250 ft to accommodate a pair of parallel lines. The poles are typically direct buried, with engineered foundations as needed. Single steel poles with concrete footings would be used, as appropriate. The typical line clearances above ground level will be 29 ft at 60°F conductor temperature. However, a more typical design for a double circuit line would use steel structures, either lattice tower or monopole construction. Use of steel structures would reduce the required right-of-way width to about 160 ft and increase spacing to over 800 ft.

The transmission structures will carry a double circuit line, consisting of six phases of two or three bundle conductor of 1,272 kilo circular mils (kcmil) ACSR, and two shield wires. Final conductor size will be determined by the transmission system owner based on several factors, including:

- Operating voltage;
- Loads to be carried, both initially and in the future;
- Thermal capacity;
- Cost of the conductor, support structures, foundations, right-of-way, and the present value of the energy losses associated with the conductor size and expected loading; and
- Electric and magnetic field strengths, which depend on operating line voltage, conductor currents, and conductor configuration and spacing.

Transmission system design, construction, and operation will comply with the relevant local, state, and industry standards including the National Electric Safety Code (NESC) and various ANSI/Institute of Electrical and Electronics Engineers (IEEE) standards. This includes ground clearances, electro magnetic fields (EMF), radio interference (RI), television interference (TVI), audible noise, aviation safety, and other factors as appropriate.

3.7.3 Radiated Electrical and Acoustical Noises

When an electric transmission line is energized, an electric field is created in the air surrounding the conductors. If this field is sufficiently intense, it may cause the breakdown of the air in the immediate vicinity of the conductor (corona). Corona can result in audible noise or RI and TVI. Audible noise levels are usually very low and not heard, except possibly directly below the line on a quiet day.

RI and TVI can occur from corona, electrical sparking and arcing between two pieces of loosely fitting hardware or burrs or edges on hardware. RI is typically experienced as static on radio reception while TVI is a snow or hold problem on a television. Problems with TVI have diminished in recent years with the increased use of cable and satellite TV, where shielded coaxial cables and shielded receivers protect against the interference. This noise occurs at discrete points and can be minimized with good design and maintenance practices. Design practices for the proposed transmission lines include the use of extra high voltage (EHV) conductors, corona resistant line hardware, and grading rings at insulators. The effect of corona on radio and television is dependent on the radio/television signal strength, distance from the transmission line, and the transmission line noise level. In a 1972 field study, in support of the CPS ER, RI and TVI were measured at existing 345 kV lines with similar construction to those proposed here (CPS, 1973). No new transmission lines have been built in the vicinity, and the CPS ER provides the most recent available data for RI and TVI. The results were summarized as follows:

- No audible noise caused by the 345-kV power lines near Baldwin Station could be measured above prevailing ambient background noise level.
- RI measurements made on the existing 345-kV lines indicated that little or no interference would be experienced in radio receivers located outside the typical 132-ft right-of-way, providing that the strength of signal from the radio stations exceeded 500 micro volts per meter, a value that is accepted by the Federal Communications Commission as the minimum for providing good reception.
- No electrical interference was experienced in a portable television receiver having a standard rod antenna when operating near lines of similar construction to those proposed here.

3.7.4 Electro Magnetic Fields

The EMF are produced by the electrical devices including transmission lines. Electric fields are produced by voltage and are typically measured in kilo volts per meter (kV/m), while magnetic fields are produced by current and are measured in gauss (G). Some epidemiological studies have suggested a link between power-frequency EMF and some types of cancer, while others have not. Although there is no scientific consensus on the topic, the presence of EMF, especially from transmission lines, has become a greater public concern in recent years. Due to the lack of evidence supporting a health risk from EMF, there are no federal health standards for EMF. However, some states have set standards for electric and magnetic field strength at the edge of transmission right-of-ways (see Table 3.7-1); Illinois is not one of these states. The parameters having the greatest effect on EMF levels near the transmission line are operating voltage, current, conductor height, electrical phasing, and distance from the source. The EMF reduction measures will be incorporated into the line and station designs so that the EMF strengths will be minimized.

3.7.5 Induced or Conducted Ground Currents

Magnetic fields can also induce current or voltage in longer conducting objects, such as fences, RR, or pipelines. Touching the object at a point remote from an electrical ground can result in a shock. To minimize these induced ground currents and distribute ground fault

currents, the tangent or inline structure will be grounded. The tangent structure will have an electrical connection between the shield wire and ground lead, which will be connected to ground rods. Ground resistance tests will be made at the tangent structure before the shield wire is electrically connected to the ground lead. Sufficient ground rods will be installed to reduce the resistance to 10 ohms or less under normal atmospheric conditions. Angle or corner structures will have a low voltage insulator installed between the shield wire and down guys to avoid possible anchor corrosion problems.

3.8 Transportation of Radioactive Materials

This section addresses the fuel and radioactive waste transportation issues associated with siting and operating a new reactor and is divided into two main subsections. The first subsection addresses the light-water-cooled reactor (LWR) designs presently being considered. The second subsection addresses the gas-cooled reactor designs also being considered. This split addresses the regulatory distinction made in 10 CFR 51.52 for light-water-cooled reactors. In addition, the source for the information discussed in this section is from the Idaho National Engineering and Environmental Laboratory, Engineering Design File # 3747, Early Site Permit Environmental Report Sections and Supporting Documentation, May 14, 2003, Revision 0.

3.8.1 Light-Water-Cooled Reactors

As required by 10 CFR 51.52, every ER prepared for the construction permit stage of an LWR, and submitted on or after February 4, 1975, is to utilize Table S-4 "Environmental Impact of Transportation of Fuel and Waste To and From One Light-Water-Cooled Nuclear Power Reactor" and shall 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 in Table 3.8-3) is a summary environmental impact statement concerning transportation of fuel and radioactive wastes to and from a reactor. The table is divided into two categories of environmental considerations: (1) normal conditions of transport and (2) 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 reactor reference year. Under "normal conditions of transport" the environmental impacts of the heat of the fuel cask in transit, weight, and traffic density are described. Also the number and range of radioactive doses to transportation workers and the general public are described. The "accidents in transport" consideration is concerned with environmental risk. Under "accidents in transport", the environmental risk from radiological effects, and common nonradiological causes such as fatal and nonfatal injuries and property damage are described.

To demonstrate 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 associated transportation impacts either meet the conditions in paragraph (a) or 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 the environmental report for the reactor. 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 LWR technologies being considered have characteristics that fall within the conditions of 10 CFR 51.52 for use of Table S-4, with minor exceptions. The effect of the exceptions is addressed in the following discussion through an evaluation and comparison to the data supporting Table S-4 as provided in WASH-1238 (USNRC, 1972) and NUREG-75/038 (USNRC, 1975).

The LWR technologies being considered are identified in Section 1.1.3 of this Environmental Report and in SSAR Section 1.3. These designs include the ABWR, Economic Simplified Boiling Water Reactor (ESBWR), AP1000, IRIS, and the ACR-700. The standard configuration for these reactor technologies (assumed in this analysis) is as follows. The ABWR is a single unit, 4,300 MWt, nominal 1,500 MWe boiling water reactor. The ESBWR is a single unit, 4,000 MWt, nominal 1,390 MWe boiling water reactor. The AP1000 is a single unit, 3,400 MWt, nominal 1,117-1,150 MWe pressurized water reactor. The IRIS is a three module pressurized water reactor configuration for a total of 3,000 MWt and nominal 1,005 Mwe, and the ACR-700 is a twin unit, 3,964 MWt, nominal 1,462 MWe, LWR with a heavy water moderator. (Note that for this analysis, the ABWR is conservatively presumed to be the uprated design while other evaluations within this ESP application are based on the certified design configuration.)

10 CFR 51.52 lists several conditions that need to be addressed by these reactor technologies. If the conditions are satisfied by the reactor technologies, then the Table S-4 values are appropriate for use in ESP. 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 for 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 S-4 that require that radioactive waste, with the exception of irradiated fuel, be packaged and in solid form. Table 3.8-1 includes the referenced conditions along with the bounding values for the various reactor technologies. The information for the various reactor technologies was provided by the reactor vendors.

10 CFR 51.52(a)(1) requires that the reactor have a core thermal power level not exceeding 3,800 MW. Of the considered LWR technologies, only the two BWRs, the ABWR and the ESBWR, exceed this value. The ABWR has a core thermal power level of 4,300 MWt while the ESBWR core thermal power level is 4,000 MWt. The higher rated core power level would typically indicate the need for more fuel and therefore more fresh and irradiated fuel shipments. This is not the case in this instance due to the higher unit capacity and higher burnup for the reactors with the increased power level. The annual fuel loading for the reference reactor in Table S-4 was 35 metric tons uranium (MTU) while the expected annual fuel loading for both the ABWR and ESBWR is only 32.8 MTU. In fact, the annual MTU of fuel for these BWRs normalized to equivalent electrical generation is just slightly more than half of the reference LWR; 18.4 MTU versus 35 MTU. This reduced annual MTU requirement of fuel will mean fewer shipments and less environmental impact. Also, WASH-1238 states: "The analysis is based on shipments of fresh fuel to and irradiated fuel and solid waste from a boiling water reactor or a pressurized water reactor with design ratings of 3,000 to 5,000 MWt or 1,000 to 1,500 Mwe" (USNRC, 1972). Both the ABWR and the ESBWR fall within these bounds.

10 CFR 51.52(a)(2) requires that the reactor fuel be in the form of sintered uranium dioxide (UO_2) pellets. The LWR technologies being considered have a sintered UO_2 pellet fuel form.

10 CFR 51.52(a)(2) requires that the reactor fuel have a uranium-235 enrichment not exceeding 4 percent by weight. The NRC has subsequently concluded that enrichments up to 5 percent is also bounded by the environmental impacts considered in Table S-4. These evaluations are documented in the "NRC Assessment of the Environmental Effects of Transportation Resulting From Extended Fuel Enrichment and Irradiation" as provided in 53 FR 30555 and 53 FR 32322, and in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. The LWR technologies being considered have uranium-235 enrichments less than 5 percent by weight and therefore meet this subsequent evaluation condition.

10 CFR 51.52(a)(2) requires that the reactor fuel pellets be encapsulated in Zircaloy rods. 10 CFR 50.44 also allows use of ZIRLO™. Prior USNRC license amendments for operating reactors approving the use of ZIRLO have repeatedly indicated that the use of ZIRLO rather than Zircaloy does not involve a significant increase in the amounts or significant change in the types of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The LWR technologies being considered will use either Zircaloy or ZIRLO rods and therefore meet this subsequent evaluation condition.

10 CFR 51.52(a)(3) requires that the average burnup is not to exceed 33,000 megawatt-days per metric ton of uranium (MWd/MTU). The NRC has subsequently concluded that average burnup up to 62,000 MWd/MTU for the peak rod is also bounded by the environmental impacts considered in Table S-4. These evaluations are also documented in the "NRC Assessment of the Environmental Effects of Transportation Resulting From Extended Fuel Enrichment and Irradiation" as provided in 53 FR 30555 and 53 FR 32322, and in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. The LWR technologies being considered will have average burnup of less than or equal to 62,000 MWd/MTU for the peak rod and therefore meet this subsequent evaluation condition.

10 CFR 51.52(a)(3) requires that no irradiated fuel assemblies 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. For the LWR technologies being considered, five years is the minimum decay time expected before shipment of irradiated fuel assemblies. The five-year minimum time is supported additionally by two practices. First, five years is the minimum cooling time specified in 10 CFR 961.11, within Appendix E of the standard DOE contract for spent fuel disposal with existing reactors. Second, the USNRC specifies five years as the minimum cooling period when it issues certificates of compliance for casks used for shipment of power reactor fuel (NUREG-1437, Addendum 1, pp 26). In addition to the minimum fuel storage time, NUREG-1555 Environmental Standard Review Plan, Section 3.8 asks for the capacity of the on-site storage facilities to store irradiated fuel. The LWR technologies being considered are designing for on-site storage of spent fuel for up to 60 years through a combination of wet (pool) and dry storage.

10 CFR 51.52(a)(4) requires that, with the exception of spent fuel, radioactive waste shipped from the reactor is to be packaged and in a solid form. The LWR technologies being considered will solidify and package their radioactive waste. Additionally, existing USNRC (10 CFR 71) and Department of Transportation (DOT) (49 CFR 173,178) packaging and

transportation regulations specify requirements for the shipment of radioactive material. The LWR technologies being considered are subject to these regulations.

10 CFR 51.52(a)(5) requires that unirradiated fuel be shipped to the reactor by truck. The LWR technologies being considered plan to ship their unirradiated fuel by truck.

10 CFR 51.52(a)(5) allows for truck, rail, or barge transport of irradiated fuel. The LWR technologies being considered will comply with this transport mode requirement. Three of the LWR reactor vendors identified rail as the shipment mode, and the vendor for the ABWR and the ESBWR stated either rail or truck. Of note, the DOE is currently (2003) responsible per the standard contract for transport of irradiated fuel from reactor sites to the storage location and, while DOE will make the decision on transport mode, it is expected that DOE will also use either truck, rail, or barge transport. NUREG-1555, Environmental Standard Review Plan, Section 3.8, also asks for the estimated transportation distance from the plant to the facility to which irradiated fuel will most likely to be sent. Recognizing the uncertainty in predicting the future destination of spent fuel in the United States, 2,500 miles is utilized as a bounding distance at this time. This length bounds the approximate average distance from typical reactor sites to potential repository locations in the U.S.

Finally, 10 CFR 51.52(a)(5) requires that low-level radioactive waste be shipped by either truck or rail. The LWR technologies being considered plan to ship their radioactive waste by truck.

In conclusion, since the LWR technologies being considered satisfy the 10 CFR 51.52(a) conditions, or subsequent USNRC evaluation conditions, for use of Table S-4, the environmental impacts of transportation of fuel and radioactive wastes for the various reactor technologies are represented and bounded by the values given in 10 CFR 51.52(c), Table S-4. Thus, the radiological and nonradiological environmental impacts of transportation of fuel to and from, and waste from, these or comparable LWRs are small and bounded by the values in Table S-4.

3.8.2 Gas-Cooled Reactors

3.8.2.1 Introduction and Background

The following assessment of the environmental impacts of the transportation of fresh and irradiated fuel to and from, and low-level waste from, the reactor for gas-cooled reactor technologies is based on a comparison of the key parameters and conditions that were used to generate the impacts listed in 10 CFR 51.52(c), Table S-4. This comparison demonstrates that the environmental impacts of these gas-cooled reactor technologies are no worse than the impacts identified in Table S-4 for the LWR technologies. The premise being that if the values of the major contributors to the health and environmental impacts that were used for the reference LWR are greater than those comparable values for the gas-cooled reactor technologies, then the reference impacts would also be greater and therefore bounding. It is important to point out that even though we are looking at the contributors individually, it is the overall cumulative impact that is of concern. That is, for purposes of comparing/evaluating cumulative impacts, there may be increases in select individual contributors that are offset by decreases in other contributors.

The parameters that have been chosen for purposes of comparison include not only the major contributors to the health and environmental impacts but also the conditions listed in 10 CFR 51.52. For example, the major contributor to transportation risk is the number of shipments. The more shipments, the greater the risk. The Table S-4 shipments include fresh fuel for both initial core loading and reloads, irradiated fuel, and low-level waste (LLW) from operations. The second main contributor to the transportation risk would be the mode of shipment. In this case, only trucks and trains are considered for the shipment of fresh fuel, irradiated fuel, and LLW. The last important risk factor relates to what kind of material is being shipped. In the category for irradiated fuel, we compared fission product inventory, krypton inventory, actinide inventory, total radioactivity, decay heat, and weight of shipment of the reference LWR to the various gas-cooled reactor technologies. For radioactive waste, we used the expected volume to determine the number of shipments. Radioactive content of the LLW was also estimated to verify that the assumption about the percentage of LLW that might require shielding was reasonable.

The 10 CFR 51.52 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 for unirradiated fuel; mode of transport for irradiated fuel; and mode of transport for radioactive waste other than irradiated fuel. In addition, there are two other conditions that require that radioactive waste, with the exception of irradiated fuel, be packaged and in solid form. Since existing packaging and transportation regulations already address those items and these regulations would also apply to these gas-cooled reactor technologies, these last two conditions are satisfied.

Before proceeding with the evaluation, it is important to note that the USNRC has an ongoing review of the safety of spent fuel transportation. One recent evaluation is documented in NUREG/CR-6672, "Reexamination of Spent Fuel Shipment Risk Estimates", published in March 2000. The USNRC in their discussion document "An Updated View of Spent Fuel Transportation Risk"(USNRC, 2000a) concluded that the NUREG/CR-6672 study confirmed that: 1) earlier risk estimates (NUREG-0170, "Final Environmental Statement on the Transport of Radioactive Materials by Air and Other Modes") to the public remain conservative by factors of 2 to 10 or more; 2) existing regulations governing the shipment of spent fuel are adequate; and 3) no unreasonable risk is posed to the public by the continued shipment of spent fuel. The range of conservative risk factors covers differences in assumed mode of transport (rail or truck) and the various accident scenarios.

These same USNRC conclusions support the position that environmental assessments of the transport casks do not have to be done for the Part 71 cask certifications because they meet the categorical exclusion criteria in 10 CFR 51.22(c)(13) that package designs used for the transportation of licensed materials do not require an environmental review. As discussed in 10 CFR 51.22(a), the USNRC has determined that certain categories of licensing and regulatory actions have already been determined individually or cumulatively to not have a significant effect on the human environment; thus, a separate environmental assessment is not required. As mentioned in the previous paragraph, a generic assessment of the environmental effects associated with transportation of radioactive material, including spent fuel, has already been done as provided in NUREG-0170, "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes" dated December 1977. This environmental impact statement (EIS) provided the regulatory basis for

continued issuance of general licenses for transportation of radioactive material under 10 CFR 71. In addition, the USNRC has conducted a reexamination of the risks associated with spent fuel shipments as documented in NUREG/CR-6672. This reexamination concluded that the estimated risks for future shipments are well below those in the 1977 study. Thus, NUREG-0170 remains valid as the baseline report on which National Environmental Policy Act (NEPA) analyses of transportation risk are based.

Table 3.8-2 describes the major features of the reference LWR that were used to develop Table S-4 and compares these same features with the gas-cooled reactor technologies being considered. The reference LWR pertains to the typical 1,100 MWe light-water-cooled nuclear reactor as described in WASH-1238. The information to construct Table 3.8-2 was derived from the "Normal Conditions of Transport" portion of the 10 CFR 51.52 Summary Table S-4 "Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor," WASH-1238 "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants" and Supplement 1 to WASH-1238 (NUREG-75/038) for the reference LWR. The information for the reactor technologies was provided by the reactor vendors.

3.8.2.2 Analysis

This section provides a detailed comparison of the individual LWR parameters supporting Table S-4 against the corresponding parameters for the various gas-cooled reactor technologies. The values for the reference reactor are given along with the corresponding values or range of values for the gas-cooled reactor technologies. As appropriate, additional information and/or observations are provided. Table 3.8-2 provides additional details regarding the reactor technology specific values.

There are two gas-cooled reactor technologies presently being considered (also see Environmental Report Section 1.1.3 and SSAR Section 1.3). These reactor technologies are the GT-MHR and the PBMR. The standard configuration for these reactor technologies is as follows. The GT-MHR is a four module, 2,400 MWt, nominal 1,140 MWe gas-cooled reactor. The PBMR is an eight module, 3,200 MWt, nominal 1,320 MWe gas-cooled reactor. The unit capacities for these reactors are as follows: 88 percent for the GT-MHR; 95 percent for the PBMR. These values are contrasted with the reference LWR, a single unit, 1,100 MWe plant with a unit capacity factor of 80 percent.

Before beginning direct comparisons, it is important to note that the gas-cooled reactor technologies being considered are a different physical size, have a different electrical rating, and have a different capacity factor from the reference LWR. In order to make proper comparisons; we need to evaluate the characteristics based on equivalent criteria. For this analysis, electrical generation is the metric of choice. The electrical generation metric establishes whether the new reactor technologies, for the same electrical output, have a greater or lesser impact on the health and environment than the reference LWR. The reference LWR is a nominal 1,100 MWe plant with a capacity factor of 80 percent. Accordingly, the gas-cooled reactor technologies have been normalized to 880 MWe using their plant specific electrical ratings and capacity factors. For many of the characteristics being examined, this adjustment is not necessary. But in a few cases, specifically those dealing with the number of shipments of fuel and waste, an adjustment is appropriate.

3.8.2.3 Table S-4 Conditions

As discussed previously, 10 CFR 51.52(a) lists several conditions that need to be addressed by the new reactor technologies for the use of Table S-4. 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 for unirradiated fuel; mode of transport for irradiated fuel; and mode of transport for radioactive waste other than irradiated fuel. Two other conditions in S-4 require that radioactive waste, with the exception of irradiated fuel, be packaged and in solid form.

10 CFR 51.52(a)(1) requires that the reactor have a core thermal power level not exceeding 3,800 MWt. The gas-cooled reactors being considered meet this condition. The GT-MHR has a core thermal power level of 600 MWt per module for a total of 2400 MWt. The PBMR has a core thermal power level of 400 MWt per module for a total of 3200 MWt.

10 CFR 51.52(a)(2) requires that the reactor fuel be in the form of sintered UO_2 pellets. The fuel forms for the gas-cooled reactors being considered are blocks of TRISO coated uranium oxycarbide fuel kernels for the GT-MHR and spheres of TRISO coated uranium dioxide fuel kernels for the PBMR.

10 CFR 51.52(a)(2) requires that the reactor fuel have a uranium-235 enrichment not exceeding 4 percent by weight. The NRC has subsequently concluded that enrichments up to 5 percent are also bounded by the environmental impacts considered in Table S-4. These evaluations are documented in the "NRC Assessment of the Environmental Effects of Transportation Resulting From Extended Fuel Enrichment and Irradiation" as provided in 53 FR 30555 and 53 FR 32322, and in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. The PBMR has an enrichment of 12.9 percent while the GT-MHR enrichment is 19.8 percent.

10 CFR 51.52(a)(2) requires that the reactor fuel pellets be encapsulated in Zircaloy rods. 10 CFR 50.44 also allows use of ZIRLO™. USNRC license amendments for operating reactors approving the use of ZIRLO have repeatedly indicated that the use of ZIRLO rather than Zircaloy does not involve a significant increase in the amounts or significant change in the types of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. However, the gas-cooled reactors being considered have a different reactor fuel configuration. The gas-cooled reactor fuel kernels are coated with layers of pyrolytic carbon and silicone carbide. These coatings are considered the equivalent of the fuel cladding. For the GT-MHR these TRISO fuel particles are blended and bonded together with a carbonaceous binder and are stacked within a graphite block. For the PBMR, the fuel unit is a 6-cm diameter graphite sphere containing approximately 15,000 TRISO fuel particles.

10 CFR 51.52(a)(3) requires that the average burnup is not to exceed 33,000 MWd/MTU. The NRC has subsequently concluded that average burnup up to 62,000 MWd/MTU for the peak fuel rod is also bounded by the environmental impacts considered in Table S-4. These evaluations are documented in the "NRC Assessment of the Environmental Effects of Transportation Resulting From Extended Fuel Enrichment and Irradiation" as provided in 53 FR 30555 and 53 FR 32322, and in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. The gas-cooled reactors have an expected burnup of 133,000 MWd/MTU for the PBMR and 112,742 MWd/MTU for the GT-MHR.

10 CFR 51.52(a)(3) requires that no irradiated fuel assemblies be shipped until at least 90 days after they are discharged from the reactor. Table S-4 assumes 150 days of decay time prior to shipment of any irradiated fuel assemblies with a condition of not less than 90 days. For the gas-cooled reactor technologies being considered, five years is the expected minimum decay time prior to shipment of irradiated fuel assemblies. The five-year minimum time is supported additionally by two practices. First, five years is the minimum cooling time specified in 10 CFR 961.11, within Appendix E of the standard DOE contract for spent fuel disposal with existing reactors. Second, the USNRC specifies five years as the minimum cooling period when it issues certificates of compliance for casks used for shipment of power reactor fuel (NUREG-1437, Addendum 1, pp 26). In addition to the minimum fuel storage time, NUREG-1555 Environmental Standard Review Plan, Section 3.8 asks for the capacity of the on-site storage facilities to store irradiated fuel. The gas-cooled reactor technologies being considered are designing for on-site storage of spent fuel for up to 60 years including potential modular storage expansions.

10 CFR 51.52(a)(5) requires that the unirradiated fuel be shipped to the reactor by truck. The gas-cooled reactor technologies being considered plan to ship their unirradiated fuel by truck.

10 CFR 51.52(a)(5) allows for truck, rail, or barge transport of irradiated fuel. The gas-cooled reactor technologies being considered plan to allow for irradiated fuel shipment by truck. However, the actual mode of shipment may be determined by DOE and could include barge, rail, or truck shipments.

10 CFR 51.52(a)(5) requires that the mode of transport of low-level radioactive waste is either truck or rail. The gas-cooled reactor technologies being considered plan to ship their radioactive waste by truck.

Finally, 10 CFR 51.52(a)(4) requires that, with the exception of spent fuel, radioactive waste shipped from the reactor is to be packaged and in a solid form. The gas-cooled technologies being considered will solidify and package their radioactive waste. Additionally, existing USNRC (10 CFR 71) and DOT (49 CFR 173,178) packaging and transportation regulations specify requirements for the shipment of radioactive material. The gas-cooled technologies being considered are also subject to these regulations.

In summary, the descriptions provided above indicate that the criteria of 10 CFR 51.52(a) are met with the exceptions of fuel form, cladding configuration, enrichment, and burnup. 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. As previously indicated, the risk to the environment associated with the transportation of fuel is a function of the number of shipments and the contents of the shipments. Thus, a detailed analysis of these risk contributors is provided discussed in the following sections.

3.8.2.4 Risk Contributors – Shipments

This section discusses the type and number of shipments for the gas-cooled reactor technologies and the values used for the reference LWR. The calculations discussed below for the gas cooled reactors are based on the following assumptions:

- Forty (40) years of operation and Low Level Waste (LLW) generation

- One (1) initial core load – shipment prior to operation
- Thirty-nine (39) annual core reloads during the 40 years of operation
- Forty-two (42) spent fuel shipments (approximately equal in size to the annual core reload shipments) – three (3) shipments are after final shutdown of the reactor

The reference LWR assumed an initial core loading of 100 MTU for a PWR and 150 MTU for a BWR. These quantities resulted in 18 truck shipments. For the new gas-cooled reactor technologies, the numbers of shipments were 44 for the PBMR and 51 for the GT-MHR.

The reference LWR assumed an annual reload of 30 MTU. This quantity resulted in 6 truck shipments. For the new gas-cooled reactor technologies, the number of annual reload shipments was 20 for both the PBMR and the GT-MHR over a 39 year period.

With respect to the number of spent fuel shipments by truck, the reference LWR assumed 60 shipments annually. For the two gas-cooled reactor technologies, the number of shipments is considerably less. The PBMR requires 16 annual shipments while the GT-MHR requires 38 truck shipments annually. It is assumed that there will be 39 years of annual spent fuel shipments. In addition, the final core will be shipped following the final shutdown of the reactor.

The reference LWR assumed 10 rail shipments annually of spent fuel. Since the gas-cooled reactor technologies are not planning to ship their spent fuel by rail, no comparison is required. However, based on the above comparison indicating that fewer truck shipments would be necessary, fewer than 10 rail shipments annually would also be expected by this mode. This could be reduced further if DOE decided to use larger and higher capacity rail transport casks for gas-reactor spent fuel.

The reference LWR also considered transporting spent fuel by barge and assumed five shipments annually. Since the gas-cooled reactor technologies are not planning to ship their spent fuel by barge, no comparison is required.

The reference LWR assumes 46 shipments annually of low-level radioactive waste. The gas cooled reactor technologies will make far fewer shipments. The PBMR will require 9 shipments and the GT-MHR will require only 6 shipments annually for the 40-year duration of operation. These results assume that 90 percent of the LLW can be shipped at 1,000 ft^3 per truck, and the remaining 10 percent can be shipped at 200 ft^3 per truck.

The Table S-4 value, traffic density in trucks per day, for the reference LWR is given as less than one per day. Both the gas-cooled reactor technologies would also have less than one shipment per day. In fact, the new gas-cooled reactor technologies would have far fewer shipments per year. The reference LWR bounding annual value for truck shipments is 115, based on a 40-year average. The 40-year average for the PBMR is 47 (1861 shipments over 40 years) while the 40-year average for the GT-MHR would be 67 (2667 shipments over 40 years). This is conservative since all shipments would actually be over a period of about 45 or 46 years considering that the final spent fuel shipments could not take place until at least 5 years beyond the 40-year life of the plant. In addition, truck shipments for each of the gas reactors would be normalized based on electrical generating capacity (the PBMR shipments are reduced by 30 percent and the GT-MHR shipments are reduced by 12 percent) yielding as few as 33 per year for the PBMR and only 59 per year for the GT-MHR.

The rail density in cars per month for the reference LWR is given as less than three per month. Since the gas-cooled reactor technologies are not planning to make any shipments by rail, no comparison is needed. However, as noted above, if DOE decided to use rail transport for spent fuel instead of truck, fewer than three shipments per month would be expected.

3.8.2.5 Risk Contributors - Contents

This section addresses the radioactive contents of the irradiated fuel shipments and their thermal loading and compares them to the reference LWR. The radioactive and decay heat values are based on the earliest time of shipment. For the gas-cooled reactor technologies, the five-year time was selected because it is the minimum allowed time before shipment of irradiated fuel for operating reactors per the standard DOE contract. These values are compared with the reference LWR that used a 90-day decay time. Ninety days was the minimum allowed time before shipment for Table S-4. Since we are evaluating the transportation impacts, it is the fission product inventory and associated decay heat at the time of shipment that is of interest, not the inventory and decay heat at any other particular time.

The fission product inventory at the time of shipment for the reference LWR was 6.19×10^6 curies (Ci) per MTU. The values for the fission product inventory at the time of shipment for the gas-cooled reactor technologies were both much lower, 1.55×10^6 Ci per MTU and 1.78×10^6 Ci per MTU which are ~ 25 percent and ~29 percent of the reference LWR value, respectively.

The actinide inventory at the time of shipment in Ci per MTU for the reference LWR was 1.42×10^5. Because of the longer burnup times for the new gas-cooled new reactor technologies, both of these reactor technologies have values that exceed the reference LWR. The GT-MHR and the PBMR actinide inventory values are 2.33×10^6 Ci per MTU and 2.26×10^6 Ci per MTU, exceeding the reference LWR by ~ 64 percent and ~59 percent, respectively. This comparison changes significantly for the GT-MHR if one considers the Ci per shipment, which is the principle concern. The reference LWR ships 0.5 MTU per truck cask while the GT-MHR ships about a third less, or 0.16044 MTU per truck cask. Based on this comparison, the actinide inventory per shipment is about half (~53 percent) for the GT-MHR versus the reference LWR. Since the PBMR plans to ship 0.495 MTU per cask, the PBMR comparison per shipment is essentially the same as the comparison of actinide inventory in Ci per MTU.

The total radioactive inventory in Ci per MTU at the time of shipment (90 days) for the reference LWR was 6.33×10^6. The new gas-cooled reactor technologies have much lower total radioactivity at time of shipment (five years) of 1.78×10^6 Ci per MTU and 2.01×10^6 Ci per MTU. The differences are ~ 28 percent and ~32 percent of the reference LWR value, respectively.

The krypton-85 (Kr-85) inventory in Ci per MTU at the time of shipment (90 days) for the reference LWR was 1.13×10^4. The GT-MHR and the PBMR values at the time of shipment (five years) of 2.50×10^4 Ci per MTU and 2.63×10^4 Ci per MTU both exceed the reference LWR by~ 122 percent and ~133 percent of the reference LWR value, respectively. As before, if one considers the Ci per shipment, the Kr-85 inventory for the GT-MHR would be about

71 percent of the Kr-85 reference LWR inventory partly because of the significantly smaller shipments (0.16044 MTU per truck cask versus 0.5 MTU per truck cask for the reference LWR). The PBMR comparison would remain essentially the same.

The kilowatts per MTU at the time of shipment (90 days) for the reference LWR were 27.1. This value is considerably higher than for the gas-cooled reactor technologies. At the time of shipment (five years), the decay heat for the gas-cooled reactor technologies being considered ranges from 6.36 kilowatts per MTU for the GT-MHR to 3.91 kilowatts per MTU for the PBMR. These values are ~24 percent and ~15 percent of the reference LWR value, respectively.

The decay heat (per irradiated fuel truck cask in transit) in kilowatts for the reference LWR was 10. Both the gas-cooled reactor truck casks generate much less heat (1.02 kw and 1.9 kw) per truck cask than the reference LWR. These values are ~10 percent and ~19 percent of the reference LWR value, respectively.

The decay heat (per irradiated fuel rail cask in transit) in kilowatts for the reference LWR was 70. Since the gas-cooled reactor technologies are not planning to ship their spent fuel by rail, no comparison is needed. However, should DOE elect to accept the fuel and transport it by rail, the expected decay heat would be less than 70 kw based on the above comparison for truck shipment decay heat.

At the time of the reference LWR evaluation, the road limit was 73,000 lbs. This has changed slightly through the years. 23 CFR 658.17 "Weight" states that for the Interstate and Defense Highways the maximum gross vehicle weight shall be 80,000 pounds. In all cases for the gas-cooled reactor technologies, the road limit is governed by state and federal regulations.

3.8.2.6 Discussion

Of the close to 30 characteristics/conditions that were examined, there are only eight that were exceeded by the gas-cooled reactor technologies being considered. Three of these characteristics, fuel form, U235 enrichment, and fuel rod cladding, have no direct transportation impact on the health and the environment since these parameters are not used when assessing transportation risks under normal transport conditions. There are operational issues and fuel cycle impact issues associated with these characteristics that are addressed as part of the operating license and as part of the evaluation of Table S-3 "Uranium fuel cycle data", respectively. Two of these characteristics (number of shipments for initial core loading and number of reload shipments) are part of the overall truck transportation analysis. When one considers the total number of truck shipments (fresh fuel, irradiated fuel, and radioactive waste), the new reactor technologies have many fewer total shipments. For example, on an average annual basis, the new reactor technologies require 56 to 72 fewer total truck shipments. One characteristic, burnup, manifests its impact through other characteristics, including fuel inventory and decay heat at time of shipment, which are addressed separately. In the case of decay heat, both of the gas-cooled reactor technologies will generate fewer watts per MTU at time of shipment, and fewer kW per truck cask at time of shipment. The fuel inventory will be discussed as part of the remaining two characteristics that were exceeded: actinide inventory and Kr-85 inventory.

That the actinide inventory per metric ton of spent fuel is greater for the majority of the new gas-cooled reactor technologies is not surprising, since actinide activity tends to increase with increasing burnup and both of the gas-cooled reactor technologies plan a higher burnup than the reference LWR. The increase in the actinide activity for the new reactor technologies ranges from 59 percent to 65 percent. And as discussed in the previous section, if one considers the actinide inventory per shipment, only the PBMR exceeds the reference LWR by 59 percent. From NUREG/CR-6703 "Environmental Effects of Extending Fuel Burnup Above 60 GWd/MTU", we learn that "none of the actinides contributes more than one percent of the external dose from an iron transportation cask, and as a group, the actinides do not contribute significantly to the dose from transportation accidents. In fact, increasing the activities of Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-242 and Cm-244 by more than a factor of 1,000 only increased the cumulative dose for a transportation accident during shipment of 43 GWd/MTU spent fuel from the northeast to Clark County, NV from 0.0358 to 0.0359 person-mSv/shipment (3.58×10^{-3} to 3.59×10^{-3} person-rem/shipment)." There is one other area where the increased actinide activity needs to be considered and that is the corresponding increase in neutron source term. NUREG/CR-6703 states "because neutrons are effectively attenuated by low-density materials such as plastics and water, it is believed that minor modifications can be made to shipping casks to allow them to transport the higher burnup fuel at full load".

Based on the analysis performed and the conclusions drawn in NUREG/CR-6703 which show that actinides are not major contributors to the transportation risk, either incident free or accident, and with the actinide activity only 59 percent greater, the environmental impacts would still be bounded even for these higher burnups.

This leaves the Kr-85 inventory as the final characteristic to be addressed. The increase of Kr-85, a long-lived noble gas, would suggest an increase of the consequences associated with an accident that resulted in a breach of the fuel cask and fuel rods. The range of increase for the gas-cooled technologies being considered is from 121 percent to 133 percent. And as discussed in the previous section, if one considers the Kr-85 inventory per shipment, only the PBMR exceeds the reference LWR. These amounts are based on a 5-year cooling time. If this decay time were increased by about 11 years, slightly greater than the half-life of Kr-85 (10.6 years), not an unlikely scenario by the way, this increase would for the most part decay away. Another factor to consider is that transportation risk is a function of both consequences and likelihood. Because the new reactor technologies require fewer truck shipments, the likelihood would decrease approximately 37 percent for the reactor with the greatest Kr-85 inventory. Another factor to consider is that the accident rate for large trucks has steadily declined for more than the past 25 years and is less than half the rate in 1975. Thus, the likelihood of a large truck accident has decreased to about 37 percent (0.63 x 0.5) of the 1975 likelihood. A final and major factor to consider is that the cask regulations are based on allowable releases independent of the inventory. Thus, regardless of the initial source term, if the cask releases more than a specific acceptable amount, it would not be licensed. Based on these considerations, the 5-year Kr-85 quantities would still be bounded by the overall transportation risk profile provided by Table S-4.

3.8.2.7 Conclusion

In conclusion, this detailed comparison of the bases for Table S-4 show that the existing environmental and health effects are also conservative for the gas-cooled reactor

technologies being considered. Of close to 30 characteristics examined, only eight were exceeded by the new technologies. In these instances, either they are independent of any impact or there are mitigating factors and controls to demonstrate that these slight increases are bounded by the impacts specified in Table S-4. This conclusion is also borne out by the observation that these new reactor technologies will be using the same transportation modes and subject to the same USNRC and DOT regulations for packaging and transportation as the original analysis that was used to develop Table S-4. Thus, the new reactor technologies under consideration and the transportation of radioactive material associated with them meet the condition in 10 CFR 51.52(b).

3.8.3 Methodology Assessment

As indicated in Section 1.1.3, the selection of a reactor design to be used for the EGC ESP Facility is still under consideration. Selection of a reactor to be used at the EGC ESP Site may not be limited to those considered above. However, the methodology utilized above is appropriate to evaluate the final selected reactor. Further, should the selected design be shown to be bounded by the above evaluation, then the selected design would be considered to be within the acceptable transportation environmental impacts considered for this ESP.

CHAPTER 3

References

Chapter Introduction

None

Section 3.1

None

Section 3.2

None

Section 3.3

None

Section 3.4

None

Section 3.5

10 CFR 20. Code of Federal Regulations. "Standards for the Protection Against Radiation."

10 CFR 50. Code of Federal Regulations. "Domestic Licensing of Production and Utilization Facilities."

Section 3.6

None

Section 3.7

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Section 3.8

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10 CFR 51. Code of Federal Regulations. "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

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23 CFR 658. Code of Federal Regulations. "Truck Size And Weight, Route Designations-- Length, Width And Weight Limitations."

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CHAPTER 3

Tables

TABLE 3.3-1
Water Balance for Clinton Lake with Proposed EGC ESP

Month	Monthly Runoff (in)[a]	Runoff (million gal)	Monthly Evaporation (in)[a]	Monthly Evaporation (million gal)	CPS Forced Evaporation (gpm)[b]	CPS Annual Forced Evaporation (million gal)	ESP Cooling Tower Evaporation (gpm)[c]	ESP Annual Cooling Tower Evaporation (million gal)	Seepage (million gal)[d]	Outfall (million gal)
Jan	0.8	4,115	-	-						
Feb	1.01	5,196	-	-						
Mar	1.99	10,237	1.17	156						
Apr	1.76	9,054	3.34	444						
May	1.86	9,568	5.19	690						
Jun	1.21	6,224	6.41	852						
Jul	0.84	4,321	6.24	829						
Aug	0.5	2,572	5.26	699						
Sep	0.21	1,080	4.14	550						
Oct	0.35	1,800	2.47	328						
Nov	0.57	2,932	0.52	69						
Dec	0.87	4,475	-	-						
Total w ESP	11.97	61,575	34.74	4,618	8,292	4,358	12,000	6,307	1,451	44,841
Total w/o ESP	11.97	61,575	34.74	4,618	8,292	4,358	0	0	1,451	51,148

[a] From Table 2.3-2 of ER. The drainage area upstream of the Clinton Dam is 296 mi^2 . The surface area of the Clinton Lake is 4,855 ac or 7.64 mi^2 .

[b] From Table 5.2-1 of ER.

[c] From Table 5.2-4 of ER.

[d] Based on 6 percent annually of the total lake volume of 74,200 ac-ft.

TABLE 3.3-2
Required Raw Water Supply with Cooling Towers Used for Turbine Cycle and Safety-Related Cooling

Service	Normal	Maximum	Source
Potable/sanitary	90 gpm	198 gpm	SSAR Table 1.4-1/PPE Section 5.2.2/5.2.1
Demineralized Water	550 gpm	720 gpm	SSAR Table 1.4-1/PPE Section 6.2.2/6.2.1
Filtered Water	138 gpm	175 gpm	25% of the demineralized water flow
NHS Cooling Tower makeup from lake	43,500 gpm	43,500 gpm [a]	SSAR Table 1.4-1/PPE Section 2.5.9
UHS Cooling Tower makeup from lake	555 gpm	1,400 gpm	SSAR Table 1.4-1/PPE Section 3.3.9
Fire Protection	10 gpm	2,500 gpm	SSAR Table 1.4-1/PPE Section 7.1.2/7.1.1
Total	**44,843 gpm**	**48,493 gpm**	

[a] The vendor supplied one value for the NHS cooling tower makeup so it was conservatively assumed to be the normal makeup flow rate from Clinton Lake.

Note: The demineralizer water system is completely independent from the filtered water system.

TABLE 3.3-3
Cooling Water, Thermal Discharges to Clinton Lake

Service	Flow	Temperature	Source
NHS turbine cycle cooling tower blowdown	12,000 gpm normal, 49,000 gpm max	100°F	SSAR Table 1.4-1/PPE Section 2.5.4
UHS cooling tower blowdown	144 gpm normal, 700 gpm max	95°F	SSAR Table 1.4-1/PPE Section 3.5.3
Total Discharge from Cooling Towers	12,144 gpm normal, 49,700 gpm max	101°F	

[a] Total discharge does not include UHS Tower blowdown, since the bounding plant does not require a UHS.

TABLE 3.5-1
Normal Radioactive Liquid Effluents

Isotope	Maximum Composite Release (Ci/yr)	Isotope	Maximum Composite Release (Ci/yr)
C-14	4.40E-04	Tc-99m	1.10E-03
Na-24	3.26E-03	Ru-103	9.86E-03
P-32	1.80E-04	Rh-103m	9.86E-03
Cr-51	7.70E-03	Rh-106	1.47E-01
Mn-54	2.60E-03	Ru-106	1.47E-01
Mn-56	3.81E-03	Ag-110m	2.10E-03
Fe-55	5.81E-03	Ag-110	2.80E-04
Fe-59	4.00E-04		
Ni-63	1.40E-04	Sb-124	6.79E-04
Cu-64	7.51E-03		
Co-56	5.19E-03	Te-129m	2.40E-04
Co-57	7.19E-05	Te-129	3.00E-04
Co-58	6.72E-03	Te-131m	1.80E-04
Co- 60	9.11E-03	Te-131	6.00E-05
Zn-65	8.20E-04	I-131	2.83E-02
W-187	2.60E-04	Te-132	4.80E-04
Np-239	3.11E-03	I-132	3.28E-03
Br-84	4.00E-05	I-133	1.34E-02
Rb-88	5.40E-04	I-134	1.70E-03
Rb-89	4.41E-05	Cs-134	1.99E-02
Sr-89	2.00E-04	I-135	9.94E-03
Sr-90	3.51E-05	Cs-136	1.26E-03
Sr-91	9.00E-04	Cs-137	2.66E-02
Y-90	3.11E-06	Cs-138	1.90E-04
Y-91	1.10E-04	Ba-137m	2.49E-02
Sr-92	8.00E-04	Ba-140	1.10E-02
Y-91m	2.00E-05	La-140	1.49E-02
Y-92	6.00E-04	Ce-141	1.80E-04
Y-93	9.00E-04	Ce-143	3.80E-04
Zr-95	1.04E-03	Pr-143	2.60E-04
Nb-95	1.91E-03	Ce-144	6.32E-03
Mo-99	1.14E-03	Pr-144	6.32E-03
		All Others	**4.00E-05**
		Subtotal (without H-3)	**5.53E-01**
		Total Tritium (H-3)	**3.1E+03**
		Total	**3.1E+03**

TABLE 3.5-2
Comparison of Liquid Releases to 10 CFR 20 Effluent Concentration Limits (ECLs)

Isotope [a]	Release (Ci/yr)[b]	Boundary Concentration (µCi/cc)	Fraction of ECL
C-14	4.40E-04	1.15E-10	3.8E-06
Na-24	3.26E-03	8.53E-10	1.7E-05
P-32	1.80E-04	4.71E-11	5.2E-06
Cr-51	7.70E-03	2.02E-0-9	4.0E-06
Mn-54	2.60E-03	6.81E-10	2.3E-05
Mn-56	3.81E-03	9.98E-10	1.4E-05
Fe-55	5.81E-03	1.52E-09	1.5E-05
Fe-59	4.00E-04	1.02E-10	1.0E-05
Ni-63	1.40E-04	3.66E-11	3.7E-07
Cu-64	7.51E-03	1.97E-09	9.8E-06
Co-56	5.19E-03	1.36E-09	2.3E-04
Co-57	7.19E-05	1.88E-11	3.1E-07
Co-58	6.72E-03	1.76E-09	8.8E-05
Co-60	9.11E-03	2.38E-09	7.9E-04
Zn-65	8.20E-04	2.15E-10	4.3E-05
W-187	2.60E-04	6.81E-11	2.3E-06
Np-239	3.11E-03	8.14E-10	4.1E-05
Br-84	4.00E-05	1.05E-11	2.6E-08
Rb-88	5.40E-04	1.41E-10	3.5E-07
Rb-89	4.41E-05	1.15E-11	1.3E-08
Sr-89	2.00E-04	5.24E-11	6.5E-06
Sr-90	3.51E-05	9.20E-12	1.8E-05
Sr-91	9.00E-04	2.36E-10	1.2E-05
Y-90	3.11E-06	8.14E-13	1.2E-07
Y-91	1.10E-04	2.88E-11	3.6E-06
Sr-92	8.00E-04	2.09E-10	5.2E-06
Y-91m	2.00E-05	5.24E-12	2.6E-09
Y-92	6.00E-04	1.57E-10	3.9E-06
Y-93	9.00E-04	2.36E-10	1.2E-05
Zr-95	1.04E-03	2.72E-10	1.4E-05
Nb-95	1.91E-03	5.00E-10	1.7E-05
Mo-99	1.14E-03	2.98E-10	1.5E-05
Tc-99m	1.10E-03	2.88E-10	2.9E-07
Ru-103	9.86E-03	2.58E-09	8.6E-05
Rh-103m	9.86E-03	2.58E-09	4.3E-07
Ru-106	1.47E-01	3.85E-08	1.3E-02

TABLE 3.5-2

Comparison of Liquid Releases to 10 CFR 20 Effluent Concentration Limits (ECLs)

Isotope [a]	Release (Ci/yr)[b]	Boundary Concentration (μCi/cc)	Fraction of ECL
Ag-110m	2.10E-03	5.50E-10	9.2E-05
Sb-124	1.78E-03	4.67E-10	6.7E-05
Te-129m	2.40E-04	6.28E-11	9.0E-06
Te-129	3.00E-04	7.85E-11	2.0E-07
Te-131m	1.80E-04	4.71E-11	5.9E-06
Te-131	6.00E-05	1.57E-11	2.0E-07
I-131	2.83E-02	7.40E-09	7.4E-03
Te-132	4.80E-04	1.26E-10	1.4E-05
I-132	3.28E-03	8.59E-10	8.6E-06
I-133	1.34E-02	3.51E-09	5.0E-04
I-134	1.70E-03	4.45E-10	1.1E-06
Cs-134	1.99E-02	5.20E-09	5.8E-03
I-135	9.94E-03	2.60E-09	8.7E-05
Cs-136	1.26E-03	3.30E-10	5.5E-05
Cs-137	2.66E-02	6.97E-09	7.0E-03
Cs-138	1.90E-04	4.97E-11	1.2E-07
Ba-140	1.10E-02	2.89E-09	3.6E-04
L-140	1.49E-02	3.89E-09	4.3E-04
Ce-141	1.80E-04	4.71E-11	1.6E-06
Ce-143	3.80E-04	9.95E-11	5.0E-06
Pr-143	2.60E-04	6.81E-11	2.7E-06
Ce-144	6.32E-03	1.65E-09	5.5E-04
Pr-144	6.32E-03	1.65E-09	2.8E-06
Subtotal (without H-3) Pr-144	**3.81E-01**	**---**	**3.73E-02**
Tritium (H-3) Subtotal (without H-3)	**3.10E+03**	**8.12E-04**	**8.14E-01**
Total (all radionuclides)			
Tritium (H-3)	**3.10E+03**	**---**	**8.50E-01**

[a] Total release based on composite of the highest activity content of the individual isotopes from the AP-1000 (2 units), ABWR/ESBWR (1 unit), ACR-700 (2 units), IRIS (3 units), GT-MHR (4 modules), and the PBMR (8 modules).

[ab] Certain nuclides such as Rh-106, Ag-110, and Ba-137m are released but not included in the table. Water ECLs are not defined for these nuclides due to short half-lives.

TABLE 3.5-3
Normal Radioactive Gaseous Effluents

Isotope	Maximum Composite Release Ci/yr	Isotope	Maximum Composite Release Ci/yr
Kr-83m	8.38E-04	Sr-89	6.00E-03
Kr-85m	7.20E+01	Sr-90	2.40E-03
Kr-85	8.20E+03	Y-90	4.59E-05
Kr-87	3.00E+01	Sr-91	1.00E-03
Kr-88	9.20E+01	Sr-92	7.84E-04
Kr-89	2.41E+02	Y-91	2.41E-04
Kr-90	3.24E-04	Y-92	6.22E-04
Xe-131m	3.60E+03	Y-93	1.11E-03
Xe-133m	1.74E+02	Zr-95	2.00E-03
Xe-133	9.20E+03	Nb-95	8.38E-03
Xe-135m	4.05E+02	Mo-99	5.95E-02
Xe-135	6.60E+02	Tc-99m	2.97E-04
Xe-137	5.14E+02	Ru-103	3.51E-03
Xe-138	4.32E+02	Rh-103m	1.11E-04
Xe-139	4.05E-04	Ru-106	1.56E-04
I-131	2.59E-01	Rh-106	1.89E-05
I-132	2.19E+00	Ag-110m	2.00E-06
I-133	1.70E+00	Sb-124	1.81E-04
I-134	3.78E+00	Sb-125	1.22E-04
I-135	2.41E+00	Te-129m	2.19E-04
C-14	1.46E+01	Te-131m	7.57E-05
Na-24	4.05E-03	Te-132	1.89E-05
P-32	9.19E-04	Cs-134	6.22E-03
Ar-41	4.00E+02	Cs-136	5.95E-04
Cr-51	3.51E-02	Cs-137	9.46E-03
Mn-54	5.41E-03	Cs-138	1.70E-04
Mn-56	3.51E-03	Ba-140	2.70E-02
Fe-55	6.49E-03	La-140	1.81E-03
Co-57	1.64E-05	Ce-141	9.19E-03
Co-58	4.60E-02	Ce-144	1.89E-05
Co-60	1.74E-02	Pr-144	1.89E-05
Fe-59	8.11E-04	W-187	1.89E-04
Ni-63	6.49E-06	Np-239	1.19E-02
Cu-64	1.00E-02	**Subtotal**	
Zn-65	1.11E-02	**(without H-3)**	**2.40E+04**
Rb-89	4.32E-05	**Tritium (H-3)**	**3.53E+03**
		Total	**2.76E+04**

TABLE 3.5-4
Comparison of Gaseous Releases to 10 CFR 20 Effluent Concentration Limits

Isotope	Release Ci/yr	Boundary Concentration µCi/cc [a]	10 CFR 20 ECL µCi/cc	Fraction of ECL
Kr-83m	8.38E-04	6.8E-17	5.0E-05	1.4E-12
Kr-85m	7.20E+01	5.8E-12	1.0E-07	5.8E-05
Kr-85	8.20E+03	6.6E-10	7.0E-07	9.5E-04
Kr-87	3.00E+01	2.4E-12	2.0E-08	1.2E-04
Kr-88	9.20E+01	7.4E-12	9.0E-09	8.3E-04
Kr-89	2.41E+02	1.9E-11	1.0E-09	1.9E-02
Kr-90	3.24E-04	2.6E-17	1.0E-09	2.6E-08
Xe-131m	3.60E+03	2.9E-10	2.0E-06	1.5E-04
Xe-133m	1.74E+02	1.4E-11	6.0E-07	2.3E-05
Xe-133	9.20E+03	7.4E-10	5.0E-07	1.5E-03
Xe-135m	4.05E+02	3.3E-11	4.0E-08	8.2E-04
Xe-135	6.60E+02	5.3E-11	7.0E-08	7.6E-04
Xe-137	5.14E+02	4.2E-11	1.0E-09	4.2E-02
Xe-138	4.32E+02	3.5E-11	2.0E-08	1.7E-03
Xe-139	4.05E-04	3.3E-17	1.0E-09	3.3E-08
I-131	2.59E-01	2.1E-14	2.0E-10	1.0E-04
I-132	2.19E+00	1.8E-13	2.0E-08	8.9E-06
I-133	1.70E+00	1.4E-13	1.0E-09	1.4E-04
I-134	3.78E+00	3.1E-13	6.0E-08	5.1E-06
I-135	2.41E+00	1.9E-13	6.0E-09	3.2E-05
C-14	1.46E+01	1.2E-12	3.0E-09	3.9E-04
Na-24	4.05E-03	3.3E-16	7.0E-09	4.7E-08
P-32	9.19E-04	7.4E-17	1.0E-09	7.4E-08
Ar-41	4.00E+02	3.2E-11	1.0E-08	3.2E-03
Cr-51	3.51E-02	2.8E-15	3.0E-08	9.5E-08
Mn-54	5.41E-03	4.4E-16	1.0E-09	4.4E-07
Mn-56	3.51E-03	2.8E-16	2.0E-08	1.4E-08
Fe-55	6.49E-03	5.2E-16	3.0E-09	1.7E-07
Co-57	1.64E-05	1.3E-18	9.0E-10	1.5E-09
Co-58	4.60E-02	3.7E-15	1.0E-09	3.7E-06
Co-60	1.74E-02	1.4E-15	5.0E-11	2.8E-05
Fe-59	8.11E-04	6.6E-17	5.0E-10	1.3E-07
Ni-63	6.49E-06	5.2E-19	1.0E-09	5.2E-10
Cu-64	1.00E-02	8.1E-16	3.0E-08	2.7E-08
Zn-65	1.11E-02	9.0E-16	4.0E-10	2.2E-06
Rb-89	4.32E-05	3.5E-18	2.0E-07	1.7E-11
Sr-89	6.00E-03	4.9E-16	2.0E-10	2.4E-06
Sr-90	2.40E-03	1.9E-16	6.0E-12	3.2E-05
Y-90	4.59E-05	3.7E-18	9.0E-10	4.1E-09
Sr-91	1.00E-03	8.1E-17	5.0E-09	1.6E-08

TABLE 3.5-4
Comparison of Gaseous Releases to 10 CFR 20 Effluent Concentration Limits

Isotope	Release Ci/yr	Boundary Concentration μCi/cc [a]	10 CFR 20 ECL μCi/cc	Fraction of ECL
Sr-92	7.84E-04	6.3E-17	9.0E-09	7.0E-09
Y-91	2.41E-04	1.9E-17	2.0E-10	9.7E-08
Y-92	6.22E-04	5.0E-17	1.0E-08	5.0E-09
Y-93	1.11E-03	9.0E-17	3.0E-09	3.0E-08
Zr-95	2.00E-03	1.6E-16	4.0E-10	4.0E-07
Nb-95	8.38E-03	6.8E-16	2.0E-09	3.4E-07
Mo-99	5.95E-02	4.8E-15	4.0E-09	1.2E-06
Tc-99m	2.97E-04	2.4E-17	2.0E-07	1.2E-10
Ru-103	3.51E-03	2.8E-16	9.0E-10	3.2E-07
Rh-103m	1.11E-04	9.0E-18	2.0E-06	4.5E-12
Ru-106	1.56E-04	1.3E-17	2.0E-11	6.3E-07
Rh-106	1.89E-05	1.5E-18	1.0E-09	1.5E-09
Ag-110m	2.00E-06	1.6E-19	1.0E-10	1.6E-09
Sb-124	1.81E-04	1.5E-17	3.0E-10	4.9E-08
Sb-125	1.22E-04	9.9E-18	7.0E-10	1.4E-08
Te-129m	2.19E-04	1.8E-17	3.0E-10	5.9E-08
Te-131m	7.57E-05	6.1E-18	2.0E-09	3.1E-09
Te-132	1.89E-05	1.5E-18	1.0E-09	1.5E-09
Cs-134	6.22E-03	5.0E-16	2.0E-10	2.5E-06
Cs-136	5.95E-04	4.8E-17	9.0E-10	5.3E-08
Cs-137	9.46E-03	7.6E-16	2.0E-10	3.8E-06
Cs-138	1.70E-04	1.4E-17	8.0E-08	1.7E-10
Ba-140	2.70E-02	2.2E-15	2.0E-09	1.1E-06
La-140	1.81E-03	1.5E-16	2.0E-09	7.3E-08
Ce-141	9.19E-03	7.4E-16	8.0E-10	9.3E-07
Ce-144	1.89E-05	1.5E-18	2.0E-11	7.6E-08
Pr-144	1.89E-05	1.5E-18	2.0E-07	7.6E-12
W-187	1.89E-04	1.5E-17	1.0E-08	1.5E-09
Np-239	1.19E-02	9.6E-16	3.0E-09	3.2E-07
Subtotal (without H-3)	**2.40E+04**	**---**	**---**	**7.2E-02**
Tritium (H-3)	**3.53E+03**	**2.9E-10**	**1.0E-07**	**2.9E-03**
Total	**2.76E+04**	**---**	**---**	**7.5E-02**

[a] Boundary concentration values based on an average annual Chi/Q at the boundary of the restricted area (taken as the EGC ESP Site exclusion area distance of 1,025 m) in the sector with the highest value (NNE) = 2.04E-6 sec/m^3 (Table 2.7-53).

TABLE 3.5-5
Composite Principal Radionuclides in Solid Radwaste

Radionuclide	Quantity (Ci/y)r
Fe-55	1.76E+03
Fe-59	2.70E+00
Co-60	3.96E+02
Mn-54	3.47E+02
Cr-51	9.71E+01
Co-58	1.87E+02
Zn-65	5.14E+01
Nb-95	1.62E+02
Ag-110m	2.18E+00
Zr-95	7.65E+01
Ba-137m	1.01E+03
Ba-140	1.06E+00
La-140	1.21E+00
Cs-134	6.28E+02
Cs-136	6.00E-02
Cs-137	1.01E+03
Sr-89	1.77E+00
Sr-90	2.48E+00
Y-90	2.48E+00
I-131	8.19E+01
I-133	4.55E+00
Na-24	4.40E-01
Rh-106	1.20E-01
Ru-103	2.18E+00
Ru-106	1.37E+00
Sb-124	1.13E+01
Ce-141	1.40E-01
Ce-144	1.10E-01
Gd-153	3.09E+00
Other	7.29E+01
Total (rounded to nearest hundred)	5.90E+03

TABLE 3.6-1
Estimated Bounding Blowdown Constituents and Concentrations

Constituents	Concentration (ppm)[a]		
	River Source	Well (Treated Water)	Bounding Estimate
Chlorine Demand	10.1	--- [b]	10.1
Free Available Chlorine	0.5	--- [b]	0.5
Copper	--- [b]	6	6
Iron	0.9	3.5	3.5
Zinc	--- [b]	0.6	0.6
Phosphate	--- [b]	7.2	7.2
Sulfate	599	3,500	3,500
Total Dissolved Solids	--- [b]	17,000	17,000
Total Suspended Solids	49.5	150	150

[a] Source: SSAR Table 1.4-2, and data supplied by the different reactor vendors (data are not site-specific.)
[b] Data not available

TABLE 3.6-2
Sanitary Discharges to Clinton Lake

Service	Normal	Maximum	Source
Sanitary waste discharge (This is the discharge from the potable/sanitary water system.)	60 gpm	198 gpm	SSAR Table 1.4-1/PPE Section 5.1.1

TABLE 3.6-3
Other Effluent Discharges

Service	Normal	Maximum	Source
Chemical waste discharge: This is the total of the regeneration wastes from the demineralized water system(s).	110 gpm	145 gpm	SSAR Table 1.4-1/PPE Section 6.1.1
Miscellaneous plant drains: This is the discharge from miscellaneous plant sources.	213 gpm	325 gpm	SSAR Table 1.4-1/PPE Section 8.1.1
Total	**323 gpm**	**470 gpm**	

TABLE 3.6-4
Bounding Estimates for Yearly Emissions from Auxiliary Boilers and Standby Diesel Generators for the EGC ESP Facility

Pollutant Discharged	Quantity (lbs)	Exhaust Elevation (ft)	Source
Auxiliary Boilers		110 ft above plant grade	SSAR Table 1.4-1/PPE Section 13.1
Particulates	34,500		SSAR Table 1.4-4
Sulfur Oxides	115,000		SSAR Table 1.4-4
Carbon Monoxide	1,749		SSAR Table 1.4-4
Hydrocarbons	100,200		SSAR Table 1.4-4
Nitrogen Oxides	19,022		SSAR Table 1.4-4
Note: Emissions from the operation of the auxiliary boilers are based on a 30-day/year operation			
Standby Generators		30 ft above plant grade	SSAR Table 1.4-1/PPE Section 16.1.2
Particulates	1,620		SSAR Table 1.4-5
Sulfur Oxides	5,010		SSAR Table 1.4-5
Carbon Monoxide	4,600		SSAR Table 1.4-5
Hydrocarbons	3,070		SSAR Table 1.4-5
Nitrogen Oxides	28,968		SSAR Table 1.4-5
Note: Emissions from the standby generators are based on a 4-hr/month operation for each generator			

TABLE 3.6-5

Bounding Estimates for Yearly Emissions from the Standby Power System Gas-Turbine Flue Gas for the EGC ESP Facility

Fuel: Distillate: LHV = 9,890 Btu/kWh, HHV = 10,480 Btu/kWh

96,960 lbs/hr fuel consumption rate

Release Height is 100 ft above plant grade (Table 1.4-1 of the SSAR/PPE Section 16.2.2)

Emissions are based on a 4-hour/month operating cycle for each generator

Effluent	PPMVD	Quantity (lbs)
NO_x (PPMVD @ 15% 0_2)	95	--
NO_x as NO_2	--	725
CO	25	85
UHC	10	20
VOC	5	10
SO_2	55	470
SO_3	5	30
Sulfur Mist	--	50
Particulates	--	22

Effluent	Exhaust Analysis Percent Volume
Argon	0.86
Nitrogen	72.56
Oxygen	11.2
Carbon Dioxide	5.19
Water	9.87

Source: SSAR Table 1.4-6

TABLE 3.7-1
State Transmission Line EMF Standards and Guidelines

	Electric Field		Magnetic Field	
State	**On Right-of-Way**	**Edge of Right-of-Way**	**On Right-of-Way**	**Edge of Right-of-Way**
Florida	8 kV/m[a]	2 kV/m		150 mG[a]
	10 kV/m[b]			200 mG[b]
				250 mG[c]
Minnesota	8 kV/m			
Montana	7 kV/m[d]			
New Jersey		3 kV/m		
New York	11.8 kV/m	1.6 kV/m		200 mG
	11 kV/m[e]			
	7 kVm[d]			
Oregon	9 kV/m			

[a] For line of 69-230 kV
[b] for 500-kV lines
[c] For 500-kV lines on certain existing right-of-way
[d] Maximum for highway crossings
[e] Maximum for private road crossings

TABLE 3.8-1
LWR Transportation Impact Evaluation

Reactor Technology	10 CFR 51.52(a) Condition Values	Bounding Values
Characteristic		
Reactor Power Level MWt	3,800 MWt	4,300 MWt
Fuel Form	Sintered UO_2 pellets	Sintered UO_2 pellets
U235 Enrichment	Not exceeding 4% by weight	Fuel cycle average ~4.85%; maximum assembly 4.95%; Reload up to 4.95%
Fuel Rod Cladding	Zircaloy	Zircaloy or ZIRLO
Average burnup MWd/MTU	33,000	55,200
Unirradiated fuel		
Transport mode	Truck	Truck
Irradiated fuel		
Transport mode	Truck, rail, or barge	Truck, rail, or barge
Decay time prior to shipment	At least 90 days	Five years
Radioactive waste		
Transport mode	Truck or rail	Truck or rail
Waste form	Solid	Solid
Packaged	Yes	Yes

TABLE 3.8-2

Gas-Cooled Reactor Transportation Impact Evaluation

Reactor Technology	Reference LWR (Single unit) (1,100 MWe)	GT-MHR (4 Modules) (2,400 MWt total) (1,140 MWe total)	PBMR (8 Modules) (3,200 MWt total) (1,320 MWe total)	Comments
Characteristic				
Capacity	80%	88%	95%	
Normalization factor	1	0.88	0.7	
Reactor Power Level MWt	~ 3,400	2,400 (600 MWt per module, 4 modules per plant)	3,200 (400 MWt per module, 8 modules per plant)	Not exceeding 3,800 MWt per reactor is a condition for use of Table S-4
Fuel Form	Sintered UO_2 pellets	Blocks of TRISO coated uranium oxycarbide (UCO) kernels [a]	Spheres of TRISO Coated UO_2 fuel kernels [a]	Sintered UO_2 pellets is a condition for use of Table S-4
U235 Enrichment	1% - 4%	Fissile particle 19.8%; fertile particle natural uranium [a]	Initial 4.9%; equilibrium 12.9% [a]	Not exceeding 4% is a condition for use of Table S-4; NUREG-1437 concludes that 5% is bounded
Fuel Rod Cladding	Zircaloy	Graphite [a]	Graphite [a]	Zircaloy rods are a condition for use of Table S-4; 10 CFR 50.44 allows use of ZIRLO)
Average burnup MWd/MTU	33,000	112,742 [a]	133,000 [a]	Not exceeding 33,000 is a condition for use of Table S-4; NUREG-1437 concludes 62,000 MWd/MTU for peak rod is bounded
Unirradiated fuel				
Unirradiated fuel transport mode	Truck	Truck	Truck	Shipment by truck is a condition for use of Table S-4
# of shipments for initial core loading	18	51 shipments (1020 fuel elements per module x 4 modules; 80 elements per truck) [a]	44 shipments (260,000 fuel spheres per module x 8 modules, 48,000 spheres per truck) [a]	100 MTU for PWR; 150 MTU for BWR

TABLE 3.8-2
Gas-Cooled Reactor Transportation Impact Evaluation

Reactor Technology	Reference LWR (Single unit) (1,100 MWe)	GT-MHR (4 Modules) (2,400 MWt total) (1,140 MWe total)	PBMR (8 Modules) (3,200 MWt total) (1,320 MWe total)	Comments
Characteristic				
# of Reload shipments/year	6	20 shipments (520 elements per reload per 1.32 years x 4 modules; 80 elements per truck)	20 shipments (120,000 fuel spheres per module x 8 modules, 48,000 spheres per truck)	30 MTU annual reload
Irradiated fuel				
Irradiated fuel transport mode	Truck, rail or barge	Truck	Truck	Shipment by truck, rail or barge is a condition for use of Table S-4
Decay time prior to shipment	150 days	Five years	Five years	Not less than 90 days is a condition for use of Table S-4; 5 years is per standard DOE contract with operating plants
Fission product inventory in Ci per MTU	$6.19x10^6$	$1.55x10^6$	$1.78x10^6$	LWR reference value is a 90-day decay time. Gas-cooled value is based on a 5-year decay time.
Actinide inventory in Ci per MTU	$1.42x10^5$	$2.33x10^5$ [a]	$2.26x10^5$ [a]	LWR reference value is a 90-day decay time. Gas-cooled value is based on a 5-year decay time.
Total radioactivity inventory in Ci per MTU	$6.33x10^6$	$1.78x10^6$	$2.01x10^6$	LWR reference value is a 90-day decay time. Gas-cooled value is based on a 5-year decay time.
Krypton-85 inventory in Ci per MTU	$1.13x10^4$	$2.50x10^4$ [a]	$2.63x10^4$ [a]	LWR reference value is a 90-day decay time. Gas-cooled value is based on a 5-year decay time.
Watts per MTU	$2.71x10^4$	$6.36x10^3$	$3.91x10^3$	LWR reference value is a 90-day decay time. Gas-cooled value is based on a 5-year decay time.
# of spent fuel shipments by truck	60	38 shipments (520 elements per module x 4 modules per 1.32 years, 42 elements per truck)	16 shipments (12 shipments for 1000 MWe)	0.5 MT of irradiated fuel per cask

TABLE 3.8-2

Gas-Cooled Reactor Transportation Impact Evaluation

Reactor Technology	Reference LWR (Single unit) (1,100 MWe)	GT-MHR (4 Modules) (2,400 MWt total) (1,140 MWe total)	PBMR (8 Modules) (3,200 MWt total) (1,320 MWe total)	Comments
Characteristic				
Decay heat (kW) (per irradiated fuel truck cask in transit)	10	1.02 (6.356 kW/MTU x 0.16044 MTU/shipment)	1.9 (3.9 kW/MTU x 0.495 MTU/shipment)	
# of spent fuel shipments by rail	10	0	0	3.2 – 3.5 MT of irradiated fuel per cask
Heat (per irradiated fuel rail cask in transit) kW	70	NA	NA	
# of spent fuel shipments by barge	5	0	0	
Radioactive waste				
Radioactive waste transport mode	Truck or rail	Truck	Truck	Shipment by truck or rail is a condition for use of Table S-4
# of rad waste shipments by truck	46	6 (98 m^3/yr)	9 (800 drums)	Assumed 90% of the waste shipped at 1000 ft^3 per truck, 10% at 200 ft^3 per truck
Weight per truck lbs.	73,000	Governed by state and federal regulations	Governed by state and federal regulations	Interstate gross vehicle limit is 80,000 lbs. (23 CFR 658.17)
# of rad waste shipments by rail	11	0	0	
Weight per cask per rail car tons	100	100	100	
Transport totals				
Traffic density, trucks per day	Less than 1	Less than 1	Less than 1	
Rail density, cars per month	Less than 3	0	0	

Source: 10 CFR 51.52, Table S-4 Environmental Impact of Transportation of Fuel and Waste

[a] Value larger than or different from the reference LWR.

Notes: The results for the reactor technologies have not been adjusted for their larger electrical generation or increased capacity factor.

TABLE 3.8-3
Summary Table S-4-Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor

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 [a] (per reactor year)	Cumulative Dose to Exposed Population (per reactor year) [b]
Transportation workers	200	0.01 to 300 millirem	4 man-rem.
General public:			
Onlookers	1,100	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 [c]
Common (nonradiological) causes	1 fatal injury in 100 reactor years
	1 nonfatal injury in 10 reactor years
	$475 property damage per reactor year

Note: 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.

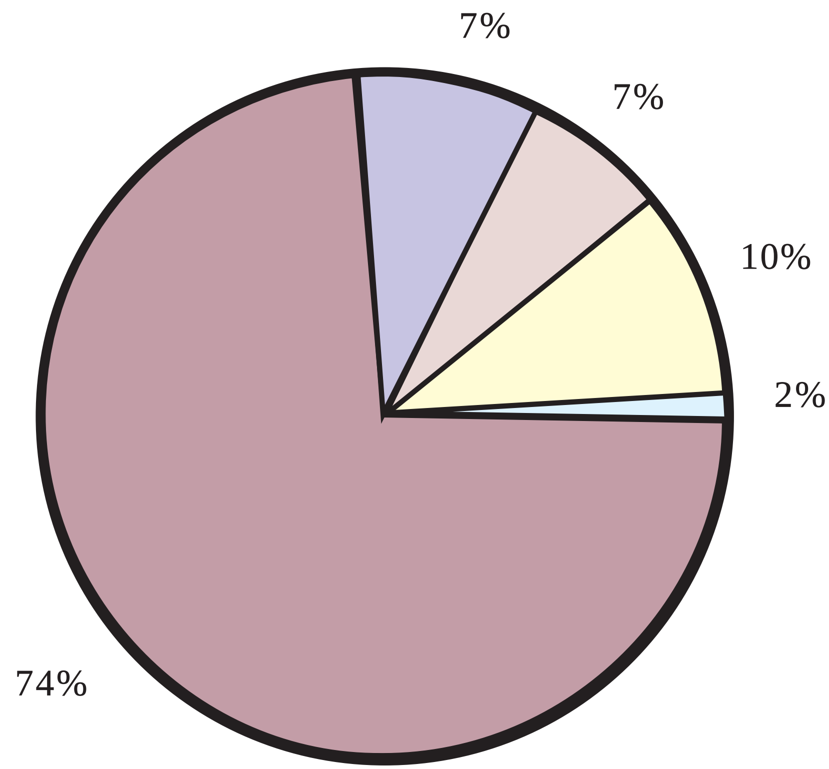
[a] The Federal Radiation Council has recommended that the radiation doses from the sources of radiation other than natural background and medical exposures should be limited to 5,000 millirem per year for individuals as a result of occupational exposure and should be limited to 500 millirem per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirem per year.

[b] 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 1,000 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.

[c] Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified since a specific reactor has not been selected, the risk remains small regardless of whether it is being applied to a single reactor or a multireactor site.

Environmental Report for the EGC Early Site Permit

Figure 3.3-1
Annual Clinton Lake Outflows with EGC ESP Facility



Legend

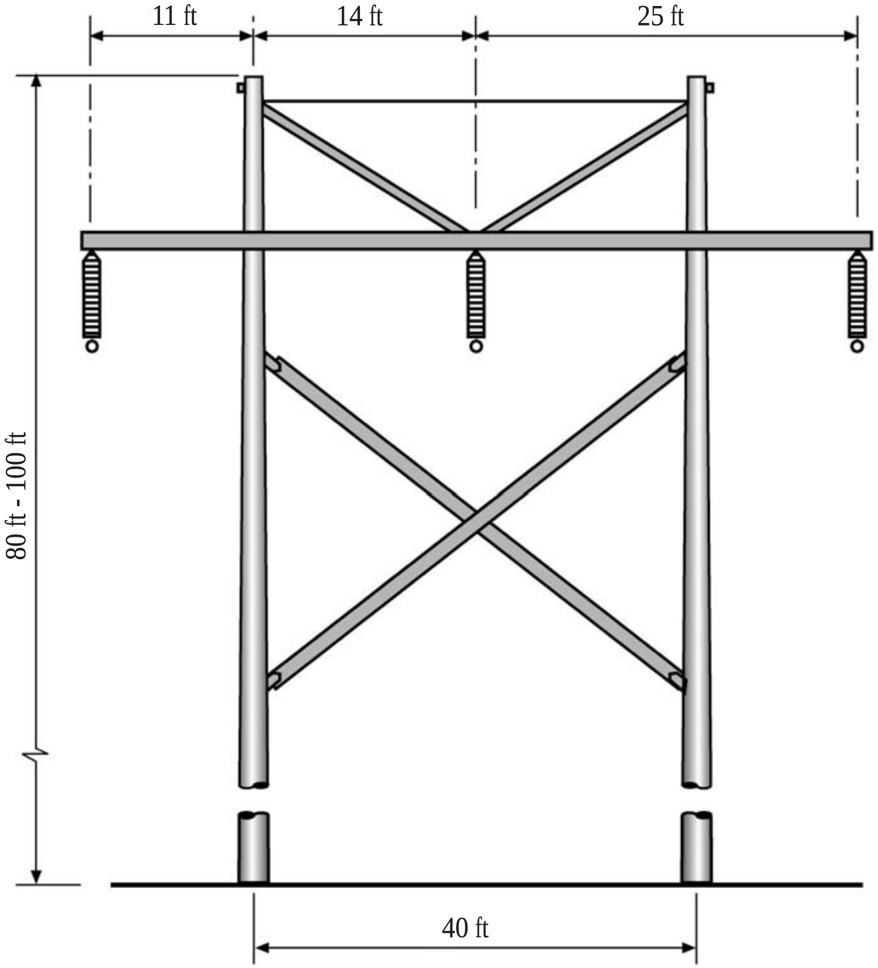
- Evaporation
- Cooling Tower Evap due to ESP
- Discharge at Clinton Lake Dam
- Forced Evap due to CPS
- Lake Bottom Seepage

Note:
Percentages are based on average annual runoff of 61,575 million gallons.

Not to Scale

Environmental Report for the EGC Early Site Permit

Figure 3.7-1
H-Frame Dimensions



Legend

Not to Scale