CHAPTER 6

Environmental Measurement and Monitoring Programs

This chapter presents the environmental measurement and monitoring programs that will be implemented at the EGC ESP Facility. These programs have been designed to provide preapplication and preoperational (preconstruction and construction phases) measurements for the EGC ESP Facility. In addition, operational measurements will be used to assess impacts of the facility operation. Although the existing database is sufficient to describe the site conditions presented in Chapter 2, the Preapplication Monitoring Program will be conducted to verify and update baseline conditions at the time of the COL application.

The discussion on measurements and the monitoring programs developed for the EGC ESP Facility have been divided into the following sections:

- Thermal Monitoring (Section 6.1);
- Radiological Monitoring (Section 6.2);
- Hydrological Monitoring (Section 6.3);
- Meteorological Monitoring (Section 6.4);
- Ecological Monitoring (Section 6.5);
- Chemical Monitoring (Section 6.6); and
- Summary of Monitoring Standards (Section 6.7).

The sampling design, constituents sampled, frequency, and locations for the specific phase of the overall program are described in each individual section.

6.1 Thermal Monitoring

This section presents the Thermal Monitoring Program for the EGC ESP Facility including:

- Preapplication monitoring that establishes baseline conditions and supports the thermal descriptions that are presented in Section 2.3.1;
- Preoperational monitoring that establishes a baseline for identifying and assessing environmental impacts resulting from facility operation; and
- Operational monitoring that establishes changes in water temperature resulting from facility operation.

6.1.1 Preapplication Monitoring

The objective of the Preapplication Monitoring Program is to establish the baseline water temperature. The available temperature information was evaluated to determine if the data are sufficient to support existing environmental descriptions presented in Section 2.3.1, and are based on the considerations listed below.

- Location and number of monitoring stations to consider factors including bathymetric characteristics of Clinton Lake; type of cooling system employed and probable operating modes; transient hydrological parameters in the vicinity of the site; and vertical and horizontal lake temperature in the vicinity of the site.
- Sampling frequency and times so that important temporal variations have been monitored.
- Duration of monitoring programs.
- Data analysis procedures.

The baseline thermal conditions presented in Section 2.3.1, are based on data collected for the environmental monitoring program (EMP) for the CPS, and on monitoring required by the CPS NPDES permit. Clinton Lake is also part of the IEPA, Bureau of Water's ambient lake program (IEPA, 2002).

Illinois Power Company monitored the water quality of Clinton Lake to satisfy various environmental regulations, licenses, and permits associated with the construction and operation of the CPS. These assessments include seven years of monitoring prior to construction of the dam (1972 to May 1978), nine years of water quality data after the dam construction and prior to the operation of the CPS (1978 through 1986), and five years of data since the CPS began operations (1987 through 1991). The thermal measurements conducted as part of the postdam water quality monitoring program are summarized in Table 6.1-1. Monitoring locations for the postdam monitoring programs are presented in Figure 6.1-1.

The thermal monitoring requirements of the CPS NPDES permit are described below (IEPA, 2000).

- The water discharge temperature into Clinton Lake from the CPS is measured at the second drop structure of the discharge flume. The reporting requirements include daily average, daily maximum, and monthly average water temperature of the discharge. Monitoring data are available from December of 1996 to 2000.
- The temperature is continuously monitored in Salt Creek at a depth of 1.6 ft, approximately 100-ft downstream of the bottom of the dam spillway (Site 1.5 on Figure 6.1-1) during the months of June, July, and August of each year (Special Condition 8). Monitoring data are available from 1992 to 2000.

As part of its ambient lake program, IEPA collects temperature and chemical data at three lake sites, including Clinton Lake. Each lake monitored is sampled five times: once during the spring runoff (April or May), three times during the summer (June, July and August) and once during the fall (September or October). The "Core Lakes," including Clinton Lake, are sampled every three years. The analytical data can be accessed from the STORET database maintained by the USEPA (IEPA, 2002). The sample locations are presented in Figure 6.1-1. The next sampling of Clinton Lake will be in the year 2003.

6.1.1.1 Freshwater Streams

The thermal baseline for Salt Creek is based on data collected by the ISWS at the Rowell gauging station, about 12-mi downstream of Clinton Lake and the summer temperature data collected at Site 1.5 about 100-ft downstream of the dam spillway. Although the existing thermal database is sufficient to describe the thermal conditions in Salt Creek, additional preapplication monitoring will be conducted to verify and update the baseline conditions at the time of the COL application. In addition to continued collection and evaluation of data collected at these locations, the proposed preapplication water quality monitoring will include monthly temperature measurements at a location downstream of the Clinton Lake Dam (Site E-3 on Figure 6.1-1). At each site, temperature measurements will be collected at the surface and 1.5-ft depth intervals to the bottom using a "YSI Multiprobe or Multiparameter Instrument" (or equivalent meter). The depth of the water column will also be recorded. The data will be used to monitor the conditions in Salt Creek between the dam and the Rowell gauging station.

6.1.1.2 Lakes and Impoundments

Although the existing thermal database is sufficient to describe the thermal conditions in Clinton Lake, additional preapplication monitoring will be conducted to verify and update the baseline conditions at the time of the COL application. The proposed preapplication monitoring will include the collection of monthly temperature measurements from general locations described below and presented in Figure 6.1-1.

- Locations Coincident with CPS Monitoring Locations
  - Site 16 is located upstream from the discharge canal. Data from this site will be used to characterize thermal conditions upstream of the discharge flume.
  - Site 2 is located offshore from the cooling water discharge flume. Data from this site will be used to characterize lake conditions at the point of thermal discharge to the lake.

  - Sites 8 and 13 are located along the path of the cooling loop between the discharge of water into the lake and the CPS intake. The data from these sites will be used to characterize conditions along the cooling loop.
  - Site 4 is located near the CPS screen house. The data from this location will be used to characterize lake conditions at the intake.
- Proposed New Monitoring Locations
  - Site E-1 will be located upstream of the furthest CPS monitoring location (Site 16). This new location has been included to help characterize the background conditions in Salt Creek prior to the point of discharge to the lake. Existing temperature data from Site 16, located downstream of the bridge over Illinois Route 48, appear to indicate thermal impacts from the CPS discharge (CPS, 1992).
  - Site E-2 will be located in Clinton Lake, near the dam. The data from this new location will be used to characterize the conditions of water being discharged to Salt Creek.

At each site, the temperature measurements will be collected at the surface and 0.5-m (1.5-ft) depth intervals to the bottom using a "YSI Multiprobe or Multiparameter Instrument" (or equivalent meter). The depth of the water column will also be recorded. If thermal stratification (temperature gradient of at least 1°C [about 35°F] per 3-ft depth interval) is present, the water column will be segmented into epilimnion, metalimnion, and hypolimnion. The temperature measurements at each site will be taken at consistent depths and at a time of day (morning) that minimizes the effect of diurnal solar warming.

Additional locations and more frequent measurements during summer months may be incorporated into the monitoring program as the engineering design progresses. Although the exact locations and procedures (e.g., some locations may be monitored remotely) may be modified. It is anticipated that the data, once collected and evaluated, will provide the necessary information to supplement the existing database and support the description of baseline conditions in Clinton Lake. In addition, the monitoring will be coordinated with the data collection activities conducted for the CPS in order to avoid duplicate efforts.

6.1.2 Preoperational Monitoring

The Preoperational Monitoring Program has been designed to monitor the developmental stages (preconstruction and construction) of the EGC ESP Facility. The data will be used to supplement the preapplication monitoring by providing additional water temperature data during the construction activities of the EGC ESP Facility.

The Preoperational Monitoring Program will consist of continuing the preapplication monitoring until the EGC ESP Facility is operational. The results of the preapplication sampling will be evaluated in order to determine if the scope and the frequency of thermal monitoring need to be modified to establish the baseline for water temperature in Clinton Lake and Salt Creek. Modifications to the Preoperational Monitoring Program will consider the following objectives:

- Determine the average, extent, and surface area of the limiting excess temperature isotherm if one has been established by the IEPA;

- Determine the temperature at positions that are appropriate in order to define the extent of existing mixing zones from the discharge flume; and
- Establish time-temperature relationships at monitoring stations.

6.1.3 Operational Monitoring

The Operational Thermal Monitoring Program will be implemented in order to establish changes in water temperature resulting from facility operation. The specific operational monitoring requirements will be developed in consultation with IEPA, relative to NPDES permit requirements and the monitoring requirements for the CPS at that time.

Although the specific procedures of the Operational Thermal Monitoring Program have not been developed, it is anticipated that the monitoring stations will be similar to those used in the Preoperational Monitoring Program. Therefore, thermal changes resulting from facility operations will be evaluated. The data will be evaluated for temperature variability (relative to both distance from the discharge canal and vertical stratification) and temporal trends. Based on the monitoring data for the CPS, the Operational Monitoring Program is anticipated to extend over a five-year period, beginning at EGC ESP Facility operation, or as conditions appear to have stabilized based on the trend analysis. Modifications to the monitoring program (e.g., changes in monitoring locations, collection procedures) will be assessed regularly and over the duration of the monitoring program.

6.2 Radiological Monitoring

The proposed Radiological Environmental Monitoring Program (REMP) for the EGC ESP Facility will be designed to monitor the radiological environment during the preconstruction and construction phases from active CPS Facility operations as well as the radiological environment surrounding the EGC ESP Facility during active facility operations. The primary objective is to monitor for potential radiological exposures to construction workers, the general public, and the surrounding environment during construction and active facility operations. To the greatest extent practical the Applicant will utilize CPS monitoring and sampling equipment as well as already established monitoring/sampling locations.

6.2.1 Proposed Radiological Environmental Monitoring Program

The proposed REMP will be implemented in accordance with the 10 CFR 20.1501 and Criterion 64 of 10 CFR 50, Appendix A. The program was developed using the following guidance published by the USNRC:

- Regulatory Guide 4.1, Revision 1, *Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants* (USNRC, 1975); and
- Regulatory Guide 4.15, Revision 1, *Quality Assumptions for Radiological Monitoring Programs (Normal Operations) – Effluent Streams and the Environment* (USNRC, 1979).

The purpose of the REMP is to sample, measure, analyze, and monitor the radiological impact of proposed reactor operation(s) on the environment. Objectives of the program include the following:

- Identification, measurement, and evaluation of existing radionuclides in the environs at the EGC ESP Facility and fluctuations in radioactivity levels that may occur;
- Evaluation of the measurements in order to determine the impact on proposed operations that are relative to the local radiation environment;
- Collection of data needed to refine environmental radiation transport models used in off-site dose calculations;
- Verification that radioactive material containment systems are functioning to minimize environmental releases to levels that are ALARA; and
- Demonstration of compliance with regulations.

Implicit in these objectives are the requirements to trend and assess radiation exposure rates and radioactivity concentrations in the environment that may contribute to radiation exposure to construction workers and the public. The program will consist of two phases, preoperational and operational.

The Preoperational Monitoring Program will be used to establish the baseline for the local radiation environment. The purpose of the Preoperational Monitoring Program is to measure background levels and their variations along the anticipated critical pathways in the area surrounding the EGC ESP Facility; to train personnel; and to evaluate

procedures, equipment, and techniques. However, as the proposed reactor will be sited near the CPS (approximately 700 ft), the proposed REMP was developed from baseline data that have already been established for the CPS, both for the preoperational and operational phases.

The operational phase implements confirmatory measurements to verify that the in-station controls for the release of radioactive material are functioning the way they were designed to function.

The elements (sampling media and analysis type) for both the preoperational and operational phases will be essentially the same. The program will utilize the same sampling locations used by the CPS Facility REMP personnel to the greatest extent practical. New sampling locations may be selected based on the selected plant design parameters.

Regulatory guidance recommends evaluating direct pathways, or the highest trophic level in a dietary pathway that contribute to an individual's dose. Figure 6.2-1 presents the basic pathways for gaseous and liquid radioactive effluent releases to the public. The "important pathways" that are selected are based primarily on how radionuclides move through the environment, and how they will eventually expose the public, taking into consideration man's use of the environment. The scope of the program will include the monitoring of six environmental elements:

- Direct radiation;
- Atmospheric;
- Aquatic;
- Terrestrial environments;
- Groundwater; and
- Surface water.

Pathways will be monitored at "indicator" and "control" locations. Indicator locations will generally be located within a 10-mi radius of the EGC ESP Facility. Control locations will be located greater than 10 mi from the EGC ESP Facility; thus, they will not be influenced by active facility operations. These control samples will provide the basis by which to measure any fluctuations in radioactivity from indicator locations relative to natural phenomena and fallout. Therefore, increases in radioactive material concentration from an indicator location due in part to active facility operations will be distinguished.

Sampling locations have been established for the operation of the CPS. Initially, these sampling locations will be utilized for the proposed facility as baseline locations and for baseline data to indicate the radiological environment prior to the proposed facility operation. The CPS established these locations by considering facility meteorology, area population distribution, facility hydrology, and land use characteristics of the local area. These locations were selected primarily on the basis of where the highest predicted environmental concentrations would occur. Different locations may be selected once the proposed reactor is actively operating.

Proposed sampling station locations are presented in Figure 6.2-2 through Figure 6.2-5. (Note: these are the locations that are utilized by the CPS facilities, with the exception of sampling location 1.) Table 6.2-1 and Table 6.2-2 provide information on the proposed sample locations, media that will be sampled at these locations, and a brief description of the location where samples will be obtained. The location is listed according to distance (in miles) and the meteorological compass sector in relationship to the EGC ESP Facility.

6.2.2 Sample Analysis

Concentrations of radioactivity present in the environment will vary due to factors such as weather conditions, and variations in the sampling collection technique and sample analysis.

Several types of measurements will be performed to provide information about the types of radiation and radionuclides present. Analyses performed on environmental samples collected will include the following:

- Gross alpha and beta analysis;
- Gamma spectroscopy analysis;
- Tritium analysis;
- Strontium analysis; and
- Gamma dose (TLD only).

A gross alpha and beta analysis measures the total amount of alpha and beta emitting radioactivity present in a sample. Both alpha and beta particles may be released by many different radionuclides. Gross activity measurements, while useful as general trend indicators, will not be used to establish specific radionuclide concentrations. Therefore, gross activity analysis will only indicate whether the sample contains normal or abnormal concentrations of alpha or beta emitting radioactivity. In addition, it will serve as a precursor in which to identify samples that may require additional follow-up analysis.

6.2.2.1 Direct Radiation Monitoring

Radionuclides present in the air, in addition to those deposited on the ground, will expose humans by immersion in the atmosphere or by deposition on the ground. The TLDs will be used to measure the ambient gamma radiation levels at many locations surrounding the EGC ESP Facility.

The TLDs are crystalline devices that store energy when they are exposed to radiation. They can be processed months after their exposure with minimal loss of information. This makes them well suited for quarterly environmental radiation measurements.

During TLD processing, stored energy is released as light, and is measured by a TLD reader. The light intensity is proportional to the radiation dose to which the TLD was exposed. The TLDs that will be used for environmental monitoring around the EGC ESP Facility will be capable of measuring environmental levels of radiation to approximately 20 mrem per quarter.

Monitoring stations will be placed in the facility proximity and approximately 5 mi from the proposed reactor in locations representing the 16 meteorological compass sectors. Other locations will be chosen to measure the radiation levels at places of special interest, such as nearby residences, meeting places, and population centers.

Control locations will be located further than 10 mi from the facility, in areas that will not be influenced by active facility operations.

6.2.2.2 Atmospheric Monitoring

The inhalation and ingestion of radionuclides in the air is a direct exposure pathway to man. A network of ten active air samplers will be used to monitor this pathway. There will be nine indicator air sampling stations strategically located in areas that are most likely to reveal any measurable effects due to the release of radioactive effluents from the EGC ESP Facility. The control will be located approximately 16-mi south of the EGC ESP Facility, in an area that is independent of any of the effects from unit operation(s).

Mechanical air samplers will be used to draw a continuous volume of air through a filter and charcoal cartridge, collecting any particulates and radioiodines that may be present in the atmosphere. These samplers are equipped with a pressure-sensing flow regulator used to maintain a constant sampling rate of airflow of about 1 cfm. The total volume is then calculated based upon the amount of time the air sampler was in operation and the flow rate. The air sampling equipment will be maintained and calibrated by facility personnel using reference standards that are traceable back to the National Institute of Standards and Technology (NIST).

Air samples will be collected every week and analyzed for gross beta and Iodine-131 activities. Quarterly, the air particulate filters collected throughout this period will be combined and counted for gamma isotopic activity. The intent of particulate sampling is to measure airborne radioactivity released from active facility operations; however, the counting of short-lived daughters, produced by the decay of natural radon and thoron, may mask any plant contributions. Therefore, the filters will not be analyzed for at least five days after their collection. This allows for the radioactive decay of short-lived daughters, thus, reducing their contribution to the overall gross beta activity.

6.2.2.3 Aquatic Monitoring

The EGC ESP Facility will utilize the existing Clinton Lake as the source for raw water and cooling tower makeup water and will discharge cooling tower blowdown to the lake. If radioactive liquid effluents were to be discharged from the proposed reactor into the cooling water outfall, long-lived radioisotopes could build up over a period time since the same water is reused on successive trips through the facility. Cooling water that exits from the facility will travel back into the eastern arm of Clinton Lake and then into the northern arm of the lake before returning back into the facility. Although the only user of Clinton Lake as a source of drinking water is the CPS, the lake is a recreation facility used for fishing, swimming, water-skiing, boating, and hunting.

Clinton Lake constitutes the primary environmental exposure pathway for radioactive materials from liquid effluents. Aquatic monitoring will provide for the collection of fish and shoreline sediments to detect the presence of any radioisotopes related to the operation

of the EGC ESP Facility. These samples will be analyzed for naturally occurring and man-made radioactive materials. Both indicator and control location(s) will be sampled. Indicator samples will be taken from various locations throughout Clinton Lake, whereas, control samples will be obtained from Lake Shelbyville, approximately 50-mi south of the EGC ESP Facility.

6.2.2.3.1 Fish

Various samples of fish will be collected from Clinton Lake and Lake Shelbyville. From both lakes, these samples will consist of largemouth bass, crappie, carp, and bluegill. The selection of these species is based on fish most commonly harvested from the lakes by sport fishermen. Fish ingest sediments during bottom feeding or prey on other organisms that also ingest sediments that may otherwise retain radionuclides. A radiological analysis from fish samples will provide key information on the potential ingestion of radionuclides by humans via this aquatic pathway. These samples will be collected semi-annually and analyzed by gamma spectroscopy.

6.2.2.3.2 Shoreline Sediments

Samples of shoreline sediments will be collected at Clinton Lake and Lake Shelbyville. Radiological analyses of shoreline sediments will provide information on any potential shoreline exposure to humans, determining long-term trends and the accumulation of long-lived radionuclides from the environment. Samples will be collected semi-annually and analyzed for gross beta, gross alpha, Strontium-90, and gamma isotopic activities.

6.2.2.4 Terrestrial Monitoring

In addition to direct radiation, radionuclides that are present in our atmosphere expose receptors when they are deposited on plants and soil, and subsequently consumed. To monitor this food pathway, samples of green leafy vegetables, grass, and milk will be analyzed.

Surface vegetation samples will be collected monthly during the growing season from a number of locations for the purpose of monitoring the potential buildup of atmospherically deposited radionuclides. The radionuclides of interest, relative to facility operations, are already present within our environment as a result of several decades of worldwide fallout or because they are naturally occurring. Therefore, the presence of these radionuclides is anticipated from the samples collected. These samples will be analyzed by gamma spectroscopy.

6.2.2.4.1 Milk

There is no known commercial production of milk for human consumption within a 5-mi radius of the EGC ESP Facility. Milk samples will be collected from a dairy located about 14-mi west southwest of the facility (twice a month during May through October, and once a month during November through April). These samples will be analyzed for Iodine-131, Strontium-90, and gamma isotopic activities.

6.2.2.4.2 Grass

Grass samples will be collected at three indicator locations and at one control location. These samples will be collected twice a month during May through October, and once a

month during November through April (when available). Grass samples will be analyzed for gamma isotopic activity including Iodine-131.

6.2.2.4.3 Vegetables

Broadleaf vegetable samples will be obtained from three indicator locations and at one control location. The indicator locations will be in the meteorological sectors with the highest potential for surface deposition. The control location will be a meteorological sector and distance approximately 13-mi downwind, which is considered to be unaffected by unit operations. Samples will be collected once a month during the growing season (June through September) and will be analyzed for gross beta and gamma isotopic activities including Iodine-131.

6.2.2.5 Water Monitoring

Water monitoring (e.g., the collection of drinking water, surface water, and groundwater [well water] samples) will be used to detect the presence of any radioisotopes relative to the operation of the EGC ESP Facility.

The only identified users of water from Clinton Lake for domestic purposes are the CPS and the EGC ESP Facility. Samples taken will be analyzed for naturally occurring and man-made radioactive isotopes.

6.2.2.5.1 Drinking Water

A composite water sampler will be located at the service building for the EGC ESP Facility. This sampler will collect a small, fixed volume sample of water at hourly intervals. The sampler will then discharge the sample into a common sample collection bottle. This monthly composite sample will then be analyzed for gross alpha, gross beta, and gamma isotopic activities. A portion of these monthly samples will then be combined with other monthly samples collected during the calendar quarter. This quarterly composite sample will then be analyzed for Tritium.

6.2.2.5.2 Surface Water

Composite water samplers will be installed at three locations to sample surface water from Clinton Lake. These composite water samplers will collect a small volume of surface water at regular intervals and discharge the sample into a large sample collection bottle. This water sample will be collected on a monthly basis.

Two of the composite water samplers will be located upstream from the operation of the EGC ESP Facility, and will therefore be unaffected by any plant liquid releases occurring downstream. The other composite water sampler will be positioned to sample water being released from the EGC ESP Facility at the start of the plant discharge flume. Grab samples will be collected from one indicator location on Clinton Lake.

Surface water samples will be analyzed for gross beta, gamma isotopic, and H-3 (Tritium) activities. Additional analyses for gross alpha activity will be performed on the upstream water samples, and for gross alpha activity and Iodine-131 activity on water samples taken from the discharge flume. Tritium analyses will be performed quarterly from the monthly composites from the water composite sample locations.

6.2.2.5.3 Well Water

Every quarter, both the treated and untreated well water samples will be collected from the well serving the Village of DeWitt and from a well serving the Illinois Department of Conservation at the Mascoutin State Recreational Area. Samples will be analyzed for Iodine-131, gross alpha, gross beta, Tritium, and gamma isotopic activities. See Table 6.2-2 for location of sample points.

6.2.3 Quality Assurance Program

To establish confidence and credibility that the data collected and reported are accurate and precise, EMP activities will be incorporated into the construction phase Quality Assurance Program established pursuant to 10 CFR 50, Appendix B, in pursuance of COL activities,

The EMP will utilize quality programs and processes to:

- Personnel will be trained and qualified to perform radiological monitoring.
- Procedures for sample collection, packaging, shipment, and receipt of samples for analysis will be created and approved, and samples at the lab will be prepared and analyzed.
- Lab processes will be documented, such as maintenance, storage, and use of radioactivity reference standards; calibration and checks of radiation radioactivity measurement systems and sample tracking and control.
- The processes and procedures of the monitoring program will be documented.
- Periodic audits of analysis laboratory functions and their facilities will be conducted.
- Records of sample collection, shipment and receipt will be maintained. Records will also be maintained of lab activities including sample description, receipt, lab identification, coding, sample preparation and radiochemical processing, data reduction, and verification.

In addition, the following activities will be performed:

- Duplicate analysis of the samples (excluding TLDs) will be performed to check laboratory precision.
- Quality indicator and control samples will be routinely counted.
- Inter-comparison programs will be participated in, such as the ERA cross-check program.
- The analytical results provided by the laboratory will be reviewed monthly to validate that the required minimum sensitivities have been achieved, and that the correct analyses have been performed.

6.3 Hydrological Monitoring

This section describes the Surface Water and Groundwater Hydrological Monitoring Programs including:

- Preapplication monitoring to support the baseline hydrologic descriptions that are presented in Section 2.3.
- Construction monitoring to control anticipated impacts from site preparation and construction. The monitoring program will be established to detect any unexpected impacts arising from construction activities and work in the transmission corridor. In addition, it may include preconstruction monitoring to establish a baseline for assessing the subsequent impacts of these activities.
- Preoperational monitoring to establish a baseline from which identification and assessment of environmental impacts that result from facility operations will be made.
- Operational monitoring to establish the impacts from facility operation and to detect any unexpected impacts that may arise from facility operation.

6.3.1 Preapplication Hydrological Monitoring Program

The objective of the Preapplication Hydrological Monitoring Program for surface water and groundwater is to provide information that will be used to aid in the assessment of site acceptability and to support the assessment of impacts that could result from construction and operation of the EGC ESP Facility. The available information was examined to determine if the existing database is sufficient to support the environmental descriptions presented in Section 2.3.1, and are based on the following considerations described below.

- Location and number of monitoring stations as required to consider the following factors: bathymetric characteristics of Clinton Lake; soil and groundwater system characteristics; type of cooling system employed and its operating modes; type of sanitary and chemical waste retention method; and transient hydrological and meteorological parameters in the vicinity of the site.
- Sampling frequency and times so that important temporal variations (e.g., seasonal variations and intense rainfall) have been adequately monitored.
- Duration of monitoring programs.
- Sediment transport characteristics.

The baseline hydrologic conditions presented in Section 2.3.1, are based on data collected for the permitting of the CPS, including requirements of its NPDES permit and other (EMP) requirements. In addition to the physical data (e.g., stream flow or sediment thickness) collected, lake characteristics presented in the CPS ER (Section 2.4.1), such as time-varying temperature and natural and forced evaporation, were based on predicted computer simulations using the LAKET computer program developed by Sargent and Lundy (CPS, 1982).

6.3.1.1 Freshwater Streams

The baseline hydrologic conditions in Salt Creek that were presented in Section 2.3.1.1 are based on data collected by the USGS at the Rowell gauging station before and after the construction of the Clinton Lake Dam (namely preoperation), and since the CPS has been in operation.

Although the hydrologic data collected provide a sufficient database to describe hydrologic conditions in Salt Creek, additional preapplication monitoring will be conducted in order to verify and update the baseline conditions at the time of the COL application. The proposed preapplication monitoring will include the following:

- The continued collection and evaluation of mean daily flow in Salt Creek downstream of the dam at the Rowell gauging station; and
- Monthly stream flow will be measured at Site E-3, concurrent with thermal and chemical monitoring (see Figure 6.1-1). Measurements will be made using a "Marsh McBirney Flowmeter" (or equivalent instrument) at a depth of 3-ft below the surface.

Additional hydrologic monitoring locations in Salt Creek may be included between the Rowell gauging station and the Clinton Lake Dam as the engineering design progresses. The recommended monitoring will supplement the existing database to support the description of baseline conditions in Salt Creek, downstream of Clinton Lake.

6.3.1.2 Lakes and Impoundments

The hydrologic monitoring of Clinton Lake conditions that were conducted during the preoperational and operational stages for the CPS, and that are being conducted for the CPS are described below.

- Annual measurement of sediment thickness from stations at Parnell Road Bridge and DeWitt County Highway 14 Bridge to determine sedimentation rates (CPS, 1982).
- Annual measurement of sediment thickness within UHS, as required per the Regulatory Guide 1.27 (USNRC, 1976).
- Continuous monitoring of Clinton Lake levels.
- Monitoring requirements in the NPDES permit including (IEPA, 2000):
  - Weekly flow measurements for the discharge flume (Outfall 002);
  - Weekly flow measurements from the sewage treatment plant (Outfall A02);
  - Weekly flow measurements from water treatment wastes (Outfall 003);
  - Monthly flow measurements of activated carbon treatment system effluents (Outfalls C02 and A03); and
  - Estimated 24-hour total flow for UHS dredge pond discharge (Outfall 015).

Although the existing database is sufficient to describe the conditions in Clinton Lake as presented in Section 2.3.1.2, additional preapplication monitoring will be conducted in order to verify and update the baseline conditions at the time of the COL application. The

proposed preapplication monitoring for Clinton Lake will include the collection of the following data:

- Mean daily stage of Clinton Lake;
- Mean daily flow being discharged from Clinton Lake (namely through the dam);
- Monthly current velocity, concurrent with thermal and chemical monitoring, measured at a depth of 3 ft from the surface using a "Marsh McBirney Flowmeter" (or equivalent instrument) (see Figure 6.1-1 for locations); and
- Depth of water column at regular intervals along transects across the impoundment used to estimate the current volume of Clinton Lake.

Additional monitoring may be incorporated into the program as the engineering design progresses. Although the exact locations or procedures (e.g., manual measurements or monitored remotely) may be modified, the recommended collection program will provide the data to supplement the existing database and support the description of baseline conditions in Clinton Lake and downstream in Salt Creek. In addition, the monitoring will be coordinated with the data collection activities conducted for the CPS in order to maximize the data collection efforts.

6.3.1.3 Groundwater

The Preapplication Monitoring Program for groundwater will be used to support the assessment of site acceptability and to identify the groundwater system impacts that could result from construction and operation of the EGC ESP Facility. The available groundwater information was evaluated in order to determine if the existing database is sufficient to support the description of the groundwater system characteristics in the vicinity of the site (see Section 2.3.2).

The description of groundwater system characteristics presented in Section 2.3, is mainly based on data collected for the CPS. The data collection activities for the CPS are described below (CPS, 1982).

- Location and identification of existing private and nonprivate wells within 5 mi of the site and nonprivate wells within 5 mi to 15 mi of the CPS.
- Implementation of an extensive boring program including 68 locations with depths from 20 ft to 356 ft at the CPS Facility (station complex), and at the main dam site to collect information on aquifer characteristics. Additional borings will be installed at the dam borrow site.
- Implementation of a piezometer installation program used to collect information on aquifer characteristics and water levels. The following piezometers were installed (see Table 2.3-15 for additional information):
  - 1972 and 1973: 12 piezometers installed in main plant area (P-series wells), 15 piezometers installed near proposed dam (D-series wells), and 8 piezometers installed in vicinity of site (E-series wells) to establish configuration of water table surface in the immediate vicinity of site;

  - 1976: 12 piezometers (OW-1 through OW-8 series) installed around the lake to monitor the effect of Clinton Lake on surrounding water levels;
  - 1977: 9 piezometers (OW-9 through OW-17 series) installed downstream of the dam to monitor dam performance; and
  - 1979: 8 piezometers (OW-18 through OW-24 series) installed downstream of the dam to monitor dam performance.

  However, many of these piezometers were destroyed during construction activities.

- Groundwater levels in the vicinity of the Clinton Lake and the CPS have been monitored intermittently since site investigations began in 1972 until about December of 1979 (normal pool level in Clinton Lake attained in May 1978).
- Installation and testing of the CPS test well, which is screened in the Mahomet Aquifer.

The findings of the previous investigations were verified with a limited subsurface investigation program conducted in July and August of 2002. This program included the drilling of four borings, installation of four cone-penetrometer borings, and installation of two shallow piezometers (total depth at about 28 ft) and one deep piezometer (depth at 90 ft). Water levels have been measured intermittently from these locations since their installation in August of 2002.

The proposed preapplication monitoring for the EGC ESP Facility will be implemented at the time of the COL application and is described below.

- Location and survey of previously installed CPS piezometers that have not been identified as destroyed by construction activities.
- Location and identification of existing private wells within 5 mi of the site.
- Installation of additional shallow water table piezometers and deep piezometers (screened in discontinuous sand layer) spaced at suitable lateral intervals away from the EGC ESP Facility, between the EGC ESP Facility and the CPS Facility. In addition, piezometers located near Clinton Lake to help define the lateral continuity of sand layers and will be used during the pumping test.
- Monitoring of water levels in the piezometers on a monthly basis to verify the hydrostatic loading on the power plant foundation, flow directions, and to estimate the amount of water that may need to be controlled during the excavation activities.
- Installation of a 12-in. test well and performance of a long-term pumping test to help evaluate the potential impacts that may be caused from the dewatering activities and the amount of water that may need to be controlled during the excavation activities.
- Installation of points to monitor for settlement or ground movement.

The specific number, depths, and locations of the piezometers and the test well will be determined as the engineering design of the facility is better defined. The data collected will be used to define the baseline conditions at the time of the COL application and

groundwater-related design elevations. In addition, the information will be used to identify additional locations that will be monitored during the construction of the EGC ESP Facility.

6.3.2 Construction Hydrological Monitoring Program

The objective of the Construction Hydrological Monitoring Program is to monitor anticipated impacts from site preparation and construction so that they can be properly controlled. Further, it will be able to detect any unexpected impacts arising from the construction activities.

6.3.2.1 Freshwater Streams

As discussed in Section 4.2, the construction-related impacts to Salt Creek are considered minimal, provided that the proper controls are implemented to minimize impacts to Clinton Lake. The proposed construction monitoring of Salt Creek will include continuing the Preapplication Monitoring Program.

6.3.2.2 Lakes and Impoundments

The Construction Hydrological Monitoring Program for Clinton Lake has been designed to monitor control of anticipated impacts from site preparation and construction and to detect any unexpected impacts arising from the construction activities. As discussed in Chapter 4, Environmental Impacts of Construction, the majority of the anticipated construction-related impacts to Clinton Lake are related to increased erosion and sediment transport (see Section 4.2). A major element of the construction monitoring will be to monitor the amount of sediment deposited in Clinton Lake as a result of the construction activities.

The proposed construction monitoring will include continuing the Preapplication Monitoring Program. In addition, the amount of sediment deposited at the stormwater outfalls will be monitored to determine if a sufficient thickness of sediment has accumulated in order to require removal upon completion of the construction.

6.3.2.3 Groundwater

The Construction Hydrological Monitoring Program for groundwater has been developed to monitor control of anticipated impacts from site preparation and construction and to detect any unexpected impacts arising from the construction activities. As discussed in Section 4.2.1.2, the major impact to the groundwater system will be related to the dewatering required for the excavation of the site for the EGC ESP Facility to the proposed embedment depth of 140 ft. Water levels from the piezometers installed for the Preapplication Monitoring Program will be measured at least daily during the active construction period in order to monitor lateral depression in the groundwater surface caused by dewatering. In addition, settlement points will be monitored to protect existing structures from settlement or ground movement during the excavation activities. These points will be monitored daily, at a minimum, and critical points may be monitored continuously. The data will be used to monitor for the potential of damage to existing structures' foundations.

6.3.3 Preoperational Hydrological Monitoring Program

The Preoperational Hydrological Monitoring Program will be designed to provide the baseline for evaluating hydrologic changes arising from the operation of the EGC ESP Facility.

6.3.3.1 Freshwater Streams

The Preoperational Hydrological Monitoring Program for Salt Creek will be a continuation of the monitoring conducted during the Preapplication and Construction Monitoring programs. The program may be modified based upon the evaluation of the preapplication and construction monitoring data collected from Clinton Lake.

6.3.3.2 Lakes and Impoundments

The continued implementation of the preapplication monitoring should provide the data to assess alterations of surface water flow fields in Clinton Lake (namely the cooling loop), sediment transport, floodplains, or wetlands. The program may be modified based upon the evaluation of the preapplication monitoring data and other information collected for the operation of the CPS.

6.3.3.3 Groundwater

The objective of the Preoperational Hydrological Monitoring Program is to provide the baseline for evaluating hydrologic changes arising from the operation of the EGC ESP Facility. Clinton Lake will be used to meet the facility's water requirements and no groundwater will be used; therefore, there should not be a significant impact to the groundwater system from the operation of the EGC ESP Facility. However, preoperational monitoring will be conducted to reestablish the baseline conditions for groundwater levels and flow after the completion of the construction activities. The monitoring will consist of collecting water levels on a monthly basis from piezometers that remain after the construction.

6.3.4 Operational Hydrological Monitoring Program

The Operational Hydrological Monitoring Program will be designed to establish the impacts from the operation of the EGC ESP Facility and detect any unexpected impacts from facility operation. Based on the monitoring data for the CPS, the Operational Hydrological Monitoring Program is anticipated to extend over a five-year period or until conditions appear to have stabilized based on the trend analysis. Modifications to the monitoring program (e.g., changes in monitoring locations or collection procedures) will be assessed regularly over the duration of the monitoring program.

6.3.4.1 Freshwater Streams

The specific procedures of the operational monitoring requirements of Salt Creek are anticipated to be similar to the Preapplication and Preoperational Monitoring programs. The program may be modified based on data collected and consultations with IEPA and the CPS. The data will be evaluated in order to monitor for changes in the discharge from Clinton Lake to Salt Creek.

6.3.4.2 Lakes and Impoundments

The Operational Hydrological Monitoring Program for Clinton Lake will be designed to identify impacts of the operation of the EGC ESP Facility. Specifics related to the operational monitoring are anticipated to be similar to the Preapplication and Preoperational Monitoring programs. In addition, the monitoring may be modified based on consultations with IEPA and the CPS. The data from this monitoring program will be evaluated in order to determine changes in the cooling system flows, water levels in Clinton Lake, and discharges from Clinton Lake to Salt Creek.

6.3.4.3 Groundwater

A limited Operational Hydrological Monitoring Program will be implemented in order to establish the impacts to the groundwater system from the operation of the EGC ESP Facility and detect any unexpected impacts from facility operation. The objective of the monitoring will be to evaluate changes to the groundwater system related to potential changes in Clinton Lake levels. The monitoring will consist of extending preoperational monitoring for an additional five-year period or until conditions appear to have stabilized based on the trend analysis of groundwater and surface water conditions. The need for modifications to the monitoring program (e.g., changes in monitoring locations or frequency of collection) will be assessed regularly over the duration of the monitoring program.

6.4 Meteorological Monitoring

The Meteorological Monitoring Program will be the same throughout the preconstruction through operational phases of the project. Therefore, this monitoring program section is not separated by project phase.

6.4.1 General Description – On-Site Meteorological Monitoring Program

On-site meteorological monitoring began at the site of the CPS on April 13, 1972. The on-site meteorological monitoring system, including details on the location, instrumentation, and data reduction protocols, have previously been described in detail in Section 2 of the CPS USAR (CPS, 2002), Section 6 of the CPS ER (CPS, 1973), and Section 6 of the CPS ER (OLS) (CPS, 1982). Data from the CPS meteorological monitoring system, as described and documented in these reports, have previously been used in the preparation of the CPS USAR and the CPS ER (OLS) for the 5-yr period that spans from April 13, 1972 through April 30, 1977. These data were also previously used in the assessment of the radiological impacts associated with routine facility operation (i.e., routine radiological releases), as well as impacts of potential accidental releases that could occur during facility operation.

The CPS meteorological monitoring tower is located approximately 3,200-ft south-southeast of the CPS containment structure, and approximately 1,800-ft south-southeast of the center of the EGC ESP Facility power block footprint (see Figure 2.7-2). During the 5-yr period of record that was reported in the CPS ER (OLS) and the CPS USAR, the meteorological system monitored the following parameters (also summarized in Table 6.1-5 of the CPS ER) (CPS, 1973):

Tower Level	Parameters Measured
Ground:	Precipitation
10 m:	Wind speed and direction Ambient air temperature Dew point
60 m:	Wind speed and direction Ambient air temperature (for computing delta temperature with 10-m temperature) Delta temperature Dew point

Data available from the CPS on-site meteorological monitoring system are obtained from the same tower system and at the same levels above ground as the original installation described above. However, some of the original monitoring equipment (e.g., sensors, data recorders, electronic data loggers, and remote interrogation equipment) has undergone routine replacement, repair, and upgrade since the original installation. Additionally, certain changes in the method of data reduction have been made since the original installation date, with a transition to a more electronic based system. However, the basic monitoring system hardware, which has been in use at the CPS from April of 1972 through October of 2002, is essentially the same as what was originally installed in 1972. The meteorological monitoring system has been demonstrated throughout this period to be

compliant with Regulatory Guide 1.23 (USNRC, 1972). It is noted that the CPS USAR identifies various USNRC authorized exceptions for this instrumentation.

Since the CPS began operation in 1987, annual reports have been prepared and submitted to the USNRC. The reports contain annual summaries of joint frequency distributions of wind speed, direction, and atmospheric stability of the meteorological data collected by the CPS on-site meteorological monitoring system. A recent example of such a report is the *CPS Annual Radioactive Effluent Release Report, January 1, 2001 through December 31, 2001* (Campbell, 2002).

For the purposes of this ER, two different periods of meteorological record have been utilized and referenced, as follows:

April 13, 1972–April 30, 1977:	The data from this period of record are representative of the EGC ESP Site prior to construction of the CPS (including the filling of Clinton Lake). Data were used in the original CPS ER (OLS) and the CPS USAR for the CPS. Analyses of these data included joint frequency distributions of wind speed, direction, and atmospheric stability, as well as short- and long-term analyses of accidental and routine radiological releases from the CPS.
January 1, 2000–August 31, 2002:	The data from this period of record were used to characterize site-specific meteorological conditions. They were also used to assess the impacts of long-term routine radiological releases from the EGC ESP Facility using operational software utilized by the CPS personnel.

6.4.2 Instrumentation: 1972-1977 Period of Operation

The on-site instrumented meteorological tower was installed and placed in operation at the CPS on April 13, 1972. Installation and operation of the instrumentation on the tower was performed under contract to Illinois Power Company by The Research Corporation (TRC) Inc. of New England. The original tower is 199-ft high, with the base at an elevation of approximately 735-ft above msl. Wind and temperature instrumentation was located at the 10-m and 60-m levels on the tower, and precipitation measurements were made at ground level. The tower is located approximately 3,200-ft south-southeast of the CPS containment structure (see Figure 2.7-2).

6.4.2.1 Wind Systems

Lower level (10-m) wind speeds were recorded by a Teledyne Geotech staggered six-cup anemometer assembly and a Model 50.1 transmitter with a starting speed of approximately 0.5 mph or about 0.22 mps. Wind direction was measured with a Teledyne Geotech Quick One direction vane and a Model 50.2 wind direction transmitter with a turning threshold of 0.7 mph at 10°. Wind direction and speed were simultaneously recorded on a Teledyne Geotech Model 87H dual recorder.

Upper level (60-m) winds were measured using a six-bladed Bendix Aerovane, which had a starting speed of approximately 1.7 mph and a stalling speed of approximately 0.8 mph.

Wind speeds and directions were simultaneously recorded on a Bendix Model 141-2 recorder.

6.4.2.2 Temperature Systems

The ambient temperature and delta temperature systems used Rosemount platinum temperature sensors, and the dew point was measured using Foxboro Dewcels. The temperature data were obtained from precision resistance bridges and simultaneously recorded on an Esterline Angus Model 1124E-multichannel recorder. One channel of the recorder was used to print a reference value of zero volts, from which the temperature traces were calibrated. The temperature and delta temperature sensors were installed in aspirated shields on the tower. The dew point sensors were installed on the tower in Foxboro Weatherhoods.

6.4.2.3 Precipitation Systems

A heated tipping bucket rain/snow gauge was installed near the tower to measure liquid precipitation at the CPS monitoring station. The gauge measured liquid precipitation in 0.01-in. step increments (tip of the bucket), and the results were transmitted electronically to a recording device.

6.4.2.4 Equipment Calibration and Data Reduction

The equipment was checked and calibrated prior to installation. TRC was engaged by Illinois Power Company to service and maintain the CPS meteorological system in compliance with Regulatory Guide 1.23. Every two months, recorded air temperatures were checked against values obtained on the tower with American Society for Testing and Materials (ASTM) precision thermometers. Tower ice bath checks were performed on the temperature systems semi-annually. Dew point sensors were calibrated against values obtained with a Bendix Psychron. Wind systems were checked for normal operation in accordance with manufacturer's recommendations.

TRC reviewed meteorological parameters recorded on strip chart recorders for possible equipment system or component failures prior to processing the data. The hourly data values, which is the average value for the 30-minutes preceding the hour, were determined directly from the strip charts. This value was manually transferred to a punched card by means of a Gerber Scientific Instrument Company semi-automatic analog-to-digital transcriber. This device transferred an operator controlled chart coordinate to a punched card. The cards were checked by computer for errors from one hour to the next, and for logical values. After checks were verified, a punched card was prepared that contained the date, hour, and hourly values for the parameters measured by the system. These cards were used to form the database for the years between 1972 and 1977.

Values for the standard deviation of wind direction were extracted from the strip charts. For each averaging period, the representative magnitude of the wind direction variability was determined. By assuming that the wind direction has a normal distribution, one-sixth of this range was assumed to be equivalent to the standard deviation of the wind direction. During periods of low wind speeds, only wind direction fluctuations that occurred with a valid wind speed were used. This procedure was intended to prevent the inclusion of "square wave" data that could occur during periods of calm or very low wind speeds.

6.4.3 Instrumentation: 2000-2002 Period of Operation

The on-site instrumented meteorological tower that was installed and placed in operation at the CPS on April 13, 1972 has remained in operation at the same location since its original installation. During the course of operation, various electronic components and sensors have been replaced with equivalent or upgraded components as a matter of routine maintenance and repair. Wind and temperature instrumentation is still located at the 10-m and 60-m levels on the tower, and precipitation measurements are still made at the ground level. The tower is still located approximately 3,200-ft south-southeast of the CPS containment structure (see Figure 2.7-2).

6.4.3.1 Wind Systems

The 10-m and 60-m level wind directions and speeds were measured by a combined cup and vane sensor manufactured by Meteorology Research, Inc. (MRI), Model No. 1074-12. The anemometer cups were positioned directly above the azimuth vane so that data may be obtained from a single point in space. Three 4.5-in. diameter conical aluminum cups sensed the wind speed, and were linked directly to a light emitting diodes (LED)-photocell transducer. Wind direction was obtained with a single blade aluminum tail vane and incorporates a nose damping vane with static balance. A one-to-one gear and idler shaft transferred vane movement into the main housing, where a connection is made to the azimuth transducer. The azimuth transducer was a 360° potentiometer whose output signal is interpreted as a 540° signal by the transmuter electronics. The wind speed sensor had a starting threshold of 0.75 mph, a response distance of 18 ft (63 percent recovery), and a range to 100 mph. The wind direction sensor had a starting threshold of 0.75 mph, a delay distance of 4 ft (50 percent recovery), a damping ratio of 0.5 to 0.6, and a range of 360° (540° output from electronics). Wind speed and direction were recorded on continuous strip chart recorders, which were located in the CPS main control room. In addition to recording data on strip chart recorders, wind parameters were continuously fed to a microprocessor, which is part of the radiation monitoring system that processes and records meteorological information.

Back up meteorological monitoring instrumentation consisted of separate wind direction and wind speed sensors installed at the 10-m level on the CPS microwave tower, the location of which is shown in Figure 2.7-2. The anemometer and the wind direction sensors were both mounted on the same plane. Three 2-in. diameter conical molded polycarbonate cups sense wind speed and were linked directly to a photo-chopper assembly that produces a variable frequency square wave that is directly proportional to the wind speed. Wind direction was sensed with a single-bladed aluminum tail vane. Vane movement was transferred by a high precision shaft and bearing assembly to a low torque resolver. The resolver rotor was supplied with a precision 1.0-kilohertz (kHz) signal from the resolver driver circuit. The two resolver rotor outputs were combined by the resolver output circuit to produce a single 1.0-kHz signal, which had a constant amplitude but whose phase varied. When the resolver rotor signal was used as a fixed reference, then the phase of the combined stator signal lagged the rotor signal by an amount that was directly proportional to the rotor shaft clockwise rotation. The wind speed sensor had a threshold of 1.0 mph, a distance constant of 5 ft, an accuracy of +/-0.1 percent, and a calibrated range to 100 mph. The wind direction sensor had a threshold of 0.7 mph, a distance constant of 3.7 ft, a damping ratio of 0.4 at 10° initial angle of attack, and a range of 360°.

6.4.3.2 Temperature Systems

Ambient temperatures were sensed by an aspirated dual temperature sensor at the 60-m level and an aspirated dual temperature sensor at the 10-m level. The sensors were manufactured by MRI, Model Numbers 896-1 (60-m) and 895-2 (10-m). One-half of the dual sensor at each elevation was used for ambient temperature, and the other half of the sensor was used to provide a differential temperature between the 10-m and 60-m elevation. Aspirated shielded housing was installed, which was designed to provide a high heat transfer from the ambient air to the sensing element. At the same time, it afforded maximum protection from incoming short wave solar radiation and outgoing long wave radiation. The aspirated airflow was approximately 15 fps. The temperature element within the dual sensor was comprised of a dual thermistor and resistor network. Combined with a temperature signal conditioning module, the circuit provided a linear voltage with respect to the air temperature. The range of temperature measurement was from –22°F to +110°F. The range of the delta temperature measurement was from -5.4°F to +12.6°F.

6.4.3.3 Dew Point Systems

Lower level (10-m) dew point temperatures were measured with an aspirated dew point sensor manufactured by MRI, Model Number 895-2. Aspirated shielded housing was used to provide a high heat transfer from the ambient air to the sensing element. At the same time, it afforded maximum protection from incoming short wave solar radiation and outgoing long wave radiation. The dew point was determined by a lithium chloride dew point sensor consisting of bifilar wire electrodes wound on a cloth sleeve covering a hollow bobbin. The electrodes are not interconnected, but depend on conductivity of the atmospherically moistened lithium chloride for current flow. As the moisture content in the air increases, the lithium chloride absorbs water vapor and becomes conductive. Current then begins to flow between the electrodes and heats the bobbin. Some of the moisture is evaporated until an equilibrium temperature is reached on the bobbin. The equilibrium bobbin temperature is, thus, related to the dew point temperature of the air. A thermistor sensor is mounted inside the bobbin to measure cavity temperature, which is converted to actual dew point temperature by the transmuter circuit card. The cavity temperature is higher than the actual dew point temperature, but this factor is taken into account by the transmitter circuit card. The range of the dew point sensor is -22°F to +110°F.

6.4.3.4 Precipitation Systems

Precipitation was and continues to be measured by using a tipping bucket rain gauge. The gauge is heated and can be used to measure both rainfall and snowfall. The gauge is mounted near the tower, but clear of any rain shadow effects from either the tower or the instrument shed. Data were recorded on a multipoint chart recorder in the main control room. An electronic transmitter card increments a 4-minute averages to 20-minute averages signal corresponding to 0.01-in. steps. Full scale corresponds to 1 in. of rainfall.

6.4.3.5 Maintenance and Calibration

Emergency maintenance and calibration was performed by a contract vendor, with routine maintenance performed by CPS technicians. Data recovery goals were in excess of 90 percent for the parameters. Semi-annual equipment calibrations were performed by trained technicians. Ice baths were used to check both ambient temperature sensors. The lithium

chloride dew cell was checked against calibrated material and test equipment. Wind speed and wind direction sensors were checked for normal operation according to vendor specifications.

6.4.3.6 Data Reduction

The meteorological parameters measured were transmitted to the CPS control building via a dedicated telephone line. The signals were received and converted to 4-minute averages to 20-minute averages signals, and fed individually to a microprocessor and chart recorders. The microprocessor was part of the CPS radiation monitoring system. This system calculated and stored 10 minute averages of the meteorological parameters.

6.4.3.7 Control Room Monitoring

Meteorological data were recorded on panel P826 of the main control room. Additionally, 10 minute averages were available on the radiation monitoring system CRT terminal in the TSC.

The main control room wind recorders were dual 5-in., continuous strip, and 3-in. per hour chart recorders. They continuously recorded wind direction and speed at the 10-m and 60-m level. A multipoint recorder recorded 10-m and 60-m temperature, delta temperature, precipitation, and 10-m dew point.

6.5 Ecological Monitoring

In accordance with the USNRC's Standard Review Plan (NUREG-1555), Ecological Monitoring Programs will cover elements of the ecosystem for which a causal relationship between facility construction and/or operation and adverse change is established or strongly expected (USNRC, 1999). The CPS implemented a monitoring program as part of its CPS ER. The data collected under this program (i.e., the initial baseline assessment and subsequent monitoring efforts) were included as part of Section 2.4. The Applicant intends to build on this existing approved Ecological Monitoring Program and database. Furthermore, in an effort not to duplicate monitoring efforts, the Applicant will coordinate its Ecological Monitoring Programs with existing Ecological Monitoring Programs and efforts being performed by the CPS, IDNR, IEPA, and other applicable groups or agencies. Any proposed Ecological Monitoring Programs would be implemented at an appropriate time, in regard to the commencement of proposed construction activities.

A description of preapplication monitoring is included in this section. Site preparation and construction monitoring, preoperational monitoring, and operational monitoring programs will be provided at the COL phase, in accordance with the schedule provided in NUREG-1555.

The following sections present information regarding ecological monitoring for terrestrial ecology and land use, and aquatic ecology of the site, vicinity, and off-site areas likely to be affected by construction, maintenance, or operation of the facility.

6.5.1 Terrestrial Ecology and Land Use

This section presents information regarding the monitoring of terrestrial ecosystems and land use, as required in support of the Application for the EGC ESP.

6.5.1.1 Terrestrial Ecology

A Terrestrial Monitoring Program was established for the CPS to monitor, on a low-level basis, the wildlife and vegetation communities in the vicinity of the site. This program was based on initial data collected during sampling activities for the CPS ER. It was designed to provide data on naturally occurring year-to-year variations within existing communities during preconstruction, construction, and postconstruction phases of the project (CPS, 1973 and CPS, 1982).

A similar program will be implemented for the EGC ESP Facility. This monitoring program will document changes in plant and animal species composition over time, and will build on the database gathered during the CPS preliminary baseline environmental assessment and monitoring. In addition, monitoring of terrestrial resources along the proposed transmission right-of-way will be implemented as appropriate.

6.5.1.1.1 Vegetation Communities

During the CPS preliminary baseline environmental assessment, five plant communities were sampled to determine species composition and abundance in the vicinity. In the CPS ER, it was proposed that these five communities be sampled on an annual basis, in May of

each year (CPS, 1973). The continuation of this sampling effort on a yearly basis, occurring each May, is expected to be adequate for the EGC ESP Facility.

Sampling methodologies for the five communities will continue with the generally accepted techniques of quadrant, quarter, and transect sampling.

6.5.1.1.2 Avian Communities

The CPS ER originally proposed that surveys of avian communities be conducted in May, July, November, and February of each year in order to determine species composition and relative abundance of bird species present within the vicinity during migratory and nesting periods. The CPS ER also proposed that roadside counts of pheasant, bobwhite quail, and mourning doves be determined in May and July. The survey methodology included both visual sight counts and auditory censuses (CPS, 1973 and CPS, 1982).

It is anticipated that the monitoring surveys for bird communities in the vicinity will be adequate to determine potential adverse effects resulting from operation of the EGC ESP Facility. In addition to surveys performed by the CPS, many bird surveys are performed by local groups, including the Audubon Society. The results of these surveys will be reviewed, as necessary, to document avian communities in the vicinity.

Monitoring surveys of waterfowl at Clinton Lake and other waterbodies within the vicinity will be performed, as appropriate, in order to confirm that changes in composition, abundance, or distribution are not occurring as a result of operation of the EGC ESP Facility.

6.5.1.1.3 Small Mammal Populations

The CPS ER proposed that monitoring programs for small mammal populations be conducted during May and November at five locations within the vicinity (CPS, 1973). Trap-lines were set to help determine the composition and abundance of small mammal populations, and roadside counts were performed in order to determine the presence of cottontail rabbits in the vicinity (CPS, 1973 and CPS, 1982).

It is anticipated that the continuation of this program will be adequate to identify any adverse effects that the EGC ESP Facility may have on small mammal populations in the vicinity. During monitoring efforts, records will also be kept of mammal sightings or signs of presence including tracks or scat.

6.5.1.2 Important Species and Habitats

6.5.1.2.1 Important Species

According to the USNRC, "important species" are defined as state- or federally-listed (or proposed for listing) threatened or endangered species; commercially or recreationally valuable species; species that are essential to the maintenance and survival of species that are rare and commercially or recreationally valuable; species that are critical to the structure and function of the local terrestrial ecosystem; and/or species that may serve as biological indicators to monitor the effects of the facilities on the terrestrial environment (USNRC, 1999).

6.5.1.2.1.1 Federally-Listed Threatened and Endangered Species

Based on preliminary database reviews, construction of the EGC ESP Facility is not anticipated to affect federally-listed threatened or endangered species in the vicinity of the EGC ESP Facility (IDNR, 2002). The USFWS will be contacted in order to confirm the

presence or absence of any federally-listed (or proposed for listing) threatened or endangered animals.

It is anticipated that construction and operation of the EGC ESP Facility will not adversely impact federally-listed threatened or endangered species, and therefore, a specific monitoring program for federally-listed species is not proposed.

6.5.1.2.1.2 State-Listed Threatened and Endangered Species

According to data provided by the IDNR, no state-listed threatened or endangered terrestrial wildlife species have been documented within the site or vicinity (IDNR, 2002). However, as discussed in Section 2.4, several state-listed threatened bird species have been observed near Clinton Lake, and other areas in the vicinity.

Direct adverse impacts to these species are not anticipated as a result of the construction or operation of the EGC ESP Facility. No additional programs are proposed to monitor state-listed threatened or endangered species.

6.5.1.2.1.3 Species of Commercial or Recreational Value

As previously mentioned, "important species" include those species that present value in a commercial or recreational manner. As discussed in Section 2.4.1, species of commercial or recreational value that potentially occur within the vicinity include white-tailed deer, various species of waterfowl, and various species of small-game mammals. The monitoring programs previously discussed in this section are adequate to monitor the composition and abundance of these species within the vicinity during construction and operation. Therefore, no additional monitoring is proposed.

6.5.1.2.2 Important Habitats

According to the USNRC, "important habitats" include any wildlife sanctuaries, refuges, or preserves; habitats identified by state or federal agencies as unique, rare, or of priority for protection; wetlands and floodplains; and land areas identified as critical habitat for species listed as threatened or endangered by the USFWS (USNRC, 1999).

6.5.1.2.2.1 Clinton Lake State Recreation Area

The EGC ESP Facility is located near Clinton Lake, which is part of the Clinton Lake State Recreation Area. This entire recreational area is approximately 9,300 ac, and provides opportunities for an array of recreational activities including fishing, picnicking, hiking, camping, swimming, boating, hunting, and wildlife viewing activities.

The parklands are owned by AmerGen, which operates the CPS. The IDNR has operated the park through a long-term lease with AmerGen since 1978 (IDNR, 2002a).

It is anticipated that the combination of monitoring for waterfowl and other aquatic species, in addition to the Water Quality Monitoring Program that will be implemented, will be adequate to identify any adverse impacts to Clinton Lake, resulting from construction or operation of the EGC ESP Facility.

6.5.1.2.2.2 Weldon Springs State Recreation Area

Based on its distance from the site, no adverse effects are anticipated to the Weldon Springs State Recreation Area as a result of construction or operation of the EGC ESP Facility. Therefore, no specific monitoring programs have been designed.

6.5.1.2.2.3 Environmentally Sensitive Areas (Illinois Natural Area Inventory Sites)

The State of Illinois designates certain environmentally sensitive areas as Illinois Natural Areas. These areas are protected to varying degrees, under the jurisdiction of the Illinois Nature Preserves Commission. There are two environmentally sensitive areas located within 6 mi of the site, specifically along Salt Creek and Tenmile Creek, approximately 3 mi and 5 mi, respectively, from the location of the EGC ESP Facility (IDNR, 2002b).

Based on their distance from the site, these areas are not anticipated to be adversely affected by construction or operation of the EGC ESP Facility. As a result, no specific monitoring programs have been designed to address impacts to these areas.

6.5.1.2.2.4 Wetlands and Floodplains

Impacts to wetlands and floodplains will be temporary during the construction of the water intake structure and modifications to the CPS discharge flume, and there will be no net loss of the resource area. It is not anticipated that there will be any adverse impacts as a result of operation of the EGC ESP Facility. As a result, no specific additional monitoring programs have been designed to address impacts to these areas.

6.5.2 Aquatic Ecology

This section presents information regarding the monitoring of aquatic ecosystems as required in support of the Application for the EGC ESP.

6.5.2.1 Fisheries Resources

An Aquatic Resources Monitoring Program was established for the CPS to monitor, on a low-level basis, fish communities existing in waterbodies located within the vicinity. This program was based on initial data collected during sampling activities that occurred in support of the CPS ER. It was designed to provide data on naturally occurring year-to-year variations within existing communities during preconstruction, construction, and postconstruction phases of the project (CPS, 1973).

The program proposed in the CPS ER included fish sampling at five sampling locations that were identified in the preliminary baseline assessment. The CPS ER proposed that sampling be continued at these locations on a quarterly basis so that fishery resources are sampled during each season of the year (CPS, 1973). Additionally, new locations within Clinton Lake will be monitored, associated with the proposed intake structure and discharge from the EGC ESP Facility, to evaluate effects on fishery resources during operation.

The sampling techniques will be in accordance to accepted methods and approved by the IDNR.

In addition to sampling programs directly associated with the CPS and the EGC ESP Facility, the IDNR implements routine sampling programs to characterize fish populations. Representatives from EGC will coordinate their efforts with the IDNR to confirm the need for additional monitoring of fisheries resources, and if deemed appropriate, to design a monitoring program that does not duplicate any of the IDNR's ongoing data collection/sampling efforts.

6.5.2.2 Important Species and Habitats

6.5.2.2.1 Important Species

According to the USNRC, "important species" are defined as state- or federally-listed (or proposed for listing) threatened or endangered species; commercially or recreationally valuable species; species that are essential to the maintenance and survival of species that are rare and commercially or recreationally valuable; species that are critical to the structure and function of the local terrestrial ecosystem; and/or species that may serve as biological indicators to monitor the effects of the facilities on the terrestrial environment (USNRC, 1999).

6.5.2.2.1.1 Federally-Listed Threatened and Endangered Species

Based on preliminary database reviews, no federally-listed threatened or endangered species are known to occur within the vicinity of the EGC ESP Facility (IDNR, 2002). The USFWS will be contacted in order to confirm the absence of any federally-listed (or proposed for listing) threatened or endangered animals.

It is anticipated that construction and operation of the EGC ESP Facility will not adversely impact federally-listed threatened or endangered species, and therefore, a specific monitoring program for federally-listed species is not proposed.

6.5.2.2.1.2 State-Listed Threatened and Endangered Species

According to information provided by the IDNR, only one aquatic state-threatened or endangered species has been identified in the project area or vicinity. Documented occurrences of the spike (*Elliptio dilatata*), a freshwater mussel, have been made approximately 10 mi from the EGC ESP Site (IDNR, 2002), which is approximately 4 mi beyond the limits of the vicinity. The spike, also known as the lady finger mussel, is designated as "threatened" in the State of Illinois (IDNR, 2002). A suitable habitat for the spike includes small to large streams. In addition, they are occasionally found in lakes with muddy or gravelly substrates (IDNR, 2002c).

Based on the distance of the spike occurrences from the site, no adverse effects to the spike are anticipated from construction or operation of the EGC ESP Facility. As a result, no specific programs are proposed for monitoring the spike.

6.5.2.2.1.3 Species of Commercial or Recreational Value

As previously mentioned, "important species" include those aquatic species that present value in a commercial or recreational manner. Species that are commercially or recreationally valuable that can be found within the vicinity of the site have been described previously in this document. These species include channel catfish, striped bass, largemouth bass, and walleye.

As previously discussed, specific monitoring programs used to identify impacts to fishery resources resulting from operation of the EGC ESP Facility will be recommended once the final design has been confirmed. Representatives from EGC will coordinate their efforts with the IDNR to design a monitoring program that does not duplicate any of the IDNR's ongoing data collection/sampling efforts. In addition, the proposed program will provide the ability to monitor species of commercial and recreational value within the vicinity.

6.5.2.2.2 Important Habitats

According to the USNRC, "important habitats" include any wildlife sanctuaries, refuges, or preserves; habitats identified by state or federal agencies as unique, rare, or of priority for protection; wetlands and floodplains; and land areas identified as critical habitat for species listed as threatened or endangered by the USFWS (USNRC, 1999).

6.5.2.2.2.1 Clinton Lake State Recreation Area

The EGC ESP Facility is located on Clinton Lake, which is part of the Clinton Lake State Recreation Area. The parklands are owned by AmerGen, which operates and maintains the CPS. The IDNR has operated the recreation area through a long-term lease with AmerGen since 1978 (IDNR, 2002a). The IDNR lease was originally executed with Illinois Power Company.

It is anticipated that the combination of monitoring for fishery resources, aquatic species, in addition to the Water Quality Monitoring Program that will be implemented, will be adequate to identify any adverse impacts to Clinton Lake resulting from construction and operation of the EGC ESP Facility.

6.5.2.2.2.2 Weldon Springs State Recreation Area

Based on its distance from the site, no adverse effects are anticipated to the Weldon Springs State Recreation Area as a result of construction or operation of the EGC ESP Facility. As a result, no specific monitoring programs have been designed to address adverse impacts to this area.

6.5.2.2.2.3 Wetlands and Floodplains

Impacts to wetlands and floodplains will be temporary during construction of the water intake structure and modifications to the discharge flume, and there will be no net loss of the resource area. It is not anticipated that there will be any adverse impacts as a result of operation of the EGC ESP Facility. As a result, no specific additional monitoring programs have been designed to address impacts to these areas.

6.6 Chemical Monitoring

This section describes the Chemical Monitoring Program for surface water and groundwater quality, which include the following:

- Preapplication monitoring that is used to support the baseline hydrologic descriptions.
- Construction monitoring to control anticipated impacts from site preparation and construction. Preoperational monitoring to establish a baseline for identification and assessment of environmental impacts resulting from facility operation.
- Operational monitoring to establish the impacts of operation of the facility and detect any unexpected impacts arising from facility operation.

The objective of the chemical monitoring is to identify environmental impacts including the degradation of water quality, and to identify alternatives or engineering measures that could be used to reduce the adverse impacts.

6.6.1 Preapplication Monitoring

The objective for the Preapplication Chemical Monitoring Program for water quality is to provide information that aids in the assessment of site suitability. In addition, the program supports the assessment of potential environmental impacts that could result from construction and operation of the EGC ESP Facility. The available information was examined in order to determine if the existing database is sufficient to support the environmental descriptions presented in Section 2.3.

6.6.1.1 Freshwater Streams

The water quality baseline for Salt Creek, presented in Section 2.3.3, is based on the data collected by the ISWS at the Rowell gauging station, about 12-mi downstream of Clinton Lake. Although the existing chemical database is sufficient to describe the chemical conditions in Salt Creek, additional preapplication monitoring will be conducted to verify and update the baseline conditions at the time of the COL application. In addition to continued collection and evaluation of data collected at the Rowell gauging station, the proposed preapplication water quality monitoring will include sampling at a location downstream of the Clinton Lake Dam (Site E-3 on Figure 6.1-1). Water samples will be collected monthly (at a minimum), concurrent with the thermal monitoring (see Section 6.1). Dissolved oxygen, specific conductance, and pH will be measured *in situ* from the water surface, and at 1.5-ft depth intervals at each site using a "YSI Multiprobe or Multiparameter Instrument" or equivalent meter. Water samples will be collected using non-metallic Van Dorn, Kemmerer, or Beta type bottles from 3-ft below the surface. The data gathered will be used to assess conditions in Salt Creek between the Clinton Lake Dam and the Rowell gauging station.

6.6.1.2 Lakes and Impoundments

The Water Quality Monitoring Program for Clinton Lake is essentially the same as the Thermal Monitoring Program conducted for the CPS (see Section 6.1.1). The additional effluent monitoring required by the CPS NPDES permit is presented in Table 6.6-1.

Although the existing chemical database is sufficient to describe the chemical conditions in Clinton Lake, additional preapplication monitoring will be conducted to verify and update the baseline conditions at the time of the COL application. The preapplication monitoring for Clinton Lake will be conducted at the same frequency and locations as the thermal measurements. These locations include (see Figure 6.1-1):

- Locations Coincident with CPS Monitoring Locations
  - Site 16 is located upstream from the discharge canal (possibly near the bridge over IL Route 48). Data from this site will be used to characterize water quality conditions upstream of the discharge flume.
  - Site 2 is located offshore from the cooling water discharge flume. Data from this site will be used to characterize lake conditions at the point of thermal discharge to the lake.
  - Sites 8 and 13 are located along the path of the cooling loop between the discharge of water into the lake and the CPS intake. The data from these sites will be used to characterize water quality conditions along the cooling loop.
  - Site 4 is located near the CPS screen house. The data from this location will be used to characterize water quality conditions at the intake.
- Proposed New Monitoring Locations
  - Site E-1 will be located upstream from the furthest CPS monitoring location (Site 16). This new location has been included to help characterize background conditions in Salt Creek prior to the point of discharge to the lake. Monitoring data from Site 16, located downstream of the bridge over IL Route 48, appear to indicate thermal impacts from the CPS discharge.
  - Site E-2 will be located in Clinton Lake, near the dam. The data from this new location will be used to characterize the water quality conditions being discharged to Salt Creek.

Water samples will be collected monthly (at a minimum), concurrent with the thermal monitoring (see Section 6.1). Dissolved oxygen, specific conductance, and pH will be measured *in situ* from the water surface, and at 1.5-ft depth intervals at each site using a "YSI Multiprobe or Multiparameter Instrument" or equivalent meter. Water samples will be collected using non-metallic Van Dorn, Kemmerer, or Beta type bottles from 3-ft below the surface. If thermal stratification is present, samples will also be collected from the metalimnion and hypolimnion strata. Metalimnion samples will be taken at the midpoint between the upper and lower levels of the layer, as defined by the temperature gradient. If a hypolimnion layer exists, samples will be collected midway between the lake bottom and the lower limit of the metalimnion.

The final list of analytical parameters that will be included in the monitoring program, will be developed in consultation with the IEPA, relative to NPDES permit requirements. It is anticipated that the analytical program will be similar to that monitored for the CPS, and is summarized in Table 6.1-1. Analytical methods will follow standard analytical protocols such as those listed in the *Standard Methods for the Examination of Water and Wastewater*

(APHA et al., 1989) or *Methods for Chemical Analysis of Water and Wastes* (USEPA, 1983). Samples will be preserved in the field as specified by the analytical method. Field and laboratory quality assurance and quality control samples will also be collected at a frequency of 10 percent. Tracking of the samples will be maintained using chain-of-custody protocols.

Additional locations may be incorporated into the monitoring program as the engineering design progresses. Based on the proposed locations, parameters, and procedures, it is anticipated that the collection and analytical methods and the statistical evaluation will provide the data to supplement the existing database and support the description of the baseline conditions. In addition, the monitoring will be coordinated with the data collection activities conducted for the CPS in order to avoid duplicate efforts.

6.6.1.3 Groundwater

The Preapplication Monitoring Program for groundwater quality will be implemented to support the assessment of site acceptability. In addition, it will identify the groundwater quality impacts that could result from construction and operation of the EGC ESP Facility. The available groundwater information was evaluated to determine if the existing database is sufficient to support the description of the groundwater system characteristics in the vicinity of the EGC ESP Facility (see Section 2.3).

The CPS Preoperational Monitoring Program consisted of semiannual monitoring of 9 public and private wells around the periphery of the lake in 1978, and 11 wells in 1979. The program identifies changes in groundwater quality that results from the impoundment of Clinton Lake (CPS, 2002).

The CPS Operational Monitoring Program was conducted in order to assure early detection of groundwater contamination that results from either normal operation or an accidental effluent release. The CPS USAR reports that an elaborate monitoring program was not considered warranted because there are no groundwater users that are downgradient from the facility (between the power block and the cooling lake). Rapid groundwater movement through the discontinuous sand deposits within the glacial tills would be precluded by the relative impermeability of these tills (CPS, 2002). The CPS USAR also indicates that as a precautionary measure, Section 2.4.13.4 of the Preliminary Safety Analysis Report (PSAR) committed to monitoring 15 public or private wells located downgradient within 1 mi of the CPS. The Clinton Lake reservoir was also monitored (CPS, 2002).

In addition to the monitoring that is specified in the PSAR, semiannual monitoring of three DeWitt County municipal wells and seven private wells peripheral to Clinton Lake began in February of 1978. The monitoring program was conducted over a four-year period (1978 to 1981) to determine if there was intrusion of Clinton Lake water into surrounding groundwater supplies (CPS, 1982). The locations and information on the wells sampled are presented in Table 6.6-2. The analytical list included as part of the monitoring is provided in Table 6.6-3. The locations of the wells that are monitored as part of this CPS monitoring program are presented in Figure 6.6-1.

A similar limited Preapplication Monitoring Program will be implemented to define baseline groundwater quality conditions. Selected piezometers and public or private wells will be sampled on a quarterly basis. The specific number and locations of the

piezometers/wells and the analytical parameters will be determined based on the groundwater flow patterns in and around the EGC ESP Facility, as determined by the measured water levels and consultation with IEPA. The results will be used to verify and update the baseline chemical conditions of the glacial drift aquifers underlying the EGC ESP Facility and in the vicinity of the site at the time of the COL application. The baseline conditions are established to monitor potential impacts from the construction and operation of the EGC ESP Facility.

In addition, water quality will be evaluated prior to and after the pumping test in order to monitor potential changes in water quality during the construction dewatering activities.

6.6.2 Construction and Preoperational Monitoring

The chemical monitoring of surface water and groundwater will be conducted to provide data necessary to assess water quality changes that result from construction and operation of the EGC ESP Facility. The objective of the preoperational monitoring is to characterize the water quality at the EGC ESP Facility, and to provide a baseline for the identification and measurement of water quality changes from operation of the EGC ESP Facility.

6.6.2.1 Freshwater Streams

The construction and preoperational monitoring of Salt Creek will be an extension of the preapplication monitoring until the EGC ESP Facility is operational. The data from the preapplication sampling of Salt Creek and Clinton Lake will be evaluated. This will determine if the scope and the frequency of chemical monitoring will need to be modified in order to establish the baseline for water quality in Salt Creek. In addition, the need for changes to the monitoring program (e.g., changes in monitoring locations, parameters, collection, or analytical procedures) will be assessed regularly over the duration of the monitoring program.

6.6.2.2 Lakes and Impoundments

The construction and preoperational monitoring will consist of continuing the preapplication monitoring until the EGC ESP Facility is operational. The results of the preapplication sampling will be evaluated, and will determine if the scope and the frequency of chemical monitoring will be to be modified in order to establish the baseline for water quality. In addition, the need for modifications to the monitoring program (e.g., changes in monitoring locations, parameters, collection, or analytical procedures) will be assessed regularly and over the duration of the monitoring program.

6.6.2.3 Groundwater

The chemical monitoring of groundwater will be conducted in order to provide data necessary to assess water quality changes that result from construction dewatering and operation of the EGC ESP Facility. The objective of preoperational monitoring is to characterize the quality of groundwater at the site and in the vicinity, and to provide a basis to identify changes in groundwater quality from the facility operation.

The construction and preoperational monitoring will consist of continuing the preapplication monitoring until the EGC ESP Facility is operational. The results of the preapplication sampling will be evaluated, and will determine if the scope and the

frequency of chemical monitoring will be modified in order to establish the baseline for groundwater quality. In addition, the need for modifications to the monitoring program (e.g., changes in monitoring locations, parameters, collection, or analytical procedures) will be assessed regularly and over the duration of the monitoring program.

6.6.3 Operational Monitoring

An Operational Monitoring Program will be implemented to identify changes in water quality that results from operation of the EGC ESP Facility. A consideration in the development of the Operational Monitoring Program is the ability to update the estimates of the effectiveness of various effluent treatment systems, and to provide real time warnings of any failures in the effluent treatment systems. The specific elements of the Operational Monitoring Program for the assessment of surface water quality will be developed in consultation with the IEPA, relative to NPDES permit requirements and with consideration of monitoring conducted for the CPS.

6.6.3.1 Freshwater Streams

Specifics related to the operational monitoring for Salt Creek are anticipated to be similar to the Preapplication, Construction, and Preoperational Monitoring programs. The program may be modified based on data collected for Salt Creek and Clinton Lake, and consultations with IEPA. The data will be evaluated by monitoring for water quality changes of the discharge from Clinton Lake to Salt Creek.

Based on the monitoring data for the CPS, the Operational Monitoring Program is anticipated to extend over a five-year period, or until conditions appear to have stabilized based on the trend analysis.

6.6.3.2 Lakes and Impoundments

The Operational Monitoring Program is anticipated to be an extension of the Preoperational Monitoring Program. Thus, chemical changes that result from facility operations can be evaluated. The data will be evaluated for chemical variability along the flow path and temporal trends. The results of the operational monitoring and previous sampling events will be evaluated to determine if the scope and the frequency of chemical monitoring will be modified. The need for modifications to the monitoring program (e.g., changes in monitoring locations, parameters, collection, or analytical procedures) will be assessed regularly and over the duration of the monitoring program.

6.6.3.3 Groundwater

The objective of the Groundwater Operational Monitoring Program is to identify the changes in water quality resulting from the operation of the EGC ESP Facility. The Operational Monitoring Program is anticipated to be an extension of the Preoperational Monitoring Program. Thus, chemical changes that result from facility operations can be evaluated. The groundwater data from the preapplication and preoperational sampling events will be evaluated, and the scope and/or the frequency of chemical monitoring will be modified, as needed. The need for modifications to the monitoring program (e.g., changes in monitoring locations, parameters, collection, or analytical procedures) will be assessed regularly and over the duration of the monitoring program.

6.7 Summary of Monitoring Standards

This section will summarize all of the monitoring programs for the EGC ESP Facility. The summary is divided into three sections:

- Site preparation and construction monitoring;
- Preoperational monitoring; and
- Operational monitoring.

6.7.1 Site Preparation and Construction Monitoring

Table 6.7-1 is a summary table of the Site Preparation and Construction Monitoring Programs that are proposed in this ER.

6.7.2 Preoperational Monitoring

Table 6.7-2 is a summary table of the Preoperational Monitoring Programs that are proposed in this ER. The programs that are listed in Table 6.7-1 will continue into the preoperational phase and are not listed again unless otherwise noted.

6.7.3 Operational Monitoring

Operational monitoring is proposed to begin after construction is complete and the EGC ESP Facility is operating. Specific operational monitoring requirements and programs have not been established at this time, although they are expected to be similar to preoperational monitoring programs. The Preoperational Monitoring Programs may be modified based on consultations with IEPA and the CPS, as well as other outside sources. The need for modifications (e.g., changes in monitoring locations, parameters, collection, or analytical procedures) will be assessed regularly, over the duration of the monitoring programs.

CHAPTER 6

References

Chapter Introduction

None

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Section 6.7

None

CHAPTER 6

Tables

TABLE 6.1-1
Summary of Clinton Power Station Thermal and Chemical Monitoring Programs

Description	Preoperational (May 1978 through 1986) [a]		Operational (February 1987 through 1991)[a]	
Objective of sampling program	Establish baseline water quality in Clinton Lake prior to operation		Document water quality changes	
Sites monitored	2, 4, 8, 16 (see Figure 6.1-1)		2, 4, 8, 13, 16 (see Figure 6.1-1)	
Frequency	Monthly		Monthly during May through September and quarterly during the rest of the year	
Field parameters	Water temperature pH Dissolved oxygen Specific conductance Turbidity		Water temperature pH Dissolved oxygen Specific conductance	
Collection points for field parameters	Surface and 3 ft depth intervals. If thermal stratification was present water column was segmented into epiliminion, metalimnion, and hypolimnion.[b]		Surface and 1.6-ft intervals. If thermal stratification was present, water column was segmented into epiliminion, metalimnion, and hypolimnion.[b]	
Water quality parameters	**General Water Chemistry** Alkalinity Ammonia Chloride Hardness Nitrate Organic nitrogen Orthophosphate Phosphorus Silica Sulfate Total dissolved solids (TDS) Total organic carbon (TOC) Total suspended solids (TSS)	**Biological** Fecal coliform Fecal streptococcus Biological oxygen demand (BOD **Metals** Copper Lead Mercury Zinc	**General Water Chemistry** Alkalinity Ammonia Calcium Chloride Hardness Nitrate Organic nitrogen Orthophosphate Oxygen, dissolved Phosphorus Silica Sulfate TDS TSS	**Metals** Mercury Magnesium
Collection points for water quality samples	3 ft below surface (i.e., epiliminion). If thermal stratification was present, samples also collected from metalimnion and hypolimnion.[b]		3 ft below surface (i.e., epiliminion). If thermal stratification was present, samples also collected from metalimnion and hypolimnion.[b]	
Data Analysis	Statistical trend analysis		Statistical trend analysis	

[a] CPS, 1992
[b] Thermal stratification defined as temperature gradient of at least 1°C change per meter.

TABLE 6.2-1
Proposed Radiological Environmental Monitoring Program TLD and Media Sampling Locations

Code	Description [a]	Sector	Distance (mi)	Code	Description	Sector	Distance (mi)
1	Station (S)	N/A	0	42	Located SE of Site (S)	SE	2.4
2	Supplemental Indicator (T)	SE	0.4	43	Special Interest (T)	ENE	2.6
3	Start of Discharge Flume (S)	SE	0.4	44	Indicator (T)	ESE	2.8
4	Indicator (T)	ENE	0.5	45	Indicator (T)	SE	2.8
5	Indicator (T)	E	0.5	46	Indicator (T)	S	2.8
6	Indicator (T)	NE	0.6	47	Indicator (T)	SSW	2.8
7	Indicator (T)	N	0.6	48	Indicator (T)	SW	3.3
8	Supplemental Indicator (T)	E	0.6	49	Special Interest (T)	N	3.4
9	Old Clinton Road (S)	E	0.6	50	End of Discharge Flume (S)	E	3.4
10	Indicator (T)	NNE	0.7	51	Special Interest (T)	W	3.5
11	Supplemental Indicator (T)	NE	0.7	52	Supplemental Indicator (T)	NNE	3.5
12	Indicator (T)	NW	0.7	53	North Fork Canoe Access (S)	NNE	3.5
13	Supplemental Indicator (T)	NNE	0.7	54	Located NNE of Site (S)	NNE	3.6
14	Site Main Access Road (S)	NNE	0.7	55	Salt Creek Bridge on Rt. 10 (S)	SW	3.6
15	Site Secondary Access Road (S)	NE	0.7	56	Indicator (T)	SE	4.1
16	Supplemental Indicator (T)	WSW	0.8	57	Indicator (T)	SSE	4.1
17	Indicator (T)	WNW	0.8	58	Indicator (T)	W	4.1
18	Supplemental Indicator (T)	SW	0.8	59	Indicator (T)	NNW	4.3
19	CPS Recreation Area (S)	WSW	0.8	60	Indicator (T)	E	4.3
20	Residence Near Recreation Area (S)	SW	0.8	61	Indicator (T)	SSW	4.3
21	Special Interest (T)	N	0.9	62	Indicator (T)	NW	4.4
22	Supplemental Indicator (T)	N	0.9	63	Indicator (T)	SW	4.5
23	Near Residence on Rt. 900 N (S)	N	0.9	64	Indicator (T)	WSW	4.5
24	Residence North of Site (S)	N	0.9	65	Indicator (T)	NNE	4.5
25	Indicator (T)	NNW	1.3	66	Indicator (T)	ENE	4.5
26	Mascoutin Recreation Area (S)	SE	1.3	67	Indicator (T)	WNW	4.5
27	DeWitt Pumphouse (S)	E	1.6	68	Indicator (T)	ESE	4.6
28	Indicator (T)	W	1.8	69	Indicator (T)	S	4.6
29	Camp Quest (S)	W	1.8	70	Indicator (T)	N	4.6
30	Special Interest (T)	W	1.9	71	Indicator	NE	4.8
31	Pasture (S)	NNE	2.0	72	Illinois Rt. 48 Bridge (S)	ENE	5.0

TABLE 6.2-1
Proposed Radiological Environmental Monitoring Program TLD and Media Sampling Locations

Code	Description [a]	Sector	Distance (mi)	Code	Description	Sector	Distance (mi)
32	Special Interest (T)	WNW	2.1	73	Supplemental Indicator (T)	ENE	6.1
33	SE of Site on Clinton Lake (S)	SE	2.1	74	Parnell Boat Access (S)	ENE	6.1
34	DeWitt Cemetery (S)	E	2.2	75	Supplemental Control (T)	SSW	10.3
35	Supplemental Indicator (T)	E	2.2	76	Supplemental Control (T)	SW	11.7
36	Supplemental Indicator (T)	SE	2.3	77	Supplemental Control (T)	SSE	12.5
37	Indicator (T)	WSW	2.3	78	Residence in Cisco (S)	SSE	12.5
38	Indicator (T)	SSE	2.3	79	Pasture in Rural Kenny (S)	WSW	14
39	Mascoutin Recreation Area (S)	SE	2.3	80	Indicator (T)	S	16
40	Mascoutin Recreation Area (S)	ESE	2.3	81	IP Station (S)	S	16
41	Special Interest (T)	E	2.4	82	Lake Shelbyville (S)	S	50

Source: Campbell, 2002

[a] T=TLD locations and S=Sampling locations

Note: These locations are the same as those utilized by CPS radiological monitoring personnel with the exception of sampling location #1, additional locations may be selected, if required.

TABLE 6.2-2
Proposed Radiological Environmental Monitoring Program Sampling Locations

Station Code	Description	Air	Surface Water	Drinking Water	Food Products	Milk	Groundwater	Grass	Fish	Shoreline Sediment
1	Station Service Building			√						
2	Start of discharge flume (0.4 mi SE)		√							
9	Old Clinton Road (0.6 mi E)	●								
14	Site's main access road (0.7 mi NNE)	√			√			●		
15	Site's secondary access road (0.7 mi NE)	√			√					
19	CPS recreation area (0.8 mi WSW)	●								
20	Residence near recreation area (0.8 mi SW)	●								
23	Near residence on Rt. 900N (0.9 mi N)	√								
24	Resident north of site (0.9 mi N)				√					
26	Mascoutin Recreation Area (1.3 mi SE)									
27	DeWitt Pumphouse (1.6 mi E)						√			
29	Camp Quest (1.8 mi W)	●						●		
31	Pasture (2.0 mi NNE)				●					
33	SE of site on Clinton Lake (2.1 mi SE)									√
34	DeWitt Cemetery (2.2 mi E)	√						●		
39	Mascoutin Recreation Area (2.3 mi SE)	●								
40	Mascoutin Recreation Area (2.3 mi ESE)						√			

TABLE 6.2-2
Proposed Radiological Environmental Monitoring Program Sampling Locations

Station Code	Description	Air	Surface Water	Drinking Water	Food Products	Milk	Groundwater	Grass	Fish	Shoreline Sediment
42	Located SE of site (2.4 mi SE)									
50	End of the discharge flume (3.4 mi E)								√	
53	North Fork canoe access area (3.5 mi NNE)		●							
54	Located NNE of site (3.6 mi NNE)									
55	Salt Creek Bridge on Rt. 10 (3.6 mi SW)		●							
72	Illinois Rt. 48 Bridge (5.0 mi ENE)									
74	Parnell Boat Access (6.1 mi ENE)		√							
78	Residence in Cisco (12.5 mi SSE)				√					
79	Pasture in rural Kenney (14 mi WSW)					√		●		
81	IP substation (16 mi S)	√								
82	Lake Shelbyville (50 mi S)								√	√

Source: Campbell, 2002

Indicator Location: Less than 10 mi from site

Control Location: Greater than 10 mi from site

√ Required samples

● Supplemental samples

Note: Location is listed by distance in miles and directional sector from the EGC ESP Facility. These locations are the same as those utilized by CPS radiological monitoring personnel.

TABLE 6.6-1
Effluent Monitoring Requirements in Clinton Power Station NPDES Permit [a]

Outfall No.	Discharge Name	Parameter	Sampling Frequency
002	Discharge Flume	Flow (million gallons per day [mgd])	1/week
			1/week
		pH	1/week
		Total residual chlorine	1/day
		Total residual oxidant	Continuous
		Temperature (average daily)	
A02	Sewage Treatment Facility	Flow (mgd)	1/week
		pH	1/week
		BOD_5	1/week
		Total suspended solids	1/week
B02	Radwaste Treatment System Effluent	Flow (mgd)	Continuous
		Total suspended solids	1/week
		Oil and grease	1/week
003	Water Treatment Works	Flow (mgd)	1/week
		pH	1/week
		Total suspended solids	1/week
		Total dissolved solids	1/week
C02 A03	Activated Carbon Treatment System Effluent	Flow (mgd)	1/month
		Oil and grease	1/month
		Benzene	1/month
		Ethyl benzene	1/month
		Toluene	1/month
		Xylenes (total)	1/month
		Priority pollutants PNAs	1/month
004	Transformer Area Oil-Water Separator	Flow (mgd)	1/month
		Oil and grease	1/month
005	Diesel Generator Area Oil-Water Separator	Flow (mgd)	1/month
		Oil and grease	1/month
006	Screen House Intake Discharges	Flow (mgd)	1/week
		Total residual chlorine	1/week
007	Safe Shutdown Service Water System	Flow (mgd)	1/week
		Total residual chlorine	1/week
008	Station Service Water	Flow (mgd)	Estimate 24-hour total
		Total residual chlorine	Daily when discharging
015	Ultimate Heat Sink Dredge Pond Discharge	Flow (mgd)	Continuous
		pH	1/week
		Total suspended solids	1/week

[a] As reported in NPDES Permit issued on April 24, 2000; effective date: May 1, 2000 (EIPA,2000).

TABLE 6.6-2
Clinton Power Station Well Monitoring Program (1978-1981)

Well Number[a]	Well	Well Description	Approx. Surface Elevation (ft)	Depth Drilled (ft)	Date Drilled	Aquifer
1	Farmer City Well No. 6	Municipal well upstream of Clinton Lake	720	172	1955	Sand & Gravel
2	Clyde Reynolds	Private well south of Clinton Lake on Parnell Road	715	180	1934	---[b]
3[c]	Weldon Well No. 3	Municipal well south of Clinton Lake	715	167	1963	Sand
3[c]	Weldon Well No. 5	Municipal well south of Clinton Lake	715	293	1978	---[b]
4	Rob Roy Twist	Private well west of DeWitt Road on south side of Clinton Lake	730	---[b]	---[b]	---[b]
5	DeWitt	Well supplying water to DeWitt Post Office	740	---[b]	---[b]	---[b]
6	Lane Sportmen's Club	Private well near Lane	725	---[b]	---[b]	---[b]
7	Bill Reynolds	Private well on peninsula	730	247	---[b]	Sand & Gravel
8	Visitor's Center	Well supplying Illinois Power Company Visitor's Center	700	39.5	1978	Sand & Gravel
9	Birbeck	Private well in Birkbeck	745	---[b]	---[b]	---[b]
10	Clinton Well No. 9	Municipal well west of Clinton Lake	725	352	1973	Sand & Gravel

Source: CPS, 1982

[a] Well number corresponds to monitoring locations presented on Figure 6.6-1
[b] Data not available
[c] Although both wells are identified as in the well water monitoring program, the data indicates that only one of Weldon municipal wells was sampled. However, it is unclear as to which well was actually sampled.

TABLE 6.6-3
Chemical and Bacteriological Analytes Measured During 1978-1981 Monitoring Program

General Water Quality Parameters	Nutrients	Biological	Trace Metals
Alkalinity	Ammonia	Fecal coliform	Copper
Specific conductance	Nitrate	Fecal streptococcus	Lead
pH	Organic nitrogen	Organic carbon, total	Mercury
Turbidity	Orthophosphate		Zinc
Hardness	Phosphorus		
Total dissolved solids	Silica		
Total suspended solids	Sulfate		
	Chloride		

Source: CPS, 1982

TABLE 6.7-1
Proposed Site Preparation (Preconstruction) and Construction Monitoring Programs

Category	Monitoring Location	Summary	Instrumentation Used	Sampling Frequency
Thermal	Salt Creek, upstream from furthest CPS monitoring location	Characterize background conditions of Salt Creek before discharging to Clinton Lake	YSI Multiprobe or Multiparameter Instrument	1/day
Thermal	Salt Creek, upstream from discharge canal	Characterize thermal conditions upstream of the discharge flume	YSI Multiprobe or Multiparameter Instrument	1/day
Thermal	Salt Creek, downstream of the Clinton Lake Dam	Monitor conditions in Salt Creek between the dam and the Rowell gauging station	YSI Multiprobe or Multiparameter Instrument	1/day
Thermal	Clinton Lake, offshore from cooling water discharge flume	Characterize lake conditions at the point of thermal discharge to lake	YSI Multiprobe or Multiparameter Instrument	1/day
Thermal	Clinton Lake, along the path of cooling loop between the discharge and intake flumes	Characterize lake conditions between intake and discharge	YSI Multiprobe or Multiparameter Instrument	1/day
Thermal	Clinton Lake, near the CPS screen house	Characterize lake conditions at intake	YSI Multiprobe or Multiparameter Instrument	1/day
Thermal	Clinton Lake, near the dam	Characterize the conditions of water being discharged to Salt Creek	YSI Multiprobe or Multiparameter Instrument	1/day
Hydrologic (Freshwater streams)	Rowell gauging station	Characterize flow conditions of Salt Creek	Marsh McBirney Flowmeter (or equivalent instrument)	Continuous
Hydrologic (Lakes and Impoundments)	Stations at Parnell Road Bridge and DeWitt County Highway 14 Bridge	Measures sediment thickness to determine annual sedimentation rates	Sediment thickness will be measured with a survey rod (or equivalent instrument)	1/year
Hydrologic (Lakes and Impoundments)	Clinton Lake at the dam	Monitoring of lake water levels as described in the dam operating procedures	Lake levels will be measured with a Miltronics Ultrasonic Level Meter and recorder (or equivalent instrument)	Continuous

TABLE 6.7-1
Proposed Site Preparation (Preconstruction) and Construction Monitoring Programs

Category	Monitoring Location	Summary	Instrumentation Used	Sampling Frequency
Hydrologic (Lakes and Impoundments)	Discharge flume (Outfall 002) Sewage treatment facility (Outfall A02) Water treatment wastes (Outfall 003)	Flow measurements	Marsh McBirney Flowmeter (or equivalent instrument)	1/week
Hydrologic (Lakes and Impoundments)	Outfall C02 Outfall A03	Flow measurements of activated carbon treatment systems effluent	Marsh McBirney Flowmeter (or equivalent instrument)	1/month
Hydrologic (Lakes and Impoundments)	Outfall 015	Estimated total flow for UHS heat sink dredge pond discharge	Marsh McBirney Flowmeter (or equivalent instrument)	Continuous
Hydrologic [a] (Groundwater)	Immediate vicinity of the EGC ESP Site Downstream of dam In Clinton Lake	Location and survey of previously installed CPS piezometers that have not been identified as destroyed by construction activities	N/A	N/A
Hydrologic [a] (Groundwater)	Immediate vicinity of site	Location and identification of existing private wells within 5 mi of the site	N/A	N/A
Hydrologic [a] (Groundwater)	Between the EGC ESP Facility, the CPS, and near Clinton Lake	Installation of additional shallow water table piezometers and deep piezometers to help define lateral continuity of sand layers and to be used during the pumping test	Water level probe	1/month

TABLE 6.7-1
Proposed Site Preparation (Preconstruction) and Construction Monitoring Programs

Category	Monitoring Location	Summary	Instrumentation Used	Sampling Frequency
Meteorological	Approximately 3,200 ft SSE of the CPS containment structure	Ground Level: precipitation 33 ft wind speed and direction, ambient air temperature Dew point 197 ft wind speed and direction, ambient air temperature (for computing delta-T with 33 ft temp), delta-T, dew point	Wind: Climatronics Model 100075-G0-H0 sensors Temperature: Climatronics Model 100093 sensors Dew point: Climatronics Model 101197 dew point sensor Precipitation: Tipping bucket rain gauge by MRI, Model Number 302/370-1	Continuous
Ecological (Terrestrial)	Site property, immediate vicinity, and the proposed transmission right-of-way, as appropriate	Plant, bird, and mammal communities will be monitored on a yearly basis to show any changes in species composition and abundance in the area	N/A	1/year
Ecological (Aquatic)	Site property, immediate vicinity, Clinton Lake, Salt Creek	Different species of fish will be monitored to show changes in population, as well as monitoring the population of the spike (*Elliptio dilatata*), a freshwater mussel, because it has been designated as "threatened" by the IDNR	N/A	4/year
Chemical [a]	Salt Creek, downstream of the Clinton Lake Dam	This location is proposed in addition to the monitoring at the Rowell gauging station and will be testing the same parameters as the existing CPS	Collections taken with non-metallic Van Dorn, Kemmerer, or Beta type bottles. Dissolved oxygen, specific conductance, and pH will be measured with a YSI Multiprobe or Multiparamter Instrument	1+/month
Chemical [a]	Upstream from furthest CPS monitoring location	Characterize background conditions in Salt Creek prior to point of discharge	Van Dorn, Kemmerer, or Beta type bottles	1+/month

TABLE 6.7-1
Proposed Site Preparation (Preconstruction) and Construction Monitoring Programs

Category	Monitoring Location	Summary	Instrumentation Used	Sampling Frequency
	(Site 16)	to the lake	YSI Multiprobe or Multiparamter Instrument	
Chemical [a]	Upstream from discharge canal (possibly near Illinois Route 48 Bridge)	Characterize thermal conditions upstream of discharge flume	Van Dorn, Kemmerer, or Beta type bottles YSI Multiprobe or Multiparamter Instrument	1+/month
Chemical [a]	Offshore from cooling water discharge flume	Characterize lake conditions at the point of thermal discharge	Van Dorn, Kemmerer, or Beta type bottles YSI Multiprobe or Multiparamter Instrument	1+/month
Chemical [a]	Sites along the path of cooling loop between discharge of water into lake and the existing plant intake	Characterize lake conditions between intake and discharge	Van Dorn, Kemmerer, or Beta type bottles YSI Multiprobe or Multiparamter Instrument	1+/month
Chemical [a]	Near the CPS screen house	Characterize water quality at the intake	Van Dorn, Kemmerer, or Beta type bottles YSI Multiprobe or Multiparamter Instrument	1+/month
Chemical [a]	Near the CPS screen house	Characterize water quality at the intake	Van Dorn, Kemmerer, or Beta type bottles YSI Multiprobe or Multiparamter Instrument	1+/month
Chemical [a]	In Clinton Lake near the dam	Characterize the conditions of water being discharged to Salt Creek	Van Dorn, Kemmerer, or Beta type bottles YSI Multiprobe or Multiparamter Instrument	1+/month

[a] Proposed new monitoring programs for the pre-construction phase of the EGC ESP Facility. Other monitoring programs are ongoing for the CPS and qualify as preapplication and preconstruction for the EGC ESP Facility.

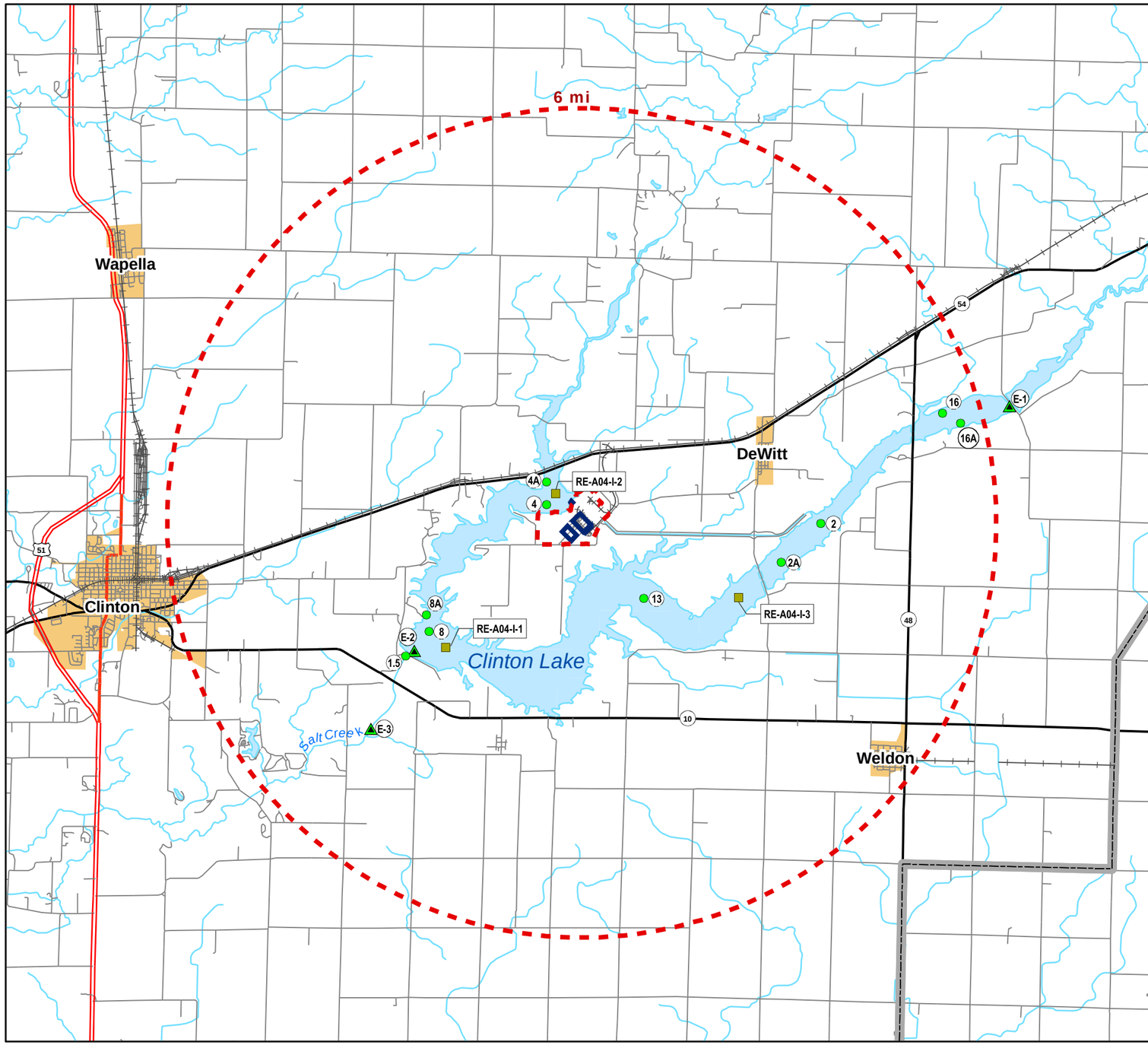
Notes: More existing chemical monitoring information is available for all effluent flows for CPS in Section 6.6.1.2, Table 6.6-1.

TABLE 6.7-2
Proposed Preoperational Monitoring Programs

Category	Monitoring Location	Summary	Instrumentation Used	Sampling Frequency
Thermal	All same locations as preconstruction and construction monitoring	Modifications to site preparation phase: • Determine the average, extent and surface area of the limiting excess temperature isotherm, if one has been established by the IEPA • Determine temperature at positions appropriate to define the extent of existing mixing zones from the discharge flume • Establish time temperature relationships at monitoring stations	YSI Multiprobe or Multiparameter Instrument	1/day
Radiological [a]	Direct radiation (Proposed sampling locations are presented in Table 6.2-1)	• "Indicator" locations will be within a 10-mi radius of the EGC ESP Site, and "control" locations will be more than 10 mi from the site. For a full list of these locations, please see Tables 6.2-1 and 6.2-2. • Gamma dose	TLD	Continuous
	Atmospheric Aquatic Terrestrial environment Ground and surface water (Exact locations to be determined)	The following analyses will be performed: • Gross alpha and beta analysis • Gamma spectroscopy analysis • Tritium analysis • Strontium analysis	Laboratory Analysis	Continuous or Grab
Hydrological [a] (Lakes and Impoundments)	Stormwater outfalls	Sediments deposits will be measured to determine if a sufficient thickness of sediment has accumulated to require removal upon completion of construction	Survey Rod (or equivalent instrument)	Upon completion of construction
Hydrological [a] (Groundwater)	Groundwater wells	The piezometers installed during the preapplication phase will be measured to monitor lateral depression in the groundwater surface caused by dewatering	Water level probe	1/day

[a] Proposed new monitoring programs for the preoperational phase of the EGC ESP Facility.

Note: Meteorological, ecological, and chemical monitoring will continue as proposed during the site preparation (preconstruction) phase. All monitoring may be slightly modified depending on the data collected and evolving demand for specific data.



Environmental Report for the EGC Early Site Permit

Figure 6.1-1
Postdam Surface Water Monitoring Locations

Legend

- Clinton Power Station Monitoring Location
- IEPA Monitoring Location
- Proposed New Monitoring Location
- Proposed Areas for EGC ESP Facility Structures
- Site Boundary: Fenceline
- Vicinity: 6-mi radius around site
- Water: Streams
- Water: Lakes and Rivers
- Incorporated/Designated Places
- County Boundary
- U.S. Highway, Multilane divided
- U.S. Highway
- State Route
- County or other minor road
- Railroads

Note:
"A" after site number indicates alternative site.

Data Sources:
CPS, 1992
USEPA, 2002
U.S. Census Bureau, 2000
U.S. Census Bureau, 2002
U.S. Census Bureau, 2002a

N

Miles
0 1 2 4

REV1

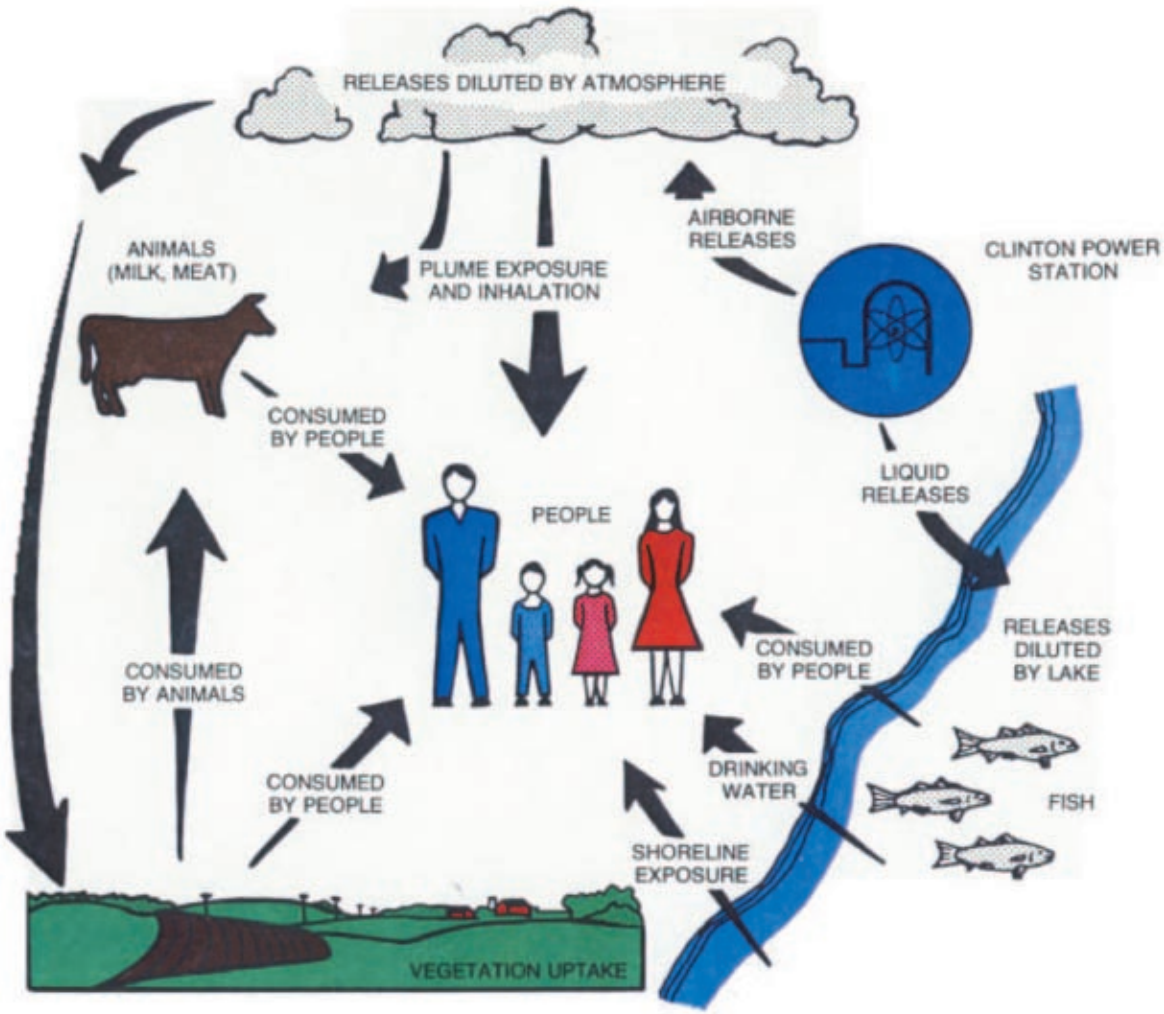


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Figure 6.2-1
Basic Pathways for Gaseous and Liquid Radioactive Effluent Releases to the Public

Legend

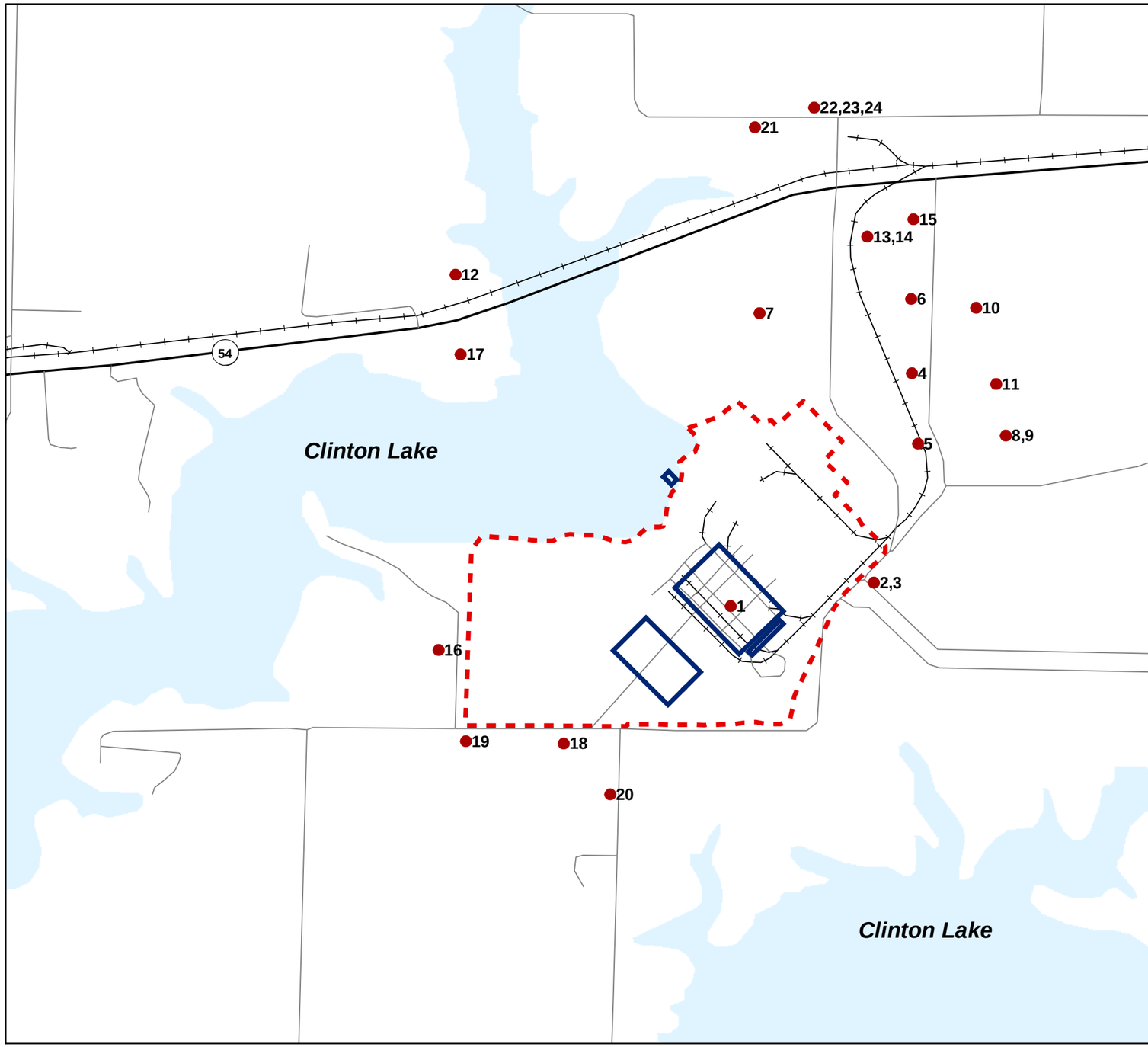
Data Source:
Campbell, 2002

Not to Scale

REV1

Environmental Report for the EGC Early Site Permit

Figure 6.2-2
Proposed EMP Sample Locations within 1 mi



Legend

- Proposed EMP Sample Locations within 1 mi
- Proposed Areas for EGC ESP Facility Structures
- Site Boundary: Fenceline
- State Route
- County or other minor road
- Railroads
- Water: Lakes and Rivers

Data Sources:
Campbell, 2002
U.S. Census Bureau, 2000

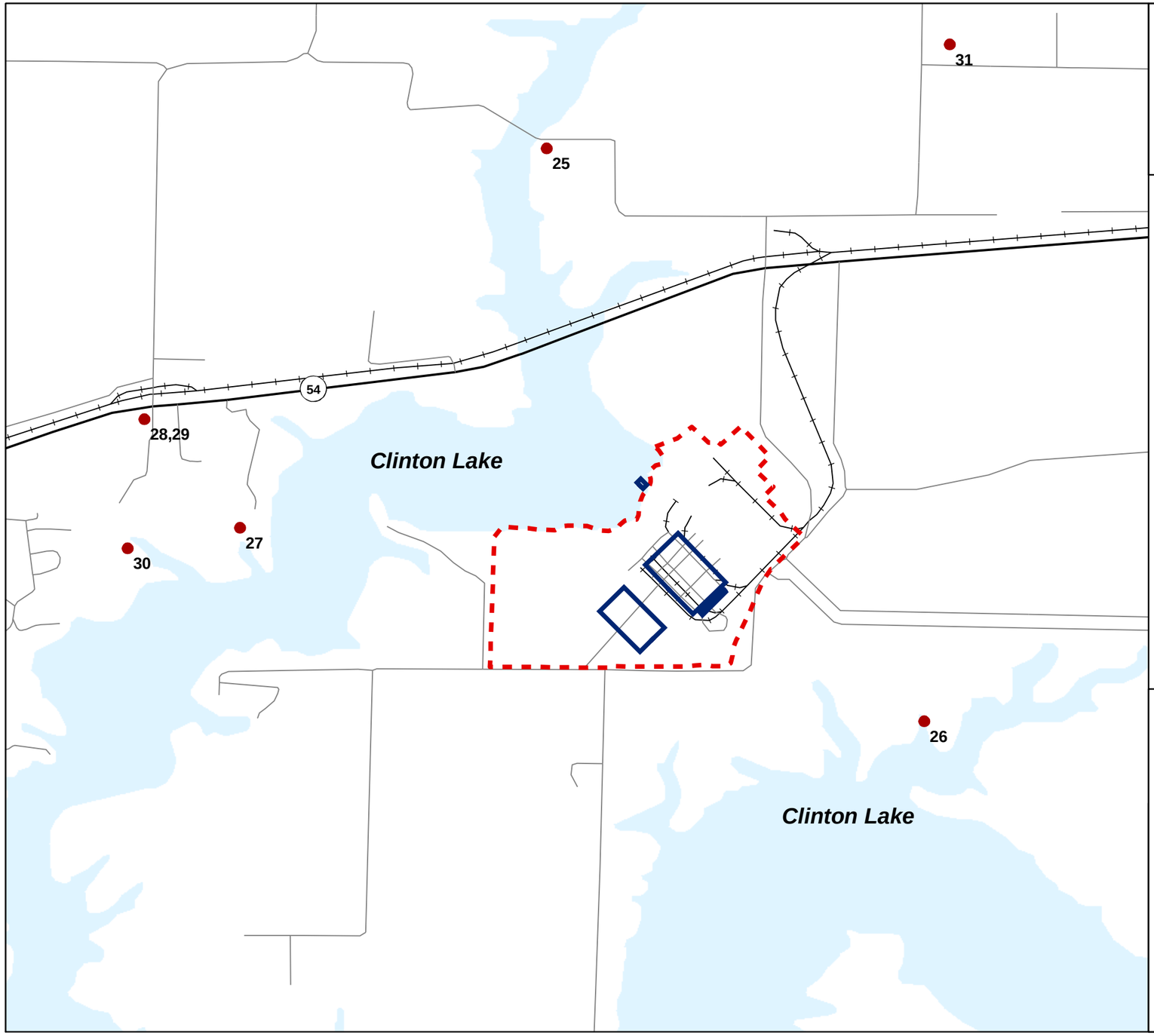
N

0 0.125 0.25 0.5
Miles

REV1

Environmental Report for the EGC Early Site Permit

Figure 6.2-3
Proposed EMP Sample Locations from 1 to 2 mi



Legend

- Proposed EMP Sample Locations from 1 to 2 mi
- Proposed Areas for EGC ESP Facility Structures
- Site Boundary: Fenceline
- State Route
- County or other minor road
- Railroads
- Water: Lakes and Rivers

Data Sources:
Campbell, 2002
U.S. Census Bureau, 2000

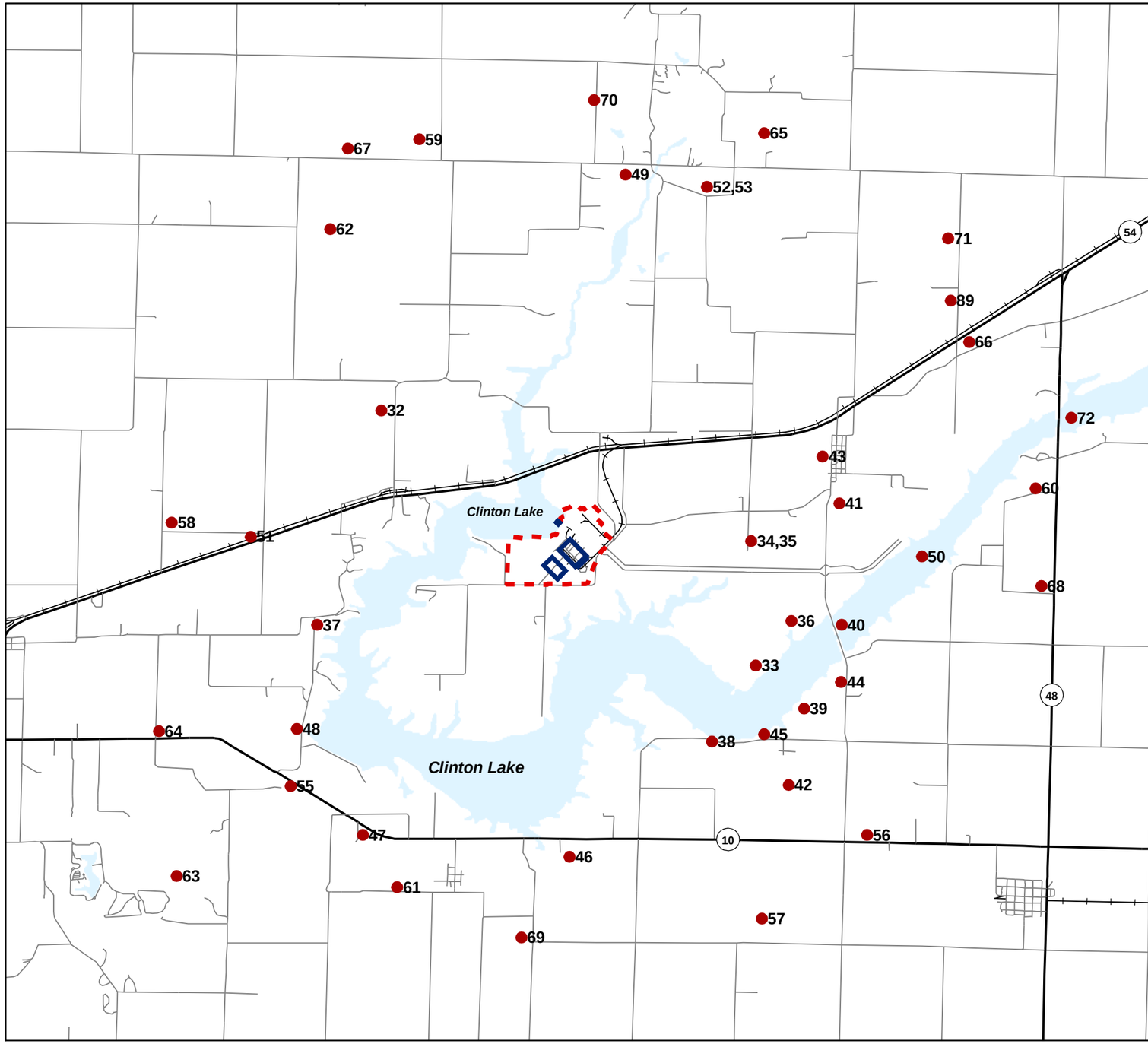
N

Miles
0 0.125 0.25 0.5

REV1

Environmental Report for the EGC Early Site Permit

Figure 6.2-4
Proposed EMP Sample Locations from 2 to 5 mi



Legend

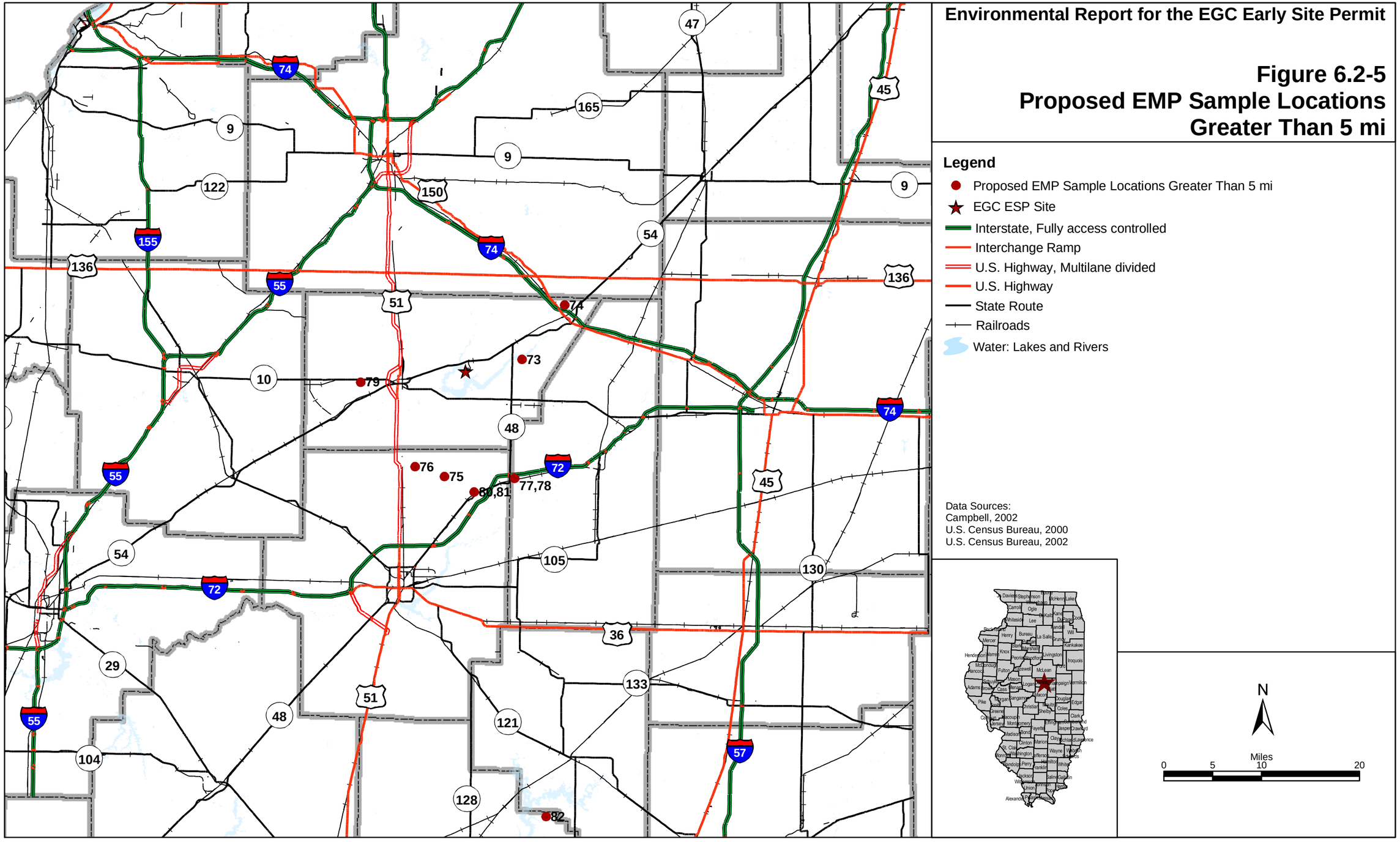
- Proposed EMP Sample Locations from 2 to 5 mi
- Proposed Areas for EGC ESP Facility Structures
- Site Boundary: Fenceline
- State Route
- County or other minor road
- Railroads
- Water: Lakes and Rivers

Data Sources:
Campbell, 2002
U.S. Census Bureau, 2000

N

0 0.5 1 2
Miles

REV1


Environmental Report for the EGC Early Site Permit
Figure 6.2-5
Proposed EMP Sample Locations
Greater Than 5 mi
Legend
Proposed EMP Sample Locations Greater Than 5 mi
EGC ESP Site
Interstate, Fully access controlled
Interchange Ramp
U.S. Highway, Multilane divided
U.S. Highway
State Route
Railroads
Water: Lakes and Rivers
Data Sources:
Campbell, 2002
U.S. Census Bureau, 2000
U.S. Census Bureau, 2002
N
Miles
0
5
10
20
74
73
79
76
75
80,81
77,78
82
47
45
165
9
122
150
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105
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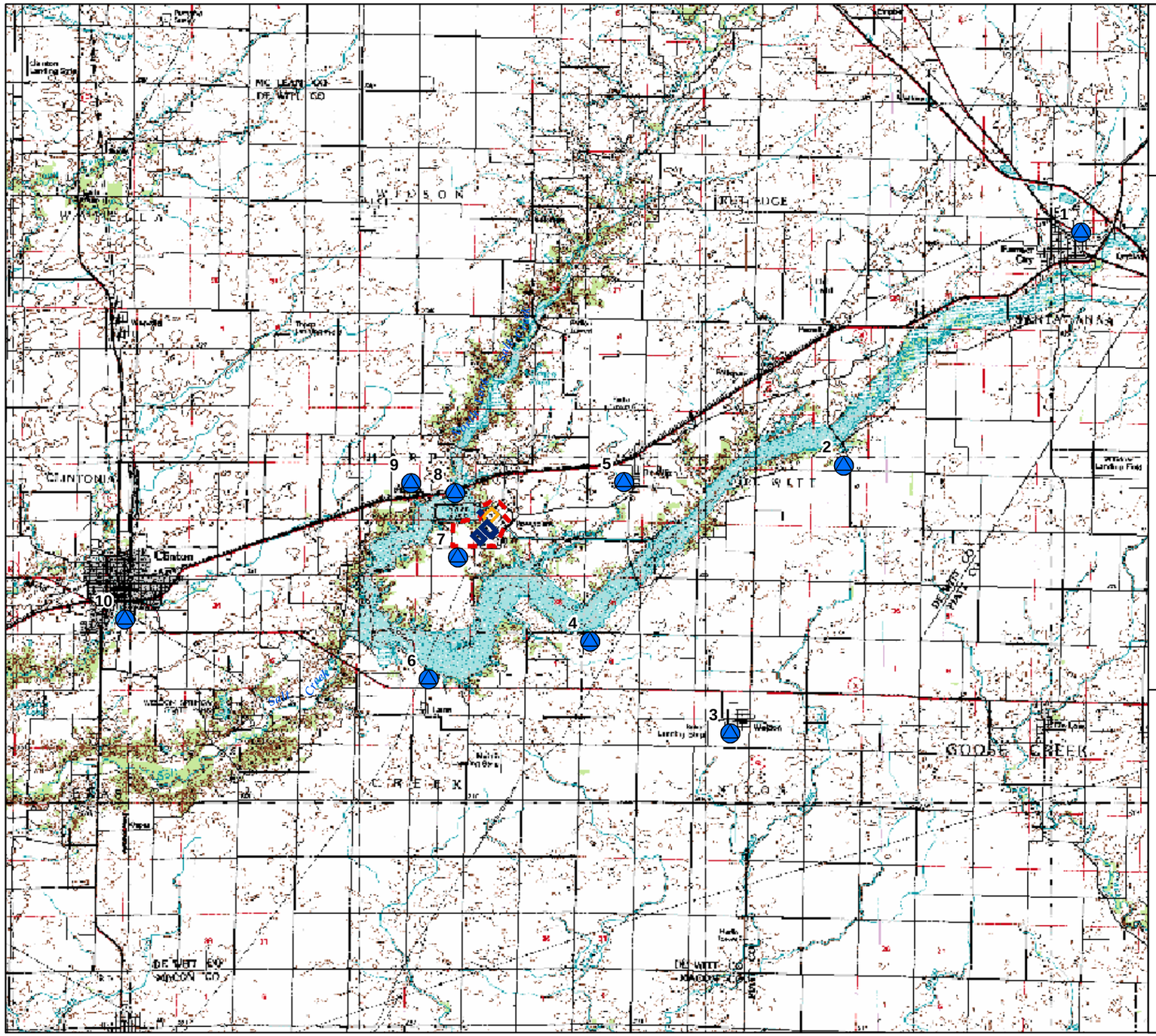
36
133
121
57
128
29
104

REV1



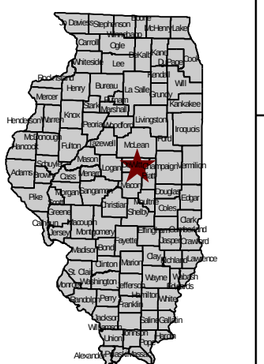
Environmental Report for the EGC Early Site Permit

Figure 6.6-1
Groundwater Monitoring Well Locations

Legend

- Groundwater Monitoring Well Locations
- Proposed Areas for EGC ESP Structures
- CPS Facility
- Site Boundary: Fenceline

Data Sources:
CPS, 1982
USGS, 1984 and 1989



N

Miles
0 0.5 1 2

REV1

CHAPTER 7

Environmental Impacts of Postulated Accidents Involving Radioactive Materials

The purpose of this section is to review and analyze a sufficiently robust spectrum of design basis accidents (DBA) and severe accidents to bracket the postaccident radiological consequences for the spectrum of reactors under consideration and provide results for use in this report. Analysis of severe accidents and mitigation of those accidents will be deferred until the COL stage.

7.1 Design Basis Accidents

The radiological consequences of potential DBAs are assessed to demonstrate that the alternative advanced reactors can be sited at the EGC ESP Site without undue risk to the health and safety of the public. The selection and evaluation of accidents is based upon USNRC regulatory guidance to the extent practical. Short-term (USNRC, 1983) site dispersion factors at the exclusion and LPZ boundaries that are based on measured site data are used to perform the assessments. The radioactivity released to the environs for DBAs is provided by the reactor supplier based upon their standard safety analysis reports or as specified in their PPE listing as being representative of the bounding DBA environmental release. The activities released to the environs are considered to be indicative of the performance of major structures, systems, and components intended to mitigate the consequences of accidents.

7.1.1 Selection of Design Basis Accidents

Accidents have been selected to cover a spectrum of design basis events and reactor types. Consistent with regulatory objectives for determining site suitability, the selection includes low probability accidents postulated to result in significant releases of radioactivity to the environs. As such, the evaluations include light water reactor (LWR) Loss of Coolant Accidents (LOCAs) that presume substantial fuel damage in the core followed by the release of significant amounts of fission products into a containment building. In addition, accidents of higher frequency but with lower potential for significant releases are considered, in order to permit quantitative assessment of the spectrum of potential risks at the EGC ESP Site.

It is not necessary or practical to analyze the DBAs associated with the alternative reactor types that could be deployed at the EGC ESP Site, but rather to include a bounding and representative set (in terms of frequency and consequences) that can be used to demonstrate site suitability.

The considered spectrum of accidents focused on the LWR designs because of their recognized postulated accident bases and the availability of data. Accidents of lesser severity (and higher frequency) for some of the newer reactor types being considered are not as well defined, and the application of accepted analytical conservatisms applied to LWRs through regulatory guides and standard review plans is not applicable based upon their unique design characteristics.

Selected accidents identified in Regulatory Guide 1.183, vendor design certification packages, vendor technical summary documents, and USNRC standard review plans for safety analyses were reviewed to establish the spectrum of accidents considered.

The following conditions and results were used in selecting DBAs for demonstrating site suitability:

- Advanced Reactors for which Design Certification DBA data are available:
  - AP1000: The AP1000 Design Control Document (Westinghouse, 2002), provides descriptions of the accidents and the technical data used to

determine the radiological consequences for DBAs at a generic site. The AP1000 evaluations consider the major DBAs identified in Regulatory Guide 1.183 and NUREG-1555. This information is part of the design certification licensing submittal for the AP1000, and is similar to the required analyses previously submitted for the certified AP600 reactor. The DBA assessments are evaluated to demonstrate EGC ESP Site suitability.

– ABWR: The ABWR Design Control Document (GE, 1997), provides descriptions of the accidents and the technical data used to determine the radiological consequences for DBAs at a generic site. This information was used by GE to obtain the design certification of the ABWR. The technical information and results are extended to the EGC ESP Site assessment.

- Non-Certified Advanced Reactor Designs:

  Non-certified advanced reactor designs are screened and selected for assessment using the DBAs identified by the reactor vendors as having the potential to result in the limiting off-site radiological consequences.

  – ESBWR: The DBAs postulated for the ABWR are expected to bound the ESBWR postaccident design assessment. The ESBWR limiting DBAs will be assessed using the alternate source term (AST) methods and guidance contained in Regulatory Guide 1.183 as opposed to the TID 14844 source term methods and NUREG-0800 guidance used for the ABWR certification. To demonstrate EGC ESP Site suitability, a conservative ESBWR LOCA assessment is provided.

  – IRIS: The low core power level and advanced design features (such as the elimination of large loop piping) of the IRIS will limit the environmental releases of radioactivity after DBAs relative to other LWRs being considered. Although the DBAs are not well finalized for this advanced concept, the vendor anticipates that postaccident radiological consequences will be well bounded by the AP600 and AP1000 evaluations. Therefore, no IRIS-specific dose assessments are performed.

  – ACR-700: The LOCA with loss of emergency core cooling is considered the most limiting DBA for the ACR-700. The source term bases and approaches utilized to license this reactor type outside the U.S. have a number of similarities to USNRC regulatory guidance. There are, however, some differences in interpretation and implementation of this guidance. Therefore, the ACR-700 LOCA is analyzed to demonstrate that this reactor plant can be sited at the EGC ESP Site and also to provide a quantitative dose perspective for this design relative to the other alternatives.

- Gas Cooled Advanced Reactor Designs

  The regulatory guidance and review standards described in USNRC publications are directed toward LWR technology and are not typically applicable to the assessment of the gas-cooled reactors.

  Depressurization events are usually the critical considerations for gas-cooled reactors. The terms coolant, primary coolant, and pressure boundary when used with gas reactor technology differ from the equivalent LWR usage. Coolant in the LWR context implies keeping the core cool in order to avoid fuel damage; maintaining the primary coolant pressure boundary is a critical safety function. The pressure boundary function in the gas reactors is to contain the helium that removes heat from the core and transfers the energy to the power conversion unit. Core geometry, however, is physically maintained under normal and postulated accident conditions. Thus, loss of helium coolant does not result in significant fuel damage. This fact, and the much lower core power levels and associated fission product inventory for the gas reactors, result in bounding post-accident environmental releases that are substantially less than the LWRs.

  The GTMHR and PBMR use mechanistic accident source terms and postulate relatively small environmental releases compared with the water reactor technologies. The limiting DBA environmental releases specified by the gas reactors vendors are provided in Table 7.1-1. Based on these projections of limiting environmental releases, the postaccident radiological dose consequences would result in less than 0.2 percent of the 10 CFR 50.34 acceptance criteria limits. Consequently, the DBAs that would be associated with the gas reactor technologies are not considered to be a major factor in assessing EGC ESP Site suitability.

The above rationale provides the basis for the spectrum of limiting DBAs selected for evaluation in assessing the EGC ESP Site suitability. The selection predominately includes the LWR accidents identified in Regulatory Guide 1.183 and its appendices as important considerations for assessing the safety of nuclear plants at the EGC ESP Site.

- Main steam line breaks (AP1000 and ABWR)
- Reactor coolant pump locked rotor (AP1000)
- Control rod ejection (AP1000)
- Control rod drop (ABWR)
- Small line break outside containment (AP1000 and ABWR)
- Steam generator tube rupture (AP1000)
- LOCA (AP1000, ABWR, ESBWR, and ACR-700)
- Fuel handling accident (AP1000 and ABWR)

7.1.2 Evaluation of Radiological Consequences

Doses for the selected DBAs were evaluated at the EAB and LPZ. These doses must meet the site acceptance criteria in 10 CFR 50.34 and 10 CFR 100. Although the emergency safety

features are expected to prevent core damage and mitigate releases of radioactivity, the surrogate LOCAs analyzed presume substantial meltdowns of the core with the release of significant amounts of fission products. The postulated LOCAs are expected to more closely approach 10 CFR 50.34 limits than the other DBAs of greater frequency but with less magnitude. For these accidents, the more restrictive dose limits in Regulatory Guide 1.183 and the NUREG-0800, Standard Review Plan, were used to make certain that the accidents were acceptable from an overall risk perspective (USNRC, 2000 and USNRC, 1987).

The evaluations used short-term accident chi/Qs. The chi/Qs were determined using Regulatory Guide 1.145 methods with on-site meteorology data (USNRC, 1983). The site 50th percentile chi/Qs from Table 2.7-52 of the SSAR were used in these evaluations.

The 0- to 2-hour Chi/Q value is used for the 2-hour release duration with the greatest dose consequences at the EAB.

- EAB
  - 0 to 2 hrs
- LPZ
  - 0 to 8 hrs
  - 8 to 24 hrs
  - 1 to 4 days
  - 4 to 30 days

The accident doses are expressed as total effective dose equivalents (TEDEs) consistent with 10 CFR 50.34. The TEDE consists of the sum of the committed effective dose equivalent (CEDE) from inhalation and the deep dose equivalent (DDE) from external exposure. The CEDE is determined using dose conversion factors in Federal Guidance Report 11 (USEPA, 1988). The DDE is taken the same as the effective dose equivalent from external exposure and the dose conversions in Federal Guidance Report 12 (USEPA, 1993) are applied.

7.1.3 Source Terms

Time-dependent activities released to the environs are used in the dose evaluations. These activities are based on the analyses used to support the reactor vendors' standard safety analysis reports. The different reactor technologies use different source terms and approaches in defining the activity releases.

The ABWR source term is based on Technical Information Document (TID)-14844 (USAEC, 1962).

The ESBWR and the AP1000 source term and approach to assessing accidents are based on the AST methods and guidance outlined in Regulatory Guide 1.183.

The ACR–700 source term definition is similar to the TID-14844 approach.

As noted, the GT-MHR and PBMR use a mechanistic approach to arrive at their accident source terms.

7.1.4 Postulated Accidents

This section identifies the postulated accidents, the resultant activity release paths, the important accident parameters and assumptions, and the credited mitigation features used in the EGC ESP Site dose consequence assessments. An overall summary of the results of the evaluated accident doses appears in Table 7.1-2. This table also compares the environmental doses to the recommended limits based on Regulatory Guide 1.183 and NUREG-0800. Table 7.1-2 shows that the evaluated dose consequences meet the accident-specific acceptance criteria invoked in Section 7.1.2.

The analysis approach for evaluating the AP1000 design basis accidents discussed in the following subsections is based upon the EAB and LPZ doses provided by Westinghouse and given in Chapter 15 of the AP1000 Design Control Document, Tier 2, Revision 2 and the ratio of the ESP Site Chi/Q value to the AP1000 representative site Chi/Q value for each post accident time period. The AP1000 representative site Chi/Q values used in the evaluations are given in Table 7.1-2A. Based upon the revisions made to the Chi/Q values by Westinghouse to support the final AP1000 design certification, the EAB doses presented in Tables 7.1-2, 7.1-5, 7.1-6, 7.1-11, 7.1-13, 7.1-16, 7.1-17, 7.1-19, 7.1-23 and 7.1-31 will increase by approximately 3.6% and the LPZ doses will remain bounding.

7.1.4.1 Main Steam Line Break Outside Containment (AP1000)

The bounding AP1000 steam line break for the radiological consequence evaluation occurs outside containment. The facility is designed so that only one steam generator experiences an uncontrolled blowdown even if one of the main steam isolation valves fail to close. Feedwater is isolated after the rupture and the faulted steam generator dries out. The secondary side inventory of the faulted steam generator is released to the environs along with the entire amount of iodine and alkali metals contained in the secondary side coolant.

The reactor is assumed to be cooled by steaming down the intact steam generator. Activity in the secondary side coolant and primary to the secondary side leakage, contribute to releases to the environment from the intact generator. During the event, primary to secondary side leakage is assumed to increase from the technical specification limit of 150 gpd per steam generator to 500 gpd (175 lbm/hr) per steam generator for the intact and faulted steam generators.

The alkali metals and iodines are the only significant nuclides released during a main steam line break. Noble gases are also released; however, there would be no significant accumulations of the noble gases in the steam generators prior to the accident since they are rapidly released during normal service. Noble gases released during the accident would primarily be due to the increase in primary to secondary side leakage assumed during the event. Reactor coolant leakage to the intact steam generator would mix with the existing inventory and increase the secondary side concentrations. This effect would normally be offset by alkali and iodine partitioning in the generator. However, for conservatism, the calculated activity release assumes the primary to secondary side activity in the intact generator that is also leaked directly to the environment. The calculated doses are based on activity releases that assume:

- Duration of accident – 72 hrs

- Steam generator initial mass – 3.03E+05 lbm
- Primary to secondary leak rate – 175 lb/hr in each steam generator
- Steam generator initial iodine and alkali metal activities – 10 percent of design basis reactor coolant concentrations at maximum equilibrium conditions
- Reactor coolant alkali activity – 0.25 percent design basis fuel defect inventory
- Reactor coolant noble gas activity – limit of 280 microcurie per gram (□Ci/g) dose equivalent Xe-133
- Accident initiated iodine spike – 500 times the fuel release rate that occurs when the reactor coolant equilibrium activity is 1.0 □Ci/g dose equivalent Iodine-131
- Preexisting iodine spike – reactor coolant at 60 □Ci/g dose equivalent Iodine-131
- Fuel damage - none

The activities released to the environment for the accident initiated and preexisting iodine spike cases are shown in Tables 7.1-3 and 7.1-4, respectively.

The vendor calculated time-dependent off-site doses for a representative site. The doses were reevaluated using the EGC ESP Site short-term accident dispersion characteristics in Table 2.3-52 of the SSAR.

The TEDE doses for the accident initiated iodine spike are shown in Table 7.1-5. The doses at the EAB and LPZ are a small fraction of the 25-roentgen equivalent man (rem) TEDE identified in 10 CFR 50.34 (USNRC, 2000). A "small fraction" is defined as 10 percent or less in the Standard Review Plan and Regulatory Guide 1.183. The doses for the preexisting iodine spike are shown in Table 7.1-6. These doses also meet the TEDE dose guidelines of 10 CFR 50.34.

7.1.4.2 Main Steam Line Break Outside Containment (ABWR)

This ABWR event assumes that the largest steam line instantaneously ruptures outside containment downstream of the outermost isolation valve. The plant is designed to automatically detect the break and initiate isolation of the line. Mass flow would initially be limited by the flow restrictor in the upstream reactor steam nozzle and the remaining flow restrictors in the three unbroken main steam lines feeding the downstream end of the break. Closure of the main steam isolation valves would terminate the mass flows out of the break.

No fuel damage would occur during this event. The only sources of activity are the concentrations present in the reactor coolant and steam before the break. The mass releases used to determine the activity available for release presume maximum instrumentation delays and isolation valve closing times. The iodine and noble gas activities in the water and steam masses discharged through the break are assumed to be released directly to the environs without hold-up or filtration. Salient features of the analyzed accident include:

- Duration of accident – 2 hrs
- Main steam isolation valve closure – 5 seconds

- Mass releases from break – steam 12,870 kilograms; water 21,950 kilograms
- Reactor coolant maximum equilibrium activity – corresponding to an offgas release rate of 100,000 Ci/s referenced to a 30 minute decay
- Preexisting iodine spike – corresponding to an offgas release rate of 400,000 Ci/s referenced to a 30 minute decay
- Fuel damage – none

The activity released to the environment for the maximum activity and preexisting spike cases is shown in Table 7.1-7.

The calculated doses for the maximum allowed equilibrium activity at full power operation are shown in Table 7.1-8. The calculated doses for the preaccident iodine spike are shown in Table 7.1-9. The EAB and LPZ doses are a small fraction of the 25-rem TEDE dose guidelines of 10 CFR 50.34.

7.1.4.3 Locked Rotor (AP1000)

The AP1000 locked rotor event is the most severe of several possible decreased reactor coolant flow events. This accident is postulated as an instantaneous seizure of the pump rotor in one of four reactor coolant pumps. The rapid reduction in flow in the faulted loop causes a reactor trip. Heat transfer of the stored energy in the fuel rods to the reactor coolant causes the reactor coolant temperature to increase. The reduced flow also degrades heat transfer between the primary and secondary sides of the steam generators. The event can lead to fuel cladding failure, which results in an increase of activity in the coolant. The rapid expansion of coolant in the core combined with decreased heat transfer in the steam generator causes the reactor coolant system pressure to increase dramatically.

Cool down of the plant by steaming off the steam generators provides a pathway for the release of radioactivity to the environment. In addition, primary side activity, carried over due to leakage in the steam generators, mixes in the secondary side and becomes available for release. The primary side coolant activity inventory increases due to the postulated failure of some of the fuel cladding with the consequential release of the gap fission product inventory to the coolant. The significant releases from this event are the iodines, alkali metals, and noble gases. No fuel melting occurs. Analysis of the dose consequences presumes:

- Duration of accident – 1.5 hrs
- Steam released – 6.48E+05 lbm
- Primary/secondary side coolant masses – 3.7E+05 lbm/6.06E+05 lbm
- Primary to secondary leak rate – 350 lbm/hr
- Steam generator initial iodine and alkali metal activities – 10 percent of design basis reactor coolant concentrations at maximum equilibrium conditions
- Reactor coolant alkali activity – 0.25 percent design basis fuel defect inventory
- Reactor coolant noble gas activity – limit of 280 Ci/g dose equivalent Xe-133

- Preexisting iodine spike – reactor coolant at 60 Ci/g dose equivalent Iodine-131
- Fission product gap activity fractions – Regulatory Guide 1.183, regulatory position C.3.2
- Fraction of fuel gap activity released – 0.16
- Partition coefficients in steam generators - 0.01 for iodines and alkali metals
- Fuel damage - none

The preexisting iodine spike has little impact since the gap activity released to the primary side becomes the dominant mechanism with respect to off-site dose contributions. The activities released to the environment are shown in Table 7.1-10.

The vendor calculated the time-dependant off-site doses for a representative site. The doses were reevaluated using the EGC ESP Facility short-term accident dispersion characteristics in Table 2.3-52 of the SSAR. The TEDE doses for the locked rotor accident are shown in Table 7.1-11. The doses at the EAB and LPZ are a small fraction of the TEDE identified in 10 CFR 50.34.

7.1.4.4 Control Rod Ejection (AP1000)

This AP1000 accident is postulated as the gross failure of one control rod mechanism pressure housing resulting in ejection of the control rod cluster assembly and drive shaft. The failure leads to a rapid positive reactivity insertion, potentially leading to localized fuel rod damage and significant releases of radioactivity to the reactor coolant.

Two activity release paths contribute to this event. First, the equilibrium activity in the reactor coolant and the activity from the damaged fuel are blown down through the failed pressure housing to the containment atmosphere. The activity can leak to the environment over a relatively long period due to the containment's design basis leakage. Decay of radioactivity occurs during hold-up inside containment prior to release to the environs.

The second release path is from the release of steam from the steam generators following the reactor trip. With a coincident loss of off-site power, additional steam must be released in order to cool down the reactor. The steam generator activity consists of the secondary side equilibrium inventory plus the additional contributions from reactor coolant leaks in the steam generators. The reactor coolant activity levels are increased for this accident since the activity released from the damaged fuel mixes into the coolant prior to being leaked to the steam generators. The iodines, alkali metals, and noble gases are the significant activity sources for this event. Noble gases entering the secondary side are quickly released to the atmosphere via the steam releases through the atmospheric relief valves. A small fraction of the iodines and alkali metals in the flashed part of the leak flow are available for immediate release without benefit of partitioning. The unlashed portion mixes with secondary side fluids where partitioning occurs prior to the release as steam.

The dose consequences analyses are performed using guidance in Regulatory Guides 1.77 and 1.183 (USAEC, 1974 and USNRC, 2000). Salient features of the analysis of activity releases include:

- Duration of accident – 30 days

- Steam released - 1.08E+05 lbm
- Secondary side coolant mass – 6.06E+05 lbm
- Primary to secondary leak rate – 350 lbm/hr
- Containment leak rate – 0.1 percent per day
- Steam generator initial iodine and alkali metal activities – 10 percent of design basis reactor coolant concentrations at maximum equilibrium conditions
- Reactor coolant alkali metal activity – 0.25 percent design basis fuel defect inventory
- Reactor coolant noble gas activity – limit of 280 Ci/g dose equivalent Xe-133
- Preexisting iodine spike – reactor coolant at 60 Ci/g dose equivalent Iodine-131
- Fraction of rods with cladding failures – 0.10
- Fission product gap activity fractions:
  - Iodines – 0.10
  - Noble gases – 0.10
  - Alkali metals – 0.12
- Fraction of fuel melting – 0.0025
- Fraction of activity released from melted fuel:
  - Iodines – 0.5
  - Noble gases – 1.0
- Iodine chemical form – per Regulatory Guide 1.183 position C.3.5
- Containment atmosphere activity removal rates – 1.7/hr for elemental iodines, and 0.1/hr for particulate iodines and alkali metals
- Partition coefficients in steam generators - 0.01 for iodines and 0.001 for alkali metals

The preexisting iodine spike has little impact since the gap activity released from the failed cladding and melted fuel become the dominant mechanisms contributing to the radioactivity released from the plant. The activities released to the environment for the 30-day accident duration are shown in Table 7.1-12.

The vendor calculated the time-dependent off-site doses for a representative site. The doses were reevaluated using the EGC ESP Site short-term accident dispersion characteristics in Table 2.3-52 of the SSAR. The doses at the EAB and LPZ shown in Table 7.1-13 are well within the 25-rem TEDE identified in 10 CFR 50.34.

7.1.4.5 Rod Drop Accident (ABWR)

The design of the ABWR fine motion control rod drive system has several new unique features compared with BWR locking piston control rod drives. The new design precludes the occurrence of rod drop accidents in the ABWR. No radiological consequence analysis is required.

7.1.4.6 Steam Generator Tube Rupture (AP1000)

The AP1000 steam generator tube rupture accident assumes the complete severance of one steam generator tube. The accident causes an increase in the secondary side activity due to reactor coolant flow through the ruptured tube. With the loss of off-site power, contaminated steam is released from the secondary system due to the turbine trip and dumping of steam via the atmospheric relief valves. Steam dump (and retention of activity) to the condenser is precluded due to the assumption of loss of off-site power. The release of radioactivity depends on the primary to secondary leakage rate, the flow to the faulted steam generator from the ruptured tube, the percentage of defective fuel in the core, and the duration/amount of steam released from the steam generators.

The radioiodines, alkali metals, and noble gases are the significant nuclide groups released during a steam generator tube rupture accident. Multiple release pathways are analyzed for the tube rupture accident. The noble gases in the reactor coolant enter the ruptured steam generator and are available for immediate release to the environment. In the intact loop, iodines and alkali metals leaked to the secondary side during the accident are partitioned as the intact steam generator is steamed down until switchover to the residual heat removal system occurs. In the ruptured steam generator, some of the reactor coolant flowing through the tube break flashes to steam while the unflashed portion mixes with the secondary side inventory. Iodines and alkali metals in the flashed fluid are not partitioned during steam releases while activity in the secondary side of the faulted generator is partitioned prior to release as steam. The following assumptions have been used:

- Duration of accident – 24 hrs
- Total flow through ruptured tube – 3.85E+05 lbm
- Steam release from faulted steam generator – 3.32E+0+5 lbm
- Steam released from intact steam generator – 1.42E+06 lbm
- Steam release duration – 13.2 hrs
- Primary/secondary side initial coolant masses – 3.8E+05 lbm/3.7E+05 lbm
- Primary to secondary leak rate – 175 lbm/hr in the intact steam generator
- Reactor coolant noble gas activity – limit of 280 □Ci/g dose equivalent Xe-133
- Reactor coolant alkali activity – 0.25 percent design basis fuel defect inventory
- Steam generator initial iodine and alkali metal activities – 10 percent of design basis reactor coolant concentrations at maximum equilibrium conditions
- Preexisting iodine spike – reactor coolant at 60 □Ci/g dose equivalent Iodine-131
- Accident initiated iodine spike – 335 times the fuel release rate that occurs when the reactor coolant equilibrium activity is 1.0 □Ci/g dose equivalent Iodine-131
- Partition coefficients in steam generators – 0.01 for iodines and alkali metals
- Off-site power and condenser – lost on reactor trip

- Fuel damage - none

The activities released to the environment for the accident-initiated and preexisting iodine spike cases are shown in Tables 7.1-14 and 7.1-15, respectively.

The vendor calculated the time-dependent off-site doses for a representative site. The doses were reevaluated using the EGC ESP Site short-term accident dispersion characteristics in Table 2.3-52 of the SSAR. The TEDE doses for the steam generator tube rupture accident with the accident-initiated iodine spike are shown in Table 7.1-16. The preexisting iodine spike doses are shown in Table 7.1-17. The doses at the EAB and LPZ are a small fraction of the 25-rem TEDE identified in 10 CFR 50.34.

7.1.4.7 Failure of Small Lines Carrying Primary Coolant Outside of Containment (AP1000)

Small lines carrying reactor coolant outside the AP1000 containment include the reactor coolant system sample line and the chemical and volume control system discharge line to the radwaste system. These lines are not continuously used. The failure of the discharge line is neither significant nor analyzed. The flow (about 100 gpm) leaving containment is cooled below 140°F and has been cleaned by the mixed bed demineralizer. The reduced iodine concentration, low flow, and temperature make this break non-limiting with respect to off-site dose consequences.

The reactor coolant system sample line break is the more limiting break. This line is postulated to break between the outboard isolation valve and the reactor coolant sample panel. Off-site doses are based on a break flow limited to 130 gpm by flow restrictors with isolation occurring at 30 minutes.

Radioiodines and noble gases are the only significant activities released. The source term is based on an accident initiated iodine spike that increases the iodine release rate from the fuel by a factor of 500 throughout the event. The activity is assumed to be released to the environment without decay or hold-up in the auxiliary building. Conditions used to determine activity releases include:

- Duration of accident – 0.5 hrs
- Break flow rate – 130 gpm
- Reactor coolant noble gas activity – limit of 280 Ci/g dose equivalent Xe-133
- Reactor coolant equilibrium iodine activity - 1.0 Ci/g dose equivalent Iodine-131
- Accident initiated iodine spike – 500 times the fuel release rate that occurs when the reactor coolant equilibrium activity is 1.0 Ci/g dose equivalent Iodine-131
- Fuel damage - none

The activities released are shown in Table 7.1-18.

Based on the vendor calculated off-site doses for a representative site, the time-dependent doses were reevaluated using the EGC ESP Site short-term accident meteorology in Table 2.3-52 of the SSAR. The results are shown in Table 7.1-19. The resulting doses at the EAB and LPZ are a small fraction of the 25-rem TEDE in 10 CFR 50.34.

7.1.4.8 Failure of Small Lines Carrying Primary Coolant Outside of Containment (ABWR)

This event consists of a small steam or liquid line break inside or outside the ABWR primary containment. The bounding event analyzed is a small instrument line break in the reactor building. The break is assumed to proceed for ten minutes before the operator takes steps to isolate the break, SCRAM the reactor, and reduce reactor pressure.

The iodine in the flashed water is assumed to be transported to the environs by the heating, ventilation and air conditioning (HVAC) system without credit for treatment by the standby gas treatment system. The other activities in the reactor water make only small contributions to the off-site dose and are neglected. The activity release assumes:

- Duration of the accident – 8 hrs
- Standby gas treatment system – not credited
- Reactor building release rate – 200 percent/hr
- Mass of reactor coolant released – 13,610 kilograms
- Mass of fluid flashed to steam – 2,270 kilograms
- Iodine plateout fraction – 0.5
- Reactor coolant equilibrium activity – maximum permitted by technical specifications corresponding to an offgas release rate of 100,000 μCi/s referenced to a 30-minute decay.
- Iodine spiking – accident initiated spike
- Fuel damage – none

The activity released to the environs is shown in Table 7.1-20. The calculated EAB and LPZ doses are shown in Table 7.1-21. The doses are a small fraction of the 25-rem TEDE limit in 10 CFR 50.34.

7.1.4.9 Large Break Loss of Coolant Accident (AP1000)

The core response analysis for the AP1000 demonstrates that the reactor core maintains its integrity for the large break LOCA. However, significant core degradation and melting is assumed in this DBA. The assumption of major core damage is intended to challenge various accident mitigation features and provide a conservative basis for calculating site radiological consequences. The source term used in the analysis is adopted from NUREG-1465 and Regulatory Guide 1.183 with the nuclide inventory determined for a three-region equilibrium cycle core at end of life (USNRC, 1995; USNRC, 2000; and Westinghouse, 2002).

The activity released consists of the equilibrium activity in the reactor coolant and the activity released from the damaged core. The AP1000 is a leak before break design; therefore, the coolant is assumed to blow down to the containment for 10 minutes. One-half of the iodine and the noble gases in the blowdown stream are released to the containment atmosphere.

The core release starts after the 10-minute blowdown of reactor coolant. The fuel rod gap activity is released over the next half hour followed by an in-vessel core melt that lasts 1.3

hrs. Iodines, alkali metals, and noble gases are released during the gap activity release. During the core melt phase, five additional nuclide groups are released including the tellurium group, the noble metals group, the cerium group, and the barium and strontium group.

Activity is released from the containment via the containment purge line at the beginning of the accident. After isolation of the purge line, activity continues to leak from the containment at its design basis leak rate. There is no emergency core cooling leakage activity because the passive core cooling system does not pass coolant outside of the containment. A coincidental loss of off-site power has no impact on the activity release to the environment because of the passive designs for the core cooling and fission product control systems. Important bases for determining activity releases and off-site doses include:

- Duration of accident – 30 days
- Reactor coolant noble gas activity – limit of 280 Ci/g dose equivalent Xe-133
- Reactor coolant equilibrium iodine activity – 1.0 Ci/g dose equivalent Iodine-131
- Reactor coolant mass – 3.7E+05 lbm
- Containment purge flow rate – 8,800 cfm for 30 seconds
- Containment leak rate – 0.1 percent per day
- Core activity group release fractions – Regulatory Guide 1.183, regulatory position C.3.2
- Iodine chemical form – Regulatory Guide 1.183, regulatory position C.3.5
- Containment airborne elemental iodine removal rate – 1.7/hr until decontamination factor (DF) of 200 is reached
- Containment atmosphere particulate removal rate – 0.43/hr to 0.7/hr during first 24 hrs

Table 7.1-22 gives the activities released to the environment for the AP1000 large break LOCA.

Based on the vendor calculated off-site doses for a representative site, the time-dependent doses were reevaluated using the EGC ESP Site short-term accident meteorology in Table 2.3-52 of the SSAR. Table 7.1-23 provides the EAB and LPZ doses. Both doses meet the dose guideline of 25-rem TEDE in 10 CFR 50.34. The activity released from the core melt phase of the accident is the greatest contributor to the off-site doses. The EAB dose in Table 7.1-23 is given for the two-hour period, during which, the dose is greatest at this location. The initial two hours of the accident is not the worst two-hour period because of the delays associated with cladding failure and fuel damage.

7.1.4.10 Large Break Loss of Coolant Accident (ABWR)

This ABWR event postulates piping breaks inside containment of varying sizes, types, and locations. The break type includes steam and liquid process lines. The emergency core cooling analyses show that the core temperature and pressure transients caused by the breaks are insufficient to cause fuel cladding perforation. Although no fuel damage occurs,

conservative assumptions from Regulatory Guide 1.3 (USAEC, 1974a) are invoked in order to conservatively assess postaccident fission product mitigation systems and the resultant off-site doses.

One hundred percent of the core-inventory noble gases and 50 percent of the iodines are instantaneously released from the reactor to the drywell at the beginning of the accident. Of the iodines, 50 percent are assumed to immediately plateout, which leaves 25 percent of the inventory airborne and available for release. Following the break and depressurization of the reactor, some of the noncondensable fission products are purged into the suppression pool. The suppression pool is capable of retaining iodine, thereby, reducing the overall concentration in the primary containment atmosphere.

Postaccident fission products are released from the primary containment via two principal pathways including leakage to the reactor building and leakage along the main steam lines. The leakage to the reactor building is due to the containment penetrations and emergency core cooling equipment leaks. The iodine activity in the reactor building is filtered through the standby gas treatment system prior to release to the environment. The gas treatment system is started and begins removing iodine from the reactor building atmosphere 20 minutes after start of the accident. The main steam line leakage is due to leaks past the main steam line isolation valves that close automatically at the beginning of the accident. The primary leakage path is through the drain lines downstream of the outboard isolation valves to the main condenser. A secondary pathway is through the main steam lines to the turbine. Activity reaching the main condenser and the turbine is held up before leaking from the turbine building to the environment. Iodine plateout occurs in the turbine, main condenser, and the steam/drain lines. Key features of the analysis of activity released include:

- Duration – 30 days
- Core power level – 4,005 MWt
- Fraction of noble iodine and noble gases released – Regulatory Guide 1.3, regulatory positions C.1.a and C.1.b
- Iodine chemical form – Regulatory Guide 1.3, regulatory position C.1.a
- Suppression pool iodine decontamination factor – 2.0 for particulate and elemental iodine (includes allowance for suppression pool bypass)
- Primary containment leakage – 0.5 percent/day
- Main steam isolation valve total leakage – 66.1 liters/minute
- Condenser leakage rate – 11.6 percent/day
- Condenser iodine removal:
  - Elemental and particulate iodine – 99.7 percent
  - Organic iodine – 0.0 percent
- Delay to achieve design negative pressure in reactor building – 20 minutes

- Reactor building leak rate during draw down – 150 percent/hr
- Standby gas system filtration – 97 percent efficiency
- Standby gas system exhaust rate – 50 percent/day

The activities released from the reactor and turbine buildings are given in Table 7.1-24. The doses at the EAB and LPZ are summarized in Table 7.1-25. The doses are within the 25-rem TEDE guidelines of 10 CFR 50.34.

7.1.4.11 Large Break Loss of Coolant Accident (ESBWR)

This ESBWR event postulates piping breaks inside containment of varying sizes, types and locations. The break type includes steam and liquid process lines. The emergency core cooling analyses show that the core temperature and pressure transients caused by the breaks are insufficient to cause fuel cladding perforation. Although no fuel damage occurs, conservative assumptions from Regulatory Guide 1.183 are invoked in order to conservatively assess postaccident fission product mitigation systems and the resultant off-site doses.

One hundred percent of the core-inventory noble gases, 30 percent of the iodines, 25 percent of the core cesium, and minor fractions (less than 1 percent) of the remaining core inventory are released from the reactor to the drywell over a 2-hour period at the beginning of the accident. The natural deposition of iodine within the drywell is credited in the analysis for the first day of the event. Following the break and depressurization of the reactor, some of the non-condensable fission products are removed by condensation within the Passive Containment Cooling System (PCCS). The PCCS is capable of retaining iodine thereby reducing the overall concentration in the primary containment atmosphere.

Postaccident fission products are released from the primary containment via two principal pathways: primary containment leakage and leakage of contaminated steam past the main steam isolation valves. The leakage to the reactor building is due to the containment penetrations. This leakage is distributed between the reactor building (50 percent), the external events shield building (45 percent), and a small fraction is released directly to the environment (5 percent). No credit is taken for any charcoal filtration systems for these paths. The main steam line leakage is due to leaks past the main steam line isolation valves, which close automatically at the beginning of the accident. The primary leakage path is through the drain lines downstream of the outboard isolation valves to the main condenser. A secondary pathway is through the main steam lines to the turbine. Activity reaching the main condenser and the turbine is held up before leaking from the turbine building to the environment. Key features of the analysis of activity released include:

- Duration – 30 days
- Core power level – 4,000 MWt
- Fraction of iodine, noble gases, and other core isotopes released – Regulatory Guide 1.183, regulatory position 3.2
- Iodine chemical form – Regulatory Guide 1.183, Appendix A, regulatory position 2

- Passive Containment Cooling System Decontamination Factor – 1.5 for particulate and elemental iodine
- Primary containment leakage – 0.5 percent/day
- Main steam isolation valve total leakage – 150 cfh
- Condenser leakage rate – 12.0 percent/day

The activities released to the environment are given in Table 7.1-26. The doses at the EAB and LPZ are summarized in Table 7.1-27. The doses are within the 25-rem TEDE guidelines of 10 CFR 50.34.

7.1.4.12 Large Break Loss of Coolant Accident (ACR-700)

The limiting design basis event for the ACR-700 is a large LOCA with coincident loss of emergency core cooling. In this accident, the heat transport system coolant is discharged into containment via the break. Without emergency core cooling injection, the fuel bundles start to heat up, which causes the pressure tube to sag and contact the calandria tube. With contact between the pressure tube and calandria, heat is transferred from the fuel channel to the moderator. In this severe accident, the heavy water in the moderator acts as the heat sink and the heat is transferred to the service water. The integrity of the pressure tube, calandria tube, and the heat transfer system core cooling geometry are maintained.

The ACR-700 source term consists of 100 percent of the core-inventory noble gases and 50 percent of the iodines. These quantities are released from the fuel at the beginning of the accident. Ninety-five percent of the iodine enters containment as CsI and dissolves as non-volatile iodine in water. The remaining 5 percent of the iodine is released inside containment as volatile elemental and organic iodines. Under the oxidizing and high radiation environment following an accident, some non-volatile iodide in water would react and become volatile and partition into the gas phase. Elemental iodine, however, is rapidly removed by adsorption on surfaces inside containment. A net reduction factor of 14 is applied to the elemental iodine based on analysis of the re-evolution and removal mechanisms during the accident.

The ECC pumps and valves, which operate during the accident, are located in the long term cooling rooms outside the reactor containment building. The rooms have a sump to collect ECC leakage and a pump to return the radioactive fluids to the reactor building. Although the rooms' ventilation systems are isolated following a LOCA signal, it is possible that iodine flashed from the ECC leakage can leak past the ventilation dampers to the environment.

The contribution from ECC leakage outside the containment is analyzed assuming 50 percent of the core iodine inventory (as elemental iodine) is uniformly distributed in the containment sump water during recirculation. ECC leakage at greater than design conditions is assumed to occur for the duration of the postaccident period. In addition, a passive component failure (such as an ECC pump seal or valve packing) is assumed to occur 24 hours after start of the LOCA.

The dose contribution from containment bypass following a LOCA is small and may be neglected. Activity can be released from the steam generator main steam relief valves in a

crash cool down of the plant during a LOCA. Even under conditions of chronic steam generator tube leakage during the LOCA, the contribution is several orders of magnitude less than the LOCA leakage contribution, and hence is neglected. Containment bypass due to operation of the containment ventilation system is not considered credible. Two independent means of rapidly isolating containment ventilation lines are provided for in the ACR generic design. This dual failure consideration offers a very high reliability of containment isolation and reduces this potential impairment mechanism.

The containment isolation systems are credited with isolating fluid systems that are not required to operate during the accident. The design basis includes a double barrier at the containment penetration with automatic closure of redundant valves. The normally sub-atmospheric containment isolates on a high-pressure signal (approximately ½ psig) during the accident, effectively promoting isolation prior to fission product release.

Features of the analysis of radioactivity released to the environment include:

- Duration – 30 days
- Core power level – 2059 MWt
- Core noble gas and iodine release fractions to containment – similar to TID-14844
- Iodine chemical form – similar to Regulatory Guide 1.183, regulatory position C.3.5
- Containment leak rate – 0.5 percent per day for 24 hours; 0.25 percent thereafter
- Containment isolation – within 5 seconds after large LOCA
- Onset of fission product release from core – after containment isolation
- Iodine removal – factor of 14 removal for elemental iodines
- Containment dousing spray – not credited
- Containment ventilation filtration – not credited
- Sump water volume during recirculation – greater than 1000 m^3
- ECC leakage – 1 gal/hour based on Regulatory Guide 1.183, Appendix A, paragraph 5.2
- ECC passive failure – 50 gpm for 30 minutes at 24 hours
- Flashing fraction – 0.1 based on Regulatory Guide 1.183, Appendix A, paragraph 5.5
- ECC iodine chemical form – consistent with Regulatory Guide 1.183, Appendix A, paragraph 5.6
- ECC pump room isolation and hold-up – not credited

The activity released during the large LOCA is shown in Table 7.1-28. The resulting doses at the EGC ESP Site EAB and LPZ are summarized in Table 7.1-29. The EAB and LPZ doses are within the 25-rem TEDE guidelines in 10 CFR 50.34.

7.1.4.13 Fuel Handling Accidents (AP1000)

The AP1000 fuel handling accident (FHA) can occur inside containment or in the fuel handling area of the auxiliary building. The accident postulates the dropping of a fuel assembly over the core or in the spent fuel pool. The cladding of the fuel rods is assumed breached and the fission products in the fuel rod gaps are released to the reactor refueling cavity water or spent fuel pool. There are numerous design or safety features to prevent this accident. For example, only one fuel assembly is lifted and transported at a time. Fuel racks are located to prevent missiles from reaching the stored fuel. Fuel handling equipment is designed to prevent it from falling on to the fuel, and heavy objects cannot be carried over the spent fuel.

Spent fuel-handling operations are performed under water. Fission gases released from damaged fuel bubble up through the water and escape above the refueling cavity water or the spent fuel pool surfaces. For FHAs inside containment, the release to the environment can be mitigated by automatically closing the containment purge lines after detection of radioactivity in the containment atmosphere. For accidents in the spent fuel pool, activity is released through the auxiliary building ventilation system to the environment.

The refueling and fuel transfer systems are designed such that the damaged fuel has a minimum depth of 23 ft of water over the fuel. This depth of water provides for effective scrubbing of elemental iodine released from the fuel. Organic iodine and noble gases are not scrubbed and escape.

The off-site doses are analyzed by only crediting the scrubbing of iodine by the refueling water. Hence, fuel handling accidents inside containment and the auxiliary building are treated in the same manner. Cesium iodide, which accounts for about 95 percent of the gap iodine, is nonvolatile and does not readily become airborne after dissolving. This species is assumed to completely dissociate and reevolve as elemental iodine immediately after damage to the fuel assembly. The dose activity released presumes:

- Core thermal power – 3,468 MWt
- Decay time after shutdown – 100 hrs
- Activity release period – 2 hrs
- One of 157 fuel assemblies in the core is completely damaged
- Maximum rod radial peaking factor – 1.65
- Iodine and noble gas fission product gap fractions - Regulatory Guide 1.183, regulatory position C.3.2 (USNRC, 2000)
- Iodine chemical form – Regulatory Guide 1.183, regulatory position C.3.5
- Pool decontamination for iodine – Regulatory Guide 1.183, Appendix B
- Filtration – none

The radioactivity released to the environment is given in Table 7.1-30.

The resulting doses at the EAB and LPZ are summarized in Table 7.1-31. The doses are applicable to fuel handling accidents inside containment and in the spent fuel pool in the auxiliary building (10 CFR 50). The EAB and LPZ doses are well within the 25-rem TEDE guidelines in 10 CFR 50.34. "Well within" is taken as being within 25 percent of the guideline limit consistent with the guidance in Regulatory Guide 1.183 and NUREG-0800, Standard Review Plan (USNRC, 2000 and 1987).

7.1.4.14 Fuel Handling Accidents (ABWR)

The ABWR fuel handling accident is postulated as the failure of the fuel assembly lifting mechanism resulting in the dropping of a fuel assembly on to the reactor core. Fuel rods in the dropped and struck assemblies are damaged releasing radioactive gases to the pool water.

The activity released in the pool water bubbles to the surface and passes to the reactor building atmosphere. The normal ventilation system is isolated, the standby gas treatment system started, and effluents are released to the environment through this system. The gas treatment system is credited with maintaining the reactor building at a negative pressure after 20 minutes. Pool water is credited with removal of elemental iodine released from the failed rods. Guidance from Regulatory Guide 1.25 is used in performance of the analysis. Key aspects include:

- Core thermal power – 4,005 MWt
- Decay time after shutdown – 24 hrs
- Activity release period from pool – 2 hrs
- Total number of fuel rods damaged – 115 in dropped and struck assemblies
- Radial peaking factor – 1.5
- Iodine and noble gas fission product gap fractions - Regulatory Guide 1.25, regulatory position C.1.d
- Iodine chemical form – Regulatory Guide 1.25, regulatory position C.1.e
- Pool decontamination for iodine – Regulatory Guide 1.25, regulatory position C.1.f
- Delay to achieve design negative pressure in reactor building – 20 minutes
- Reactor building leak rate during draw down – 150 percent/hr
- Standby gas system filtration – 99 percent efficiency
- Standby gas system exhaust rate – 50 percent/day

The radioactivity released to the environment is provided in Table 7.1-32.

The doses at the site EAB and LPZ are summarized in Table 7.1-33. Activity remaining in the reactor building after two hours is assumed filtered and released without benefit of decay over the next six hours to determine the LPZ dose. Although assumptions in Regulatory Guide 1.25 are used, the off-site dose conversions are made using the guidance

in Regulatory Guide 1.183 (USAEC, 1972 and USNRC, 2000). The EAB and LPZ doses are shown to be well within the 25-rem TEDE guidelines of 10 CFR 50.34.

7.2 Severe Accidents

This section discusses the probabilities and consequences of accidents of greater severity than the design basis accidents. As a class, they are considered less likely to occur, but because their consequences could be more severe, they are considered important both in terms of impact to the environment and off-site costs. These severe accidents, can be distinguished from design basis accidents in two primary respects: (1) they involve substantial physical deterioration of the fuel in the reactor core, including overheating to the point of melting, and (2) they involve deterioration of the capability of the containment system to perform its intended function of limiting the release of radioactive materials to the environment. In NUREG-1437, the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* [GEIS], the USNRC generically assessed the impacts of severe accidents during license renewal periods, using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the renewal period (USNRC, 1996). This methodology is used as a basis for evaluating the severe accident environmental impacts of a new nuclear power plant that may be built on the EGC ESP Site.

7.2.1 Applicability of Existing Generic Severe Accident Studies

Section 5.3.3 of NUREG-1437 presents a thorough assessment of impacts of severe accidents during the license renewal period by the USNRC staff. Methodologies therein were developed to evaluate each of the dose pathways by which a severe accident may result in adverse environmental impacts and to estimate off-site costs of severe accidents. This assessment methodology and the resulting conclusions are considered, for reasons discussed below, broadly applicable beyond the license renewal context, including evaluation of severe accident impacts associated with determining site suitability for a nuclear power plant. The three NUREG-1437 pathways for release of radioactive material to the environment from severe accidents, i.e., atmospheric, air to surface water, and groundwater to surface water, are discussed in this section. The economic impacts from severe accidents are also comparatively evaluated in this section.

The GEIS evaluations and conclusions are based on existing assessments of severe accident impacts presented in numerous Final Environmental Statements (FES) published after 1980 and for a representative set of U.S. plants and sites in NUREG-1150. The GEIS results are expressed as a range of values in terms of risk of severe accident impact per reactor-year of operation. The USNRC later confirmed, in 61 FR 28480, that "the analyses performed for the GEIS represent adequate, plant-specific estimates of the impacts from severe accidents…" (USNRC, 1996a).

As described in the GEIS, the purpose of the evaluation of severe accidents was "to use, to the extent possible, the available severe accident results, in conjunction with those factors that are important to risk and that change with time to estimate the consequences of nuclear plant accidents for all plants for a time period that exceeds the time frame of existing analyses." This estimation process was completed by predicting increases or decreases in consequences as the plant lifetime was extended past the normal license period by considering the projected changes in the risk factors. The primary assumption in this analysis was that regulatory controls ensure that the physical plant condition (i.e., the

predicted probability of and radioactive releases from an accident) is maintained at a constant level during the renewal period; therefore, the frequency and magnitude of a release remains relatively constant. In other words, significant changes in consequences would result only from changes in the plant's external environment. The logical approach, then, would be to incorporate the most significant environmental factors into calculations of consequences for subsequent correlation with existing analyses (which use the consequence computer codes).

The staff concluded in NUREG-1437 that the primary factors affecting risk are the site population (which reflects the number of people potentially at risk to severe accident exposure) and wind direction (which reflects the likelihood of exposure). Secondary factors, such as terrain, rainfall, and wind stability, also have some effect on risk, but their impact was judged to be much smaller than the effects of population and wind direction. These factors were included in the FES analyses whose results are the bases for the GEIS analyses. Consequently, their effects are indirectly considered in the prediction of future risks and are reflected within the uncertainty bounds generated by the regression of the FES risk values. To ensure that the existing FES analyses covered a range of secondary factors representative of the total population of plants, the more significant secondary factors were also examined in the GEIS. Variations in these factors (precipitation, 50-mi population, 0-mi population in the direction of highest wind frequency, general terrain and emergency planning) were found to be enveloped by the FES analyses and thus reasonably accounted for in the GEIS evaluation of severe accidents.

Detailed severe accident consequence (early and latent fatalities and total dose) evaluations were not available for all plants considered in the GEIS. Therefore, a predictor for these consequences was developed using correlations based upon the calculated results from the existing FES severe accident analyses. This predictor was then used to infer the future consequence level of all individual nuclear plants. Correlations were developed using two environmental parameters that are available for all plants. This correlation process was well described in NUREG-1437.

While the NUREG-1437 discussions dealt with the environmental impacts of accidents during operation after license renewal. The primary assumption for this evaluation was that the frequency (or likelihood of occurrence) of an accident at a given plant would not increase during the plant lifetime (inclusive of the license renewal period) because regulatory controls ensure the plant's licensing basis is maintained and improved, where warranted. The GEIS use of severe accident risk per reactor-year of operation as the principal metric for evaluating severe accident environmental impacts and the assumption that this risk remains constant over the life of the plant are equally applicable and appropriate in both the license renewal and ESP/COL context. Therefore, the thorough generic analysis of severe accident impacts presented in the GEIS also provides an appropriate basis and method for evaluating severe accident impacts for early site permitting.

However, it was recognized that the changing environment around the plant is not subject to regulatory controls and introduces the potential for changing risk. Thus, the site-specific environmental considerations, i.e., population and meteorology, were evaluated in the GEIS and are considered in the following sections.

Specifically, the following evaluation of the significant factors associated with the environment shows these factors for the EGC ESP Site are not substantially different from those factors identified for previously analyzed sites. Thus, it follows that the environmental impacts for the EGC ESP Site will not be substantially different from the acceptable environmental impacts identified for the previously analyzed sites.

7.2.2 Evaluation of Potential Severe Accident Releases

EGC has identified the significance of the impacts associated with each issue as either Small, Moderate, or Large, consistent with the criteria that USNRC established in 10 CFR 51, Appendix B, Table B-1, Footnote 3 as follows:

- SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small.
- MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource.
- LARGE - Environmental effects are clearly noticeable and are sufficient to destabilize any important attributes of the resource.

In accordance with National Environmental Policy Act practice, EGC considered ongoing and potential additional mitigation in proportion to the significance of the impact to be addressed (i.e., impacts that are small receive less mitigative consideration than impacts that are large).

7.2.2.1 Evaluation of Potential Releases via Atmospheric Pathway

The site-specific significant factors of demography and meteorology are considered in the evaluation of the atmospheric exposure pathway for the EGC ESP Site. For this evaluation, NUREG-1437 calculates an exposure index (EI) for use in comparing the relative risk for the current fleet of nuclear power plants.

NUREG-1437 provides the following discussion of EI:

> *"Population, which changes over time, defines the number of people within a given distance from the plant. Wind direction, which is assumed not to change from year to year, helps determine what proportion of the population is at risk in a given direction, because radionuclides are carried by the wind. Therefore, an EI relationship was developed by multiplying the wind direction frequency (fraction of the time per year) for each of 16 (22.5°) compass sectors times the population in that sector for a given distance from the plant and summing all products.…Population varies with population growth and movement, and with the distance from any given plant. As the population changes for that plant, the EI also changes (the larger the EI, the larger the number of people at risk). Thus, EI is proportional to risk and an EI for a site for a future year can be used to predict the risk to the population around that site in that future year."*

Thus, the EI is a function of population surrounding the plant, weighted by the site-specific wind direction frequency, and is, therefore, a site-specific parameter. Because meteorological patterns, including wind direction frequency, tend to remain constant over

time, the site meteorology will not be significantly different for the EGC ESP Site than the meteorology considered in NUREG-1437 for the Clinton site and only population can significantly affect the resulting risk in any given year of reactor operation.

However, the 50-mi population projections for the EGC ESP Site (i.e., ~914,000) are not significantly different than for the Clinton site as projected for the year 2050 in Table 5.3 of NUREG-1437, (i.e., ~870,000). Thus, the EGC ESP Site EI will not be significantly different from those established in NUREG-1437 for the Clinton site.

Two EIs were evaluated in NUREG-1437. A 10-mi EI was found to best correlate with early fatalities, and a 150-mi EI was found to best correlate with latent fatalities and total dose. Using these indices, it was determined that the risk of early and latent fatalities from individual nuclear power plants is small and represents only a small fraction of the risk to which the public is exposed from other sources.

The 10-mi EI for the Clinton site was 760, as shown in NUREG-1437, Table 5.7, for the year 2050. The 10-mi EI range provided (in Table 5.7 of NUREG-1437) for the current generation of nuclear power plant sites has a low of 96 and a high of 18,959. Thus, the EGC ESP Site is expected to be within the range of risk calculated for the existing fleet of nuclear power plants.

The 150-mi EI for the CPS Site was 1,418,383, as shown in NUREG-1437, Table 5.8, for the year 2050. The 150-mi EI range provided (in Table 5.8 of NUREG-1437) for the current generation of nuclear power plant sites has a low of 132,195 and a high of 2,863,844. Thus, the EGC ESP Site is expected to be within the range of risk calculated for the existing fleet of nuclear power plants.

Thus, the EGC ESP Site risks for the atmospheric exposure pathway will be within the range of those considered as "Small" in NUREG-1437. Section 5.5.2.1 of NUREG-1437 indicated these predicted effects of a severe accident "are not expected to exceed a small fraction of that risk to which the population is already exposed."

7.2.2.2 Evaluation of Potential Releases via Atmospheric Fallout onto Open Bodies Of Water

This section examines such radiation exposure risk for a nuclear power reactor at the EGC ESP Site in the event of a severe reactor accident in which radioactive contaminants are released into the atmosphere and subsequently deposited onto open bodies of water. In the GEIS, the drinking water pathway was treated separately while the aquatic food, swimming, and shoreline pathways were addressed collectively. Population dose estimates for both the drinking water and aquatic food pathways were then compared with estimates from the atmospheric pathway.

As reported in NUREG-1437, analyses for both the drinking water and aquatic food pathways were performed with and without considering interdiction. In the case of the drinking-water pathway, the Great Lakes and the estuarine sites are bound by those of a previous site evaluation (i.e., Fermi); while small river sites with relatively low annual flow rates, long residence times, and large surface-area-to-volume ratios may potentially not be bound by the previous analysis. In all cases, however, interdiction can reduce relative risk to levels at or below that of the previous acceptable analysis and significantly below that for the atmospheric pathway. River sites that may have relatively high concentrations of contaminants but which remove contaminants within short periods of time (hours to several

days) are amenable to short-term interdiction. A similar level of reduced risk can be achieved at those sites with longer residence times (months) by more extensive interdictive measures.

For the aquatic food pathway, population dose and population exposure per reactor-year are directly related to aquatic food harvest. For river sites, un-interdicted population exposure is an order of magnitude lower than that for the atmospheric pathway. For Great Lakes sites, the un-interdicted population exposure is a substantial fraction of that predicted for the atmospheric pathway but is reduced significantly by interdiction. For estuarine sites with large annual aquatic food harvests, dose reduction of a factor of 2 to 10 through interdiction provides essentially the same population exposure estimates as the atmospheric pathway.

For these reasons, population dose for the drinking-water pathway was found to be a small fraction of that for the atmospheric pathway. Risk associated with the aquatic food pathway was found to be small relative to the atmospheric pathway for most sites and essentially the same as the atmospheric pathway for the few sites with large annual aquatic food harvests.

Environmental parameters important for input in performing the above analyses, and for use in analyses of additional sites, are (1) the surface area of the receiving body, (2) the volume of water in the body, and (3) the flow rate. In the absence of rigorous site-specific analyses, these data can provide estimates of the extent of contamination in the receiving water body and the residence time of the contaminant in the affected water body. Comparing these estimates and site environmental parameters with those for the previously evaluated site, i.e., Fermi, can provide some indication of the comparative hazard associated with drinking contaminated surface water among sites and the need for site-specific analyses. Accounting for population and meteorological data in the comparison can provide further indication of relative risk among sites.

The above-identified environmental parameters have been identified in the GEIS for the Clinton site. These same parameters are applicable for the EGC ESP Site (since these environmental parameters are generally constant for a given site and no major changes have been identified that would impact these parameters), thus, the drinking-water pathway and the aquatic food, swimming, and shoreline pathways for the EGC ESP Site are comparable to those considered in the GEIS evaluation. Therefore, the risk from the air fallout to a water body exposure pathway generally compares favorably with the risk to the population from atmospheric releases and the EGC ESP Site risks for the water body exposure pathway will also be within the range of those considered as “Small” in NUREG-1437.

7.2.2.3 Evaluation of Potential Releases to Groundwater

This section discusses the potential for radiation exposure from the groundwater pathway as the result of postulated severe accidents at a nuclear reactor on the EGC ESP Site. Severe accidents are the only accidents capable of producing significant groundwater contamination.

As identified in NUREG-1437, groundwater contamination due to severe accidents has been evaluated generically in NUREG-0440, Liquid Pathway Generic Study (LPGS) (USNRC, 1978). The LPGS assumes that core melt with subsequent basemat melt-through occurs, and evaluates the consequences. The LPGS examines six generic sites using typical or comparative assumptions on geology, adsorption factors, etc.

Per NUREG-1437, the LPGS results are believed to provide generally conservative uninterdicted population dose estimates in the six generic plant-site categories. Five of these categories are site groupings in common locations adjacent to small rivers, large rivers, the Great Lakes, oceans, and estuaries. In a severe accident, contaminated groundwater could reach nearby surface water bodies, and the population could be exposed to this source of contamination through drinking of surface water, ingestion of finfish and shellfish, and shoreline contact. Exposure by drinking contaminated groundwater is considered to be minor or nonexistent in these five categories because of a limited number of drinking-water wells. The sixth category is a "dry" site located either at a considerable distance from surface water bodies or where groundwater flow is away from a nearby surface water body. In this case, the only population exposure results from drinking contaminated groundwater.

NUREG-1437 concludes that the risk from the groundwater exposure pathway generally contributes only a small fraction of that risk attributable to the population from the atmospheric pathway but in a few cases may contribute a comparable risk.

In the GEIS analysis, site-specific information on groundwater travel time; retention-adsorption coefficients; distance to surface water; and soil, sediment, and rock characteristics is compared with previous groundwater contamination analyses. Previous analyses are contained in the LPGS and site-specific FESs. These environmental parameters have been identified in the GEIS for the Clinton site. These same parameters are applicable for the EGC ESP Site (since these environmental parameters are generally constant for a given site and no major changes have been identified that would impact these parameters); thus, the groundwater pathway for the EGC ESP Site is comparable to those considered in the GEIS evaluation.Therefore, the risk from the groundwater exposure pathway generally compares favorably with the risk to the population from atmospheric releases and the EGC ESP site risks for the groundwater exposure pathway will also be within the range of those considered as "Small" in NUREG-1437.

7.2.3 Evaluation of Economic Impacts of Severe Accidents

This section discusses the potential economic impact as the result of postulated severe accidents at a nuclear reactor on the EGC ESP Site. Similar to Section 7.2.2.1, the EI is used as a predictor of cost because, as identified in the GEIS, the cost should be dependent upon the economic impact in the same way and for the same reason that population dose estimates are dependent on the EI values.

As noted in NUREG-1437, FES analyses used the "Calculation of Reactor Accident Consequences" (CRAC) computer code to calculate off-site severe accident costs for the area contaminated by the accident. The off-site costs that were considered relate to avoidance of adverse health effects and are categorized as follows:

- Evacuation costs;
- Value of crops contaminated and condemned;
- Value of milk contaminated and condemned;
- Costs of decontamination of property where practical; and

- Indirect costs resulting from the loss of use of property and incomes derived therefrom (including interdiction to prevent human injury).

For those FES analyses that addressed severe accidents, the off-site accident costs were estimated to be to be as high as 6 billion dollars to 8 billion dollars (1994 dollars) but with accident probabilities that were extremely low (1E-6 years), as would be expected for this class of events. Because key variables (used in the FES cost analyses) are strongly related to population density, NUREG-1437 further evaluated the FES results using normalization techniques and the 150-mile EI values. This evaluation, which included the Clinton site, demonstrated that the FES cost predictions remained valid, even considering population changes represented by the EI values.

In addition, the generic NUREG-1437 predicted conditional land contamination is small (10 ac/yr at most). This is also consistent with (USNRC 1975) and a 1982 study on siting criteria (USNRC, 1982) which predicts small conditional land contamination values. The GEIS concluded that land contamination values for the evaluated plants can be considered representative of all plants since they cover the major vendor and containment types and include sites at the upper end of annual rainfall. However, even considering that land contamination values can vary at other sites, it is not expected that predicted land contamination from plants at other sites would vary more than 1 or 2 orders of magnitude from the values listed above and would, therefore, still be a small impact.Based on the evaluations of the expected economic costs and land contamination as a result of a severe accident, the GEIS concludes in Section 5.5.2.4 that the conditional impacts in both cases are of small significance for all plants. As for other aspects of the GEIS evaluation of severe accident impacts, this evaluation and conclusion is broadly applicable to beyond the license renewal context. Thus the economic impacts and land contamination resulting from postulated severe accidents at a new nuclear reactor or reactors on the EGC ESP Site should be comparable as well (i.e., within the range of those considered as "Small" in NUREG-1437).

7.2.4 Consideration of Commission Severe Accident Policy

In 1985, the USNRC adopted a Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants (USNRC, 1985). This policy statement indicated:

> *"The Commission fully expects that vendors engaged in designing new standard (or custom) plants will achieve a higher standard of severe accident safety performance than their prior designs. This expectation is based on:*
>
> *The growing volume of information from industry and government-sponsored research and operating reactor experience has improved our knowledge of specific severe accident vulnerabilities and of low-cost methods for their mitigation. Further learning on safety vulnerabilities and innovative methods is to be expected.*
>
> *The inherent flexibility of this Policy Statement (that permits risk-risk tradeoffs in systems and sub-systems design) encourages thereby innovative ways of achieving an improved overall systems reliability at a reasonable cost.*
>
> *Public acceptance, and hence investor acceptance, of nuclear technology is dependent on demonstrable progress in safety performance, including the reduction in frequency of*

accident precursor events as well as a diminished controversy among experts as to the adequacy of nuclear safety technology."

Thus, implementation of the Commission's Severe Accident Policy can be expected to show that the environmental impact of any new reactor(s) on the EGC ESP Site will be within the range of risk previously determined to be "Small."

A significant factor in the risk associated with the plant design is the frequency of the considered accident sequences. As indicated above, the designs certified in accordance with 10 CFR 52 are expected to exhibit a "higher standard of severe accident safety performance than the prior designs." The ABWR is a currently certified design under 10 CFR 52, Appendix A, and is considered to be representative of advanced light water reactor standard designs. The USNRC Safety Evaluation Report (SER) for the ABWR states "the ABWR design and the submittals made for the ABWR in the SSAR meet the intent of the Commission's Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants" (USNRC, 1994). Similar findings have been made for the other currently certified designs, i.e., the System 80+ and the AP-600. Thus, the Severe Accident Policy Statement expectations have been met for each of the three advanced standard designs considered to-date by the USNRC and are expected to continue to be met for future design certifications and COL approvals.

7.2.5 Conclusion

- The GEIS concludes, based on the generic evaluations presented, that the probability-weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to ground water and societal and economic impacts from severe accidents are "Small" for all plants.
- As described above, the methodology and evaluations of the GEIS are applicable to the consideration of new plants in the ESP and/or COL context. Evaluation of site specific factors for purposes of this application have shown that the EGC ESP Site is within the range of sites considered in the GEIS. Thus we conclude that the GEIS conclusion is applicable to the EGC ESP Site.
- Use of pertinent site specific information to confirm the applicability of existing generic analyses is consistent with USNRC staff plans for addressing severe accident environmental impacts at ESP as identified in SECY-91-041 (USNRC, 1991).

In summary, the environmental impacts considered in NUREG-1437 evaluations include potential radiation exposures to individuals and to the population as a whole, the risk of near- and long-term adverse health effects that such exposures could entail, and the potential economic and societal consequences of accidental contamination of the environment. These impacts could be severe, but due to their low likelihood of occurrence, the impacts are judged to be small. This conclusion is based on (1) considerable experience gained with the operation of similar facilities without significant degradation of the environment; (2) the requirement that in order to obtain a license the applicant must comply with the applicable Commission regulations and requirements; and (3) a previously analyzed assessment of the risk of design-basis and severe accidents (USNRC, 1999).

Specifically, based on the USNRC and industry implementation of the 1985 policy statement, the generic NUREG-1437 risk evaluations, and the EGC ESP Site specific

demography and meteorology, the probability weighted consequences of atmospheric and (surface and ground) water pathways, and the societal and economic impacts for severe accidents for a future nuclear power plant on the EGC ESP Site will also be "Small."

7.3 Severe Accident Mitigation Alternatives

The purpose of severe accident mitigation alternatives (SAMA) is to review and evaluate plant-design alternatives that could significantly reduce the radiological risk from a severe accident by preventing substantial core damage (i.e., preventing a severe accident) or by limiting releases from containment in the event that substantial core damage occurs (i.e., mitigating the impacts of a severe accident) (USNRC, 1999).

No design has been selected and SAMAs cannot be meaningfully discussed in this ESP application. SAMAs are design issues evaluated during standard design certification, and any discussion is more appropriately developed when a certified design is selected and submitted in a COL application. The design of the reactor and analyses of projected severe accidents are major contributing factors in the determination of SAMAs. In order to determine whether mitigation alternatives are cost beneficial, severe accident analyses must be included in these evaluations. A design has not been selected; therefore, these mitigation alternatives cannot be meaningfully evaluated in this Application for the EGC ESP.

7.4 Transportation Accidents

The assessment of transportation accidents is provided in Section 3.8.

CHAPTER 7

References

Chapter Introduction

None

Section 7.1

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None

CHAPTER 7

Tables

TABLE 7.1-1

PBMR Design Basis Event Curies Released to Environment by Interval

Isotope	0 to 2 hr	2 to 720 hr
C-14	3.87E+02	0
Br-83	2.00E-02	0
Br-84	8.00E-02	0
Br-85	4.70E-01	0
I-131	0	2.43E+01
I-132	1.10E-01	5.00E-02
I-133	3.00E-02	8.11E+00
I-134	3.80E-01	0
I-135	7.00E-02	7.90E-01
I-136	1.00E-02	0
Kr-83m	2.42E+00	2.00E-02
Kr-85m	7.14E+00	6.40E-01
Kr-85	2.60E+00	1.96E+00
Kr-87	9.84E+00	2.00E-02
Kr-88	1.69E+01	5.60E-01
Kr-89	5.85E+00	0
Kr-90	2.92E+00	0
Kr-91	1.39E+00	2.88E+00
Xe-131m	4.90E-01	8.19E+00
Xe-133m	1.38E+00	4.72E+02
Xe-133	6.01E+01	0
Xe-135m	2.36E+00	1.90E+00
Xe-135	9.28E+00	0
Xe-137	6.17E+00	0
Xe-138	1.13E+01	0
Xe-139	1.78E+00	0
Xe-140	7.90E-01	0

TABLE 7.1-1

PBMR Design Basis Event Curies Released to Environment by Interval

Isotope	0 to 2 hr	2 to 720 hr
Sr-90	2.00E-05	0
Cs-137	3.00E-04	0

Note: Bounding activities released based on PBMR and GT-MHR.

TABLE 7.1-2
Comparison of Reactor Types for Limiting Off-Site Dose Consequences

Design Basis Accident	ESP EAB Dose TEDE (rem)	Vendor EAB Dose TEDE (rem)	ESP/Vendor EAB X/Q Ratio	ESP LPZ Dose TEDE (rem)	Vendor LPZ Dose TEDE (rem)	ESP/Vendor LPZ X/Q Ratio
AP1000 Reactor						
Main Steam Line Break						
Accident-initiated Iodine Spike						
0 -2 hrs	4.75E-02	8.00E-01	5.93E-02			
0 - 8 hrs				1.61E-02	6.4E-01	2.52E-02
8 - 24 hrs				1.20E-02	4.2E-01	2.85E-02
24 -96 hrs				2.16E-02	6.3E-01	3.43E-02
Total	**4.75E-02**	**8.00E-01**		**4.97E-02**	**1.69E+00**	
Preexisting Iodine Spike						
0 -2 hrs	4.15E-02	7.00E-01	5.93E-02			
0 - 8 hrs				6.04E-03	2.40E-01	2.52E-02
8 - 24 hrs				2.28E-03	8.00E-02	2.85E-02
24 -96 hrs				4.45E-03	1.30E-01	3.43E-02
Total	**4.15E-02**	**7.00E-01**		**1.28E-02**	**4.50E-01**	
Reactor Coolant Pump Locked Rotor						
0 -2 hrs	1.48E-01	2.50E+00	5.93E-02			
0 - 8 hrs				1.51E-02	6.00E-01	2.52E-02
Total	**1.48E-01**	**2.50E+00**		**1.51E-02**	**6.00E-01**	
Control Rod Ejection Accident						
0 -2 hrs	1.78E-01	3.00E+00	5.93E-02			
0 - 8 hrs				3.53E-02	1.4E+00	2.52E-02
8 - 24 hrs				7.41E-03	2.6E-01	2.85E-02
24 -96 hrs				1.58E-03	4.6E-02	3.43E-02
96 - 720 hrs				5.45E-04	1.2E-02	4.55E-02
Total	**1.78E-01**	**3.00E+00**		**4.48E-02**	**1.72E+00**	
Steam Generator Tube Rupture						
Accident-initiated Iodine Spike						
0 -2 hrs	8.90E-02	1.50E+00	5.93E-02	-	-	-

TABLE 7.1-2
Comparison of Reactor Types for Limiting Off-Site Dose Consequences

Design Basis Accident	ESP EAB Dose TEDE (rem)	Vendor EAB Dose TEDE (rem)	ESP/Vendor EAB X/Q Ratio	ESP LPZ Dose TEDE (rem)	Vendor LPZ Dose TEDE (rem)	ESP/Vendor LPZ X/Q Ratio
0 – 8 hrs				4.53E-03	1.80E-01	2.52E-02
8 – 24 hrs				2.05E-03	7.2E-02	2.85E-02
Total	**8.90E-02**	**1.50E+00**		**6.60E-03**	**2.52E-01**	
Preexisting Iodine Spike						
0 –2 hrs	1.78E-01	3.00E+00	5.93E-02	-	-	
0 - 8 hrs				8.06E-03	3.20E-01	2.52E-02
8 - 24 hrs				7.41E-04	2.60E-02	2.85E-02
Total	**1.78E-01**	**3.00E+00**		**8.80E-03**	**3.46E-01**	
Small Line Break						
0 -2 hrs	7.71E-02	1.30E+00	5.93E-02			
0 - 8 hrs				7.56E-03	3.00E-01	2.52E-02
Total	**7.71E-02**	**1.30E+00**		**7.56E-03**	**3.00E-01**	
Fuel Handling Accident						
0 -2 hrs	1.42E-01	2.40E+00	5.93E-02			
0 - 8 hrs				1.51E-02	6.00E-01	2.52E-02
Total	**1.42E-01**	**2.40E+00**		**1.51E-02**	**6.00E-01**	
Loss of Coolant Accident						
1 - 3 hrs	1.47E+00	2.48E+01	5.93E-02			
0 - 8 hrs				2.32E-01	9.20E+00	2.52E-02
8 - 24 hrs				9.41E-03	3.30E-01	2.85E-02
24 -96 hrs				1.06E-02	3.10E-01	3.43E-02
96 - 720 hrs				1.32E-02	2.90E-01	4.55E-02
Total	**1.47E+00**	**2.48E+01**		**2.65E-01**	**1.01E+01**	
ABWR						
Main Steam Line Break						
Max Equilibrium Iodine Activity						
0 -2 hrs	3.43E-03	1.32E-01	2.60E-02			

TABLE 7.1-2
Comparison of Reactor Types for Limiting Off-Site Dose Consequences

Design Basis Accident	ESP EAB Dose TEDE (rem)	Vendor EAB Dose TEDE (rem)	ESP/Vendor EAB X/Q Ratio	ESP LPZ Dose TEDE (rem)	Vendor LPZ Dose TEDE (rem)	ESP/Vendor LPZ X/Q Ratio
0 - 8 hrs				3.28E-04	1.50E-02	2.18E-02
Total	**3.43E-03**	**1.32E-01**		**3.28E-04**	**1.50E-02**	
Preexisting Iodine Spike						
0 -2 hrs	6.85E-02	2.63E+00	2.60E-02			
0 - 8 hrs				6.54E-03	3.00E-01	2.18E-02
Total	**6.85E-02**	**2.63E+00**		**6.54E-03**	**3.00E-01**	
Control Rod Drop Accident	*Not Applicable to the ABWR design*					
Small Line Break						
0 -2 hrs	2.97E-03	1.14E-01	2.60E-02			
0 - 8 hrs				5.75E-04	2.64E-02	2.18E-02
Total	**2.97E-03**	**1.14E-01**		**5.75E-04**	**2.64E-02**	
Fuel Handling Accident						
0 -2 hrs	8.04E-02	3.09E+00	2.60E-02			
0 - 8 hrs				9.78E-03	4.49E-01	2.18E-02
Total	**8.04E-02**	**3.09E+00**		**9.78E-03**	**4.49E-01**	
Loss of Coolant Accident						
0 - 2 hrs	2.35E-01	9.04E+00	2.60E-02			
0 - 8 hrs				3.78E-02	1.73E+00	2.18E-02
8 - 24 hrs				3.20E-02	1.08E+00	2.97E-02
24 -96 hrs				1.65E-01	2.99E+00	5.51E-02
96 - 720 hrs				5.29E-01	3.92E+00	1.35E-01
Total	**2.35E-01**	**9.04E+00**		**7.63E-01**	**9.73E+00**	

TABLE 7.1-2A
Ratio of EGC ESP 50% Accident Site Chi/Q Values to AP1000 Final Design Approval (FDA) Chi/Q Values

Post Accident Time Period (hr)	EGC ESP Site Chi/Q Values(sec/m^3)	AP1000 Chi/Q Values (sec/m^3)	Chi/Q Ratio
			EGC Site / AP1000 FDA
EAB[1] 0 - 2	3.56E-05	6.00E-04	5.93E-02
LPZ			
0 - 8	3.40E-06	1.35E-04	2.52E-02
8 -24	2.85E-06	1.00E-04	2.85E-02
24 -96	1.85E-06	5.40E-05	3.43E-02
96 - 720	1.00E-06	2.20E-05	4.55E-02

Note 1: 2 hour period with greatest EAB dose consequences.

TABLE 7.1-3
AP1000 Main Steam Line Break Curies Released to Environment by Interval - Accident-Initiated Iodine Spike

Isotope	0 to 2 hr	2 to 8 hr	8 to 24 hr	24 to 96 hr
I-130	6.84E-01	3.33E+00	5.27E+00	3.30E+00
I-131	3.92E+01	1.92E+02	5.18E+02	1.35E+03
I-132	9.12E+01	3.26E+02	7.46E+01	6.00E-01
I-133	7.75E+01	3.81E+02	7.54E+02	8.34E+02
I-134	3.03E+01	6.23E+01	8.85E-01	2.78E-06
I-135	5.57E+01	2.59E+02	2.61E+02	5.82E+01
Kr-85m	2.30E-01	3.82E-01	2.26E-01	2.03E-02
Kr-85	9.47E-01	2.83E+00	7.47E+00	2.17E+01
Kr-87	9.24E-02	4.49E-02	1.76E-03	2.84E-07
Kr-88	3.77E-01	4.59E-01	1.34E-01	2.72E-03
Xe-131m	4.28E-01	1.27E+00	3.26E+00	8.78E+00
Xe-133m	5.31E-01	1.51E+00	3.45E+00	6.69E+00
Xe-133	3.95E+01	1.15E+02	2.87E+02	7.03E+02
Xe-135m	1.02E-02	4.44E-05	0	0
Xe-135	1.04E+00	2.31E+00	2.78E+00	1.11E+00
Xe-138	1.34E-02	3.81E-05	0	0
Cs-134	1.91E+01	6.52E-01	1.72E+00	5.00E+00
Cs-136	2.84E+01	9.57E-01	2.47E+00	6.69E+00
Cs-137	1.38E+01	4.70E-01	1.24E+00	3.61E+00
Cs-138	1.02E+01	3.41E-03	1.48E-06	0

TABLE 7.1-4
AP1000 Main Steam Line Break Curies Released to Environment by Interval - Preexisting Iodine Spike

Isotope	0 to 2 hr	2 to 8 hr	8 to 24 hr	24 to 96 hr
I-130	4.98E-01	4.74E-01	6.95E-01	4.36E-01
I-131	3.37E+01	4.05E+01	1.03E+02	2.67E+02
I-132	4.02E+01	1.39E+01	2.68E+00	2.16E-02
I-133	6.03E+01	6.35E+01	1.17E+02	1.30E+02
I-134	8.24E+00	5.47E-01	4.77E-03	1.50E-08
I-135	3.56E+01	2.73E+01	2.51E+01	5.60E+00
Kr-85m	2.30E-01	3.82E-01	2.26E-01	2.03E-02
Kr-85	9.47E-01	2.83E+00	7.47E+00	2.17E+01
Kr-87	9.24E-02	4.49E-02	1.76E-03	2.84E-07
Kr-88	3.77E-01	4.59E-01	1.34E-01	2.72E-03
Xe-131m	4.28E-01	1.27E+00	3.26E+00	8.78E+00
Xe-133m	5.31E-01	1.51E+00	3.45E+00	6.69E+00
Xe-133	3.95E+01	1.15E+02	2.87E+02	7.03E+02
Xe-135m	1.02E-02	4.44E-05	0	0
Xe-135	1.04E+00	2.31E+00	2.78E+00	1.11E+00
Xe-138	1.34E-02	3.81E-05	0	0
Rb-86	*	*	*	*
Cs-134	1.91E+01	6.52E-01	1.72E+00	5.00E+00
Cs-136	2.84E+01	9.57E-01	2.47E+00	6.69E+00
Cs-137	1.38E+01	4.70E-01	1.24E+00	3.61E+00
Cs-138	1.02E+01	3.41E-03	1.48E-06	0

Note: * = Rb-86 contribution considered negligible for this accident.

TABLE 7.1-5
AP1000 Main Steam Line Break - Accident-Initiated Iodine Spike

Time	Exclusion Area Boundary Dose TEDE (rem)	Low Population Zone Dose TEDE (rem)
0 to 2 hrs	4.75E-02	--
0 to 8 hrs	--	1.61E-02
8 to 24 hrs	--	1.20E-02
24 to 96 hrs	--	2.16E-02
96 to 720 hrs	--	0
Total	4.75E-02	4.97E-02

TABLE 7.1-6
AP1000 Main Steam Line Break - Preexisting Iodine Spike

Time	Exclusion Area Boundary Dose TEDE (rem)	Low Population Zone Dose TEDE (rem)
0 to 2 hrs	4.15E-02	--
0 to 8 hrs	--	6.04E-03
8 to 24 hrs	--	2.28E-03
24 to 96 hrs	--	4.45E-03
96 to 720 hrs	--	0
Total	4.15E-02	1.28E-02

TABLE 7.1-7
ABWR Main Steam Line Break Outside Containment

Isotope	Maximum Equilibrium Value for Full Power Operation Curies Released 0 to 2 hr	Preexisting Iodine Spike Curies Released 0 to 2 hr
I-131	1.97E+00	3.95E+01
I-132	1.92E+01	3.84E+02
I-133	1.35E+01	2.70E+02
I-134	3.78E+01	7.54E+02
I-135	1.97E+01	3.95E+02
Kr-83m	1.10E-02	6.59E-02
Kr-85m	1.94E-02	1.16E-01
Kr-85	6.11E-05	3.68E-04
Kr-87	6.59E-02	3.97E-01
Kr-88	6.65E-02	4.00E-01
Kr-89	2.67E-01	1.60E+00
Kr-90	6.89E-02	4.19E-01
Xe-131m	4.76E-05	2.86E-04
Xe-133m	9.16E-04	5.51E-03
Xe-133	2.56E-02	1.54E-01
Xe-135m	7.81E-02	4.59E-01
Xe-135	7.30E-02	4.38E-01
Xe-137	3.32E-01	2.00E+00
Xe-138	2.55E-01	1.53E+00
Xe-139	1.17E-01	7.00E-01

TABLE 7.1-8
ABWR Main Steam Line Break Outside Containment -Maximum Equilibrium Value for Full Power Operation

Dose Type	EAB (rem)	LPZ (rem)
Thyroid	6.64E-02	6.34E-03
Whole Body	1.46E-03	1.39E-04
TEDE	3.43E-03	3.28E-04

TABLE 7.1-9
ABWR Main Steam Line Break Outside Containment - Preexisting Iodine Spike

Dose Type	EAB (rem)	LPZ (rem)
Thyroid	1.33E+00	1.27E-01
Whole Body	2.89E-02	2.76E-03
TEDE	6.85E-02	6.54E-03

TABLE 7.1-10
AP1000 Locked Rotor Accident Curies Released to Environment

Isotope	0 to 1.5 hr
I-130	4.15E+00
I-131	1.83E+02
I-132	1.33E+02
I-133	2.31E+02
I-134	1.44E+02
I-135	2.04E+02
Kr-85m	4.09E+02
Kr-85	3.77E+01
Kr-87	6.05E+02
Kr-88	1.05E+03
Xe-131m	1.87E+01
Xe-133m	1.02E+02
Xe-133	3.33E+03
Xe-135m	1.63E+02
Xe-135	8.01E+02
Xe-138	6.48E+02
Rb-86	6.69E-02
Cs-134	5.83E+00
Cs-136	1.85E+00
Cs-137	3.42E+00
Cs-138	3.05E+01

TABLE 7.1-11
AP1000 Locked Rotor Accident, 0 to 1.5 hr Duration - Preexisting Iodine Spike

Time	Exclusion Area Boundary Dose TEDE (rem)	Low Population Zone Dose TEDE (rem)
0 to 2 hr	1.48E-01	--
0 to 8 hr	--	1.51E-02
8 to 24 hr	--	0
24 to 96 hr	--	0
96 to 720 hr	--	0
Total	1.48E-01	1.51E-02

TABLE 7.1-12
AP1000 Control Rod Ejection Accident Curies Released to Environment by Interval - Preexisting Iodine Spike

Isotope	0 to 2 hr	2 to 8 hr	8 to 24 hr	24 to 96 hr	96 to 720 hr
I-130	5.93E+00	7.28E+00	4.32E+00	4.06E-01	5.88E-04
I-131	1.64E+02	2.45E+02	2.31E+02	6.20E+01	3.33E+01
I-132	1.90E+02	9.94E+01	9.85E+00	1.65E-02	0
I-133	3.29E+02	4.40E+02	3.18E+02	4.56E+01	4.81E-01
I-134	2.18E+02	2.85E+01	1.37E-01	8.96E-08	0
I-135	2.91E+02	2.97E+02	1.19E+02	4.79E+00	1.46E-04
Kr-85m	2.85E+02	6.48E+01	3.87E+01	3.53E+00	5.01E-05
Kr-85	1.24E+01	5.60E+00	1.49E+01	6.70E+01	5.71E+02
Kr-87	4.86E+02	2.60E+01	1.03E+00	1.67E-04	0
Kr-88	7.49E+02	1.18E+02	3.49E+01	7.18E-01	1.68E-08
Xe-131m	1.22E+01	5.46E+00	1.42E+01	5.72E+01	2.31E+02
Xe-133m	6.62E+01	2.81E+01	6.49E+01	1.69E+02	1.06E+02
Xe-133	2.18E+03	9.58E+02	2.40E+03	8.53E+03	1.68E+04
Xe-135m	2.18E+02	5.30E-02	4.33E-09	0	0
Xe-135	5.39E+02	1.72E+02	2.09E+02	8.69E+01	3.58E-01
Xe-138	8.89E+02	1.38E-01	3.19E-09	0	0
Rb-86	3.70E-01	7.27E-01	6.96E-01	1.73E-01	6.79E-02
Cs-134	3.15E+01	6.22E+01	6.03E+01	1.55E+01	1.03E+01
Cs-136	8.98E+00	1.75E+01	1.67E+01	4.10E+00	1.31E+00
Cs-137	1.83E+01	3.62E+01	3.51E+01	9.04E+00	6.05E+00
Cs-138	1.13E+02	7.05E+00	1.68E-03	0	0

TABLE 7.1-13
AP1000 Control Rod Ejection Accident - Preexisting Iodine Spike

Time	Exclusion Area Boundary Dose TEDE (rem)	Low Population Zone Dose TEDE (rem)
0 to 2 hr	1.78E-01	--
0 to 8 hr	--	3.53E-02
8 to 24 hr	--	7.41E-03
24 to 96 hr	--	1.58E-03
96 to 720 hr	--	5.45E-04
Total	1.78E-01	4.48E-02

TABLE 7.1-14
AP1000 Steam Generator Tube Rupture Accident Curies Released to Environment by Interval - Accident Initiated Iodine Spike

Isotope	0 to 2 hr	2 to 8 hr	8 to 24 hr
I-130	7.30E-02	1.19E-02	3.13E-02
I-131	4.90E+00	1.15E+00	3.55E+00
I-132	5.79E+00	1.75E-01	2.30E-01
I-133	8.79E+00	1.68E+00	4.73E+00
I-134	1.12E+00	1.18E-03	5.21E-04
I-135	5.15E+00	6.01E-01	1.36E+00
Kr-85m	5.67E+01	1.91E+01	2.50E-02
Kr-85	2.25E+02	1.07E+02	4.44E-01
Kr-87	2.46E+01	3.56E+00	3.02E-04
Kr-88	9.44E+01	2.61E+01	1.80E-02
Xe-131m	1.02E+02	4.82E+01	1.96E-01
Xe-133m	1.26E+02	5.83E+01	2.19E-01
Xe-133	9.37E+03	4.41E+03	1.75E+01
Xe-135m	3.61E+00	5.78E-03	0
Xe-135	2.51E+02	1.00E+02	2.35E-01
Xe-138	4.78E+00	4.99E-03	0
Rb-86	*	*	*
Cs-134	1.65E+00	6.35E-02	2.27E-01
Cs-136	2.45E+00	9.30E-02	3.30E-01
Cs-137	1.19E+00	4.58E-02	1.64E-01
Cs-138	5.71E-01	3.07E-06	6.00E-07

Note: * = Rb-86 contribution considered negligible for this accident.

TABLE 7.1-15
AP1000 Steam Generator Tube Rupture Accident Curies Released to Environment by Interval - Preexisting Iodine Spike

Isotope	0 to 2 hr	2 to 8 hr	8 to 24 hr
I-130	1.81E+00	6.12E-02	2.90E-01
I-131	1.22E+02	5.97E+00	3.32E+01
I-132	1.43E+02	8.53E-01	2.08E+00
I-133	2.19E+02	8.68E+00	4.41E+01
I-134	2.78E+01	5.16E-03	4.57E-03
I-135	1.28E+02	3.06E+00	1.26E+01
Kr-85m	5.67E+01	1.91E+01	2.50E-02
Kr-85	2.25E+02	1.07E+02	4.44E-01
Kr-87	2.46E+01	3.56E+00	3.02E-04
Kr-88	9.44E+01	2.61E+01	1.80E-02
Xe-131m	1.02E+02	4.82E+01	1.96E-01
Xe-133m	1.26E+02	5.83E+01	2.19E-01
Xe-133	9.37E+03	4.41E+03	1.75E+01
Xe-135m	3.61E+00	5.78E-03	0
Xe-135	2.51E+02	1.00E+02	2.35E-01
Xe-138	4.78E+00	4.99E-03	0
Rb-86	*	*	*
Cs-134	1.65E+00	6.35E-02	2.27E-01
Cs-136	2.45E+00	9.30E-02	3.30E-01
Cs-137	1.19E+00	4.58E-02	1.64E-01
Cs-138	5.71E-01	3.07E-06	6.00E-07

Note: * = Rb-86 contribution considered negligible for this accident.

TABLE 7.1-16
AP1000 Steam Generator Tube Rupture - Accident-Initiated Iodine Spike

Time	Exclusion Area Boundary Dose TEDE (rem)	Low Population Zone Dose TEDE (rem)
0 to 2 hr	8.90E-02	--
0 to 8 hr	--	4.53E-03
8 to 24 hr	--	2.05E-03
24 to 96 hr	--	0
96 to 720 hr	--	0
Total	8.90E-02	6.59E-03

TABLE 7.1-17
AP1000 Steam Generator Tube Rupture - Preexisting Iodine Spike

Time	Exclusion Area Boundary Dose TEDE (rem)	Low Population Zone Dose TEDE (rem)
0 to 2 hr	1.78E-01	--
0 to 8 hr	--	8.06E-03
8 to 24 hr	--	7.41E-04
24 to 96 hr	--	0
96 to 720 hr	--	0
Total	1.78E-01	8.80E-03

TABLE 7.1-18
AP1000 Small Line Break Accident Curies Released to Environment - Accident Initiated Iodine Spike

Isotope	0 to 0.5 hr
I-130	1.90E+00
I-131	9.26E+01
I-132	3.49E+02
I-133	2.01E+02
I-134	1.58E+02
I-135	1.68E+02
Kr-85m	1.24E+01
Kr-85	4.40E+01
Kr-87	7.00E+00
Kr-88	2.21E+01
Xe-131m	1.99E+1
Xe-133m	2.50E+01
Xe-133	1.84E+02
Xe-135m	2.60E+00
Xe-135	5.20E+01
Xe-138	3.60E+00
Cs-134	4.20E+00
Cs-136	6.20E+00
Cs-137	3.00E+00
Cs-138	2.20E+00

TABLE 7.1-19
AP1000 Small Line Break Accident, 0- to 0.5-hr Duration - Accident-Initiated Iodine Spike

Time	Exclusion Area Boundary Dose TEDE (rem)	Low Population Zone Dose TEDE (rem)
0 to 2 hr	7.71E-02	--
0 to 8 hr	--	7.56E-03
8 to 24 hr	--	0
24 to 96 hr	--	0
96 to 720 hr	--	0
Total	7.71E-02	7.56E-03

TABLE 7.1-20
ABWR Small Line Break Outside Containment - Activity Released to Environment

Isotope	Curies Released 0 to 2 hr	Curies Released 0 to 8 hr
I-131	1.84E+00	3.81E+00
I-132	1.61E+01	3.22E+01
I-133	1.24E+01	2.55E+01
I-134	2.68E+01	5.14E+01
I-135	1.78E+01	3.62E+01
Total	7.50E+01	1.49E+02

TABLE 7.1-21
ABWR Small Line Break Outside Primary Containment

Dose Type	EAB (rem)	LPZ (rem)
Thyroid	6.10E-02	1.20E-02
Whole Body	1.14E-03	2.16E-04
TEDE	2.97E-03	5.75E-04

TABLE 7.1-22
AP1000 Design Basis Loss of Coolant Accident Curies Released to Environment by Interval

Isotope	0 to 1 hr	1 to 3 hr	0 to 8 hr	8 to 24 hr	24 to 96 hr	96 to 720 hr
Halogen Group						
I-130	5.62E+00	4.92E+01	7.80E+01	2.96E+00	1.11E+00	1.99E-02
I-131	1.54E+02	1.44E+03	2.36E+03	1.56E+02	3.74E+02	1.12E+03
I-132	1.79E+02	1.18E+03	1.67E+03	7.64E+00	2.29E-02	0
I-133	3.11E+02	2.80E+03	4.51E+03	2.16E+02	1.63E+02	1.62E+01
I-134	1.96E+02	7.51E+02	1.02E+03	1.26E-01	1.07E-07	0
I-135	2.75E+02	2.27E+03	3.50E+03	8.31E+01	9.55E+00	4.95E-03
Noble Gas Group						
Kr-85m	6.74E+01	1.31E+03	3.77E+03	1.87E+03	1.71E+02	2.43E-03
Kr-85	3.08E+00	7.32E+01	2.96E+02	7.05E+02	3.17E+03	2.70E+04
Kr-87	9.54E+01	1.14E+03	1.94E+03	4.97E+01	8.11E-03	0
Kr-88	1.70E+02	2.95E+03	7.26E+03	1.70E+03	3.49E+01	8.16E-07
Xe-131m	3.07E+00	7.28E+01	2.94E+02	6.79E+02	2.74E+03	1.11E+04
Xe-133m	1.68E+01	3.92E+02	1.54E+03	3.15E+03	8.21E+03	5.15E+03
Xe-133	5.49E+02	1.30E+04	5.19E+04	1.16E+05	4.11E+05	8.10E+05
Xe-135m	1.44E+01	2.14E+01	3.59E+01	2.14E-07	0	0
Xe-135	1.32E+02	2.85E+03	9.64E+03	1.01E+04	4.21E+03	1.73E+01
Xe-138	5.31E+01	6.69E+01	1.20E+02	1.58E-07	0	0
Alkali Metal Group						
Rb-86	3.32E-01	2.61E+00	4.26E+00	9.37E-02	2.03E-03	1.05E-02
Cs-134	2.81E+01	2.22E+02	3.63E+02	8.06E+00	1.88E-01	1.59E+00
Cs-136	8.01E+00	6.30E+01	1.03E+02	2.25E+00	4.72E-02	2.03E-01
Cs-137	1.64E+01	1.29E+02	2.11E+02	4.70E+00	1.10E-01	9.39E-01
Cs-138	1.06E+02	2.06E+02	3.19E+02	6.92E-04	0	0
Tellurium Group						
Sr-89	3.23E+00	7.56E+01	1.19E+02	2.87E+00	6.54E-02	4.60E-01
Sr-90	2.78E-01	6.52E+00	1.03E+01	2.48E-01	5.82E-03	4.97E-02
Sr-91	3.77E+00	8.14E+01	1.22E+02	1.74E+00	2.76E-03	1.44E-05
Sr-92	3.45E+00	6.13E+01	8.30E+01	3.26E-01	1.06E-05	0
Sb-127	8.55E-01	1.98E+01	3.11E+01	7.13E-01	1.16E-02	1.60E-02
Sb-129	2.25E+00	4.43E+01	6.28E+01	4.83E-01	1.01E-04	1.00E-09
Te-127m	1.10E-01	2.58E+00	4.06E+00	9.83E-02	2.27E-03	1.77E-02

TABLE 7.1-22
AP1000 Design Basis Loss of Coolant Accident Curies Released to Environment by Interval

Isotope	0 to 1 hr	1 to 3 hr	0 to 8 hr	8 to 24 hr	24 to 96 hr	96 to 720 hr
Te-127	7.99E-01	1.72E+01	2.57E+01	3.65E-01	5.63E-04	2.72E-06
Te-129m	3.76E-01	8.80E+00	1.38E+01	3.33E-01	7.47E-03	4.79E-02
Te-129	1.50E+00	1.89E+01	2.32E+01	8.54E-03	7.27E-10	0
Te-131m	1.15E+00	2.62E+01	4.05E+01	8.29E-01	6.86E-03	1.60E-03
Te-132	1.14E+01	2.65E+02	4.15E+02	9.42E+00	1.44E-01	1.60E-01
Ba-139	3.83E+00	5.30E+01	6.63E+01	4.73E-02	2.03E-08	0
Ba-140	5.71E+00	1.33E+02	2.10E+02	5.00E+00	1.05E-01	4.41E-01
Noble Metals Group						
Mo-99	7.63E-01	1.77E+01	2.76E+01	6.19E-01	8.79E-03	7.72E-03
Tc-99m	6.09E-01	1.26E+01	1.83E+01	1.94E-01	1.08E-04	2.73E-08
Ru-103	6.07E-01	1.42E+01	2.23E+01	5.38E-01	1.21E-02	8.11E-02
Ru-105	3.59E-01	7.08E+00	1.01E+01	7.97E-02	1.82E-05	2.40E-10
Ru-106	2.00E-01	4.67E+00	7.36E+00	1.78E-01	4.16E-03	3.46E-02
Rh-105	3.70E-01	8.48E+00	1.32E+01	2.76E-01	2.64E-03	8.48E-04
Lanthanide Group						
Y-90	2.90E-03	6.65E-02	1.04E-01	2.32E-03	3.25E-05	2.75E-05
Y-91	4.19E-02	9.71E-01	1.53E+00	3.69E-02	8.43E-04	6.09E-03
Y-92	3.70E-02	6.93E-01	9.64E-01	5.77E-03	5.86E-07	0
Y-93	4.75E-02	1.02E+00	1.53E+00	2.25E-02	4.05E-05	2.91E-07
Nb-95	5.64E-02	1.31E+00	2.06E+00	4.95E-02	1.11E-03	7.23E-03
Zr-95	5.61E-02	1.30E+00	2.05E+00	4.94E-02	1.13E-03	8.29E-03
Zr-97	5.35E-02	1.19E+00	1.81E+00	3.26E-02	1.38E-04	7.58E-06
La-140	6.06E-02	1.38E+00	2.14E+00	4.58E-02	4.84E-04	1.97E-04
La-141	4.69E-02	8.98E-01	1.26E+00	8.69E-03	1.31E-06	0
La-142	3.58E-02	5.15E-01	6.53E-01	6.67E-04	6.96E-10	0
Nd-147	2.19E-02	5.06E-01	7.95E-01	1.89E-02	3.88E-04	1.49E-03
Pr-143	4.93E-02	1.14E+00	1.79E+00	4.27E-02	9.01E-04	3.95E-03
Am-241	4.23E-06	9.81E-05	1.54E-04	3.74E-06	8.75E-08	7.48E-07
Cm-242	9.98E-04	2.31E-02	3.64E-02	8.81E-04	2.04E-05	1.64E-04
Cm-244	1.22E-04	2.84E-03	4.47E-03	1.08E-04	2.53E-06	2.16E-05
Cerium Group						
Ce-141	1.37E-01	3.19E+00	5.02E+00	1.21E-01	2.71E-03	1.72E-02

TABLE 7.1-22
AP1000 Design Basis Loss of Coolant Accident Curies Released to Environment by Interval

Isotope	0 to 1 hr	1 to 3 hr	0 to 8 hr	8 to 24 hr	24 to 96 hr	96 to 720 hr
Ce-143	1.25E-01	2.85E+00	4.42E+00	9.20E-02	8.29E-04	2.34E-04
Ce-144	1.03E-01	2.41E+00	3.80E+00	9.19E-02	2.14E-03	1.77E-02
Pu-238	3.22E-04	7.51E-03	1.18E-02	2.86E-04	6.71E-06	5.73E-05
Pu-239	2.83E-05	6.60E-04	1.04E-03	2.52E-05	5.90E-07	5.04E-06
Pu-240	4.15E-05	9.69E-04	1.53E-03	3.69E-05	8.65E-07	7.39E-06
Pu-241	9.33E-03	2.17E-01	3.42E-01	8.30E-03	1.94E-04	1.66E-03
Np-239	1.60E+00	3.69E+01	5.76E+01	1.27E+00	1.67E-02	1.17E-02

TABLE 7.1-23
AP1000 Design Basis Loss of Coolant Accident

Time	Exclusion Area Boundary Dose TEDE (rem)	Low Population Zone Dose TEDE (rem)
1 to 3 hr	1.47E+00	--
0 to 8 hr	--	2.32E-01
8 to 24 hr	--	9.41E-03
24 to 96 hr	--	1.06E-02
96 to 720 hr	--	1.32E-02
Total	1.47E+00	2.65E-01

Notes: 2-hr period with greatest EAB dose shown. LOCA based on Regulatory Guide 1.183 (USNRC, 2000).

TABLE 7.1-24
ABWR LOCA Curies Released to Environment by Interval

Isotope	0 to 2 hr (Ci)	0 to 8 hr (Ci)	8 to 24 hr (Ci)	24 to 96 hr (Ci)	96 to 720 hr (Ci)
I-131	2.60E+02	3.74E+02	9.23E+02	8.70E+03	6.22E+04
I-132	3.52E+02	3.85E+02	3.24E+01	0	0
I-133	5.41E+02	7.43E+02	1.18E+03	3.32E+03	6.76E+02
I-134	5.14E+02	5.15E+02	0	0	0
I-135	5.14E+02	6.47E+02	3.32E+02	1.68E+02	0
Kr-83m	3.26E+02	9.00E+02	4.32E+01	0	0
Kr-85m	8.44E+02	3.74E+03	4.36E+03	7.03E+02	0
Kr-85	4.09E+01	3.49E+02	2.19E+03	2.18E+04	2.86E+05
Kr-87	1.20E+03	2.17E+03	8.92E+01	2.70E+00	0
Kr-88	2.12E+03	7.14E+03	3.43E+03	2.97E+02	0
Kr-89	1.81E+02	1.81E+02	0	0	0
Xe-131m	2.13E+01	1.72E+02	1.12E+03	9.52E+03	6.22E+04
Xe-133m	3.00E+02	2.48E+03	1.38E+04	7.59E+04	7.27E+04
Xe-133	7.63E+03	6.11E+04	3.77E+05	2.78E+06	8.41E+06
Xe-135m	4.87E+02	4.87E+02	0	0	0
Xe-135	9.26E+02	5.51E+03	1.52E+04	1.17E+04	0
Xe-137	5.14E+02	5.14E+02	0	0	0
Xe-138	2.00E+03	2.00E+03	0	0	0

TABLE 7.1-25
ABWR Design Basis Loss of Coolant Accident

Dose Type	EAB (rem)	LPZ (rem)
Thyroid	4.96E+00	2.15E+01
Whole Body	1.02E-01	1.79E-01
TEDE	2.35E-01	7.63E-01

TABLE 7.1-26
ESBWR Design Basis Loss of Coolant Accident Curies Released to Environment by Interval

Isotope	0 to 1.4 hr	1.4 to 3.4 hr	0 to 8 hr	8 to 24 hr	24 to 96 hr	96 to 720 hr
Halogen Group						
I-131	9.28E+01	2.85E+02	8.72E+02	1.60E+03	5.09E+03	6.64E+03
I-132	1.21E+02	3.11E+02	7.18E+02	4.42E+02	1.02E+03	4.80E+02
I-133	1.89E+02	5.56E+02	1.62E+03	2.09E+03	2.36E+03	1.50E+02
I-134	1.01E+02	1.09E+02	2.31E+02	0	0	0
I-135	1.66E+02	4.42E+02	1.16E+03	6.90E+02	1.40E+02	0
Noble Gas Group						
Kr-85m	1.09E+02	7.25E+02	2.90E+03	3.83E+03	6.40E+02	0
Kr-85	3.56E+00	2.96E+01	1.75E+02	1.24E+03	1.23E+04	1.99E+05
Kr-87	1.30E+02	5.02E+02	1.09E+03	7.00E+01	0	0
Kr-88	2.43E+02	1.42E+03	4.72E+03	2.82E+03	1.10E+02	0
Xe-133	7.68E+02	6.36E+03	3.70E+04	2.46E+05	1.89E+06	6.68E+06
Xe-135	2.02E+02	1.66E+03	8.14E+03	2.44E+04	1.90E+04	1.00E+02
Alkali Metal Group						
Rb-86	4.50E-02	1.30E-01	4.03E-01	7.37E-01	2.40E+00	2.91E+00
Cs-134	1.36E+01	3.95E+01	1.22E+02	2.28E+02	7.90E+02	1.26E+03
Cs-136	3.64E+00	1.06E+01	3.25E+01	5.90E+01	1.87E+02	2.04E+02
Cs-137	8.14E+00	2.37E+01	7.32E+01	1.37E+02	4.72E+02	7.58E+02
Tellurium Group						
Sr-89	4.70E+00	2.15E+01	6.27E+01	1.19E+02	4.03E+02	5.85E+02
Sr-90	3.33E-01	1.53E+00	4.45E+00	8.55E+00	2.94E+01	4.75E+01
Sr-91	5.62E+00	2.36E+01	6.07E+01	5.03E+01	2.00E+01	0
Sr-92	4.78E+00	1.60E+01	3.30E+01	4.90E+00	1.00E-01	0
Sb-127	9.76E-01	4.43E+00	1.28E+01	2.23E+01	5.73E+01	3.06E+01
Sb-129	2.85E+00	1.08E+01	2.44E+01	8.60E+00	6.00E-01	0
Te-127	9.51E-01	4.36E+00	1.26E+01	2.33E+01	6.51E+01	4.80E+01
Te-127m	1.28E-01	5.89E-01	1.72E+00	3.29E+00	1.14E+01	1.78E+01
Te-129	3.11E+00	1.30E+01	3.19E+01	2.69E+01	6.22E+01	8.50E+01
Te-129m	8.43E-01	3.87E+00	1.13E+01	2.13E+01	7.14E+01	9.80E+01
Te-131m	1.58E+00	7.02E+00	1.97E+01	2.86E+01	4.23E+01	5.30E+00
Te-132	1.57E+01	7.10E+01	2.04E+02	3.51E+02	8.55E+02	4.00E+02
Ba-139	4.82E+00	1.21E+01	2.15E+01	5.00E-01	0	0

TABLE 7.1-26
ESBWR Design Basis Loss of Coolant Accident Curies Released to Environment by Interval

Isotope	0 to 1.4 hr	1.4 to 3.4 hr	0 to 8 hr	8 to 24 hr	24 to 96 hr	96 to 720 hr
Ba-140	8.33E+00	3.81E+01	1.11E+02	2.06E+02	6.49E+02	7.04E+02
Noble Metals Group						
Co-58	3.24E-03	1.49E-02	4.33E-02	8.27E-02	2.80E-01	4.18E-01
Co-60	3.88E-03	1.78E-02	5.19E-02	9.91E-02	3.43E-01	5.56E-01
Mo-99	1.02E+00	4.61E+00	1.32E+01	2.22E+01	5.11E+01	1.95E+01
Tc-99m	8.91E-01	4.09E+00	1.19E+01	2.14E+01	5.21E+01	2.06E+01
Ru-103	7.81E-01	3.58E+00	1.04E+01	1.98E+01	6.64E+01	9.34E+01
Ru-105	4.37E-01	1.65E+00	3.78E+00	1.37E+00	1.10E-01	0
Ru-106	2.12E-01	9.78E-01	2.84E+00	5.42E+00	1.87E+01	2.97E+01
Rh-105	3.91E-01	1.79E+00	5.17E+00	8.43E+00	1.44E+01	2.40E+00
Lanthanide Group						
Y-90	4.85E-03	3.54E-02	1.90E-01	1.35E+00	1.33E+01	4.16E+01
Y-91	5.78E-02	2.69E-01	8.07E-01	1.72E+00	6.26E+00	9.31E+00
Y-92	4.03E-01	3.88E+00	1.58E+01	1.50E+01	1.10E+00	0
Y-93	6.74E-02	2.84E-01	7.36E-01	6.44E-01	2.80E-01	0
Zr-95	7.55E-02	3.47E-01	1.01E+00	1.92E+00	6.51E+00	9.66E+00
Zr-97	7.42E-02	3.24E-01	8.77E-01	1.04E+00	9.00E-01	2.00E-02
Nb-95	7.14E-02	3.28E-01	9.56E-01	1.83E+00	6.33E+00	1.02E+01
La-140	1.37E-01	1.14E+00	6.70E+00	4.90E+01	4.12E+02	7.42E+02
La-141	6.45E-02	2.38E-01	5.32E-01	1.59E-01	9.00E-03	0
La-142	4.57E-02	1.21E-01	2.21E-01	7.00E-03	0	0
Pr-143	7.23E-02	3.33E-01	9.75E-01	1.92E+00	6.67E+00	7.94E+00
Nd-147	3.22E-02	1.47E-01	4.27E-01	7.93E-01	2.46E+00	2.52E+00
Am-241	3.72E-06	1.71E-05	4.98E-05	9.62E-05	3.37E-04	5.87E-04
Cm-242	9.81E-04	4.50E-03	1.31E-02	2.51E-02	8.58E-02	1.34E-01
Cm-244	5.29E-05	2.43E-04	7.08E-04	1.35E-03	4.69E-03	7.55E-03
Cerium Group						
Ce-141	1.89E-01	8.71E-01	2.53E+00	4.79E+00	1.60E+01	2.18E+01
Ce-143	1.80E-01	8.05E-01	2.26E+00	3.37E+00	5.37E+00	8.00E-01
Ce-144	1.23E-01	5.64E-01	1.64E+00	3.14E+00	1.08E+01	1.71E+01
Pu-238	1.67E-04	7.68E-04	2.24E-03	4.28E-03	1.48E-02	2.39E-02
Pu-239	4.24E-05	1.95E-04	5.68E-04	1.09E-03	3.78E-03	6.16E-03

TABLE 7.1-26
ESBWR Design Basis Loss of Coolant Accident Curies Released to Environment by Interval

Isotope	0 to 1.4 hr	1.4 to 3.4 hr	0 to 8 hr	8 to 24 hr	24 to 96 hr	96 to 720 hr
Pu-240	5.31E-05	2.44E-04	7.10E-04	1.36E-03	4.70E-03	7.53E-03
Pu-241	9.14E-03	4.20E-02	1.22E-01	2.34E-01	8.14E-01	1.30E+00
Np-239	2.37E+00	1.07E+01	3.06E+01	5.05E+01	1.09E+02	3.50E+01

TABLE 7.1-27
ESBWR Design Basis Loss of Coolant Accident

Time	EAB Dose TEDE (rem)	LPZ Dose TEDE (rem)
0 to 2 hr	3.10E-01	--
0 to 8 hr	--	8.94E-02
8 to 24 hr	--	7.06E-02
24 to 96 hr	--	1.68E-01
96 to 720 hr	--	1.41E-01
Total	3.10E-01	4.69E-01

Note: LOCA based on Regulatory Guide 1.183

TABLE 7.1-28
ACR-700 Design Basis Large LOCA - Curies Released to Environment by Interval

Isotope	0 to 2 hr	0 to 8 hr	8 to 24 hr	24 to 96 hr	96 to 720 hr
I-131	7.76E+01	3.06E+02	5.84E+02	1.56E+04	4.24E+03
I-132	8.55E+01	1.71E+02	1.61E+01	1.42E+01	0
I-133	1.59E+02	5.78E+02	7.75E+02	1.52E+04	6.20E+01
I-134	8.91E+01	1.12E+02	5.10E-02	0	0
I-135	1.37E+02	4.12E+02	2.49E+02	2.36E+03	0
Kr-83m	2.09E+03	3.76E+03	1.91E+02	0	0
Kr-85m	5.70E+03	1.52E+04	5.67E+03	2.60E+02	0
Kr-85	4.50E+01	1.81E+02	3.63E+02	8.13E+02	6.78E+03
Kr-87	7.98E+03	1.18E+04	1.50E+02	0	0
Kr-88	1.45E+04	3.21E+04	5.20E+03	5.30E+01	0
Kr-89	8.64E+02	8.64E+02	0	0	0
Xe-131m	2.52E+02	1.00E+03	1.94E+03	3.91E+03	1.55E+04
Xe-133m	1.40E+03	5.37E+03	9.16E+03	1.19E+04	7.45E+03
Xe-133	4.56E+04	1.79E+05	3.35E+05	5.94E+05	1.16E+06
Xe-135m	1.78E+03	1.79E+03	0	0	0
Xe-135	3.74E+03	1.21E+04	1.01E+04	2.10E+03	9.00E+00
Xe-137	1.89E+03	1.89E+03	0	0	0
Xe-138	6.78E+03	6.79E+03	0	0	0

TABLE 7.1-29
ACR-700 Large Loss of Coolant Accident

Time	EAB Dose TEDE (rem)	LPZ Dose TEDE (rem)
0 to 2 hr	3.77E-01	-
0 to 8 hr	-	7.84E-02
8 to 24 hr	-	2.56E-02
24 to 96 hr	-	2.73E-01
96 to 720 hr	-	3.95E-02
Total	3.77E-01	4.16E-01

TABLE 7.1-30
AP1000 Fuel Handling Accident - Curies Released to Environment

Isotope	0 to 2 hrs (Ci)
I-130	3.52E-02
I-131	2.90E+02
I-132	1.54E+02
I-133	1.91E+01
I-134	0
I-135	1.36E-02
Kr-83m	0
Kr-85m	2.68E-03
Kr-85	1.10E+03
Kr-87	0
Kr-88	0
Kr-89	0
Xe-131m	5.36E+02
Xe-133m	1.29E+03
Xe-133	6.94E+04
Xe-135m	4.37E-01
Xe-135	1.32E+02
Xe-137	0
Xe-138	0

Note: Activity is based on a 100-hr shutdown before fuel movement begins. Source term and pool DF are based on Regulatory Guide 1.183 (USNRC, 2000).

TABLE 7.1-31
AP1000 Fuel Handling Accident

Time	Exclusion Area Boundary Dose Total Effective Dose Equivalent (rem)	Low Population Zone Dose Total Effective Dose Equivalent (rem)
0 to 2 hrs	1.42E-01	--
0 to 8 hrs	--	1.51E-02
8 to 24 hrs	--	0
24 to 96 hr	--	0
96 to 720 hrs	--	0
Total	1.42E-01	1.51E-02

TABLE 7.1-32
ABWR Fuel Handling Accident - Curies Released to Environment by Interval

Isotope	0 to 2 hrs (Ci)	2 to 8 hrs (Ci)
I-131	1.23E+02	1.82E+00
I-132	1.52E+02	1.29E+00
I-133	1.27E+02	1.77E+00
I-134	6.16E-06	2.13E-08
I-135	2.06E+01	2.52E-01
Kr-83m	6.43E+00	4.57E+00
Kr-85m	8.54E+01	9.14E+01
Kr-85	4.78E+02	6.76E+02
Kr-87	1.23E-02	6.51E-03
Kr-88	2.43E+01	2.21E+01
Kr-89	8.14E-11	1.00E-20
Xe-131m	0	0
Xe-133m	8.35E+01	1.18E+02
Xe-133	1.10E+03	1.52E+03
Xe-135m	2.81E+04	3.95E+04
Xe-135	2.21E+02	2.34E+00
Xe-137	6.38E+03	7.84E+03
Xe-138	2.07E-10	2.81E-19
Xe-138	0	0

Notes: Activity is based on a 24-hr shutdown before fuel movement begins. Source term and pool DF are based on Regulatory Guide 1.25 (USAEC, 1972).

TABLE 7.1-33
ABWR Fuel Handling Accident

Dose Type	EAB (rem)	LPZ (rem)
Thyroid	1.97E+00	1.91E-01
Whole Body	2.82E-02	5.56E-03
TEDE	8.04E-02	9.78E-03

CHAPTER 8

Need For Power

The Applicant is not currently seeking approval for the construction or operation of nuclear reactor(s) at the CPS as part of this Application for the EGC ESP. Although, the Applicant believes future demand for power will warrant future construction of additional generating capacity, 10 CFR 52.18 and 52.17(a)(2) do not require the evaluation of a need for power to be provided in an ESP application. Therefore, this evaluation will be provided at the time an application for a construction permit or COL is submitted, in accordance with the applicable regulations (USNRC, 1999).

CHAPTER 8

References

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

U.S. Nuclear Regulatory Commission (USNRC). *Standard Review Plans for Environmental Reviews of Nuclear Power Plants*. NUREG-1555. Office of Nuclear Reactor Regulation. October 1999.

CHAPTER 9

Alternatives to the Proposed Action

This chapter identifies alternatives to the proposed action in three ways. It identifies the impact of No Action; it reviews possible energy resources that could be used as alternatives to the proposed action; and it reviews alternative sites to determine if any are obviously superior to the EGC ESP Site. The review contained herein is in keeping with the effects from deregulation of the electric generation industry.

Efforts to deregulate the electric utility industry began with passage of the National Energy Policy Act of 1992. Provisions of this Act required electric utilities to allow open access to their transmission lines and encouraged development of a competitive wholesale market for electricity. The market place no longer follows traditional organizational, power production, transmission and sales patterns that were the norm when the nation's current nuclear fleet were constructed and licensed. The Act did not mandate competition in the retail market, leaving that decision to the states (NEI, 2000).

In December of 1997, the State of Illinois began the process of restructuring its retail electricity market (i.e., deregulation) by enacting the Illinois Electric Service Customer Choice and Rate Relief Act of 1997 (also known as the Illinois Electricity Choice Law). This Act eliminates regulated generation service areas and enables customers of electric distribution companies in the state to purchase electricity from their choice of electric generation suppliers by May 1, 2002. Electric generation supply is based on customers' needs and preferences (ICC, 1999). As discussed below, the regulatory imposition of competition among electric generators affects the need for power and the selection of alternatives for the EGC ESP Facility.

Before Illinois enacted its Electricity Choice Law, primarily two entities, electric utilities and the Illinois Commerce Commission, made decisions regarding reasonable alternatives for meeting electrical demands in Illinois. As a result of the Electricity Choice Law, the Illinois Commerce Commission no longer has a formal role in assessing Illinois's electricity needs or mandating additional capacity. Instead, market forces are expected to spur innovation, attract competition, drive the appropriate supply/demand balance, and attract new power suppliers to the State (IPCB, 2000). Therefore, generators of electric power in the State of Illinois are solely responsible for decisions regarding reasonable alternatives for meeting electrical demands.

Since the Illinois Electricity Choice Law was enacted, the IEPA has received more than 60 applications for construction of new generating facilities. Citizens, local governments, and legislators objected to several of the proposed plants. In response, the Illinois Pollution Control Board conducted hearings to evaluate whether additional siting or other regulations in connection with the construction of proposed plants should be recommended. The Illinois Pollution Control Board recommended that the IEPA adopt new rules that would

tighten restrictions on air emissions from new power plants and require public participation in the construction permit process, but stated that the IEPA does not have the authority to consider other issues related to the siting of a proposed facility (e.g., need for a proposed power plant, aesthetics, etc.) during permitting (IPCB, 2000).

It is not clear whether EGC or another supplier would ultimately construct new generating units. The decision to actually construct a new facility would be driven by market conditions. However, regardless of which entities construct and operate new generating facilities, certain environmental parameters would be constant among these alternative power sources.

Chapter 9 addresses reasonable alternatives to the EGC ESP Facility. The chapter evaluates what alternative actions might be undertaken, which alternatives are not reasonable and why and, for reasonable alternatives, what the associated environmental impacts might be. The impacts are then compared to those associated with the proposed action.

In determining the level of detail and analysis to be provided, the Applicant relied on the USNRC decision-making standard in that the discussion of alternatives:

> *"…shall be sufficiently complete to aid the Commission in developing and exploring, pursuant to section 102(2)(E) of NEPA, 'appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources.' To the extent practicable, the environmental impacts of the proposal and the alternatives should be presented in comparative form." (10 CFR 51.45(b)(3)).*

Further, for consistency of alternate siting criteria, the process outlined in NUREG-1555 was employed.

This environmental report supports USNRC decision-making by providing sufficient information to clearly indicate whether an alternative would have a smaller, comparable, or greater environmental impact than the proposed action. Providing additional details or analysis would serve no function if it only brings to light the additional adverse impacts of alternatives to the EGC ESP Facility. This approach is consistent with regulations of the Council on Environmental Quality, which provide that the consideration of alternatives (including the proposed action) should enable reviewers to evaluate their comparative merits (40 CFR 1500-1508). This chapter includes sufficient details about alternatives and siting to establish the basis for necessary comparison to the discussions of impacts of the proposed action.

The chapter also identifies and evaluates a set of alternative sites for the proposed EGC ESP Facility. The objective of the evaluation is to verify that there is no 'obviously superior site' for the eventual construction and operation of a new nuclear facility.

9.1 No-Action Alternative

"No Action" means the USNRC denies the application for an ESP and no other generating station (either nuclear or non-nuclear) is constructed and operated.

The impacts of the No-Action Alternative are closely-related to a need for power, which has not been discussed in this ER; under Part 52, an analysis of the need for power is not required to issue an ESP (10 CFR 52.17).

As stated in NUREG-1555, *Standard Review Plans for Environmental Reviews of Nuclear Power Plants* (USNRC, 1999):

> *"The no-action alternative would result in the facility not being built, and no other facility would be built or other strategy implemented to take its place. This would mean that the electrical capacity to be provided by the project would not become available."*

Under the "No Action" alternative, the need for power would need to be met by other alternative means that involve no new generating capacity. These alternatives would include such approaches as demand-side management, energy conservation, and power purchased from other electricity providers. These alternatives are discussed in Section 9.2.1. Given the fact that the early site permit might not be used for twenty or more years, it is not feasible to evaluate other aspects of the need for power in a meaningful way at the ESP stage. Therefore, the need for power will not be evaluated as part of this ESP.

9.2 Energy Alternatives

The EGC ESP Facility will be constructed and operated as a merchant independent power producer (also referred to as a "merchant plant" or "merchant generator"). The power produced will be sold on the open wholesale market, without specific consideration to supplying a traditional service area or satisfying a reserve margin objective. Thus, discussion of the "relevant service area" for this facility is irrelevant and inconsistent with the facility's sales objectives and thus does not provide a means to evaluate the site in the context of a service territory, as has been historically the practice. Therefore, for the purposes of this alternatives analysis, the "region of interest" has been defined as the State of Illinois rather than the more traditional "relevant service area." The delineation of this region of interest is in keeping with current deregulation policies and the proposed location of the facility within the State of Illinois.

Alternatives that do not require new generating capacity were considered, and these include energy conservation and Demand-Side Management (DSM). Other alternatives that do require the construction of new generating capacity such as wind, geothermal, oil, natural gas, hydropower, Municipal Solid Wastes (MSW), coal, photovoltaic (PV) cells, solar power, wood waste/biomass, and energy crops were also analyzed. The technologies under consideration for the project were not regarded as alternatives.

While alternative energy technologies are reviewed here for the purposes of this ER, their availability was not important in selecting emerging nuclear technologies as the superior alternative. The decision to develop a nuclear power plant on land adjacent to the existing CPS was based on market factors such as the proximity to an already-licensed station, the ability to incorporate existing environmental permits in the operation and plant parameters, property ownership, and other location features conducive to the plant's intended merchant generating objective.

Alternatives that do not require new generating capacity are discussed in Section 9.2.1, while alternatives that do are discussed in Section 9.2.2. In Section 9.2.2, some of the alternatives that require new generating capacity were eliminated from further consideration and discussion based on their availability in the region, overall feasibility, and environmental consequences. In Section 9.2.3, the alternatives that were not eliminated based on these factors addressed in Section 9.2.2 are investigated in further detail relative to specific criteria such as environmental impacts, reliability, and economic costs.

9.2.1 Alternatives That Do Not Require New Generating Capacity

In 1997, Illinois General Assembly enacted the Electric Service Customer Choice and Rate Relief Law. It noted that the citizens and businesses of the State of Illinois had been well served by a comprehensive electrical utility system that had provided safe, reliable, and affordable service. The electrical utility system in the State had historically been subject to State and federal regulation, aimed at assuring the citizens and businesses of the State of safe, reliable, and affordable service, while at the same time assuring the utility system of a safe return on investment.

The Assembly noted that competitive forces were affecting the market for electricity as a result of federal regulatory and statutory changes and the activities of other states.

Competition in the electric services market created opportunities for new products and services for customers and lower costs for users of electricity. Long-standing regulatory relationships needed to be altered to accommodate the competition that fundamentally altered the structure of the electric services market.

Lawmakers saw that, with the advent of increasing competition in the industry, the State had a continued interest in assuring that the safety, reliability, and affordability of electrical power was not sacrificed to competitive pressures, and to that end, intended to implement safeguards to assure that the industry continued to operate the electrical system in a manner that would serve the public's interest. Under the existing regulatory framework, the industry had been encouraged to undertake certain investments in its physical plant and personnel to enhance its efficient operation, the cost of which it had been permitted to pass on to consumers. It recognized that the State had an interest in providing the existing utilities a reasonable opportunity to obtain a return on investments on which they depended in undertaking those commitments in the first instance which, at the same time, not permitting new entrants into the industry to take unreasonable advantage of the investments made by the formerly regulated industry.

The Assembly dictated that a competitive wholesale and retail market must benefit all Illinois citizens. They told the Illinois Commerce Commission to act to promote the development of an effectively competitive electricity market that operates efficiently and is equitable to all consumers. Consumer protections were put in place to ensure that all customers continue to receive safe, reliable, affordable, and environmentally safe electric service.

They further determined that all consumers must benefit in an equitable and timely fashion from the lower costs for electricity that result from retail and wholesale competition and receive sufficient information to make informed choices among suppliers and services.

To that end, in Illinois, merchant generators do not have to request the permission from the Illinois Commerce Commission (ICC) for siting approval or demonstrate to the ICC that they are needed to meet energy demand. The ICC is also not involved in any formal energy planning for the State.

This section is intended to provide an assessment of the economic and technical feasibility of supplying the demand for energy without constructing new generating capacity. Specific elements may to include:

- Initiating conservation measures (including implementing DSM actions),
- Reactivating or extending the service life of existing plants within the power system,
- Purchasing power from other utilities or power generators, and
- A combination of these elements that would be equivalent to the output of the project and therefore eliminate its need.

All of the above elements have been traditionally connected with an electric utility that supplies power within its service territory and not for a merchant generator whose revenue is derived from the sale of electricity generated from its own power plants. Therefore, alternatives that do not require additional generating capacity are not considered reasonable

alternatives to colocating a new merchant power plant with the CPS in Illinois. Nonetheless, an evaluation of these alternatives was performed within the context of emerging energy demands.

9.2.1.1 Initiating Conservation Measures

Historically, state regulatory bodies have required regulated utilities to institute programs designed to reduce demand for electricity. DSM programs included energy conservation and load modification measures. In the current deregulated Illinois market, EGC anticipates that it will not be able to offer competitively priced power if it has to retain an extensive conservation and load-modification-incentive program. However, EGC has evaluated the DSM alternative as a mitigative technique to the proposed action.

Traditionally, DSM programs either conserved energy or allowed the electric company to reduce customers' load requirements during periods of peak demand. DSM programs generally fall into the following categories:

9.2.1.1.1 Conservation Programs

- Educational programs that encourage the prudent use of energy
- Financial incentives to businesses and private customers
- Government - private partnerships to encourage conservation of energy resources.

9.2.1.1.2 Energy Efficiency Programs

- Discounted residential rates for homes that met specific energy efficiency standards
- Energy audit programs that provided residential energy audits and encouraged efficiency upgrades
- Incentive programs that encouraged customers to replace old, inefficient appliances or equipment with new high-efficiency appliances or equipment
- Government partnerships that assisted federal facilities in meeting mandated energy efficiency goals through design and installation of high-efficiency lighting systems and computerized energy management.

9.2.1.1.3 Load Management Programs

- Standby generator programs – encouraged customers to permit their electricity provider to switch loads to the customer's standby generators during periods of peak demand
- Interruptible service program – encouraged customers to allow blocks of their load to be interrupted during periods of peak demand
- Real time pricing – encouraged customers to discontinue electricity usage during specific times

Traditional utilities annually projected the summer and winter peak power, annual energy requirements, and impacts of DSM. Market and regulatory conditions, which provided the initial support for utility-sponsored conservation and DSM efforts during the late 1970s and early 1980s, can be broadly characterized by:

- Increasing long-term marginal prices for capacity and energy production resources

- Forecasts projecting increasing demand for electricity across the nation
- General agreement that conditions outlined above would continue for the foreseeable future
- Limited competition in the generation of electricity
- Economies of scale in the generation of electricity, which supported the construction of large central power plants, and
- The use of average embedded cost as the basis for setting electricity prices within a regulated context.

These market and regulatory conditions have undergone dramatic changes in a deregulated market, as previously described. Changes that have significantly impacted the cost effectiveness of utility-sponsored DSM, can be described as follows:

1. A decline in generation costs, due primarily to technological advances that have reduced the cost of constructing new generating units (e.g., the combined cycle gas generating facility), and
2. National energy legislation, which has encouraged wholesale competition through open access to the transmission grid, as well as state legislation designed to facilitate retail competition.

Consistent with (1) and (2) above, the typical electric utility planning environment has more recently been considering lower energy prices than during earlier periods, shorter planning horizons, lower reserve margins, and increased reliance on market prices to direct resource planning.

Other significant changes accompanying the newly deregulated marketplace include the following:

- The adoption of increasingly stringent national appliance standards for most major energy-using equipment and the adoption of energy efficiency requirements in state building codes. These mandates have further reduced the potential for cost-effective electric utility-sponsored measures.
- In states that are currently transitioning into deregulation, third parties are increasingly providing energy load management services and products in competitive markets at prices that reflect their value to the customer. Market conditions can be expected to continue this shift among providers of cost-effective load management.

For these reasons, EGC determined that DSM programs, which are primarily directed toward load management, are not a sufficient substitute for the generation contemplated by the EGC ESP Facility.

9.2.1.2 Reactivating or Extending Service Life of Existing Plants

Fossil plants slated for retirement tend to be ones that are old enough to have difficulty in economically meeting today's restrictions on air contaminant emissions. In the face of increasingly stringent environmental restrictions, delaying retirement, or reactivating plants

in order to compensate for the closure of a large base-loaded plant, would require major construction to upgrade or replace plant components. EGC concludes that the environmental impacts of such a scenario are bounded by its coal- and gas-fired alternatives discussed in Section 9.2.2.

9.2.1.3 Purchasing Power from Other Utilities or Power Generators

In a traditional alternatives analysis for examining the energy alternative to utility generation capacity, the purchased power alternative meant that the utility would meet a portion of its service territory demand using power that it purchased from another utility. Deregulation, however, has changed this traditional analysis. First, the end-user could purchase electricity from another entity (in this case, from a company other than EGC). Second, EGC expects retail competition to decrease generators' incentives to provide wholesale power to competing companies for resale, thus reducing the availability of power for EGC to purchase and resell competitively.

Because Illinois is a net exporter of power and would be fully deregulated, EGC assumes that in-state power could be purchased. For example, in 1999 Illinois exported 76 million kilowatt-hours of electricity (USDOE/EIA, 2001a). The GEIS, in Section 8.3, evaluated the environmental impacts of thirteen alternative energy sources (USNRC, 1996). EGC assumes that the generating technology producing purchased power would be one of the alternatives that were analyzed, and that the environmental impact from the alternative would occur to meet the market need.

Imported power from Canada or Mexico is unlikely to be available to supply the equivalent capacity of the EGC ESP Facility. In Canada, 62 percent of the country's electricity capacity is derived from renewable sources, principally hydropower (USDOE/EIA 2001). Canada has plans to continue developing hydroelectric power, but the plans generally do not include large-scale projects (USDOE/EIA, 2001). Canada's nuclear generation is projected to decrease by 1.7 percent by 2020, but its share of power generation in Canada is projected to decrease from 14 percent currently to 13 percent by 2020 (USDOE/EIA 2001). EIA projects that total gross U.S. imports of electricity from Canada and Mexico will gradually increase from 47.4 billion kilowatt-hours in 2000 to 66.1 billion kilowatt-hours in year 2005, and then gradually decrease to 47.4 billion kilowatt-hours in year 2020 (USDOE/EIA 2001). It is anticipated that the amount of electricity available for import from Canada and Mexico follows the amount of electricity that would be available for export from Canada and Mexico.

EGC has evaluated conventional and prospective purchase power supply options that could be reasonably implemented. In 1999, Unicom's subsidiary ComEd, completed a sale of its fossil-fuel-fired coal, gas, and oil units to Midwest Generation. As part of the sale, Unicom entered into long-term purchase contracts with Midwest Generation to provide firm capacity and energy (ComEd, 1999). Because these contracts are part of current and future capacity, however, EGC does not consider these power purchases to be a feasible source of power to satisfy the purchased power alternative.

If power were to be purchased from sources within the United States or a foreign country, the generating technology likely would be one of those described in this ER (probably coal, natural gas, or nuclear). The description of the environmental impacts of other technologies

described here is representative of the purchased electrical power alternative to the EGC ESP Facility. Thus, the environmental impacts of imported power would still occur, but would be located elsewhere within the region, nation, or another country.

9.2.2 Alternatives That Require New Generating Capacity

While many methods are available for generating electricity and many combinations or mixes can be assimilated to meet system needs, such expansive consideration would be too unwieldy to reasonably examine given the purposes of the alternatives analysis. In keeping with the USNRC's evaluation of alternatives to license renewal, a reasonable set of alternatives should be limited to analysis of single discrete electrical generation sources and those electric generation technologies that are technically reasonable and commercially viable (USNRC, 1996). Accordingly, EGC has not evaluated mixes of generating sources. The impacts from coal- and gas-fired generation presented in this chapter bounds the impacts from any generation mixture of the two technologies.

The current mix of power generation options in Illinois is one indicator of the feasible choices for electric generation technology within the state. EGC evaluated Illinois electric generation capacity and utilization characteristics. "Capacity" is the categorization of the various installed technology choices in terms of its potential output. "Utilization" is the degree to which each choice is actually used.

In 1999, Illinois's electric industry had a total generating capacity of 34,338 megawatts-electric. As Figure 9.2-1 indicates, this capacity includes units fueled by coal (46.7 percent); nuclear (31.2 percent); oil (3.2 percent); dual (e.g., oil/gas)-fired (0.9 percent); hydroelectric (0.1 percent); and other (2.3 percent) (USDOE/EIA, 2001).

Based on 1999 generation data, Illinois's electric industry provided approximately 164 terawatt hours of electricity. As Figure 9.2-2 depicts, Illinois's generation utilization was primarily from nuclear (50 percent), followed by coal (45.3 percent), gas (3.4 percent), oil (0.5 percent), other (0.7 percent), and hydroelectric (0.1 percent) (USDOE/EIA 2001).

The difference between capacity and utilization is the result of preferential usage by electricity suppliers. For example, in 1999, nuclear energy represented 31.2 percent of Illinois's installed capability, but produced 50 percent of the electricity generated (USDOE/EIA 2001, Tables 4 and 5). This reflects Illinois's preferential reliance on nuclear energy as a base-load generating source.

This section identifies alternatives that EGC has determined are not reasonable and the EGC basis for this determination. EGC's ESP application is premised on the installation of a facility that would primarily serve as a large base-load generator and that any feasible alternative would also need to be able to generate base-load power. In performing this evaluation, EGC relied heavily upon USNRC's Generic Environmental Impact Statement (GEIS) (USNRC, 1996).

The GEIS is useful for the analysis of alternative sources because the USNRC has determined that the technologies of these alternatives will enable the agency to consider the relative environmental consequences of an action given the environmental consequences of other activities that also meet the purpose of the proposed action. To generate the reasonable set of alternatives used in the GEIS, the USNRC included commonly known

generation technologies and consulted various state energy plans to identify the alternative generation sources typically being considered by state authorities across the country. From this review, the USNRC had established a reasonable set of alternatives to be examined. These alternatives include wind energy, PV cells, solar thermal energy, hydroelectricity, geothermal energy, incineration of wood waste and MSW, energy crops, coal, natural gas, oil, and delayed retirement of existing non-nuclear plants. The USNRC has considered these alternatives pursuant to its statutory responsibility under NEPA. Although the GEIS is for license renewal, the alternatives analysis in the GEIS can be compared to the proposed action to determine if the alternative represents a reasonable alternative to the proposed action.

Each of the alternatives are assessed and discussed in the subsequent sections relative to the following criteria:

- The alternative energy conversion technology is developed, proven, and available in the relevant region within the life of the ESP permit.
- The alternative energy source provides baseload generating capacity equivalent to the capacity needed, and to the same level as the proposed EGC ESP Facility.
- The alternative energy source does not result in environmental impacts in excess of a nuclear plant, and the costs of an alternative energy source do not exceed the costs that make it economically impractical.

Each of the potential alternative technologies considered in this analysis are consistent with national policy goals for energy use, and are not prohibited by federal, state, or local regulations. These criteria were not factors in evaluating alternative technologies.

Based on one or more of these criteria, several of the alternative energy sources were considered technically or economically infeasible after a preliminary review and were not considered further. Alternatives that were considered to be technically and economically feasible were assessed in greater detail in Section 9.2.3.

9.2.2.1 Wind

Wind resource maps usually identify areas by wind power class (See Figure 9.2-3). Although some midwestern states like North and South Dakota, as well as parts of Iowa, have excellent potential (Class 6 and above) for development of wind generation, the potential for generation is more intermittent in Illinois (ELPC, 2001).

In general, areas identified as Class 4 and above are regarded as potentially economical for wind energy production with current technology. The Department of Energy's Wind Program and National Renewable Energy Laboratory (NREL) wind resource maps for Illinois show that there are scattered areas in central and northern Illinois with the classification of Class 4 with the total of these sites capable of 3000 MWe of potential installed capacity for wind generation. The most favorable of these sites are located southeast of Quincy, the greater Bloomington area, north of Peoria, the Mattoon area, and between Sterling and Aurora (USDOE/EERE, 2004b). EGC does not own or have rights to build a wind generating station on these sites.

At a Class 4 site, the average annual output of a wind power plant is typically about 25 percent of the installed capacity (USDOE/EERE, 2004b). For example, a wind farm on all of the land area identified as Class 4 by NREL within Illinois would generate an average annual output of 750 MWe. In fact, the National Electric Reliability Council (NERC) credits wind capacity at approximately 17 percent (USNRC, 2004). More optimistic assessments place the capacity factor for a Class 4 wind facility at about 29 percent, rising to 35 percent in 2020 based upon assumed improvements in technology (ELPC, 2001). However, even using such numbers would not affect the conclusions presented below (e.g., land usage per average MWe would decrease proportionately with increasing capacity factors, but would still be several times higher than the land usage for a nuclear plant).

As a result of advances in technology and the current level of financial incentive support within Illinois, a number of additional areas with a slightly lower wind resource (Class 3+) may also be suitable for wind development. These would, however, operate at an even lower annual capacity factor and output than that used by NREL for Class 4 sites.

In Illinois, the total amount of Class 4 and 3+ lands is about 1800 km2 (695 mi^2, or 444,800 acres) and the wind potential from these sites is about 9000 MWe of installed capacity (USDOE/EERE, 2004b).

In any wind facility, the land use could be significant. Wind turbines must be sufficiently spaced to maximize capture of the available wind energy. If the turbines are too close together, one turbine can impact the efficiency of another turbine. A 2 MWe turbine requires only about a quarter of an acre of dedicated land for the actual placement of the wind turbine, leaving landowners with the ability to utilize the remaining acreage for some other uses that do not impact the turbine, such as agricultural use.

For illustrative purposes, if all of the resource in Class 3+ and 4 sites were developed using 2 MWe turbines, with each turbine occupying one-quarter acre, 9000 MWe of installed capacity would utilize 1125 acres just for the placement of the wind turbines alone. Based upon the NERC capacity factor, this project would have an average output of 1530 MWe (approximately 0.73 acres / MWe). This is a conservative assumption since Class 3+ sites will have a lower percentage of average annual output, but it is being used here for illustrative purposes. In contrast, the EGC ESP Facility (operating at 90 percent capacity) would have an average annual output of 1962 MWe (2180 MWe * 0.9) and would only occupy approximately 461 acres (approximately 0.23 acres / MWe).

Although wind technology is considered mature, technological advances may make wind a more economic choice for developers than other renewables (CEC, 2003). Technological improvements in wind turbines have helped reduce capital and operating costs. In 2000, wind power was produced in a range of $0.03 - $0.06 / kWh (depending on wind speeds), but by 2020 wind power generating costs are projected to fall to $0.03 - $0.04 / kWh (ELPC, 2001).

The installed capital cost of a wind farm includes planning, equipment purchase and construction of the facilities. This cost, typically measured in $/kWe at peak capacity, has decreased from more than $2,500/kWe in the early 1980's to less than $1,000/kWe for wind farms in the U.S. Illinois Rural Electric Cooperative recently installed a single 1.65 MWe turbine at a cost of $1.7 million (Halstead, 2004). This cost includes the purchase of the

turbine itself, construction of access roads and foundations, and connection to the transmission system. This decrease in construction costs is due primarily to improvements in wind turbine technology, but also to the general increase in wind farm sizes. Larger wind farms in windy areas benefit from economies of scale in all phases of a wind project from planning to decommissioning, as fixed costs can be spread over a larger total generating capacity. These "economies of scale" may not be available in the region of interest, given the availability of the resource (CEC, 2003).

As an example of cost, a wind generating facility that has an installed capacity of 75 MWe can produce power at a levelized rate of $0.049/kWh. With the Federal Production Tax Credit (PTC), the cost is reduced to $0.027 - $0.035/kWh. The PTC primarily reduced the tax burden and operating costs for wind generating facilities, which was vital to financing of facilities. The PTC expired in December 2003 and has not been renewed, even though it has support in the 2003 Energy Policy Act (U.S. Senate, 2003). As a result, a smaller number of completed wind projects in Illinois are anticipated. As the General Manager of the Illinois Rural Electric Cooperative explains "The energy bill stalled in Congress last fall, and still has not been passed, so right now there's not an authorization for production tax credits for new turbines. As a consequence, you're not going to have new turbines being installed by developers until that production tax credit returns. And the economics are such that you absolutely have to have a substantial body of grants and support as we do, and/or the production tax credits" (Halstead, 2004). As a tax credit, the PTC represented 1.8 cent per kWh of tax-free money to the project owner. If the owner did not receive the tax credit and wanted to recoup the 1.8 cents per kWh with taxable revenue from electricity sales, the owner would have to add at least 1.8 cents and possibly as much as 2.8 cents to the sales price of each kWh, assuming a 36-percent marginal tax rate.

The Energy Information Agency's (EIA) *Annual Energy Outlook 2004 with projections to 2025* assumes no extension of the PTC beyond 2003. Further, the EIA projects that the levelized cost of electricity generated by wind plants coming on line in 2006 (over a 20-year financial project life) would range from approximately 4.5 cents per kilowatthour at a site with excellent wind resources to 5.7 cents per kilowatthour at less favorable sites (USDOE/EIA, 2004a). In contrast, the levelized cost for electricity from new natural gas combined-cycle plants is 4.7 cents per kWh, and for new coal-fired plants, the projected cost in 2007 is 4.9 cents per kWh (USDOE/EIA, 2004a). Nuclear plants are anticipated to produce power in the range of 3.1 to 4.6 cents per kWh (USDOE, 2002) (USDOE, 2004).

In addition to the construction and operating and maintenance costs for wind farms, there are costs for connection to the transmission grid. Any wind project would have to be located where the project would produce economical generation and that location may be far removed from the nearest possible connection to the transmission system. A location far removed from the power transmission grid might not be economical, as new transmission lines will be required to connect the wind farm to the distribution system. Existing transmission infrastructure may need to be upgraded to handle the additional supply. Soil conditions and the terrain must be suitable for the construction of the towers' foundations. Finally, the choice of a location may be limited by land use regulations and the ability to obtain the required permits from local, regional and national authorities. The further a wind energy development project is from transmission lines, the higher the cost of connection to the transmission and distribution system. A recent report to Congress on

wind resource locations and transmission requirements in the upper Midwest (Upper Midwest for this report was defined as the States of North and South Dakota, Minnesota, Illinois, Iowa, Nebraska, and Wisconsin) concluded, "Transmission in the upper Midwest is generally constrained. In addition, because power generation is often transmitted over long distances to metropolitan centers, the upper Midwest has voltage and stability issues that must be considered. Since it is more economic to transmit wind from remote areas, developing more wind energy in remote areas may aggravate these voltage and stability issues (USDOE/EERE, 2004a)." In contrast, the EGC ESP site is located in southern Illinois, and is located near interties with the adjoining transmission systems.

The distance from transmission lines at which a wind developer can profitably build depends on the cost of the specific project. Consider, for example, the cost of construction and interconnection for a 115-kV transmission line that would connect a 50 MWe wind farm with an existing transmission and distribution network. The EIA estimated, in 1995, the cost of building a 115-kV line to be $130,000 per mile, excluding right-of-way costs (USDOE/EIA, 2004b). This amount includes the cost of the transmission line itself and the supporting towers. It also assumes relatively ideal terrain conditions, including fairly level and flat land with no major obstacles or mountains (more difficult terrain would raise the cost of erecting the transmission line.). In 1993, the cost of constructing a new substation for a 115-kV transmission line was estimated at $1.08 million and the cost of connection for a 115-kV transmission line with a substation was estimated to be $360,000 (USDOE/EIA, 1995).

In 1999, the USDOE analyzed the total cost of installing a wind facility in various NERC regions. They first looked at the distribution of wind resources and excluded land from development based on the classification of land. For example, land that is considered wetlands and urban are totally excluded whereas land that is forested has 50 percent of its land excluded. They then characterized those resources that were sufficiently close to existing 115- to 230-kV transmission lines, classified them into three distinct zones, and applied an associated standard transmission fee for connecting the new plant with the existing network. They then used additional cost factors to account for the greater distances between wind sites and the existing transmission networks. Capital costs were added based on whether the wind resource was technically accessible now and whether it could be economically accessible by 2020. Based on this USDOE analysis, Illinois has no known economically useful wind resources (USDOE/EIA, 1999a).

Another consideration on the integration of the wind capacity into the electric utility system is the variability of wind energy generation. Wind-driven electricity generating facilities must be located at sites with specific characteristics to maximize the amount of wind energy captured and electricity generated (ELPC, 2001). In addition, for transmission purposes, wind generation is not considered "dispatchable," meaning that the generator can control output to match load and economic requirements. Since the resource is intermittent, wind, by itself, is not considered a firm source of baseload capacity. The inability of wind alone to be a dispatchable, baseload producer of electricity is inconsistent with the objectives for the EGC ESP Facility.

Finally, wind does have environmental impacts, in addition to the land requirements posed by large facilities. First, some consider large-scale commercial wind farms to be an aesthetic problem. In one case, residents opposing the Cordelia Hills wind project in Solano County,

northeast of San Francisco, reportedly did not want to see turbines sited nearby, even though the hills chosen for the project already had numerous electronic relays and transmission lines. Aesthetic impacts were also a key factor behind opposition to wind development at Tejon Pass, one of the most scenic areas close to Los Angeles (NWCC, 1997). Second, high-speed wind turbine blades can be noisy, although technological advancements continue to lessen this problem. Finally, wind facilities sited in areas of high bird use can expect to have fatality rates higher than those expected if the wind facility were not there. Water within the vicinity of wind turbines, such as sites around the Great Lakes, may attract waterfowl and shorebirds, increasing the collision potential for water bird species, although other factors such as adjacent habitats and movement patterns would also greatly influence mortality near these water sources (NWCC, 2001). Land use and aesthetic impacts could be moderate to large, while other impacts to human health and the environment would be small. The environmental impacts of wind power are discussed in more detail in Table 9.2-7.

EGC has concluded that, due to the inability of wind power to generate baseload power, the projected land use impacts of development of Class 3+ and Class 4 sites in Illinois, the cost factors in construction and operation, along with the impacts associated with development, and cost of additional transmission facilities to connect all of these turbines to the transmission system, wind by itself is not a feasible alternative to the EGC ESP.

Wind power could be included in a combination of alternatives to the EGC ESP. The study of combinations is discussed in Section 9.2.3.3.

9.2.2.2 Geothermal

As illustrated by Figure 8.4 in the GEIS, geothermal plants might be located in the western continental United States, Alaska, and Hawaii, where hydrothermal reservoirs are prevalent. However, because there are no known high-temperature geothermal sites in the region of interest, EGC concludes that geothermal is not a reasonable alternative.

9.2.2.3 Hydropower

A small portion (about 80 MW) of Illinois utility generating capacity is hydroelectric. As the GEIS points out in Section 8.3.4, hydropower's percentage of United States generating capacity is expected to decline because hydroelectric facilities have become difficult to site as a result of public concern over flooding, destruction of natural habitat, and destruction of natural river courses. According to the U.S. Hydropower Resource Assessment for Illinois (INEL, 1997), there are no remaining sites in Illinois that would be environmentally suitable for a large hydroelectric facility.

The GEIS (Section 8.3.4) estimates land use of 1,600 mi^2 per 1,000 MWe generated by hydropower. Based on this estimate, a project the size of the EGC ESP Facility would require flooding more than 3,520 mi^2 resulting in a large impact on land use. Further, operation of a hydroelectric facility would alter aquatic habitats above and below the dam, which would impact existing aquatic species.

EGC has concluded that, due to the lack of suitable sites in Illinois and the amount of land needed (approximately 3,520 mi^2), in addition to the adverse environmental impacts, hydropower is not a reasonable alternative.

9.2.2.4 Solar Power

Solar energy is dependent on the availability and strength of sunlight (strength is measured as kWh/m^2). Solar power is considered an intermittent source of energy. This section addresses solar power alone and only those solar technologies capable of being connected to a transmission grid. Combinations of solar power with other generating sources are discussed in Section 9.2.3.3.

Solar power is not generally considered a baseload source. Storage technologies have not advanced to a point where solar power can be considered as feasible alternatives to large baseload capacity (USDOE/EERE, 2004e). However, all solar technologies provide a fuel-saving companion to a baseload source. These technologies can be divided into two groups. The first group concentrates the sun's energy to drive a heat engine (concentrating solar power systems). The other group of solar power technologies directly converts solar radiation into electricity through the photoelectric effect by using photovoltaics (also known as PV).

In Illinois, solar energy varies from 4-5 kWh/m^2/day in the summer to as low as 2-3 kWh/m^2/day in the winter (see figure 9.2-4). The areas with the highest amount of solar radiation are in the southwestern part of the state, with radiation rates of 6-7 kWh/m^2 at the brightest time of a summer day, but most of Illinois falls in the range of 5.5-6 kWh/m^2. This resource is relatively low, particularly when compared to the southwestern United States. For example, parts of southern California can generate 10-12 kWh/m^2 of solar radiation during the brightest part of summer days. From a national resource availability perspective, then, it can be seen that the region of interest is not an attractive location for development of solar power. In addition to the relatively low amount of solar resource available, solar radiation varies by month (USDOE/NREL, 2004c). Solar energy also has a definite diurnal characteristic – the sun does not shine at night. Recognizing the comparative "abundance" of solar energy in the region of interest and the intermittent nature of solar-based electricity generation, various solar technologies are discussed below.

9.2.2.4.1 Concentrating Solar Power Systems

Concentrating solar power plants only perform efficiently in very sunny locations, specifically the arid and semi-arid regions of the world (USDOE/EERE, 1999). This does not include Illinois.

Concentrating solar plants produce electric power by converting the sun's energy into high-temperature heat using various mirror configurations. The heat is then channeled through a conventional generator, via an intermediate medium (i.e., water or salt). Concentrating solar plants consist of two parts: one that collects the solar energy and converts it to heat, and another that converts heat energy to electricity.

Concentrating solar power systems can be sized for "village" power (10 kW) or grid-connected applications (up to 100 MW). Some systems use thermal energy storage (TES), setting aside heat transfer fluid in its hot phase during cloudy periods or at night. These attributes, along with solar-to-electric conversion efficiencies, make concentrating solar power an attractive renewable energy option in the Southwest of the United States and other Sunbelt regions worldwide (USDOE/EERE, 2004d). Others can be combined with natural gas. This type of combination is discussed in Section 9.2.3.3.

There are three kinds of concentrating solar power systems—troughs, dish/engines, and power towers—classified by how they collect solar energy (USDOE/EERE, 2004d). Each is briefly discussed below.

Trough systems: The sun's energy is concentrated by parabolically curved, trough- shaped reflectors onto a receiver pipe running along the inside of the curved surface. This energy heats oil flowing through the pipe and the heat energy is then used to generate electricity in a conventional steam turbine generator.

A collector field comprises many troughs in parallel rows aligned on a north-south axis. This configuration enables the single-axis troughs to track the sun from east to west during the day to ensure that the sun is continuously focused on the receiver pipes. Individual trough systems currently can generate about 80 MWe. Experimental trough systems in California can currently generate approximately 300 MWe.

Current storage capacity at trough plants is minimal – most plant only have a storage capacity of 25 percent. Trough designs can incorporate TES allowing for electricity generation several hours into the evening. Currently, all parabolic trough plants are "hybrids," meaning they use fossil-fueled generation to supplement the solar output during periods of low solar radiation. This type of combination is discussed in Section 9.2.3.3.

Dish/engine systems: A dish/engine system is a stand-alone unit composed primarily of a collector, a receiver, and an engine. The sun's energy is collected and concentrated by a dish-shaped surface onto a receiver that absorbs the energy and transfers it to the engine's working fluid. The engine converts the heat to mechanical power in a manner similar to conventional engines—that is, by compressing the working fluid when it is cold, heating the compressed working fluid, and then expanding it through a turbine or with a piston to produce work. The mechanical power is converted to electrical power by an electric generator or alternator.

Dish/engine systems use dual-axis collectors to track the sun. The ideal concentrator shape is parabolic, created either by a single reflective surface, multiple reflectors, or facets. Many options exist for receiver and engine type, including Stirling engine and Brayton receivers.

Dish/engine systems are not commercially available yet, although ongoing demonstrations indicate the potential for commercial viability. Individual dish/engine systems currently can generate about 25 kW of electricity. More capacity is possible by connecting dishes together. These systems can be combined with natural gas generation and the resulting hybrid provides continuous power generation. This type of combination is discussed in Section 9.2.3.3.

Power tower systems: The sun's energy is concentrated by a field of hundreds or even thousands of mirrors (called "heliostats") onto a receiver located on top of a tower. This energy heats molten salt flowing through the receiver, and the salt's heat energy is then used to generate electricity in a conventional steam turbine generator. The molten salt retains heat efficiently, so it can be stored for hours or even days before it loses its capacity to generate electricity. Solar Two, a demonstration power tower located in the Mojave Desert in California, generated about 10 MW of electricity before the project was discontinued in 1999.

In these systems, the molten salt at 550°F is pumped from a "cold" storage tank through the receiver, where it is heated to 1,050°F and then on to a "hot" tank for storage. When power is needed from the plant, hot salt is pumped to a steam generating system that produces steam to power a turbine generator. From the steam generator, the salt is returned to the cold tank, where it is stored and eventually reheated in the receiver.

With TES, power towers can operate at an annual capacity factor of 65 percent which means they can potentially operate for 65 percent of the year without the need for a back-up fuel source. Without energy storage, solar technologies like this are limited to annual capacity factors near 25 percent. The power tower's ability to operate for extended periods of time on stored solar energy separates it from other solar energy technologies.

Concentrating solar energy systems have a close resemblance to most power plants operated by the nation's power industry and their ability to provide central generation. Concentrating solar power technologies utilize many of the same technologies and equipment used by conventional power plants, simply substituting the concentrated power of the sun for the combustion of fossil fuels to provide the energy for conversion into electricity. This "evolutionary" aspect—as distinguished from "revolutionary" or "disruptive"—allows for easy integration into the transmission grid. It also makes concentrating solar power technologies the most cost-effective solar option for the production of large-scale electricity generation (10 MWe and above).

While concentrating solar power technologies currently offer the lowest-cost solar electricity for large-scale electricity generation, these technologies are still in the demonstration phase of development and cannot be considered competitive with fossil- or nuclear-based technologies (CEC, 2003). Current technologies cost 9 to 12 cents per kilowatt-hour (kWh). New innovative hybrid systems that combine large concentrating solar power plants with conventional natural gas combined cycle or coal plants can reduce costs to $1.5 per watt and drive the cost of producing electricity from solar power to below 8 cents per kWh (USDOE/EERE, 2004b). This type of combination is discussed in Section 9.2.3.3. Future advances are expected to allow electricity from solar power to be generated for 4 to 5 cents per kWh in the next few decades (USDOE/EERE, 2004d). In contrast, nuclear plants are anticipated to produce power in the range of 3.1 to 4.6 cents per kWh (USDOE, 2002) (USDOE, 2004).

9.2.2.4.2 Photovoltaic Cells

The second main method for capturing the sun's energy is through the use of photovoltaics. A typical PV or solar cell might be a square that measures about 4 inches (10 cm) on a side. A cell can produce about 1 watt of power—more than enough to power a watch, but not enough to run a radio.

When more power is needed, some 40 PV cells can be connected together to form a "module." A typical module is powerful enough to light a small light bulb. For larger power needs, about 10 such modules are mounted in PV "arrays," which can measure up to several meters on a side. The amount of electricity generated by an array increases as more modules are added.

"Flat-plate" PV arrays can be mounted at a fixed-angle facing south, or they can be mounted on a tracking device that follows the sun, allowing them to capture more sunlight over the

course of a day. Ten to 20 PV arrays can provide enough power for a household; for large electric utility or industrial applications, hundreds of arrays can be interconnected to form a single, large PV system (USDOE/EERE, 2004b). According to USDOE estimates, land use for this technology is approximately 2.5 ac to 12 ac/MWe (USDOE/NREL, 2004b).

Some PV cells are designed to operate with concentrated sunlight, and a lens is used to focus the sunlight onto the cells. This approach has both advantages and disadvantages compared with flat-plate PV arrays. Economics of this design turns on the use of as little of the expensive semiconducting PV material as possible, while collecting as much sunlight as possible. The lenses cannot use diffuse sunlight, but must be pointed directly at the sun and move to provide optimum efficiency. Therefore, the use of concentrating collectors is limited to the west and southwest areas of the country. According to the USDOE estimates, land use for this method is approximately 5 ac to 12 ac/MWe (USDOE/NREL, 2004a).

Available photovoltaic cell conversion efficiencies are in the range of approximately 15 percent (15 percent) (Siemens, 2004). The average solar energy falling on a horizontal surface in the Illinois region in June, a peak month for sunlight, is approximately 4 to 5 kWh/m^2 per day (USDOE/EERE, 2004b). If an average solar energy throughout the year of approximately 5 kWh/m^2 per day and a conversion efficiency of 15 percent were used, photovoltaic cells would yield an annual electricity production of approximately 274 kWh/m^2 per year in Illinois. At this rate of generation, generating base-loaded electricity equivalent to the EGC ESP Facility would require approximately 62,726,715 m^2 [(2180 MWe (See ER Sec. 3.7.2) *0.9 * 8760 hr/yr * 1000 kW/MW / 274 kWh/m^2/yr)] or approximately 63 km^2 (24 mi^2) of PV arrays.

The same values that drive the PV system market also set the wide range of PV costs. The high range of capital costs of $5 to $12 per watt is offset by low operating costs, measured in kWh. The 20-year life-cycle cost ranged from 20 to 50 cents per kWh (USDOE/EERE, 2004f).

Currently, photovoltaic solar power is not competitive with other methods of producing electricity for the open wholesale electricity market. When determining the cost of solar systems, the totality of the system must be examined. There is the price per watt of the solar cell, price per watt of the module (whole panel), and the price per watt of the entire system. It is important to remember that all systems are unique in their quality and size, making it difficult to make broad generalizations about price. The average PV cell price was $2.40 per peak watt in 2000 and the average per peak watt cost of a module was $3.46 in the same year (USDOE/EIA, 1999). The module price however does not include the design costs, land, support structure, batteries, an inverter, wiring, and lights/appliances. With all of these included, a full system can cost anywhere from $7 to $20 per watt (Fitzgerald, 2004). Costs of PV cells in the future may be expected to decrease with improvements in technology and increased production. Optimistic estimates are that costs of grid-connected PV systems could drop to $2,275 per kW and to $0.15 to $0.20 per kWh by 2020 (ELPC, 2001). These costs would still be substantially in excess of the costs of power from a new nuclear plant.

9.2.2.4.3 Environmental Impacts

Land use and aesthetics are the primary environmental impacts of solar power. Land requirements for each of the individual solar energy technologies is large, compared to the land used for the EGC ESP Facility. The land required for the solar generating technologies

discussed here ranges from 3 to 12 ac/MWe compared to 0.23 acres per MWe for nuclear. In addition, this land use is pre-emptive; land used for solar facilities would not be available for other uses such as agriculture.

Depending on the solar technology used, there may be thermal discharge impacts. These impacts are anticipated to be small. During operation, PV and solar thermal technologies produce no air pollution, little or no noise, and require no transportable fuels.

There are environmental impacts of PV related to manufacture and disposal. The process to manufacture PV cell is similar to the production of a semiconductor chip. Chemicals used in the manufacture of PV cells include cadmium and lead. Potential human health risks also arise from the manufacture and deployment of PV systems, since there is a risk of exposure to heavy metals such as selenium and cadmium during use and disposal (CEC, 2004). There is some concern that landfills could leach cadmium, mercury, and lead into the environment in the long term. Generally, PV cells are sealed and the risk of release is considered slight, however, the long-term impact of these chemicals in the environment is unknown. Another environmental consideration with solar technologies is the lead-acid batteries that are used with some systems. The impact of these lead batteries is lessening, however, as batteries become more recyclable, batteries of improved quality are produced and better quality solar systems that enhance battery lifetimes are created (Real, et. al., 2001).

9.2.2.4.4 Summary

Solar power alone cannot be used to generate baseload power, because of the intermittent nature of the resource. Therefore, solar power alone is not a reasonable alternative to the baseload generating facility being considered for the Clinton site. Solar power in combination with storage facilities (e.g., power troughs with molten salt storage) can be used to generate baseload power. However, such a facility is still in the developmental stage and such facilities (and solar facilities in general) are not economically competitive alternatives to the proposed EGC ESP Facility because the resource is intermittent and incoming solar radiation is low for most of the year throughout the region of interest. Additionally, there are potential environmental impacts associated with any large-scale solar generation facilities. Land use and aesthetic impacts would most likely be large compared to a nuclear plant.

The solar resource could contribute to a competitive combination of alternative energy sources. This combination of alternatives is discussed in Section 9.2.3.3.

9.2.2.5 Wood Waste (and Other Biomass)

The use of wood waste to generate electricity is largely limited to those states with significant wood resources, such as California, Maine, Georgia, Minnesota, Oregon, Washington, and Michigan. Electric power is generated in these states by the pulp, paper, and paperboard industries, which consume wood and wood waste for energy, benefiting from the use of waste materials that could otherwise represent a disposal problem. However, the largest wood waste power plants are 40 to 50 MW in size.

Nearly all of the wood-energy-using electricity generation facilities in the United States use steam turbine conversion technology. The technology is relatively simple to operate and it can accept a wide variety of biomass fuels. However, at the scale appropriate for biomass,

the technology is expensive and inefficient. Therefore, the technology is relegated to applications where there is a readily available supply of low-, zero-, or negative-cost delivered feedstocks.

Further, as discussed in Section 8.3.6 of the GEIS, construction of a wood-fired plant would have an environmental impact that would be similar to that for a coal-fired plant, although facilities using wood waste for fuel would be built on smaller scales. Like coal-fired plants, wood-waste plants require large areas for fuel storage, processing, and waste disposal (i.e., ash). Additionally, operation of wood-fired plants has environmental impacts, including impacts on the aquatic environment and air.

EGC has concluded that, due to the lack of significant wood resources in Illinois and the lack of an obvious environmental advantage, wood energy is not a reasonable alternative.

9.2.2.6 Municipal Solid Waste

As discussed in Section 8.3.7 of the GEIS, the initial capital costs for municipal solid waste plants are greater than for comparable steam turbine technology at wood-waste facilities. This is due to the need for specialized waste separation and handling equipment.

The decision to burn municipal solid waste to generate energy is usually driven by the need for an alternative to landfills, rather than by energy considerations. The use of landfills as a waste disposal option is likely to increase in the near term; however, it is unlikely that many landfills will begin converting waste to energy due to the numerous obstacles and factors that may limit the growth in MSW power generation. Chief among them are environmental regulations and public opposition to siting MSW facilities.

Estimates in the GEIS suggest that the overall level of construction impacts from a waste-fired plant should be approximately the same as that for a coal-fired plant. Additionally, waste-fired plants have the same or greater operational impacts (including impacts on the aquatic environment, air, and waste disposal). Some of these impacts would be moderate, but still larger than the proposed action.

EGC has concluded that, due to the high costs and lack of obvious environmental advantages, burning municipal solid waste to generate electricity is not a reasonable alternative.

9.2.2.7 Energy Crops

In addition to wood and municipal solid waste fuels, there are several other concepts for fueling electric generators, including burning energy crops, converting crops to a liquid fuel such as ethanol (ethanol is primarily used as a gasoline additive), and gasifying energy crops (including wood waste). As discussed in Section 8.3.8 of the GEIS, none of these technologies has progressed to the point of being competitive on a large scale or of being reliable enough to replace a base-load plant.

Further, estimates in the GEIS suggest that the overall level of construction impacts from a crop-fired plant should be approximately the same as that for a wood-fired plant. Additionally, crop-fired plants would have similar operational impacts (including impacts on the aquatic environment and air). In addition, these systems have large impacts on land use, due to the acreage needed to grow the energy crops.

EGC has concluded that, due to the high costs and lack of obvious environmental advantage, burning other biomass-derived fuels is not a reasonable alternative.

9.2.2.8 Petroleum Liquids (Oil)

Illinois has several oil-fired units; however, they produce less than one percent of the State's electricity. The cost of oil-fired operation is much more expensive than nuclear or coal-fired operation. The high cost of oil has prompted a steady decline in its use for electricity generation. From 1997 to 1998, production of electricity by oil-fired plants dropped by about 39.9 percent in Illinois (USDOE/EIA, 1998).

Also, construction and operation of an oil-fired plant would have environmental impacts. For example, Section 8.3.11 of the GEIS estimates that construction of a 1,000-MWe oil-fired plant would require about 120 ac. Additionally, operation of oil-fired plants would have environmental impacts (including impacts on the aquatic environment and air) that would be similar to those from a coal-fired plant (USNRC, 1996).

EGC has concluded that, due to the high fuel costs and lack of obvious environmental advantage, oil-fired generation is not a reasonable alternative.

9.2.2.9 Fuel Cells

Phosphoric acid fuel cells are the most mature fuel cell technology, but they are only in the initial stages of commercialization. Two hundred turnkey plants have been installed in the United States, Europe, and Japan. Recent estimates suggest that a company would have to produce about 100 MW of fuel cell stacks annually to achieve a price of $1,000 to $1,500 per kilowatt. However, the current combined production capacity of fuel cell manufacturers only totals about 60 MW per year (KE, 2002). EGC believes that this technology has not matured sufficiently to support production for a base load facility. EGC has concluded that, due to the cost and production limitations, fuel-cell technology is not a reasonable alternative.

9.2.2.10 Coal

Coal-fired steam electric plants provide the majority of electric generating capacity in the U.S., accounting for about 56 percent of the electric utility industry's net generation and 43 percent of its capacity in 1992 (USDOE/EIA, 1994). Conventional coal-fired plants generally include two or more generating units and have total capacities ranging from 100 MWe to more than 2,000 MWe. Coal is likely to continue to be a reliable energy source well into the future (USDOE/EIA, 1993), assuming environmental constraints do not cause the gradual substitution of other fuels.

The U.S. has abundant low-cost coal reserves, and the price of coal for electric generation is likely to increase at a relatively slow rate. Even with recent environmental legislation, new coal capacity is expected to be an affordable technology for reliable, near-term development and for potential use as a replacement technology for nuclear power plants (USNRC, 1996).

The environmental impacts of constructing a typical coal-fired steam plant are well known because coal is the most prevalent type of central generating technology in the U.S. The impacts of constructing a 1,000-MWe coal plant at a greenfield site can be substantial, particularly if it is sited in a rural area with considerable natural habitat. An estimated 1,700

ac would be needed, and this could amount to the loss of about 3 mi^2 of natural habitat and/or agricultural land for the plant site alone, excluding land required for mining and other fuel cycle impacts (USNRC, 1996).

EGC defined the coal-fired alternative as consisting of four 550-MWe units. EGC chose this configuration to be equivalent to the gas-fired alternative described below. This equivalency makes impact characteristics most comparable, facilitating impact analysis

Table 9.2-3 describes assumed basic operational characteristics of the coal-fired units. EGC based its emission control technology and percent-control assumptions on alternatives that the USEPA has identified as being available for minimizing emissions (USEPA, 1998). For the purposes of analysis, EGC has assumed that coal and lime (calcium oxide) would be delivered by rail after upgrading the existing rail spur into CPS.

Based on the well-known technology, fuel availability, and generally understood environmental impacts associated with constructing and operating a coal-fired power generation plant, it is considered a competitive alternative and is therefore examined further in Section 9.2.3.

9.2.2.11 Natural Gas

EGC has chosen to evaluate gas-fired generation, using combined-cycle turbines, because it has determined that the technology is mature, economical, and feasible. A scenario, for example, of four units with a net capacity of 2,200 MWe could be assumed to equal the EGC ESP Facility total net capacity. However, EGC's experience indicates that, although customized unit sizes can be built, using standardized sizes is more economical. Existing manufacturers' standard-sized units include a gas-fired combined-cycle plant of 550-MWe net capacity, consisting of two 184-MWe gas turbines (e.g., General Electric Frame 7FA) and 182 MWe of heat recovery capacity.

EGC assumed four 550-MWe units, having a total capacity of 2,200 MWe, as the gas-fired alternative at the EGC ESP Site. This provides the approximate EGC ESP capacity for estimating the environmental impacts of this alternative. Any shortfall in capacity could be replaced by other methods, such as purchasing power. However, for the reasons discussed above, EGC did not analyze a mixture of these alternatives and purchased power.

Table 9.2-5 describes assumed basic operational characteristics of the gas-fired units. As for the coal-fired alternative, EGC based its emission control technology and percent-control assumptions on alternatives that the EPA has identified as being available for minimizing emissions (USEPA, 1998). For the purposes of analysis, EGC has assumed that there would be sufficient gas availability.

Based on the well-known technology, fuel availability, and generally understood environmental impacts associated with constructing and operating a natural gas-fired power generation plant, it is considered a competitive alternative and is therefore examined further in Section 9.2.3.

9.2.3 Assessment of Reasonable Alternative Energy Sources and Systems

This chapter evaluates the environmental impacts from what EGC has determined to be reasonable alternatives to the EGC ESP Facility: coal-fired generation, and gas-fired generation.

EGC has identified the significance of the impacts associated with each issue as Small, Moderate, or Large. This characterization is consistent with the criteria that USNRC established in 10 CFR 51, Appendix B, Table B-1, Footnote 3 as follows:

- SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small.
- MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource.
- LARGE - Environmental effects are clearly noticeable and are sufficient to destabilize any important attributes of the resource.

In accordance with National Environmental Policy Act (NEPA) practice, EGC considered ongoing and potential additional mitigation in proportion to the significance of the impact to be addressed (i.e., impacts that are small receive less mitigative consideration than impacts that are large).

9.2.3.1 Coal-Fired Generation

The USNRC evaluated environmental impacts from coal-fired generation alternatives in the GEIS (USNRC, 1996) and concluded that construction impacts could be substantial, due in part to the large land area required (which can result in natural habitat loss) and the large workforce needed. USNRC pointed out that siting a new coal-fired plant where an existing nuclear plant is located would reduce many construction impacts. USNRC identified major adverse impacts from operations as human health concerns associated with air emissions, waste generation, and losses of aquatic biota due to cooling water withdrawals and discharges.

The coal-fired alternative defined by EGC in Section 9.2.2.10 would be located at the EGC ESP Site.

9.2.3.1.1 Air Quality

Air quality impacts of coal-fired generation are considerably different from those of nuclear power. A coal-fired plant would emit sulfur dioxide (SO_2, as SO_x surrogate), oxides of nitrogen (NO_x), particulate matter (PM), and carbon monoxide (CO), all of which are regulated pollutants. As Section 9.2.2.10 indicates, EGC has assumed a plant design that would minimize air emissions through a combination of boiler technology and post-combustion pollutant removal. EGC estimates the coal-fired alternative emissions to be as follows:

SO_x = 8,127 tons per year

NO_x = 2,054 tons per year

CO = 2,118 tons per year

PM:

PM = 292 tons per year

PM_{10} (particulates having a diameter of less than 10 microns) = 67 tons per year

Table 9.2-1 presents the methodology and basis for the above emission figures.

Coal combustion results in emissions of heavy metals such as mercury, hazardous air pollutants such as benzene, polychlorinated dibenzo-p-dioxins, and polychlorinated dibenzo-fuiana.

In 1999, emissions of SO_2 and NO_X from Illinois's generators ranked 7th and 4th highest nationally, respectively (USDOE/EIA, 2002). In fact, seventeen Illinois generators were cited in the Clean Air Act Amendments of 1990 as requiring that by 1995 they be in compliance with stricter emission controls for SO_2 and NO_x. The acid rain requirements of the Clean Air Act Amendments capped the nation's SO_2 emissions from power plants. Each company having fossil-fuel-fired units was allocated SO_2 allowances. To be in compliance with the Act, the companies must hold enough allowances to cover their annual SO_2 emissions. EGC, having no fossil units, would have to purchase allowances from the open market to operate a fossil-fuel-burning plant at the EGC ESP Site. A company that has fossil units might also have the option of shutting down existing capacity and applying credits from that plant to the new one, thus mitigating the air quality impacts of these generating sources.

Both SO_2 and NO_X will increase with operation of a new coal-fired plant at the EGC ESP Site. In order to operate a fossil-fuel-fired plant at the site, EGC would have to obtain sufficient pollution credits to cover annual emissions either from the set-aside pool or by purchasing pollution credits from other sources.

While this option is available, it is unlikely that it will be feasible for a new generating facility. In October 1998, EPA promulgated the NO_x State Implementation Plan Call regulation that requires 22 states, including Illinois, to reduce their NO_x emissions by over 30 percent to address national ozone transport (USEPA, 2001). The regulation imposes a NO_x "budget" to limit the NO_x emissions from each state. The IEPA allocated NO_x credits among the existing electrical generating units in the State (IAC, 2000). Beginning May 31, 2004, each electrical generating unit must hold enough NO_x credits to cover its annual NO_x emissions. A small percentage of NO_x credits was set aside for new sources.

The likelihood, however, of buying setoffs for a new facility is extremely remote, if at all possible. This being the case, the coal-fired alternative, while possible, will not be economically feasible since there are no mitigating efforts (like emissions trading) to make the alternative worthwhile. In addition, emission credits' trading generally applies to non-attainment areas. The site that EGC has chosen as the preferred site is located in an attainment area, making emission credit trading not effective as a mitigation technique.

The USNRC did not quantify coal-fired emissions, but implied that air impacts from fossil fuel generation would be substantial. The USNRC noted that adverse human health effects from coal combustion have led to important federal legislation in recent years and that

public health risks, such as cancer and emphysema, have been associated with coal combustion. USNRC also mentioned global warming and acid rain as potential impacts. EGC concludes that federal legislation and large-scale concerns, such as global warming and acid rain, are indications of concerns about destabilizing important attributes of air resources. However, SO_2 emission allowances, NO_x emission offsets, low NO_x burners, overfire air, fabric filters or electrostatic precipitators, and scrubbers are regulatorily imposed mitigation measures. As such, EGC concludes that the coal-fired alternative may have moderate to large impacts on air quality; the impacts may be clearly noticeable and may destabilize air quality in the area.

9.2.3.1.2 Waste Management

EGC concurs with the GEIS assessment that the coal-fired alternative would generate substantial solid waste. The coal-fired plant, using coal having an ash content of 6.9 percent, would annually consume approximately 8,500,000 tons of coal (Table 9.2-1). Particulate control equipment would collect most (99.9 percent) of this ash, approximately 584,000 tons per year. Illinois regulations encourage recycling of coal-combustion by-products. ComEd, as the former owner of certain fossil fuel electric generating facilities now currently owned by Mid-West Generation historically recycled 87 percent of its coal ash (ComEd, 2000). Assuming continuation of this waste mitigation measure, the coal-fired alternative would generate approximately 76,000 tons of ash per year for disposal.

SO_x-control equipment, annually using nearly 150,000 tons of calcium oxide, would generate another 443,000 tons per year of waste in the form of scrubber sludge. EGC estimates that ash and scrubber waste disposal over a 40-yr plant life would require approximately 234 ac (a square area with sides of approximately 3,200 ft). Table 9.2-4 shows how EGC calculated ash and scrubber waste volumes.

With proper placement of the facility, coupled with current waste management and monitoring practices, waste disposal would not destabilize any resources. There would be space within the EGC ESP Site footprint for this disposal. After closure of the waste site and revegetation, the land would be available for other uses. For these reasons, EGC believes that waste disposal for the coal-fired alternative would have moderate impacts; the impacts of increased waste disposal would be clearly noticeable, but would not destabilize any important resource and further mitigation of the impact would be unwarranted.

9.2.3.1.3 Other Impacts

Construction of the power block and coal storage area would impact approximately 300 ac of land and associated terrestrial habitat. Because most of this construction would be in previously disturbed areas, impacts would be minimal. Visual impacts would be consistent with the industrial nature of the site. As with any large construction project, some erosion, collection of lake sedimentation, and fugitive dust emissions could be anticipated, but would be minimized by using best management practices. It is assumed that construction debris from clearing and grubbing could be disposed of on site and municipal waste disposal capacity would be available. Socioeconomic impacts would result from the approximately 250 people needed to operate the coal-fired facility. EGC believes that these impacts would be small due to the mitigating influence of the site's proximity to the surrounding population area. Cultural resource impacts would be unlikely, due to the previously disturbed nature of the site, and could be, if needed, minimized by survey and recovery techniques.

Impacts to aquatic resources and water quality would be minimized but could be construed as moderate due to the plant's use of a new cooling water system. The new stacks, boilers, and rail deliveries would be an incremental addition to the visual impact from existing CPS structures and operations. Coal delivery would add noise and transportation impacts associated with unit-train traffic.

EGC believes that other construction and operation impacts would be small. In most cases, the impacts would be detectable, but they would not destabilize any important attribute of the resource involved. Due to the minor nature of these impacts, mitigation would not be warranted beyond that mentioned.

9.2.3.1.4 Design Alternatives

The CPS Site location lends itself to coal delivery by rail.

Use of cooling towers as the cooling mechanism for coal-fired generation would reduce cooling water intake and discharge water usage by 90 percent when compared to once thru cooling as is used currently by the CPS. Use of cooling towers would reduce impingement, entrainment, and thermal impacts, increase consumptive water use through evaporation, and introduce a visual impact (100-foot-high mechanical towers or 600-foot-high natural draft towers). Wet/dry cooling towers may be used to reduce makeup water consumption to match water demand with available water supply.

9.2.3.2 Natural Gas Generation

The USNRC evaluated environmental impacts from gas-fired generation alternatives in the GEIS, focusing on combined-cycle plants. Section 9.2.2.11 presents EGC's reasons for defining the gas-fired generation alternative as a combined-cycle plant on the EGC ESP Site. Land-use impacts from gas-fired units on the site would be less than those of the coal-fired alternative. Reduced land requirements, due to construction on the existing site and a smaller facility footprint would reduce impacts to ecological, aesthetic, and cultural resources as well. As discussed under "Other Impacts," an incremental increase in the workforce could have socioeconomic impacts. Human health effects associated with air emissions would be of concern, but the effect would likely be less than those presented by coal-fired generation. Aquatic biota losses due to cooling water withdrawals would be exacerbated by the concurrent operation of CPS.

The gas-fired alternative defined by EGC in Section 9.2.2.11 would be located at the EGC ESP Site.

9.2.3.2.1 Air Quality

Natural gas is a relatively clean-burning fossil fuel. Also, because the heat recovery steam generator does not receive supplemental fuel, the combined-cycle operation is highly efficient (56 percent vs. 33 percent for the coal-fired alternative). Therefore, the gas-fired alternative would release similar types of emissions, but in lesser quantities than the coal-fired alternative. Control technology for gas-fired turbines focuses on the reduction of NO_x emissions. EGC estimates the gas-fired alternative emissions to be as follows:

- SO_x = 177 tons per year
- NO_x = 568 tons per year

- CO = 120 tons per year
- PM = 99 tons per year (all particulates are PM_{10})

Table 9.2-2 presents the methodology and basis for the above emission figures.

The Section 9.2.3.1 discussion of regional air quality, Clean Air Act requirements, and the NO_x State Implementation Plan Call is also applicable to the gas-fired generation alternative. NO_x effects on ozone levels, SO_x allowances, and NO_x emission offsets could be issues of concern for gas-fired combustion. The emissions from a gas-fired plant are substantial. EGC concludes that emissions from a gas-fired alternative located at the EGC ESP Site may noticeably alter local air quality, but may not destabilize regional resources. Air quality impacts would therefore be moderate, but substantially larger than those of nuclear generation.

9.2.3.2.2 Waste Management

Gas-fired generation would result in almost no waste generation, producing minor (if any) impacts. EGC concludes that gas-fired generation waste management impacts would be small.

9.2.3.2.3 Other Impacts

Similar to the coal-fired alternative, the ability to construct the gas-fired alternative on the EGC ESP Site would reduce construction-related impacts relative to construction on a greenfield site.

To the extent practicable, EGC would route the gas supply pipeline along previously disturbed rights-of-way to minimize impacts. However, this would still be a costly (i.e., approximately $1 million/mi) and potentially controversial action with ecological impacts from installation of a minimum of 2.5 mi of buried 24-in. gas pipeline to the EGC ESP Site. An easement encompassing 30 to 40 ac would need to be graded to permit the installation of the pipeline. Construction impact would be minimized through the application of best management practices that minimize soil loss and restore vegetation immediately after the excavation is backfilled. Construction would result in the loss of some less mobile animals (e.g., frogs and turtles). Because these animals are common throughout the area, EGC expects negligible reduction in their population as a result of construction. EGC does not expect that installation of a gas pipeline would create a long-term reduction in the local or regional diversity of plants and animals. In theory, these impacts from construction of a pipeline could be reduced or eliminated by locating the gas-fired plant at a different site adjacent to an existing pipeline.

The USNRC estimated in the GEIS that 110 ac would be needed for a plant site; this much previously disturbed acreage is available at the EGC ESP Site, reducing loss of terrestrial habitat. Aesthetic impacts, erosion and sedimentation buildup, fugitive dust, and construction debris impacts would be similar to the coal-fired alternative, but smaller because of the reduced site size. Socioeconomic impacts would result from the approximately 150 people needed to operate the gas-fired facility as estimated in the GEIS. EGC expects this number to be closer to 40 to 80 workers for a plant this size. EGC believes that these impacts would be small due to the mitigating influence of the site's proximity to the surrounding population area.

Use of cooling towers as the cooling mechanism for gas-fired generation would reduce cooling water intake and discharge by 90 percent when compared to once thru cooling as is used currently by the CPS. Use of cooling towers would also reduce impingement, entrainment, and thermal impacts, increase consumptive water use through evaporation, and introduce a visual impact (100-foot-high mechanical towers or 600-ft-high natural draft towers). Wet / dry cooling towers may be used to reduce makeup water consumption to match water demand with available water supply.

9.2.3.3 Combination of Alternatives

This section examines combinations of alternatives that could generate baseload power in an amount equivalent to the proposed EGC ESP Facility.

As discussed in Section 9.2.2.1, the capacity of the EGC ESP facility is 2180 MWe, with an annual energy output of about 17,200,000 MWh. There are a number of combinations of alternatives that have the potential of producing this baseload capacity and output.

Because of the intermittent nature of the resource and the lack of cost-effective technology, wind and solar are not sufficient on their own to generate the equivalent baseload capacity or output of the EGC ESP Facility, as discussed in Section 9.2.2.1 and 9.2.2.4. As shown in Sections 9.2.3.1 and 9.2.3.2, fossil-fired generation generates baseload capacity, but environmental impacts are greater than the EGC ESP Facility. It is conceivable, however, that a combination of alternatives (renewables in combination with fossil-fired generation) might be cost-effective and have less environmental impact than the EGC ESP Facility.

There is a multitude of possible combinations when considering the power sources and the output of each source. For the renewal of licenses pursuant to 10 CFR, Part 54, the NRC has already determined that expansive consideration of combinations would be too unwieldy given the purposes of the alternative analysis (USNRC, 1996). However, the combination alternative analysis should be sufficiently complete to aid the Commission in its analysis of alternative sources of energy pursuant to the National Environmental Policy Act (NEPA). The following analysis provides the basis for an evaluation of a reasonable combination of alternative energy sources to the EGC ESP Facility that is required by NEPA.

9.2.3.3.1 Determination of Alternatives

Many possible combinations of alternatives could satisfy the baseload capacity requirements of the EGC ESP Facility. Some combinations can include renewable sources, such as wind and solar. As discussed earlier in Section 9.2.2.1 and 9.2.2.4, wind and solar do not, by themselves, provide a reasonable alternative energy source to the baseload power to be produced by the EGC ESP Facility. However, wind and solar, in combination with fossil fuel-fired plant(s), may be a reasonable alternative to nuclear energy produced by the EGC ESP Facility.

The EGC ESP Facility is to operate as a baseload merchant independent power producer. The power produced will be sold on the wholesale market, without specific consideration to supplying a traditional service area or satisfying a reserve margin objective. The ability to generate baseload power in a consistent, predictable manner meets the business objective of the EGC ESP Facility. Therefore, when examining combinations of alternatives to the EGC ESP Facility, the ability to generate baseload power must be the determining feature when analyzing the reasonableness of the combination. This section reviews the ability of the

combination alternative to have the capacity to generate baseload power equivalent to the EGC ESP Facility.

When examining a combination of alternatives that would meet the business objectives similar to that of the EGC ESP Facility, any combination that includes a renewable power source (either all or part of the capacity of the EGC ESP Facility) must be combined with a fossil-fueled facility equivalent to the generating capacity of the EGC ESP Facility. This combination would allow the fossil-fueled portion of the combination alternative to produce the needed power if the renewable resource is unavailable and to be displaced when the renewable resource is available. For example, if the renewable portion is some amount of potential wind generation and that resource became available, then the output of the fossil-fueled generation portion of the combination alternative could be lowered to offset the increased generation from the renewable portion. This facility, or facilities, would satisfy business objectives similar to those of the EGC ESP Facility in that it would be capable of supporting fossil-fueled baseload power.

Coal - and gas – fired generation have been examined in Sections 9.2.3.1 and 9.2.3.2, respectively, as having environmental impacts that are equivalent to or greater than the impacts of the EGC ESP Facility. Based on the comparative impacts of these two technologies, as shown in Table 9.2-6, it can be concluded that a gas-fired facility would have less of an environmental impact than a comparably sized coal-fired facility. In addition, the operating characteristics of gas-fired generation are more amenable to the kind of load changes that may result from inclusion of renewable generation such that the baseload generation output of 2180 MWe is maintained. "Clean Coal" power plant technology could decrease the air pollution impacts associated with burning coal for power. Demonstration projects show that clean coal programs reduce NO_x, SO_x, and particulate emissions. However, the environmental impacts from burning coal using these technologies, if proven, are still greater than the impacts from natural gas (USDOE/NETL, 2001). Therefore, for the purpose of examining the impacts from a combination of alternatives to the EGC ESP Facility, a facility equivalent to that described in Section 9.2.3.2 (gas-fired generation) will be used in the environmental analysis of combination alternatives. The analysis accounts for the reduction in environmental impacts from a gas-fired facility when generation from the facility is displaced by the renewable resource. The impact associated with the combined-cycle natural gas-fired unit is based on the gas-fired generation impact assumptions discussed in Section 9.2.3.2. Additionally, the renewable portion of the combination alternative would be any combination of renewable technologies that could produce power equal to or less than the EGC ESP Facility at a point when the resource was available. The environmental impacts associated with wind and solar generation schemes are outlined in Sections 9.2.2.1 and 9.2.2.4, respectively. This combination of renewable energy and natural gas fired generation represents a viable mix of non-nuclear alternative energy sources.

For the purpose of the economic comparison of a combination of alternatives, a coal plant in combination with the renewable resource was analyzed. Coal is used for the purposes of the economic comparison because coal plants generate power at a lower cost than gas plants.

9.2.3.3.2 Environmental Impacts

The environmental impacts associated with a gas-fired facility sized to produce power equivalent to the EGC ESP Facility have already been analyzed in Section 9.2.3.2. Depending on the level of potential renewable output included in the combination alternative, the level of impact of the gas-fired portion will be comparably lower. If the renewable portion of the combination alternative were not enough to displace the power produced by the fossil fueled facility, then there would be some level of impact associated with the fossil fueled facility. Consequently, if the renewable portion of the combination alternative were enough to fully displace the output of the gas-fired facility, then, when the renewable resource is available, the output of fossil fueled facility could be eliminated, thereby eliminating its operational impacts. The lower the output of the renewable portion of the combination alternative, the closer the impacts approach the level of impact described in Section 9.2.3.2 for gas-fired generating facilities.

Determination of the types of environmental impacts of these types of 'hybrid' plants or combination of facilities can be surmised from analysis of past projects.

For instance, in 1984, Luz International, Ltd. built the Solar Electric Generating System (SEGS) plant in the California Mojave Desert. The SEGS technology consists of modular parabolic-trough solar collector systems, which use oil as a heat transfer medium. One unique aspect of the Luz technology is the use of a natural-gas-fired boiler as an oil heater to supplement the thermal energy from the solar field or to operate the plant independently during evening hours. SEGS I was installed at a total cost of $62 million (~$4,500/kW) and generates power at 24 cents/kWh (in 1988 real levelized dollars). The improvements incorporated into the SEGS III-VI plants (~$3,400/kW) reduced generation costs to about 12 cents/kWh, and the third-generation technology, embodied in the 80-MW design at an installed cost of $2,875/kW, reduced power costs still further, to 8 to 10 cents/kWh. Because solar energy is not a concentrated source, the dedicated land requirement for the Luz plants is large compared to conventional plants--on the order of 5 ac/MW (2 ha/MW) (USDOE/NREL, 2004b), compared to 0.23 acres per MWe for a nuclear plant.

In Illinois, the solar thermal source is approximately 4.5 kWh/m^2; the SEGS units were built in an area of where the solar source is 5.5 kWh/m^2. Using the above metrics for land use and the solar source of 4.5 kWh/m^2 per day in Illinois, a similar SEGS unit within the region of interest would require dedicated land of approximately 6 acres/MWe (USDOE/EERE, 2004b), compared to 0.23 acres per MWe for a nuclear plant. Land use for generating baseload equivalent to the EGC ESP Facility would require approximately 13,000 acres (20 mi^2)(2180 MWe *6 acres/MW). Additionally, given the lower thermal source in Illinois, the capital costs for the solar portion of the hybrid plant would be proportionally greater than for the SEGS.

In the case of parabolic trough plants, all plants of this type of solar technology are configured in combination with a fossil fueled generation component. A typical configuration is a natural gas-fired heat or a gas steam boiler/reheater coupled to the trough system. Troughs also can be integrated with existing coal-fired plants. With the current trough technology, annual production nationwide is about 100 kWh/m^2 (USDOE/EERE, 2004d). Parabolic trough plants require a significant amount of land; typically the use is preemptive because parabolic troughs require the land to be graded level. A report,

developed by the California Energy Commission (CEC), notes that 5 to 10 acres per MWe is necessary for concentrating solar power technologies such as trough systems (CEC, 2004).

The environmental impacts associated with a solar and a wind facility equivalent to the EGC ESP Facility have already been analyzed in Sections 9.2.2.1 and 9.2.2.4, respectively. It is reasonable to expect that the impacts associated with an individual unit of a smaller size would be similarly scaled. None of the impacts would be greater than those discussed in Sections 9.2.2.1 and 9.2.2.4. If the renewable portion of the combination alternative is unable to generate an equivalent amount of power as the EGC ESP Facility, then the combination alternative would have to rely on the gas-fired portion to meet the equivalent capacity of the EGC ESP Facility. Consequently, if the renewable portion of the combination alternative has a potential output that is equal to that of the EGC ESP Facility, then the impacts associated with the gas-fired portion of the combination alternative would be lower but the impacts associated with the renewable portion would be greater. The greater the potential output of the renewable portion of the combination alternative, the closer the impacts would approach the level of impact described in Sections 9.2.2.1 and 9.2.2.4.

The environmental impacts associated with a gas-fired facility and equivalent renewable facilities are shown in Table 9.2-7 and summarized in Table 9.2-6. The gas-fired facility alone has impacts that are larger than the EGC ESP Facility; some environmental impacts of renewables are also greater than or equal to the EGC ESP Facility.

The combination of a gas-fired plant and wind or solar facilities would have environmental impacts that are equal to or greater than those of a nuclear facility.

- All of the environmental impacts of a new nuclear plant at the EGC ESP Site and all of the impacts from a gas-fired plant are small, except for air quality impacts from a gas-fired facility (which are moderate). Use of wind and/or solar facilities in combination with a gas-fire facility would be small, and therefore would be equivalent to the air quality impacts from a nuclear facility.
- All of the environmental impacts of a new nuclear plant at the EGC ESP Site and all of the impacts from wind and solar facilities are small, except for land use and aesthetic impacts from wind and solar facilities (which range from moderate to large). Use of a gas-fired facility in combination with wind and solar facilities would reduce the land usage and aesthetic impacts from the wind and solar facilities. However, at best, those impacts would be small, and therefore would be equivalent to the land use and aesthetic impacts from a nuclear facility.

Therefore the combination of wind and solar facilities and gas-fired facilities is not environmentally preferable to the EGC ESP Facility.

9.2.3.3.3 Economic Comparison

As noted earlier, the combination alternative must generate power equivalent to the capacity of the EGC ESP Facility. The USDOE has estimated the cost of generating electricity from a gas-fired facility (4.7 cents per kWh), a coal facility (4.9 cents per kWh), as well as wind (5.7 cents per kWh for sites similar to those in the region of interest), and solar (4 to 5 cents per kWh). The cost for gas-fired facility in combination with a renewable facility would increase, because the facility would not be operating at full availability when it is displaced by the renewable resource. As a result, the capital costs and fixed operating

costs of the gas facility would be spread across fewer kWh from the gas facility, thereby increasing its cost per kWh. The projected cost associated with the operation a new nuclear facility similar to the EGC ESP Facility is in the range of 3.1 to 4.6 cents per kWh (USDOE, 2002) (USDOE, 2004). The projected costs associated with all other forms of generation other than the EGC ESP Facility are greater than the EGC ESP Facility. Therefore, the cost associated with the operation of the combination alternative would not be competitive with the EGC ESP Facility.

9.2.3.3.4 Summary

Wind and solar facilities in combination with fossil facilities could be used to generate baseload power and would serve the purpose of the EGC ESP Facility. However, wind and solar facilities in combination with fossil facilities would have equivalent or greater environmental impacts relative to a new nuclear facility at the EGC ESP Site. Similarly, wind and solar facilities in combination with fossil facilities would have higher costs than a new nuclear facility at the EGC ESP Site. Therefore, wind and solar facilities in combination with fossil facilities are not preferable to the EGC ESP Facility.

9.2.4 Conclusion

As shown in detail in Tables 9.2-6 and 9.2-7, based on environmental impacts, EGC has determined that neither a coal-fired, nor a gas-fired, nor a combination of alternatives, including wind and solar facilities, would provide an appreciable reduction in overall environmental impact relative to a nuclear plant. Furthermore, each of these types of alternatives, with the possible exception of the combination alternative, would entail a significantly greater environmental impact on air quality than would a nuclear plant. To achieve the small air impact in the combination alternative, however, a moderate to large impact on land use would be needed. Therefore, EGC concludes that neither a coal-fired, nor a gas-fired, nor a combination of alternatives would be environmentally preferable to a nuclear plant. Furthermore, these alternatives would have higher economic costs, and therefore are not economically preferable to a nuclear plant.

9.3 Alternative Sites

This section identifies and evaluates a set of alternatives for the proposed EGC ESP Site. The objective of this evaluation is to verify there is no "obviously superior site" for the eventual construction and operation of a new nuclear unit.

The EGC ESP Facility will be constructed and operated by an unregulated merchant generator as a "merchant plant." This means that there is no regulatory structure in place to guarantee a return on investments, and many of the decisions affecting the location of the plant are based on factors such as cost, ease of construction, and the ability to transmit the power to customers. The facility will operate in the competitive marketplace created by the National Energy Policy Act of 1992 and subsequent actions by the FERC to impose open transmission requirements. These changes have fundamentally altered both the marketplace for electricity and the makeup of electricity generating companies.

Additionally, existing nuclear sites have also changed the way alternatives are reviewed and selected, since a new plant could be located at these sites. Existing sites offer decades of environmental and operational information about the impact of a nuclear plant on the environment. These sites are licensed nuclear facilities, thus, the USNRC has found them to be acceptable relative to other undeveloped sites in the region of interest. The USNRC recognizes (in NUREG-1555, ESRP, Section 9.3(III)(8)) that proposed sites may not be selected as a result of a systematic review (USNRC, 1999):

> *"Recognize that there will be special cases in which the proposed site was not selected on the basis of a systematic site-selection process. Examples include plants proposed to be constructed on the site of an existing nuclear power plant previously found acceptable on the basis of a NEPA review and/or demonstrated to be environmentally satisfactory on the basis of operating experience, and sites assigned or allocated to an applicant by a State government from a list of State-approved power-plant sites. For such cases, the reviewer should analyze the applicant's site-selection process only as it applies to candidate sites other than the proposed site, and the site-comparison process may be restricted to a site-by-site comparison of these candidates with the proposed site. As a corollary, all nuclear power plant sites within the identified region of interest having an operating nuclear power plant or a construction permit issued by the NRC should be compared with the applicant's proposed site."*

In addition to looking at other nuclear power plant sites in Illinois, EGC's site selection was also based on an evaluation of undeveloped sites (commonly known as "greenfields"), and previously developed sites (commonly known as "brownfields"). These sites are not obviously superior to existing nuclear sites in the region of interest. Ultimately, the proposed location was chosen based on the applicant's ability to colocate an additional power facility at an existing nuclear power facility near Clinton, Illinois, and transmit power to the wholesale marketplace. The existing facility currently operates under a USNRC license, and the proposed location has already been found acceptable under the requirements for that license. Further, operational experience at the existing facility has shown that the environmental impacts are small, and operation of a new facility at the site should have essentially the same environmental impacts.

The traditional "relevant service area" does not necessarily provide a meaningful way to evaluate the alternative sites because once the facility is built it will generate power for sale

to consumers in a deregulated marketplace. For the purposes of this review, the "region of interest" (ROI) is defined as the State of Illinois rather than the "relevant service area." This is due to current deregulation policies, the proposed location in the State of Illinois, the availability of transmission capabilities in the state, and market flexibility. The ROI is explained below in Section 9.3.1.

The decision to colocate the new nuclear power facility at the EGC ESP Site near Clinton, Illinois was based on market factors and a comparison of the seven existing nuclear sites within the state and an evaluation of postulated brownfield and greenfield sites. The review process outlined in this section was consistent with the special case noted in NUREG-1555, ESRP, Section 9.3(III)(8), and took into account the advantages already present at existing nuclear facilities within the ROI (USNRC, 1999). The evaluation of alternative sites, and a comparison with greenfield and brownfield sites focused on whether there are any sites that are obviously superior to the EGC ESP Site.

9.3.1 Site Preferences and the Region of Interest

9.3.1.1 Site Preferences

The review procedure described in this chapter compares and evaluates existing nuclear sites within the ROI. The candidate site criteria described in NUREG-1555 are incorporated into the site review in Section 9.3.3. This section explains the Applicant's preference for an existing nuclear site. The following preference factors influenced the decision to review existing nuclear sites within the ROI.

- There are benefits offered by existing nuclear sites. For example, colocated sites offer existing infrastructure and other advantages.
- The environmental impacts of an existing unit are known and the impacts of a new unit should be comparable to those of the operating nuclear plant.
- Site physical criteria, primarily geologic/seismic suitability, have been characterized at existing sites; these criteria are important in determining site suitability.
- Transmission is available and the existing sites have nearby markets.
- Existing nuclear plants have local support and the availability of experienced personnel.

Initially, candidate sites within the ROI were identified and screened. Given the factors listed above, colocating a facility at the EGC ESP Site became the preferable alternative. The EGC has made agreements with AmerGen for access to and control of the proposed site at Clinton. The CPS has been a licensed facility there since 1987, and the site has a proven record of environmental, health, socioeconomic, and market performance

As discussed in Sections 9.3.3.1 and 9.3.3.2, the economically and environmentally preferable alternative for the EGC ESP Facility is colocation; therefore, the consideration of alternative sites within the region of interest focused primarily on sites with an existing nuclear power facility. It considered additional issues such as environmental impacts, land use, transmission congestion, proximity to population centers, and economical viability. The assessment was focused on existing nuclear sites controlled by EGC within the identified ROI, and evaluations were also performed of hypothetical greenfield and

brownfield sites. A site-by-site comparison of candidate sites with existing power plants did not result in identification of a site obviously superior to the EGC ESP Site as the preferred site.

9.3.1.2 Region of Interest

NUREG-1555 provides that the ROI includes the state where the candidate site is located, so that alternatives sites may be considered for review (USNRC, 1999). The basis for the ROI is the candidate site's location within the State of Illinois. There are sufficient existing nuclear sites that meet the threshold criteria discussed below. The ROI also was the geographic area considered in searching for a comparative evaluation of greenfield and brownfield sites. While power generated at the proposed facility will be sold in a deregulated marketplace, the potential for line loss, flexibility of transmission, and the proximity of EGC's customer base limits the ROI to the State of Illinois. The topography, ecology, and socieoeconomics throughout the region are roughly the same. Generally, the region is rural/agricultural with pockets of heavy population near important waterways such as the Mississippi River and Lake Michigan, or in traditionally populated areas such as the State Capital and university sites.

9.3.1.3 The Candidate Site

The candidate site is reviewed at length in this ER. This section reviews the EGC ESP Site in relation to the selection criteria suggested in NUREG 1555, ESRP 9.3 in order to consider whether the site is "obviously superior" to other candidate sites. The criteria are more fully discussed in Section 9.3.3.

9.3.1.3.1 Consumptive Use of Water

Clinton Lake is specifically available for cooling. The lake/impoundment of Salt Creek was constructed for the CPS, and includes the UHS. The UHS is a submerged impoundment located within Clinton Lake that provides emergency cooling water. There are other small lakes and ponds, both man-made and natural, scattered throughout the region. Most of these other water bodies are used for farming and recreation. Salt Creek is a tributary of the Sangamon River.

There is no groundwater used at the CPS, and it is not anticipated that groundwater will be used at the EGC ESP Facility (see Chapter 5).

9.3.1.3.2 No Further Species Endangerment

As noted in Chapters 4 and 5, there are no endangered species in the vicinity of the site. Important species and habitats are presented in Table 2.4-3.

9.3.1.3.3 Effects on Spawning Grounds

The Clinton Lake State Recreation Area, along with adjacent recreation areas, is designated as an important habitat for some species. Table 2.4-1 identifies those species and their habitats. There are no identified spawning grounds at the EGC ESP Site.

9.3.1.3.4 Effluent Discharge and Water Quality

The CPS discharges blowdown water through a discharge canal into Clinton Lake. As noted in Chapter 5, the proposed plant will also discharge any blowdown water through the canal and into Clinton Lake. One target established for the EGC ESP Facility is to maintain the cumulative discharge rate within CPS NPDES permit conditions. It is not anticipated

that construction and operation of the EGC ESP Facility at the EGC ESP Site will adversely affect water quality.

9.3.1.3.5 Preemption and Other Land Use Issues

Land in the region is designated primarily for agricultural use (92.5 percent). However, the land inside the CPS Site boundary (including the candidate site) is zoned industrial; approximately 0.6 percent is designated industrial within the region. Approximately 6 percent of the land in the region is classified for recreational use, and 1.5 percent has been designated for residential use. There are 10 areas within the region specifically reserved for state recreation areas, historical sites, or wildlife areas. Figure 2.2-5 shows the land use designations within the region.

9.3.1.3.6 Potential Effect on Aquatic and Terrestrial Environment

As noted in Chapters 4 and 5, wetland and floodplain forest areas are present along Salt Creek and North Fork of Salt Creek. Additionally, some floodplain forest areas can be found along Clinton Lake, north of the EGC ESP Facility (USFWS, 2002). Clinton Lake, and other waterbodies located within the site vicinity, provide a suitable habitat for a variety of waterfowl species. Waterfowl observed, or documented to occur within the site vicinity include the blue-winged teal, mallard, American widgeon, wood duck, lesser scaup, and Canada goose. In addition, migratory shorebirds were also observed during surveys. Common species identified include a variety of sandpipers and heron (CPS, 1972). Reptiles and amphibians that commonly occur within the site vicinity include various species of frogs, salamanders, snakes, and turtles (CPS, 1972).

The EGC ESP Facility is located on Clinton Lake, a 4,895-ac waterbody created as a cooling source for the CPS. Since its creation, Clinton Lake has become a resource for a variety of stocked and naturally occurring populations of fish species. Fisheries in watercourses of the site vicinity are consistent with fisheries commonly found in the central Illinois region. During extensive surveys performed in Salt Creek and the North Fork of Salt Creek, species collected include several species of shiner (common, bigmouth, red, sand, and redfin), bluntnose minnow, creek chub, white sucker, black bullhead, channel catfish, bluegill, largemouth bass, and crappie (CPS, 1972).

9.3.1.3.7 Population Characteristics

Major population centers (as defined by 10 CFR 100) include Decatur, the closest population center (22-mi south-southwest) with a population of 81,860 as of the year 2000. Other population centers within an 80-km (50-mi) radius include Champaign and Urbana with populations of 67,518 and 36,395, respectively. Otherwise, the vicinity's population is relatively low; Clinton, the nearest incorporated town, has a current population over 7,000. In addition, the population density for the vicinity is approximately 97 people per mi^2. The population within 10 mi of the site is expected to decrease through the year 2060 (see ER Table 2.5-2). Figure 2.5-2 shows the regional population centers.

9.3.2 Superiority of Existing Sites Within the Region of Interest

During initial review, EGC determined that the advantages of colocating the new facility with an existing nuclear power facility outweighed the advantages of any other probable siting alternative. The preferred siting alternative was, therefore, to colocate the EGC ESP Facility with the CPS Facility, an existing nuclear facility in Illinois. In addition to the

factors assessed and described previously in this section, there are several advantages to colocating nuclear facilities as a general rule. Some of the potential environmental and market advantages include:

- The total number of required generating sites is reduced.
- Construction of new transmission corridors may not be required due to potential use of existing corridors.
- No additional land acquisitions will be necessary, and the applicant can readily obtain control of the property.
- The site has already gone through the alternatives review process mandated by the National Environmental Policy Act (NEPA), and was the subject of extensive environmental screening during the original selection process.
- The site development costs and environmental impact of any preconstruction activities are reduced.
- Construction, installation, and operation and maintenance costs are reduced because of existing site infrastructure.

Existing facilities where EGC could obtain access and control were preferred over the other sites within the region of interest. Sites that were originally designed for more generation than actually constructed also received preference.

The applicant considered colocating with the following existing nuclear power facilities within the region of interest:

- Braidwood Generating Station;
- Byron Generating Station;
- Clinton Power Station;
- Dresden Generating Station;
- LaSalle County Generating Station;
- Quad Cities Generating Station; and
- Zion Generating Station.

The CPS near Clinton, Illinois, was the preferred site. The proposed site is preferable to the sites of the other existing nuclear facilities within Illinois, primarily based upon the alternative site reviews described below.

9.3.3 Alternative Site Review

Regulatory Guide 4.2 notes: "The applicant is not expected to conduct detailed environmental studies at alternative sites; only preliminary reconnaissance-type investigations need be conducted" (USNRC, 1976). The alternatives described here are compared based on recently updated safety analysis report (USAR) information about the existing plants and the surrounding area, and existing environmental studies and Final

Environmental Impact Statements issued by the Atomic Energy Commission or USNRC. An undeveloped site (greenfield) and former industrial site (brownfield) were also considered for comparison in order to determine if they were obviously superior to an existing nuclear site.

9.3.3.1 Greenfield Site

An undeveloped (greenfield) site is useful as a bounding comparison for identifying impacts at the site, and this concept has been used by the USNRC in other licensing activities (USNRC, 1996), where the USNRC has developed generic characteristics of a greenfield site for comparison during license renewal. Some of the issues identified for greenfields in the USNRC's *Generic Environmental Impact Statement (GEIS) for License Renewal* can correlate with the issues the applicant faces in determining the superiority of the proposed site.

In order to maximize the advantages and minimize the disadvantages of the greenfield site, the applicant assumed the greenfield site would be in Illinois, have characteristics where cooling water would be available and where access to transmission lines would be available. Otherwise, the site would be undeveloped for generating capacity and no existing infrastructure would be available.

EGC has made some conservative assumptions using the characteristics of two potential greenfield sites in Illinois. One potential site, on the shores of Clinton Lake, has similar characteristics to the undeveloped areas around the lake. As noted in Chapter 2, the undeveloped greenfield site along Clinton Lake is close to transmission lines and transportation corridors, and a railway spur could likely be developed from the current CPS. The population near this greenfield site is also reported in Chapter 2. Another site is on the banks of the Illinois River near the Dresden Station and Collins Station, a large gas-fired generating plant. The land itself is cleared farm land and forest terrain. There is potential access to cooling water from the Illinois River and Mizan Creek. Additionally, there is a ComEd Transmission right-of-way adjacent to the property, and asphalt road frontage leads to IL Rt. 47 and IL Rt. 155. Land use is predominantly agricultural. The population around the site is characteristically rural, with low population similar to the Dresden site. There is a lessee living in a small farm house on the site.

A greenfield site is not considered environmentally preferable for a number of reasons including:

- The applicant does not own a suitable area with the required characteristics for a nuclear plant. The land (and/or access to it), including any easements, would have to be obtained from third parties.
- An undeveloped site would require an area of considerable size (USNRC, 1996), with a potentially adverse economic impact. The USNRC has determined that a new nuclear generating facility (e.g. an advanced light water reactor) would require 500 to 1,000 ac including an exclusion area. The exclusion area requirement would be mitigated by building at a greenfield inside the existing CPS exclusion area (the total area of the existing CPS Site is 13,700 ac, including the 5,000 ac Clinton Lake). According to Chapter 4, a total of 461 ac are included in the site boundary, and approximately 96 ac will be disturbed. (This area will likely be greater at either greenfield site, because much

of the area for the proposed ESP site has been cleared.) The greenfield area near Collins Station is approximately 500 ac, and could likely meet the land requirements. Although both greenfield sites have sufficient acreage for construction of the EGC ESP Facility, construction of the facility at these greenfields may disturb important habitats and resources that are not present at the EGC ESP Site.

- The USNRC notes that the impact of a new reactor at a greenfield would be severe but could be moderated somewhat by locating the plant at a current nuclear site (USNRC 1996). While the impact of this new plant at the CPS greenfield site would still be moderate, impact at the Collins Station site would be severe, since it is a relatively pristine site. Transmission and other issues could be moderated by the proximity of existing infrastructure.
- New transmission lines and corridors would be required to intertie with the existing system. Existing transmission lines near a potential CPS greenfield and at a potential Collins Station greenfield could be modified; however, new interties would be required. With the use of existing corridors, some disturbance would still occur at either greenfield site, since new transmission lines from the new plant to existing lines would require some clearing, grubbing and other construction (see Chapter 3.7).
- Terrestrial and aquatic resource impacts are expected to be greater than those experienced at an existing site (USNRC, 1996). These impacts are similar to the construction of any large energy generating facility (see Chapter 9.2.3). Destruction of wildlife and aquatic habitat would occur with construction of the plant, corridors, and intake and discharge structures. As noted in Chapters 4 and 5, most aquatic displacement from construction and operation may be temporary; loss of terrestrial habitat at the greenfield will be permanent. However, the site near Collins Station is part of the Prairie Parklands Resource Rich Area (RRA) , and is proximate to marshes, wetlands, and forests (INHS, 2003). The Heideke State Fish and Wildlife Area is also near the Collins Station greenfield (IDNR, 2003). Unlike the CPS greenfield, which has no critical habitat or endangered species, the second site is near critical habitat for the endangered upland sandpiper (INHS, 2003).
- Aesthetic and socioeconomic impacts from construction and operation of a new nuclear facility at the greenfield sites would be similar to those forecast for the EGC ESP Site in Chapters 4 and 5. Erosion, sedimentation, and fugitive dust are likely aesthetic impacts from construction, and operational impacts would include an increased workforce, increased transportation requirements, and public services would be affected.

In summary, the environmental impacts from construction and operation of a nuclear power plant at a greenfield site would be similar to or greater than those at the proposed CPS Site. Therefore, a greenfield site is not obviously superior to the EGC ESP Site.

9.3.3.2 Brownfield Site

A "brownfield" site is one that is released for redevelopment after cleanup under Resource Conservation and Recovery Act or Superfund programs (USEPA, 2002). Such sites have been recommended for redevelopment by the EPA, and general characteristics can be identified based on EPA reports describing such sites (USEPA, 2003). The sites reviewed here are former industrial facilities where existing buildings and other infrastructure have

been removed to facilitate cleanup. The environmental consequences of building on a brownfield site will not be as severe as those noted for greenfield development.

There are no brownfield sites near Clinton. EGC has made some conservative assumptions based on available EPA information about two brownfield sites in Illinois to compare the brownfield site with an existing nuclear site. The EPA has recently identified example sites in Antioch and DePue, Illinois (USEPA, 2002). The site in Antioch, IL, is a former landfill where the remedy included a clay cap and an updated methane and leachate collection system. The site in DePue, IL, is a former zinc plant located along the Illinois River. Part of the site may be re-used as an industrial site, while remaining portions of the site may be set aside for a recreational or ecological resort. These sites serve as a baseline to identify characteristics of the hypothetical brownfield site.

The hypothetical brownfield site would be the site of a former industrial complex in Illinois. Generally, these sites are in areas where heavy industry has been the predominant land use. The hypothetical brownfield will be near an existing water source such as the Mississippi or Illinois River. This alternative site will not have all of the infrastructure currently available at the existing nuclear sites. Most potential brownfield sites in Illinois do not have the all of the required infrastructure, although some interties with existing transmission corridors may be close to the site.

The brownfield site is not considered environmentally preferable for the following reasons:

- New infrastructure requirements such as pipeline construction, transmission corridor development or expansion, supply line development (e.g., a rail spur or other transportation), and cooling systems, will incur economic costs and environmental impacts not associated with location of a plant at an existing nuclear site. These impacts would be greater than construction at an existing nuclear facility.
- Terrestrial habitat loss will be minimal, but aquatic habitat will be moderately affected. Some ecological impacts would occur as intake, heat sink, and discharge capabilities were constructed. For example, if the EGC ESP Facility were built at the DePue brownfield, there may be entrainment and impingement to the sports fisheries in the neighboring lake as a result of construction of intake structures.
- Aesthetic impacts would include impaired views from cooling towers, fugitive dust, erosion, and sedimentation. These impacts would likely be similar to those impacts forecast for the EGC ESP Site in Chapters 4 and 5.
- Socioeconomic and environmental justice impacts are assumed to occur at brownfield sites, since sites such as those considered in this evaluation are located in or near urban areas (Deason, 2001). Larger urban areas could accommodate changes in population brought about by the construction of a new nuclear generating facility. However, urban and industrial communities such as those near the Antioch and DePue sites may be disproportionately affected by development of a new nuclear plant in those areas, compared to the relatively homogeneous socioeconomic structure at Clinton. Other socioeconomic issues would be roughly similar to those forecast for the EGC ESP Site.

- Impacts associated with new transportation corridors, housing and other public services may be affected by an influx of an experienced workforce, however, necessary infrastructure will likely be available.
- Most brownfield example sites do not meet the size requirements for a new nuclear plant. These requirements would be more difficult to meet than the greenfield example site. Enough area for the proposed plant, site boundaries and exclusion area boundaries would likely be unavailable. For example, the Antioch site is 160 ac adjacent to a wetland and recreational lakes. The DePue site sits on 250 ac adjacent to a lake and other commercial and industrial development. According to Chapter 4, a total of 461 ac are included in the site boundary, and approximately 96 ac will be disturbed. The existing exclusion area boundary for the CPS exceeds 10,000 ac.

In summary, the environmental impacts from construction and operation of a nuclear power plant at a brownfield site would be greater than or equal to those at the proposed EGC ESP Site. Therefore, a brownfield site is not obviously superior to the EGC ESP Site.

9.3.3.3 Existing Nuclear Facilities in the ROI

Since development of greenfield or brownfield sites was not considered obviously superior, EGC preferred siting a proposed nuclear power facility adjacent to an existing facility. There are six existing nuclear power facility sites in Illinois that were considered as potential siting alternatives. The discussion below reviews information about the sites that assist the applicant in a site-by-site comparison. This review is based on siting and safety criteria outlined in 10 CFR 100, and as identified in the updated safety analysis reports (USARs) and environmental reports for each site. These reports provide the most recent information about the sites. Each site was reviewed using the site characteristic criteria noted in NUREG 1555, ESRP 9.3. They are:

- Consumptive use of water should not cause significant adverse effects on other users.
- There should not be any further endangerment of federal, state, regional, local, and affected Native American tribal listed threatened, endangered, or candidates species.
- There should not be any potential significant impacts to spawning grounds or nursery areas of populations of important aquatic species on federal, state, regional, local, and affected Native American tribal lists.
- Discharges of effluents into waterways should be in accordance with federal, state, regional, local, and affected Native American tribal regulations and would not adversely impact efforts to meet water quality objectives.
- There would be no preemption of or adverse impacts on land specially designated for environmental, recreational, or other special purposes.
- There would not be any potential significant impact on terrestrial and aquatic ecosystems including wetlands, which are unique to the resource area.
- Population density and numbers conform to 10 CFR 100.

Using the available information, EGC then determined whether there were any environmentally preferred sites among the candidate sites, and then identified whether

economic, technological or institutional factors outweighed the proposed EGC ESP Site. This approach is similar to the two part "obvious superiority" test outlined in NUREG 1555. This review performs "only preliminary reconnaissance-type investigations" based on environmental information available (USNRC, 1976). For purposes of review, EGC assumed that the EGC ESP Facility would be the bounding case for each candidate site. The applicant performed sufficient review to determine whether the sites met the candidate criteria and if there were obviously superior sites. The proposed EGC ESP Site is not summarized here since it is the subject of this ER. Rather, the alternative sites are summarized below, and compared with the proposed EGC ESP Site in Table 9.3-1.

9.3.3.3.1 Braidwood Generating Station

Braidwood Generating Station is located in northeastern Illinois about 50-mi southwest of Chicago and about 20-mi south-southwest of Joliet. The site is located primarily on flat agricultural land that has been scarred by strip coal mining. The site itself is located primarily on a former strip mining area. The roughly rectangular site occupies about 4,457 ac, and the main cooling pond occupies about 2,537 ac. The cooling pond is located on a former strip mine area. Water for the pond is withdrawn from, and eventually returned to, the Kankakee River. The Kankakee River is a popular recreational area and supports numerous sports such as fishing and hunting. Despite its proximity to Joliet and Chicago, the area is not heavily industrialized, and remains an agricultural area. Braidwood was originally developed for four units; two are operational (EGC, 2000). It is assumed that a new nuclear facility at the area would have roughly the same general environmental impact as the existing facility.

9.3.3.3.1.1 Consumptive Use of Water

Cooling water for the plant is obtained from the Kankakee River, and is held in the cooling pond. There is little public consumptive use of the water, although downstream uses include fishing and other recreational activities (EGC, 2000). Makeup water for the pond is pumped from the river screen house on the Kankakee River via pipeline to the northeast corner of the cooling pond. Blowdown water is discharged from the plant by pipeline to the blowdown outfall structure and discharge flume to the Kankakee River. The existing Braidwood units withdraw greater than 50 million gallons of water per day, with corresponding discharge. The 1973 ER predicts withdrawals up to 150 million gpd by the year 2020, anticipating the operation of 4 units (ComEd, 1973). However, the EGC ESP Facility may use a number of cooling systems options that do not require this kind of consumption. Consumptive use of water predicted for the EGC ESP Facility cooling systems is described in Table 5.2-2. Consumptive use is expected to be minimal for the EGC facility.

Groundwater has not been used at the Braidwood Station during plant operation. All plant water requirements are currently met from the Kankakee River. For a detailed review of site and regional conditions, please see the Braidwood USAR (EGC, 2000). There are approximately 31 wells within the vicinity used for public supply of groundwater. There is large-scale industrial and municipal use of groundwater around Joliet, and studies show that a resulting cone of depression could affect groundwater use around the Braidwood facility (EGC, 2000).

9.3.3.3.1.2 No Further Species Endangerment

The Goose Lake Prairie Nature Preserve is located 9-mi northwest of the plant, along the borders of the Dresden Facility. Some sensitive habitats and species exist there, including the upland sandpiper. The Kankakee Nature Preserve is also approximately 13 mi from the facility, and hosts some sensitive species and plants. There have been no reported observations of sensitive species and plants within the facility boundaries (EGC, 2000).

9.3.3.3.1.3 Effects on Spawning Grounds

There is no evidence of spawning grounds on the facility or in the vicinity.

9.3.3.3.1.4 Effluent Discharge and Water Quality

Blowdown water is discharged into the Kankakee River. Stormwater discharge and other effluents are occasionally discharged into the river, but they do not exceed the limits set forth in the station's National Pollution Discharge Elimination System (NPDES) permit. However, with new units, additional permitting would be required. As noted in Section 5.2, one target established for the EGC ESP Facility is to maintain the cumulative discharge rate within CPS permit conditions. For the purposes of this review, it is anticipated that the bounding case for the proposed facility would be the existing permits at Braidwood.

9.3.3.3.1.5 Preemption and Other Land Use Issues

No land would be preempted for additional facilities built at the station.

9.3.3.3.1.6 Potential Effect on Aquatic and Terrestrial Environment

Terrestrial habitats in the area are characterized as reclaimed strip mining sites. The strip mine spoil habitat is different from the surrounding agricultural habitat. Most species have adjusted to both habitat types. The site boundaries are characterized by overgrown drainage, fallow fields, and woodlands. There is marshy habitat created by water-filled strip mine spoil. Mammals and bird species are adapted to the various habitats. Important small game species have also been observed at the site, including ring-necked pheasants, bobwhite, rabbits, mourning dove, and big game is likewise observed. The cooling pond serves as some habitat for migrating water fowl, but there have been no adverse affects noted from operation of the existing facilities (ComEd, 1973).

The Kankakee River is the aquatic habitat most affected by site operations. The river supports sport fishing opportunities, but there is no commercial fishing (EGC, 2000). Aquatic life within the Braidwood cooling pond is similar to that in Dresden Lake, about 10-mi downstream from the Braidwood site. As with Dresden, the major impact of to the aquatic environment is entrainment and impingement as a result of the intake and discharge structures (ComEd 1973, EGC, 2000).

9.3.3.3.1.7 Population Characteristics

Projected population of the area suggests that the population (including transient population) within 10 mi of the Braidwood Station will reach nearly 86,000 by the year 2020. The population between 10 and 50 mi includes the Chicago metroplex, and the total population is predicted to reach more than 5 million by the year 2020. The low population zone (LPZ) is predicted to include 1,465 people by the year 2020 (EGC, 2000).

The closest population centers over 25,000 include Joliet, with a predicted 2020 population of 85,000, and Kankakee, with a projected population of 31,065. There are approximately 22 urban centers within a 30-mi radius of the site (EGC, 2000).

The population density within 10 mi of the site is estimated to be approximately 187 people per mi^2 by the year 2020. The predicted density for the 50-mi radius from the site is 653 people per mi^2 by the year 2020 (EGC, 2000).

9.3.3.3.2 Byron Generation Station

A construction permit was issued for the Byron Station in 1975; Unit 1 and has been operating since approximately 1984, and Unit 2 has been operating since approximately 1985. The Byron Station is located in northern Illinois, 3.7-mi south-southwest of the city of Byron, and 2.2-mi east of the Rock River, in Ogle County. The site is situated in the approximate center of the county in a predominately agricultural area. The Byron Station occupies approximately 1,782 ac of land. This area consists of the main site area and the transmission and pipeline corridor to the Rock River. The main site area occupies approximately 1,398 ac, while the corridor occupies the remaining 384 ac. Byron is a two-unit operational nuclear generating facility with 495-ft-high twin cooling towers that help cool the pressurized water reactors. EGC owns and operates the facility. There are no industrial, institutional, commercial, recreational, or residential structures on the site, other than those used by EGC in the normal conduct of its utility business. The development of the site for uses other than power generation and agriculture is not planned (EGC, 2002). It is assumed that a new nuclear facility at the area would have roughly the same general environmental impact as the existing facility.

9.3.3.3.2.1 Consumptive Use of Water

The major source of plant makeup water is the Rock River. Rock River is nonnavigable for commercial purposes, but remains a popular recreation area. Boating, fishing, and water-skiing are popular pastimes on the river. The only other uses for Rock River are industrial water and some irrigation (EGC, 2002). Plant blowdown water is discharged to the Rock River.

While some surface water is used at the site, makeup can be supplied to the cooling towers by two deep wells. Generally, most of the water for domestic, municipal, and industrial use in the region is obtained from groundwater sources. The major unit is the St. Peter Sandstone within the Cambrian-Ordovician Aquifer, although minor supplies commonly are obtained from the shallower glacial drift and dolomite aquifers. There are seven public water supply systems within 10 mi of the plant site. All use groundwater wells for water supply. Due to the relatively low level of urbanization around the site area and the small amount of on-site use, it is unlikely that future increases in groundwater withdrawal in the area would have much effect on the groundwater supply at the site (EGC, 2002).

A site groundwater monitoring program was begun in December of 1975. This monitoring program was performed (1) to define existing conditions as a base for future comparisons; (2) to monitor the effects of construction; (3) to check for either plant operation or groundwater use by others; and (4) to protect off-site groundwater users in case of detrimental changes in groundwater quality. The site groundwater monitoring program was not part of any radiological monitoring program. Six domestic and agricultural water wells were monitored for monthly changes in piezometric levels. Three of the water wells are now owned by EGC and are located on the inside perimeter of the Byron site boundaries. The other three wells are on the outside perimeter of the site boundary. Data from this monitoring program indicated no changes in groundwater chemistry or

piezometric levels attributable to excavation, grouting, groundwater pumping, or other activities at the Byron site (EGC, 2002).

In addition to this site groundwater monitoring program, the detailed site geotechnical investigation identified an area of groundwater contaminated by toxic materials prior to the purchase of the land by Commonwealth Edison and EGC. The operation of the Byron Station is not expected to effect groundwater at the site (EGC, 2002). Consumptive use of water predicted for the EGC ESP Facility cooling systems is described in Table 5.2-2. Consumptive use is expected to be minimal.

9.3.3.3.2.2 No Further Species Endangerment

At the time early environmental assessments were made of the Byron facilities, all large-scale construction activities had been completed and operation was in full force. No evidence has been found to indicate that construction or operation of a new nuclear plant would have any detrimental effects on the area around the facility (USNRC, 1982).

9.3.3.3.2.3 Effects on Spawning Grounds

The Byron Station received its construction permit in 1975, and operating licenses were issued for both units in the mid-1980s. No spawning grounds or otherwise sensitive ecosystems were noted. It is expected that no adverse effect on spawning grounds will occur with the construction and operation of new units at the facility (USNRC, 1982).

9.3.3.3.2.4 Effluent Discharge and Water Quality

Byron operates under a NPDES permit issued by the State of Illinois. The early environmental reports note that water quality may be affected by chemical discharge (USNRC, 1982). It is not anticipated that discharges from a new facility will exceed current limits. As noted in Section 5.2, one target established for the EGC ESP Facility is to maintain the cumulative discharge rate within CPS permit conditions. For the purposes of this review, it is anticipated that the bounding case for the proposed facility would be the existing permits at Byron.

9.3.3.3.2.5 Preemption and Other Land Use Issues

Land use within the 5-mi radius of the Byron Station is agricultural. There is little industry in the vicinity, and that is primarily developed for supporting the agrarian economy. Wheat, corn, and soybeans are the primary products (EGC, 2002).

Illinois State Route 2, which is the closest major highway to the site, is located 2.5-mi west of the plant and has an annual average traffic flow per 24-hr period that ranges from 4,000 cars between Byron and Oregon to 8,800 cars in Oregon. State Routes 72 and 64 are also well traveled, having 24-hr annual averages that exceed 2,000 cars (EGC, 2002).

The Rock River is the major waterway for the area surrounding the Byron site, although it is considered nonnavigable to commercial traffic in this vicinity. It is a popular recreation spot (EGC, 2002). Construction and operation of new nuclear units are not expected to preempt these uses.

9.3.3.3.2.6 Potential Effect on Aquatic and Terrestrial Environment

Currently, the Byron Station uses the Rock River for makeup water and blow down is likewise discharged into the river (EGC 2002). Water from Rock River will likely serve these functions for any new units placed on the site.

Sport fisheries and other aquatic and terrestrial habitats could be temporarily affected by a construction of the EGC ESP Facility at this site. The Rock River is a popular recreational river. It is not expected that construction and operation of a new nuclear plant will significantly affect the water quality of the river.

Terrestrial effects are also expected to be limited to short-term displacement during construction. Earlier reports and current reviews indicate that wildlife inhabit undisturbed areas at the Byron site; this trend is expected to continue.

9.3.3.3.2.7 Population Characteristics

The site currently meets population criteria for 10 CFR 100. The population for the 10-mi radius around the Byron Station is projected to be approximately 31,616 by the year 2020, or 101 people per mi^2. That population generally lives between 5 and 10 mi from the site. The regional population in the 10- to 50-mi radius is expected to reach 1,514,138 people by the year 2020, with 269 people per mi^2 (EGC, 2002).

The primary population center is Rockford, 17 mi to the northeast of the plant. The projected 2020 population is 246,700. DeKalb, about 28-mi east-southeast of the plant, has a projected 2020 population of more than 73,000. The population density is generally at its greatest between 10 to 20 mi from the Byron Station (EGC, 2002).

There are 28 industries within 10 mi of the site. There are 16 schools within the 10-mi radius, and it is anticipated that most of the students live in the same radial area (EGC, 2002).

Transient populations are expected to be composed primarily of recreational users. The transient population is estimated at 43,617 due to the influx of recreational users to the vicinity (EGC, 2002).

There are several recreational facilities in the LPZ, which is defined for Byron as a 3-mi radius from the plant. Peak daily usage of these areas occurs on the weekends (EGC, 2002).

9.3.3.3.3 Dresden Generating Station

The Dresden Nuclear Power Station site consists of approximately 953 ac. It is a three-unit station. The site boundaries generally follow the Illinois River to the north, the Kankakee River to the east, a county road from Divine extended eastward to the Kankakee River on the south, and the Elgin, Joliet and Eastern Railway right-of-way on the west (EGC, 2003).

Unit 1 is located in the northeast quadrant of the site with an intake canal extending west from the Kankakee River and a discharge canal extending north to the Illinois River. Unit 1 was officially retired on August 31, 1984, but its major structures are still present and intact. It is now designated a nuclear Historic Landmark by the American Nuclear Society. Unit 2 is located on the site directly west of and adjacent to Unit 1. The location of Unit 3 is directly west of and adjacent to Unit 2 (EGC, 2003). Units 2 and 3 are operational.

Portions of the area outside the station footprint have been leased to a neighboring farmer for grazing cattle and raising crops. Hunting is also permitted outside security areas. A microwave relay tower belonging to International Bell Telephone system is located approximately 1,000 ft from the reactor building. A meteorological tower is located approximately 3,000 ft from the reactor building (EGC, 2003). It is assumed that a new

nuclear facility at the area would have roughly the same general environmental impact as the existing facility.

9.3.3.3.3.1 Consumptive Use of Water

Dresden's primary source of makeup water is the Kankakee River, with discharge flowing into the Illinois River. Earlier environmental reports on the Dresden Station note little discernable effect caused by consumptive use of surface water or groundwater. The top of the Cambrian-Ordovician aquifer is 500 to 800 ft below the surface and use of surface water for cooling and other activities at a new plant would not affect aquifer levels. However, shallow aquifers were affected by initial construction of the units in the late 1960s and EGC assumes that the same effect would occur if a new facility were built at the site. Some change in the pattern of surface water runoff was noted, although the impacts were considered indiscernible (USNRC, 1972).

The station only draws water from the deep aquifer in small amounts, compared to other consumptive uses in the area. It is expected that the continued use of groundwater will not have any significant impact on shallow aquifers or water use in the area. The two operating units use indirect closed cycle systems, and the effect on surface water use is minimal (EGC, 2003). The bounding case for this report also plans cooling towers, as described in Chapter 3, that will mitigate consumptive water use. Consumptive use of water predicted for the EGC ESP Facility cooling systems is described in Table 5.2-2. Consumptive use is expected to be minimal.

9.3.3.3.3.2 No Further Species Endangerment

At the time early environmental assessments were made of the Dresden facilities, all large-scale construction activities had been completed and operation was in full force. Recent environmental reviews show that three Illinois-listed threatened and endangered species have been collected in the vicinity of the site (EGC, 2003a). It is not expected that construction or operation of a new nuclear plant would have any detrimental effects on the area around the facility.

9.3.3.3.3.3 Effects on Spawning Grounds

The Dresden site has been operated as a nuclear plant since the early 1960s. No spawning grounds or otherwise sensitive ecosystems have been noted. It is expected that no adverse effect on spawning grounds will occur with the construction and operation of new units at the facility (EGC, 2003a).

9.3.3.3.3.4 Effluent Discharge and Water Quality

Dresden operates under a NPDES permit issued by the State of Illinois. The early environmental reports note that water quality of the Illinois River may be affected by chemical discharge (USNRC, 1972).

It is not anticipated that discharges from a new facility will exceed current limits. As noted in Section 5.2, one target established for the EGC ESP Facility is to maintain the cumulative discharge rate within CPS permit conditions. For the purposes of this review, it is anticipated that the bounding case for the proposed facility would be the existing permits at Dresden.

9.3.3.3.3.5 Preemption and Other Land Use Issues

Current land use is industrial. Given the fact that the entire Dresden site has been a large power generating facility since 1965, the current land use is not expected to change. However, the Dresden site does not have additional available land within the boundaries. In order to build a new facility, an operating unit or Unit 1 would require decommissioning. The area around Dresden has become increasingly urbanized, and it is expected that the trend will continue. The construction and operation of a new nuclear facility at the site would not be expected to affect the land use patterns of the area.

9.3.3.3.3.6 Potential Effect on Aquatic and Terrestrial Environment

The major rivers within 5 mi of the plant are the Illinois, Des Plaines, and Kankakee rivers. The Kankakee River joins the Des Plaines River, east of the plant, to form the Illinois River, which extends along the north boundary of the site. The closest navigational channel is on the Illinois River, located approximately 0.5-mi north of the plant. The closest river lock is the Dresden Island Lock, approximately 1-mi northwest of the plant (EGC, 2003).

Sport fisheries and other aquatic and terrestrial habitats could be affected by a proposed new facility at this site, as well as decommissioning activities. The Illinois River is an industrial river. Although water quality has improved somewhat through environmental regulation and cleanup efforts, large commercial and sports fisheries are virtually nonexistent. Increased turbidity, commercial traffic (e.g. barges), and effluent discharges unrelated to the operation of the Dresden facility have contributed to a decrease in vegetation and other aquatic life in the river. It is not expected that construction and operation of a new nuclear plant will significantly affect the water quality of the river.

The Kankakee River serves as the existing station's source of cooling water, and would likely provide cooling water for any new facility. The Kankakee is a small river. It is several degrees cooler than the Illinois River, and supports a sports fishery. Entrainment and impingement are both noted at the intake of the existing units, and are expected to continue during the operations of a new facility (USNRC, 1972).

Terrestrial effects are also expected to be limited to short-term displacement during construction. Earlier reports and current reviews indicate that wildlife inhabit undisturbed areas at the Dresden site; this trend is expected to continue (USNRC, 1972; EGC, 2003a).

9.3.3.3.3.7 Population Characteristics

The Dresden site currently meets the population requirements of 10 CFR 100. The LPZ for the station is an area within a 5-mi radius. The population within the 5-mi radius area is 8,948. The nearest resident population within the LPZ is contained in a cluster of cottages along the west shore of the Kankakee River; the nearest line of cottages is just outside the exclusion area boundary (EAB). The estimated population of this cluster of homes is approximately 280. The other closest residences are widely separated in several directions from the station. A single residence is located approximately 0.6-mi southeast of the station on the east shore of the Kankakee River (EGC, 2003).

The closest significant residential concentration of over 1,000 residents is 3- to 4-mi northeast of the station along the Illinois River (EGC, 2003).

The Chicago metropolitan area lies within 50 mi of the site.

9.3.3.3.4 LaSalle County Station

The LaSalle County Station is a 2-unit, 3060 ac site located in Brookfield Township of LaSalle County in northeastern Illinois. The Illinois River is 5-mi north of the site. The major transportation routes near the site include the Illinois River, approximately 3-mi north of the northern boundary; IL State Highway 170, 0.5-mi east of the eastern boundary of the site; and Interstate Highway 80, 8-mi north of the northern site boundary. The Chicago, Rock Island, & Pacific RR, approximately 3.25-mi north of the northern site boundary, is the closest operable RR line (EGC, 2002a).

It is assumed that a new nuclear facility at the area would have roughly the same general environmental impact as the existing facility.

9.3.3.3.4.1 Consumptive Use of Water

The Illinois River is the primary surface water source for the facility. The river is an important source of commercial and recreational navigation. Surface consumption is primarily by neighboring industrial and agricultural use. The LaSalle County Station does not significantly affect surface water use from the Illinois River, because a 2058 ac cooling lake was created to provide water for cooling and discharge.

Groundwater is used at LaSalle County Station to supply the water requirements for the plant systems, makeup demineralizer and potable supply (EGC, 2002a).

Groundwater is obtained from two deep wells in the Cambrian-Ordovician Aquifer, which underlies the site. Each well is equipped with a deep well submersible pump with a rated capacity of 300 gpm. The water is stored in a 350,000-gallon, ground level tank prior to distribution to the demineralizer and domestic systems. Maximum groundwater use is presently estimated to be approximately 521,600 gpd. The maximum water requirements for each system and the percentage of the total used are as follows: makeup demineralizer, 479,600 gpd (92 percent); potable supply, 15,000 gpd (3 percent); sand filter backwash, 11,500 gpd (2 percent); and recreational supply, 15,500 gpd (3 percent) (EGC, 2002a). The use of water for the EGC ESP Facility depends on the cooling system and plant design selected. Consumptive use of water predicted for the EGC ESP Facility cooling systems is described in Table 5.2-2. It is expected to be minimal.

Groundwater for public use within 10 mi of the site is obtained predominantly from wells in the Cambrian-Ordovician Aquifer. A large cone of depression has developed in the potentiometric surface of the Cambrian-Ordovician Aquifer in response to continuous and increasing withdrawals of groundwater at the major municipal and industrial pumping centers along the Illinois River (EGC, 2002a). However LaSalle County Station groundwater use does not create a significant impact on the groundwater at the site.

9.3.3.3.4.2 No Further Species Endangerment

Bald eagle and peregrine falcon are known to occur in LaSalle County. Other listed threatened or endangered species (Indiana bat and timber rattlesnake) are known to occur in LaSalle County. However, sightings are rare and occur along the bluffs of the Illinois River, offsite from the LaSalle County Station. Most sightings have been determined to be incidental during migration, and not an indication of an established population. None of these threatened or endangered species occur on the site, since there is no suitable habitat

available in the site boundaries. There are no records of endangered aquatic species on this stretch of the Illinois River (USNRC, 1972).

9.3.3.3.4.3 Effects on Spawning Grounds

No spawning grounds or otherwise sensitive ecosystems have been noted. It is expected that no adverse effect on spawning grounds will occur with the construction and operation of new units at the facility.

9.3.3.3.4.4 Effluent Discharge and Water Quality

LaSalle County Station operates under a NPDES permit issued by the State of Illinois. The early environmental reports note that water quality may be affected by chemical discharge; there is no record that NPDES limits have been exceeded during operation of the existing plants. As noted in Section 5.2, one target established for the EGC ESP Facility is to maintain the cumulative discharge rate within CPS permit conditions. For the purposes of this review, it is anticipated that the bounding case for the proposed facility would be the existing permits at the Station.

9.3.3.3.4.5 Preemption and Other Land Use Issues

Land use remains predominantly agricultural. No new land will be preempted if new units are placed on the site.

9.3.3.3.4.6 Potential Effect on Aquatic and Terrestrial Environment

No long term negative effects are anticipated if new units were placed at the LaSalle County Station site. Three groups of terrestrial bird life (waterfowl, upland game, and raptors) use the area, but no difference in the populations has been attributed to the operation of the LaSalle Station. Mammalian species have likewise adjusted to the station's operations, and no change in range or viability of these populations has been noted. The applicant expects that the population will remain stable if new units are placed at the site. However, some temporary displacement is expected as a result of construction of new units (see Chapter 4).

Adverse impacts to aquatic environments are not expected to result from operation of new units at the site. The Illinois River is best characterized as a recovering river system, and abundance and diversity of aquatic species and habitats is restricted by upstream pollutants, commercial and recreational boat traffic, and continuing habitat alteration. These factors arise from offsite use of the river corridor; operation of the current LaSalle County Station is not a significant factor in the overall quality of aquatic habitats in the vicinity of the plant.

9.3.3.3.4.7 Population Characteristics

The LaSalle County Station site currently meets the population requirements of 10 CFR 100, and overall population is consistent with a rural, agrarian community. The population within 5 mi is expected to grow to 1,273 by the year 2020, which maintains the low population density of 16.20. The density reflects the continuing rural character of the site. The population within 50 mi is expected to reach 1.6 million by the year 2020. Population growth is expected to occur in the 35- to 50-mi range, as population centers like Joliet continue to grow, and Chicago suburbs expand. It is expected that population density in the 50-mi radius will grow to approximately 211.1 people per mi^2. However, it is predicted that the density between 40 and 50 mi will increase to 292.7 people per mi^2. Low density expected to continue inside the 10-mi radius (EGC, 2002a).

Transient populations will include recreational users. Some parks outside the 5-mi radius generally expect over one-half million visitors each year. However, no projections are available for the area within the 5-mi radius (EGC, 2002a).

The LPZ has no schools, industry or other facilities. It is anticipated that the population within the LPZ will be approximately 502 in the year 2020 (EGC, 2002a).

The nearest population center is Ottowa, with a projected population of 25,904 by the year 2020. The population density in the year 1980 within 50 mi of the LaSalle County Station is projected to be approximately 141 people per mi^2. By the year 2020, the density is projected to reach 211 people per mi^2 (EGC, 2002a).

9.3.3.3.5 Quad Cities Generating Station

The Quad Cities Generating Station is a two-unit facility on the east bank of the Mississippi River opposite the mouth of the Wapsipinicon River, and about 3-mi north of Cordova, Illinois. The facility was licensed and began operations in 1973. It is roughly the same design as the Dresden Units 2 and 3, described above. The site is about 20-mi northeast of the Quad Cities (Davenport, Iowa; Rock Island, Moline, and East Moline, Illinois). Topographic relief at the site is low and relatively flat. The station elevation represented by the ground floor level of the reactor building, is 595 ft above msl datum. The ground surface drops off abruptly at the bank of the river, forming a bluff about 30-ft high. The station is located on a 784-ac tract of land and has a 310-ft cooling tower.

It is assumed that a new nuclear facility at the area would have roughly the same general environmental impact as the existing facility.

9.3.3.3.5.1 Consumptive Use of Water

Cooling water is obtained from the Mississippi river. Water for other industrial and home use comes from the river and wells in the area. Groundwater sources in the area come from three aquifer systems composed of unconsolidated alluvial and outwash sand and gravel deposits, shallow Silurian dolomite formations, and the Cambrian-Ordovician aquifer. Neither groundwater use nor surface water use has been adversely affected by the continuing operation of the facility.

The facility obtains water for circulation cooling and other plant uses from the Mississippi River. The facility operates open cycle per an agreement with the states of Illinois and Iowa. No groundwater is used to operate the plant (EGC, 2003c). Consumptive use of water predicted for the EGC ESP Facility cooling systems is described in Table 5.2-2. Consumptive use is expected to be minimal.

9.3.3.3.5.2 No Further Species Endangerment

There has been no indication that endangered or threatened species will be affected by the operation of a new nuclear facility at the site. No evidence has been found to indicate that construction or operation of a new nuclear plant at the Quad Cities site would have any detrimental effects on the area around the facility (EGC, 2003b).

9.3.3.3.5.3 Effects on Spawning Grounds

The Quad Cities site has been operated as a nuclear plant since the early 1970s. EGC is not aware of any federally-listed endangered or threatened terrestrial species at the Quad Cities site. However, relatively few threatened and endangered terrestrial species have been

recorded in the counties crossed by the transmission corridors associated with Quad Cities, including bald eagle, the Indiana bat, two orchid species, snails and reptiles (EGC, 2003b).

Pool 14 of the Upper Mississippi River harbors a diverse freshwater mussel community, including one federally-listed species, the Higgins' eye pearly mussel (*Lampsilis higginsi*) (EGC, 2003b). *Lampsilis higginsi* has historically been found in Pool 14 up- and downstream of Quad Cities, with highest densities and spawning areas in the vicinity of Cordova, Illinois, some 1.5- to 3.5-mi downstream of the Station (EGC, 2003b).

9.3.3.3.5.4 Effluent Discharge and Water Quality

Quad Cities currently operates under a NPDES permit issued by the State of Illinois. As noted in Section 5.2, one target established for the EGC ESP Facility is to maintain the cumulative discharge rate within CPS permit conditions. For the purposes of this review, it is anticipated that the bounding case for the proposed facility would be the existing permits at the Station.

9.3.3.3.5.5 Preemption and Other Land Use Issues

Land use around the station is a combination of agriculture and industrial uses (EGC, 2003c). Some land in the region been set aside for recreational and environmental use; the Mississippi River supports a large sport fishery as well as commercial and recreational boating. It is not expected that current land use at Quad Cities will change or expand, and there will be no preemption or adverse effects on land that has been set aside for environmental or recreational uses.

9.3.3.3.5.6 Potential Effect on Aquatic and Terrestrial Environment

The woody islands and sloughs near the site are popular habitats for waterfowl as well as small game animals such as squirrel, rabbit, muskrat, beaver, and mink. The upper Mississippi Wildlife and Fish Refuge is located opposite the site. Ducks and geese rely on the refuge for nesting and other habitat. There are marshy wetlands along the banks of the river across from and above the site, but none are apparent within the site boundaries (EGC, 2003b).

Industrial waste discharges unrelated to the operation of the Quad Cities site have occasionally affected aquatic habitat in the river. The river pool at Quad Cities encompasses a variety of aquatic habitats and communities. These habitats are diverse and represent important variety for aquatic and terrestrial ecosystems. The river provides important habitat for sport and commercial fisheries as well as the biota that support those fisheries. Major Mississippi River habitats around the station include channel habitats, border habitats, side channel habitats, river lake and pond habitat, slough habitat, and island lake habitat (EGC, 2003b).

9.3.3.3.5.7 Population Characteristics

The site currently meets the population requirements of 10 CFR 100. The population distribution around the site is quite low with typical rural characteristics. Within a 5-mi radius of the site, the 1980 population density is approximately 72 people per mi^2 and is less than 10 people per mi^2 in some areas. The nearest population center is Clinton, Iowa (population approximately 32,828) located 8.5 mi to the northeast. Southwest of the site, at distances of 15 to 20 mi, are the Quad-Cities of Rock Island, Moline, and East Moline, Illinois, and Davenport, Iowa. Total population and density from the site out to a distance

of 25 mi are approximately 449,082 and 229 people per mi^2, respectively. Davenport, Iowa, is the largest population center within 50 mi, with a population of over 100,000. Population growth near the plant has been slow and generally consistent with the rural population growth rate in the Quad Cities area of about 1 percent per year maximum. There are no known factors that would change the 1 percent maximum rural growth rate in the foreseeable future (EGC 2003c).

9.3.3.3.6 Zion Generating Station

Zion Generating Station is located on the west shore of Lake Michigan about 40-mi north of Chicago, Illinois, and about 42-mi south of Milwaukee, Wisconsin. The site is in the extreme eastern portion of the city of Zion, Illinois (Lake County). It is on the west shore of Lake Michigan, approximately 6-mi north-northeast of the center of the city of Waukegan, Illinois, and 8-mi south of the center of the city of Kenosha, Wisconsin. The site comprises approximately 250 ac, which are owned by the EGC. The site is traversed from west to east by Shiloh Boulevard near the northern property boundary.

The facility is a former nuclear facility that has been converted into a voltage-stabilizing facility. The two reactors were shut down in early 1998. The unit's generators were converted to synchronous condensers (EGC, 1998).

The most current information is from the Zion decommissioning SAR prepared in 1998. However, some of the existing environmental information from the 1972 final environmental statement has been used to postulate impacts from siting a new nuclear facility at Zion. The Zion station is currently in SAFSTOR. The Zion facilities still exist; however, they are currently used for synchronous condenser operations. It is assumed that a new nuclear facility at the area would have roughly the same general environmental impact as the existing facility.

9.3.3.3.6.1 Consumptive Use of Water

The plant's cooling water is drawn from Lake Michigan. The Lake County Public Water District operates a water intake about 1-mi north of the site and about 3,000 ft out in the Lake. Operation of a new plant will not result in releases greater than 10 CFR 20 limits at the point of discharge, and consequently, normal operation should not result in significant radioactivity concentrations in drinking water. The topography of the site and its immediate environs is relatively flat with elevations varying from the lake shoreline to approximately 20 ft above the level of the lake. Approximately 2-mi west of Lake Michigan is a topographical divide causing surface water drainage west of the divide to flow away from the lake while the east drainage flows toward the lake (EGC, 1998).

At the time of operation, the Zion facility used more than 1.5 million gpm water in its cooling system, along with minor consumption. The domestic water was obtained from the City of Zion's system. It is assumed that for a new plant, consumptive water use would also come from the City of Zion (USNRC, 1972b). However, consumptive use of water for the EGC ESP Facility depends on the cooling system and plant design selected. Bounding requirements for consumptive use of water from the EGC ESP Facility are described in Table 5.2-2. Consumptive use is expected to be minimal.

9.3.3.3.6.2 No Further Species Endangerment

The Final Environmental Statement contained no reviews of endangered species to determine whether operation of the station would lead to further species endangerment. The current information shows that no endangered species have been identified at the site. However, Lake Michigan provides an important habitat and spawning grounds for several species.

9.3.3.3.6.3 Effects on Spawning Grounds

There is no indication from available data that there are any spawning grounds in the vicinity of the site. Generally, inshore regions with sand-gravel bottoms are considered valuable spawning grounds in the Great Lakes ecosystem, and it is anticipated that additional impacts from construction and operation of a new facility at the site will affect these areas.

9.3.3.3.6.4 Effluent Discharge and Water Quality

Aside from cooling water discharge, some industrial effluent and stormwater will be discharged. As noted in Section 5.2, one target established for the EGC ESP Facility is to maintain the cumulative discharge rate within CPS permit conditions. For the purposes of this review, it is anticipated that the bounding case for the proposed facility would be the permits historically issued at the Station.

9.3.3.3.6.5 Preemption and Other Land Use Issues

The Zion Station site was acquired in the 1950s, and has been used as a generating facility and synchronous condenser site. Land use at the site and surrounding vicinity is expected to remain industrial. It is not anticipated that any additional land will be preempted if the site were used for a new nuclear facility.

9.3.3.3.6.6 Potential Effect on Aquatic and Terrestrial Environment

The terrestrial ecology around the site is characterized by dunes, prairie, forest, and beach environments. There is a unique dune environment in the vicinity of the site, but there was no history of adverse impacts from operation of the Zion nuclear facility. There may be some temporary adverse impacts from construction of the EGC ESP Facility at Zion, as noted in the construction impacts discussion of this ER (see Chapter 4). There is no evidence of permanent adverse environmental impacts on terrestrial ecology if a new facility were to be built on this site.

The primary aquatic ecology is Lake Michigan. The lake is characterized by low nutrient concentrations and biological productivity. Near the Zion site, inshore waters are characterized as mesotrophic or intermediate, with respect to nutrients. Substantial declines in fish populations have occurred in Lake Michigan due to pollution and other uses. Nothing in the USNRC's environmental statement or the decommissioning SAR indicate that operation of a facility at the site would adversely affect aquatic environments (USNRC, 1972b; EGC, 1998).

9.3.3.3.6.7 Population Characteristics

The Zion station is less than 50 mi from Chicago, with a current population of more than 5 million. Additionally, The Waukegan-North Chicago area is predominantly an industrial region with 144 manufacturing establishments. The product of the largest of these manufacturing firms is pharmaceuticals and chemicals. The most predominant product of

the remainder is in the metallurgical and fabricated metal products field. The Zion-Winthrop Harbor area is a small industrial region. A portion of this industry is located between the western boundary of the site and the Chicago and Northwestern RR tracks, approximately 0.8-mi west of the plant location, and is light in nature. There are no schools or hospitals within 1 mi of the station. The site is bordered on the north and the south by the Illinois Beach State Park (EGC, 1998). The centers of the communities of Zion and Winthrop Harbor are located 1.6 mi and 2.5 mi, respectively, from the plant location.

The estimated population within 5 mi of the site for the year 2000 was 88,700 persons (USNRC, 1972b). The 2002 population for Lake County is over 600,000. The Chicago/Cook County population is estimated at 5.3 million (US Census Bureau, 2003).

9.3.3.3.7 Site Comparison Summary

All sites generally meet the criteria outlined in NUREG-1555. However, three of the six candidate sites (e.g., Byron, Quad Cities, and Dresden) do not have enough remaining land at the site to construct and operate a new nuclear facility while remaining operational. The applicant has already determined that early retirement of existing plants is not preferable (see Section 9.2.4). Therefore, construction of new units on these sites would entail a loss of existing generating capacity, which would largely offsite the benefits of operation of the new units. The three remaining candidate sites (e.g., Braidwood, LaSalle, and Zion) have available land, but the impacts of construction and operation there would be greater than or equal to those postulated for the EGC ESP Site.

Braidwood and LaSalle may provide alternative sites, but neither is obviously superior, based on the site review. Braidwood is closer to larger population centers; as noted in the Braidwood USAR, the projected population within the vicinity is 187 per mi^2. The LPZ is expected to reach nearly 2,000 people by 2020. Thus, impacts from severe accidents at Braidwood will be greater than or equal to the proposed EGC ESP Site. At the LaSalle County Station, the population within 5 mi is expected to grow to 1,273 by the year 2020, which maintains the low population density of 16.20. It is predicted that the density between 40 and 50 mi will increase to 292.7 people per mi^2 by 2020. The site comparison showed that impacts of the EGC ESP Facility at Braidwood or LaSalle would be equal to those postulated for the EGC ESP Site.

Zion provides another alternative, and other than the proposed EGC ESP Facility, presents a viable alternative from a market view. The site is linked to existing transmission facilities and the transmission flow pattern around Chicago lends itself to additional generation north of the city. Unlike any of the other candidate sites, Zion is no longer operational. However, the Waukegan-North Chicago area near Zion is predominantly an industrial region with 144 manufacturing establishments and an urban population similar to other Chicago suburbs. The greater Chicago area is home to more than 5 million people. Zion is on the shores of Lake Michigan, and, as noted in Section 9.3.3.3.6, environmental impacts from construction and operation of the EGC ESP Facility at Zion would be equal to or greater than the impacts postulated for the EGC ESP Site. Because Zion is also in a highly populated and industrialized area, impacts from severe accidents and socioeconomic factors would be disproportionately greater than or equal to those predicted for the EGC ESP Site.

The EGC ESP Site is the environmentally preferred site among the candidate sites:

- The postulated consumptive use of water at the EGC ESP Site is less than or equal to water use at other sites.
- The EGC ESP Site does not contain any critical habitat or occurrence of listed threatened or endangered species. Therefore, the impact to any endangered species is less than or equal to the impact postulated for the other candidate sites.
- The EGC ESP Site does not contain spawning grounds for any threatened or endangered species. Most other sites record no endangered species or spawning areas in the site vicinity. Quad Cities, as a bounding case, is near an important spawning area. Thus, the impact to any spawning areas are less than or equal to other candidate sites.
- The EGC ESP Site impact review (see Chapters 4 and 5) does not postulate effluent discharge beyond the limits of existing NPDES permits or regulations. Based on the information available for the candidate sites, the impacts from effluent discharge are less than or equal to other candidate sites.
- The EGC ESP Site review postulates no preemption or land use changes for construction and operation of the proposed facility. Likewise, it is not anticipated that preemption or other land use changes would be required to co-locate a facility at any of the candidate sites. Therefore impact would equal at all sites.
- Terrestrial and aquatic impacts at the EGC ESP Site are noted in Chapters 4 and 5. The potential impact of a new nuclear facility on terrestrial and aquatic environments at the other sites varies, depending on the location of the site. However, with the exception of the Quad Cities site, it is anticipated that the impacts will be generally equal to those postulated for the EGC ESP Site.
- Each site generally meets the population criteria of 10 CFR 100. However, candidate sites like Zion and Braidwood are located in largely urban areas with high population density, and construction or operation may result in disproportionate impacts in those areas. Therefore, the impact on population density would be greater than the EGC ESP Site. The impact at other candidate sites would be similar to those postulated for the EGC ESP Site.
- The EGC ESP Site does not require decommissioning or dismantlement of an existing facility as required for Byron, Quad Cities or Dresden.

Therefore, none of the other existing nuclear sites is obviously superior to the EGC ESP Site on the basis of environmental considerations. Table 9.3-1 reviews the criteria in relation to all seven sites.

Although the preferred candidate sites are not obviously superior to the proposed EGC ESP Site, the applicant also considered the second test for superiority by reviewing economic, technological, and institutional factors. Three additional criteria were used to further evaluate these factors: 1) Ability to transmit to demand centers; 2) Not proximate to population centers; and 3) Ease of construction. The candidate sites are evaluated using these additional review criteria in the following sections.

9.3.3.3.8 Ability to Transmit to Demand Centers

Since the site will eventually support a merchant generating plant, EGC must consider opportunities the site offers for transmitting generated power to customers who buy it. Each candidate site, including Clinton, has existing transmission corridors that may, according to discussions with the transmission operator and ComEd, be expanded to accommodate new power lines. However, early discussions with ComEd and Illinois Power noted that the southern end of Illinois has relatively sparse transmission and light loads as opposed to the heavily loaded lines serving Chicago. All sites except the EGC ESP Facility are in northern Illinois, and are affected by transmission congestion around the major metropolitan areas around Chicago and the Quad Cities (USDOE, 2001). Section 3.7 also describes the transmission systems and load requirements in southern Illinois.

Transactions between the Midwest, Southeastern, and Eastern transmission grids are limited because they are interconnected at only a few points through interties (USDOE, 2001). For example, electricity and pricing spikes in the Midwest in the summer of 1998 were caused in part by transmission constraints limiting the availability of the region to import electricity from other regions of the country that had available electricity (USDOE, 2001). Additionally, high levels of congestion are found from Minnesota to Wisconsin, the Midwest through the Mid-Atlantic, and often power must be routed through the Chicago hub (USDOE, 2002). Transmission capacity limits are predicted to affect reliability throughout the Great Lakes Region (USDOE, 2001). On the other hand, the existing site at Clinton offers more flexible transmission opportunities, since power can be transmitted to the Chicago hub, and south through other interconnections.

A high or medium score indicates that additional nuclear power generated at the site could be transmitted to different markets. Six of the seven sites were rated with medium ability, and the EGC ESP Site was rated with high ability, primarily because the site has direct interties in multiple directions, and flexible access opportunities to other markets. Therefore, the EGC ESP Site is preferable with respect to transmission.

9.3.3.3.9 Not Proximate to Population Centers

Sites with low populations within their vicinity were scored high. For example, the proposed EGC ESP Site is located about 6 mi from the Town of Clinton, and the smaller Town of Dewitt is also in the vicinity. Both towns (and other smaller towns in the vicinity) have low populations, and thus, the EGC ESP Site scores high. Sites that scored medium are in rural areas, but are nearer to large populations. For example, the other sites are located closer to the Chicago area, such as Zion and Braidwood, or are relatively close to other metropolitan areas, such as Quad Cities. These sites were not rated high because of their proximity to the larger population bases. Therefore, the EGC ESP Site is preferable with respect to its lack of proximity to population centers.

9.3.3.3.10 Ease of Construction

The ability to achieve cost savings and potential ease of construction at an existing nuclear site is an important additional factor in selecting a site. For example, the EGC ESP Site scored high because only one unit is currently constructed, when most existing infrastructure at the facility was intended for two units. Thus, the EGC ESP Site presents opportunities in land availability and infrastructure that are not present at some of the other two-unit candidate sites, such as Quad Cities, Dresden, and Byron. The sites undergoing decommissioning (i.e., Zion) actually scored higher than the alternative sites with existing

units because the decommissioning process has already begun and the dismantling process can shortly follow. One site (i.e., Dresden) with three units (two operating and one decommissioned) also scored medium. Sites with two existing and operating units scored low (e.g., Byron, Dresden, and Quad Cities), based on available land within the site boundaries for new construction, and the fact that one or both units would need to be removed from operation to acquire space for construction.

9.3.3.3.11 Summary

Table 9.3-2 summarizes how each existing site was rated based on the factors described in this section. This table shows that the EGC ESP Site scored high in each secondary category.

9.3.4 Conclusions

The EGC ESP Site was chose as the preferred site for reasons described below.

- Alternative greenfield, brownfield, and nuclear sites offer no environmental advantages. In fact, construction and operation of a new nuclear plant at each of the alternative sites would entail environmental impacts that are equal to or greater than those at the EGC ESP Site.
- The EGC ESP Site is the best location from which to transmit generated power to demand centers. As noted above, congestion and reliability issues through the Chicago hub and surrounding areas have been documented in national grid studies. These reliability issues, as well as congestion problems north of Chicago into Wisconsin and the upper Midwest, make the EGC ESP Site a more reliable site. These studies also indicate that transmission constraints hinder a generator's ability to sell cheap Midwest power to the south during periods of peak demand (USDOE, 2001). The EGC ESP Site is positioned to produce and transmit power through the Chicago hub if necessary, but the sparse transmission and light loads on the existing system will also allow reliable power transmission through interties to the Southeastern and Eastern grids. This is an important advantage over the other sites. The capability of these systems to support future market demand weighed heavily in favor of the EGC ESP Site.
- Other sites are located in more suburban areas and lack the flexibility in site characteristics and areal extent that the EGC ESP Site possesses, and present potentially disproportionate socioeconomic and environmental impacts.
- The facility at the EGC ESP Site was originally designed for two units, and much of the existing infrastructure can be utilized in the construction and operation of a new unit.

In summary, there are no alternative sites that are obviously superior to the EGC ESP Site in the region of interest.

9.4 Alternative Facility Systems

The design for the EGC ESP Facility has not yet been selected. The detail in this section depends on the selection of a vendor design, and the design of individual components of the system. As noted elsewhere in this ER (see Chapter 3, Chapter 4, and Chapter 5), the bounding parameters of a number of facility designs were used to develop the composite parameters for the site. Based on the evaluations provided in this ER, the site will accommodate the operational and environmental requirements for any one of them. Therefore, alternative facility systems will be discussed at the COL stage, when the full spectrum of design alternatives will be available.

CHAPTER 9

References

Chapter Introduction

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Section 9.4

None

CHAPTER 9

Tables

TABLE 9.2-1
Air Emissions from Coal-Fired Alternative

Parameter	Calculation	Result
Annual coal consumption	$4\text{ units} \times \frac{583\text{ MW}}{\text{unit}} \times \frac{10{,}200\text{ Btu}}{\text{kW} \times \text{hr}} \times \frac{1{,}000\text{ kW}}{\text{MW}} \times \frac{\text{lb}}{9{,}648\text{ Btu}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times 0.85 \times \frac{24\text{ hr}}{\text{day}} \times \frac{365\text{ day}}{\text{yr}}$	8,470,288 tons of coal per year
SO_x[a,c]	$\frac{38 \times 1.01\text{ lb}}{\text{ton}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times (1 - 95/100) \times \frac{8{,}470{,}288\text{ tons}}{\text{yr}}$	8,127 tons SO_x per year
NO_x[b, c]	$\frac{9.7\text{ lb}}{\text{ton}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times (1 - 95/100) \times \frac{8{,}470{,}288\text{ tons}}{\text{yr}}$	2,054 tons NO_x per year
CO[c]	$\frac{0.5\text{ lb}}{\text{ton}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times \frac{8{,}470{,}288\text{ tons}}{\text{yr}}$	2,118 tons CO per year
PM[d]	$\frac{10 \times 6.9\text{ lb}}{\text{ton}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times (1 - 99.9/100) \times \frac{8{,}470{,}288\text{ tons}}{\text{yr}}$	292 tons PM per year
PM_{10}[d]	$\frac{2.3 \times 6.9\text{ lb}}{\text{ton}} \times \frac{\text{ton}}{2{,}000\text{ lb}} \times (1 - 99.9/100) \times \frac{8{,}470{,}288\text{ tons}}{\text{yr}}$	67 tons PM_{10} per year

[a] USEPA, 1998, Table 1.1-1.
[b] USEPA, 1998, Table 1.1-2.
[c] USEPA, 1998, Table 1.1-3.
[d] USEPA, 1998, Table 1.1-4.
Notes: CO = carbon monoxide
NO_x = oxides of nitrogen
PM = particulate matter
PM_{10} = particulate matter having diameter nominally less than 10 microns
SO_2 = sulfur dioxide

TABLE 9.2-2
Air Emissions from Gas-Fired Alternative

Parameter	Calculation	Result
Annual gas consumption	$4\,\text{unit} \times \frac{572\,\text{MW}}{\text{unit}} \times \frac{6{,}120\,\text{Btu}}{\text{kW} \times \text{hr}} \times \frac{1{,}000\,\text{kW}}{\text{MW}} \times 0.85 \times \frac{\text{ft}^3}{1{,}021\,\text{Btu}} \times \frac{24\,\text{hr}}{\text{day}} \times \frac{365\,\text{day}}{\text{yr}}$	102,118,571,753 ft^3 per year
Annual Btu input	$\frac{102{,}118{,}571{,}753\ \text{ft}^3}{\text{yr}} \times \frac{1{,}021\,\text{Btu}}{\text{ft}^3} \times \frac{\text{MM Btu}}{10^6\,\text{Btu}}$	104,263,061 MMBtu per year
SO_x[a]	$\frac{0.0034\,\text{lb}}{\text{MM Btu}} \times \frac{\text{ton}}{2{,}000\,\text{lb}} \times \frac{104{,}263{,}061\,\text{MMBtu}}{\text{yr}}$	177 tons SO_x per year
NO_x[b]	$\frac{0.0109\,\text{lb}}{\text{MM Btu}} \times \frac{\text{ton}}{2{,}000\,\text{lb}} \times \frac{104{,}263{,}061\ \text{MMBtu}}{\text{yr}}$	568 tons NO_x per year
CO[b]	$\frac{0.0023\,\text{lb}}{\text{MMBtu}} \times \frac{\text{ton}}{2{,}000\,\text{lb}} \times \frac{104{,}263{,}061\ \text{MMBtu}}{\text{yr}}$	120 tons CO per year
PM[a]	$\frac{0.0019\,\text{lb}}{\text{MMBtu}} \times \frac{\text{ton}}{2{,}000\,\text{lb}} \times \frac{104{,}263{,}061\ \text{MMBtu}}{\text{yr}}$	99 tons filterable PM per year
PM_{10}[a]	$\frac{99\ \text{tons TSP}}{\text{yr}}$	99 tons filterable PM_{10} per year

[a] USEPA, 2000, Table 3.1-2.
[b] USEPA, 2000, Table 3.1 database.
Notes: Btu = British thermal units
CO = carbon monoxide
MM = million
NO_x = oxides of nitrogen
PM = particulate matter
PM_{10} = particulate matter having diameter less than 10 microns
SO_2 = sulfur dioxide
TSP = total suspended particulates

TABLE 9.2-3
Coal-Fired Alternative

Characteristic	Basis
Unit size = 550 MW ISO rating net[a]	Set to match capacity of gas-fired alternative
Unit size = 583 MW ISO rating gross[a]	Calculated based on 6 percent onsite power
Number of units = 4	Calculated to be approximate to EGC ESP facility net capacity of 2,200 MW
Boiler type = tangentially fired, dry-bottom	Minimizes nitrogen oxides emissions (USEPA, 1998).
Fuel type = bituminous, pulverized coal	Typical for coal used in Illinois
Fuel heating value = 9,648 Btu/lb	1999 value for coal used in Illinois (USDOE/EIA, 2000)
Fuel ash content by weight = 6.9 percent	1999 value for coal used in Illinois (USDOE/EIA, 2000)
Fuel sulfur content by weight = 1.01 percent	1999 value for coal used in Illinois (USDOE/EIA, 2000)
Uncontrolled NO_X emission = 9.7 lb/ton Uncontrolled CO emission = 0.5 lb/ton Uncontrolled SO_x emission = 38.4 lb/ton	Typical for pulverized coal, tangentially fired, dry-bottom, with low- NO_x burner (USEPA, 1998)
Uncontrolled PM = 10 lb/ton Uncontrolled PM_{10} = 2.3 lb/ton	Typical for pulverized coal, tangentially fired, dry-bottom (USEPA, 1998)
Heat rate = 10,200 Btu/kWh	Typical for coal-fired single-cycle steam turbines (USDOE/EIA, 2000)
Capacity factor = 0.85	Typical for large coal-fired units (Exelon Corporation experience)
NO_X control = low NO_X burners, overfire air and selective catalytic reduction (95 percent reduction)	Best available and widely demonstrated for minimizing NO_X emissions (USEPA 1998).
Particulate control = fabric filters (baghouse-99.9 percent removal efficiency)	Best available for minimizing particulate emissions (USEPA, 1998)
SO_x control = Wet scrubber –lime (95 percent removal efficiency)	Best available for minimizing SOx emissions (USEPA, 1998)

[a] The difference between "net" and "gross" is electricity consumed onsite.

Notes: Btu = British thermal unit
CO = carbon monoxide
ISO rating = International Standards Organization rating at standard atmospheric conditions of 59°F, 60 percent relative humidity, and 14.696 pounds of atmospheric pressure per square inch
kWh = kilowatt hour
lb = pound
MW = megawatt
NO_X = nitrogen oxides
PM = particulate matter
PM_{10} = particulate matter nominally less than 10 microns diameter
SO_x = sulfur oxides

TABLE 9.2-4
Solid Waste from Coal-Fired Alternative

Parameter	Calculation	Result
Annual SO_x generated[a]	$\frac{8{,}470{,}2887\ \text{ton coal}}{\text{yr}} \times \frac{1.01\ \text{ton S}}{100\ \text{ton coal}} \times \frac{64.1\ \text{ton } SO_2}{32.1\ \text{ton S}}$	170,833 tons of SO_x per year
Annual SO_x removed	$\frac{170{,}833\ \text{ton } SO_2}{\text{yr}} \times (95/100)$	162,291 tons of SO_x per year
Annual ash generated	$\frac{8{,}470{,}288\ \text{ton coal}}{\text{yr}} \times \frac{6.9\ \text{ton ash}}{100\ \text{ton coal}} \times (99.9/100)$	583,865 tons of ash per year
Annual lime consumption[b]	$\frac{170{,}833\ \text{ton } SO_2}{\text{yr}} \times \frac{56.1\ \text{ton CaO}}{64.1\ \text{ton } SO_2}$	149,512 tons of CaO per year
Calcium sulfate[c]	$\frac{162{,}291\ \text{ton } SO_2}{\text{yr}} \times \frac{172\ \text{ton } CaSO_4 \bullet 2H_2O}{64.1\ \text{ton } SO_2}$	435,477 tons of $CaSO_4 \cdot 2H_2O$ per year
Annual scrubber waste[d]	$\frac{149{,}512\text{ton CaO}}{\text{yr}} \times \frac{(100-95)}{100} + 354{,}653\text{ton } CaSO_4 \bullet 2H_2O$	442,952 tons of scrubber waste per year
Total volume of scrubber waste[e]	$\frac{442{,}952\ \text{ton}}{\text{yr}} \times 40\ \text{yr} \times \frac{2{,}000\ \text{lb}}{\text{ton}} \times \frac{\text{ft}^3}{144.8\ \text{lb}}$	244,724,862 ft^3 of scrubber waste
Total volume of ash dispensed onsite[f,g]	$\frac{583{,}865\ \text{ton}}{\text{yr}} \times \frac{100-87}{100} \times 40\ \text{yr} \times \frac{2{,}000\ \text{lb}}{\text{ton}} \times \frac{\text{ft}^3}{100\ \text{lb}}$	60,721,960 ft^3 of ash
Total volume of solid waste disposed onsite	244,724,862 ft^3 + 60,721,960 ft^3	305,446,822 ft^3 of solid waste
Waste pile area (acres)	$\frac{305{,}446{,}822\ \text{ft}^3}{30\ \text{ft}} \times \frac{\text{acre}}{43{,}560\ \text{ft}^2}$	234 acres of solid waste
Waste pile area (ft × ft square)	$\sqrt{(305{,}446{,}822\ \text{ft}^3/30\text{ft})}$	3,191 feet by 3,191 feet of solid waste

[a] Calculations assume 100 percent combustion of coal.
[b] Lime consumption is based on total SO_2 generated.
[c] Calcium sulfate generation is based on total SO_2 removed.
[d] Total scrubber waste includes scrubbing media carryover.
[e] Density of $CaSO_4 \cdot 2H_2O$ is 144.8 lb/ft^3.
[f] Density of coal bottom ash is 100 lb/ft^3 (FHA, 2000).
[g] Assumed 87 percent of ash is recycled.
Notes: S = sulfur
SO_2 = sulfur dioxide
CaO = calcium oxide (lime)
$CaSO \cdot 2H_2O$ = calcium sulfate dihydrate

TABLE 9.2-5
Gas-Fired Alternative

Characteristic	Basis
Unit size = 550 MW ISO rating net:[a] Two 184-MW combustion turbines and a 182-MW heat recovery boiler	Manufacturer's standard size gas-fired combined cycle plant
Unit size = 572-MW ISO rating gross:[a] Two 191.4-MW combustion turbines 189.3-MW heat recovery boiler	Calculated based on 4 percent onsite power
Number of units = 4	Calculated to be approximate to EGC ESP Facility net capacity of 2,200 MW
Fuel type = natural gas	Assumed
Heat rate = 6,120 Btu/kWh	Manufacturer's listed heat rate for General Electric Frame 7FA unit.
Fuel heating value = 1,021 Btu/ft^3	1999 value for natural gas used in Illinois (USDOE/EIA, 2000)
NO_X emission = 0.0109 lb/MMBtu	Typical for large SCR-controlled gas fired units with water-steam injection (USEPA, 2000)
CO emission = 0.00226 lb/MMBtu	Typical for large SCR-controlled gas fired units with water-steam injection (USEPA, 2000)
Uncontrolled SO_x emission = 0.0034 lb/ton	Typical for gas-fired units (USEPA, 2000)
Uncontrolled PM emission = 0.0066 lb/MMBtu	Typical for gas-fired units (USEPA, 2000)
Uncontrolled PM_{10} emission = 0.0066 lb/MMBtu	Typical for gas-fired units (USEPA, 2000)
Capacity factor = 0.85	Typical for large gas-fired base load units
NO_X control = selective catalytic reduction (SCR) with steam/water injection (90 reduction)	Best available for minimizing NO_X emissions (USEPA, 2000)

[a] The difference between "net" and "gross" is electricity consumed on site.

Notes: Btu = British thermal unit
CO = carbon monoxide
ft^3 = cubic foot
ISO rating = International Standards Organization rating at standard atmospheric conditions of 59°F, 60 percent relative humidity, and 14.696 pounds of atmospheric pressure per square inch
kWh = kilowatt hour
MM = million
MW = megawatt
NO_X = nitrogen oxides
PM = particulate matter
PM_{10} = particulate matter nominally less than 10 microns diameter

TABLE 9.2-6
Impacts Comparison Summary

Impact Category	Proposed Action (EGC ESP)	Coal-Fired Generation	Gas-Fired Generation	Combinations
Land Use	Small	Small	Small	Small to Large
Water Quality	Small	Small	Small	Small
Air Quality	Small	Moderate to Large	Moderate	Small to Moderate
Ecological Resources	Small	Small	Small	Small
Threatened and Endangered Species	Small	Small	Small	Small
Human Health	Small	Moderate	Small	Small
Socioeconomics	Small	Small	Small	Small
Waste Management	Small	Moderate	Small	Small
Aesthetics	Small	Small	Small	Small to Large
Cultural Resources	Small	Small	Small	Small
Accidents	Small	Small	Small	Small

Notes: SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize not noticeably alter any important attribute of the resource.
MODERATE – Environmental effects are sufficient to alter noticeably, but not destabilize, any important attribute of the resource.
LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.
10 CFR 51, Subpart A, Appendix B, Table B-1, Footnote 3.

TABLE 9.2-7

Impacts Comparison Detail

Proposed Action (EGC ESP)	Coal-Fired Generation	Gas-Fired Generation	Combination
EGC ESP for 20 years, followed by construction, operation, and decommissioning.	New construction at the CPS site.	New construction at the CPS site.	New construction at the CPS site and construction for solar/wind installations throughout region of interest.
Upgrade existing switchyard and transmission lines.	Upgrade existing switchyard and transmission lines.	Upgrade existing switchyard and transmission lines.	Upgrade existing switchyard and transmission lines. Construction of transmission and rights-of-way for renewable generation.
	Upgrade existing rail spur.	Construct 2.5 miles of gas pipeline along existing rights-of-way.	Construct 2.5 miles of gas pipeline along existing rights-of-way.
	Four 550-MW tangentially-fired, dry bottom units; capacity factor 0.85.	Four 550-MW units, each consisting of two 184-MW combustion turbines and a 182-MW heat recovery boiler; capacity factor 0.85.	Four 550-MW units, each consisting of two 184-MW combustion turbines and a 182-MW heat recovery boiler; capacity factor 0.85 maximum and probably less depending upon the amount of generation by renewable sources. Renewable energy sources: combination of solar and wind turbine technologies to produce up to 2180 MWe when resource is available.
New cooling water system with potential construction of new cooling towers.	New cooling water system with potential construction of new cooling towers.	New cooling water system with potential construction of new cooling towers.	New cooling water system with potential construction of new cooling towers. Depending on solar technology utilized, cooling water may also be needed.

TABLE 9.2-7

Impacts Comparison Detail

Proposed Action (EGC ESP)	Coal-Fired Generation	Gas-Fired Generation	Combination
	Pulverized bituminous coal, 9,648 Btu/pound; 10,200 Btu/kWh; 6.9% ash; 1.01% sulfur; 9.7 pound/ton nitrogen oxides; 8,470,288 tons coal/yr.	Natural gas, 1,021 Btu/ft^3; 6,120 Btu/kWh; 0.0034 lb sulfur/MMBtu; 0.0109 lb NO_x/MMBtu; 102,118,571,753 ft^3 gas/yr.	Natural gas, 1,021 Btu/ft^3; 6,120 Btu/kWh; 0.0034 lb sulfur/MMBtu; 0.0109 lb NO_x/MMBtu; 102,118,571,753 ft^3 gas/yr when operating at capacity mentioned above. Effluents would be scaled based on level of renewable generation.
	Low NO_x burners, overfire air, and selective catalytic reduction (95% NO_x reduction efficiency).	Selective catalytic reduction with steam/water injection.	Selective catalytic reduction with steam/water injection.
	Wet scrubber – lime desulfurization system (95% SO_x removal efficiency); 149,512 tons limestone/yr.		
	Fabric filters (99.9% particulate removal efficiency.		
580 workers	250 workers	25-40 workers	40-50 workers

TABLE 9.2-7

Impacts Comparison Detail

Proposed Action (EGC ESP)	Coal-Fired Generation	Gas-Fired Generation	Combination	
			Gas-fired	Renewable
Land Use Impacts				
SMALL – Construction at CPS would be in previously disturbed areas. Facility would consist of approximately 150 acres.	SMALL – Construction at CPS would be in previously disturbed areas. The plant would upgrade existing rail spur and use transportation corridors. Forty years of ash and scrubber waste disposal would require 234 acres and construction of the power block and coal storage areas would impact approximately 200 acres.	SMALL – Construction at CPS would be in previously disturbed areas. 110 acres for facility; pipeline could be routed along existing rights-of-way and would require an additional 40 acres for easement.	SMALL – Construction at CPS would be in previously disturbed areas. 110 acres for facility; pipeline could be routed along existing rights-of-way and would require an additional 40 acres for easement.	SMALL to LARGE – Impacts are dependent on the level of renewables included in the combination alternative. Wind/solar siting and building of transmission access infrastructure could remove substantial amounts of land throughout the ROI and would remove substantially more land per MWe produced when compared to any other form of generation. Land use impacts for wind are discussed in 9.2.2.1; for solar technologies see 9.2.2.4.
Water Quality Impacts				
SMALL – Construction impacts minimized by use of best management practices. Operational impacts minimized by use of best management practices by use of new cooling water system.	SMALL – Construction impacts minimized by use of best management practices. Operational impacts minimized by use of best management practices by use of new cooling water system.	SMALL – Smaller cooling water demands (then coal), inherent in combined-cycle design. Construction of pipeline could cause temporary erosion and sedimentation in streams crossed by right-of-way.	SMALL – Smaller cooling water demands (then coal), inherent in combined-cycle design. Construction of pipeline could cause temporary erosion and sedimentation in streams crossed by right-of-way.	SMALL - Some water use and quality issues will occur depending on solar technology used.

TABLE 9.2-7

Impacts Comparison Detail

Proposed Action (EGC ESP)	Coal-Fired Generation	Gas-Fired Generation	Combination	
			Gas-fired	Renewable
Air Quality Impacts				
SMALL – Construction impacts minimized by use of best management practices. Operational impacts are negligible.	MODERATE to LARGE – 8,127 tons SO_x/yr 2,054 tons NO_x/yr 2,118 tons CO/yr 292 tons PM/yr 67 tons PM_{10}/yr	MODERATE – 117 tons SO_x/yr 568 tons NO_x/yr 120 tons CO/yr 99 tons PM_{10}/yr[a]	SMALL to MODERATE – 117 tons SO_x/yr 568 tons NO_x/yr 120 tons CO/yr 99 tons PM_{10}/yr[a] These would be reduced based on the level of renewable generation.	SMALL - Small risk of fugitive emissions from manufacture of PV cells, or accidental leaks.
Ecological Resource Impacts				
SMALL – Construction of power block would impact up to 150 acres of terrestrial habitat, potentially displacing various species. Potential new cooling towers would reduce impingement, entrainment, and thermal impacts to aquatic species.	SMALL – Construction of the power block and coal storage areas and 40 years of ash/sludge disposal would impact approximately 300 acres of terrestrial habitat, displacing various species. Potential new cooling towers would reduce impingement, entrainment, and thermal impacts to aquatic species.	SMALL – Construction of power block would impact up to 150 acres of terrestrial habitat, potentially displacing various species. Potential new cooling towers would reduce impingement, entrainment, and thermal impacts to aquatic species.	SMALL – Construction of power block would impact up to approximately 150 acres of terrestrial habitat, potentially displacing various species. Potential new cooling towers would reduce impingement, entrainment, and thermal impacts to aquatic species.	SMALL - Avian mortality remains an issue at wind farms; heavy metals (e.g., cadmium) in PV cells can lead to a variety of impacts, depending on organism and exposure.
Threatened and Endangered Species				
SMALL – No resident threatened and endangered species are known to occur at the site or along transmission corridors.	SMALL – No resident threatened and endangered species are known to occur at the site or along transmission corridors.	SMALL – No resident threatened and endangered species are known to occur at the site or along transmission corridors.	SMALL – No resident threatened and endangered species are known to occur at the site.	SMALL – Siting and routing of additional transmission corridors for wind/solar installations can be altered to minimize impacts, however, altered siting may remove resources from availability.

TABLE 9.2-7

Impacts Comparison Detail

Proposed Action (EGC ESP)	Coal-Fired Generation	Gas-Fired Generation	Combination	
			Gas-fired	Renewable
Human Health Impacts				
SMALL – Impacts associated with noise are not anticipated. Radiological exposure is not considered significant. Risk from microbiological organisms minimal due to thermal characteristics at the discharge and lack of innoculant. Risk due to transmission-line induced currents minimal due to conformance with consensus code.	MODERATE – Adopting by reference GEIS conclusion that risks such as cancer and emphysema from emissions are likely (USNRC, 1996).	SMALL – Adopting by reference GEIS conclusion that some risk of cancer and emphysema exists from emissions (USNRC, 1996).	SMALL – Adopting by reference GEIS conclusion that some risk of cancer and emphysema exists from emissions (USNRC, 1996).	SMALL - Small carcinogen exposure risk noted from leaching materials during PV cell manufacture and at installations.
Socioeconomic Impacts				
SMALL – The socioeconomic impacts for this option are discussed in Section 3.8 and Section 4.8. Public service impacts are not anticipated. Location in low population area without growth controls minimizes potential for housing impacts. Plant contribution to county tax base may be significant, and continued plant operation would benefit county. Capacity of public water supply and transportation infrastructure minimizes potential or related impacts.	SMALL – Increase in permanent work force at CPS by 250 workers could affect surrounding counties, but would be mitigated by site's proximity to metropolitan areas within the region.	SMALL – Increase in permanent work force at CPS by 25-40 workers could affect surrounding counties, but would be mitigated by the site's proximity to metropolitan areas within the region.	SMALL – Increase in permanent work force at CPS by 40-50 workers could affect surrounding counties, but would be mitigated by the site's proximity to metropolitan areas within the region.	SMALL – Potential minor impacts from reliability and transmission congestion. These transmission issues are more likely with wind. Land values may increase due to lease revenue to landowners from wind installations.
Waste Management Impacts				
SMALL – Non-radiological impacts will be negligible. Radiological impacts will be small.	MODERATE – 583,865 tons of coal ash per year and 442,952 tons of scrubber sludge per year would require 234 acres over the 40-year term.	SMALL – Almost no waste generation.	SMALL – Almost no waste generation.	SMALL - Used PV cells contain potential hazardous wastes, but chemicals are sealed within the cell. Waste minimization practices also limits waste issues for used cells. Potential for leaching at landfills unknown.

TABLE 9.2-7

Impacts Comparison Detail

Proposed Action (EGC ESP)	Coal-Fired Generation	Gas-Fired Generation	Combination	
			Gas-fired	Renewable
Aesthetic Impacts				
SMALL – Visual impacts would be consistent with the industrial nature of the site.	SMALL – Visual impacts would be consistent with the industrial nature of the site.	SMALL – Visual impacts would be consistent with the industrial nature of the site.	SMALL – Visual impacts would be consistent with the industrial nature of the site.	SMALL to LARGE - Visual/auditory impacts of wind/solar installations could be substantial but could be mitigated through placement. Placement to mitigate this impact may remove resources from availability. The amount of the impact will depend on the amount of resource used.
Cultural Resource Impacts				
SMALL – Impacts to cultural resources would be unlikely due to developed nature of the site.	SMALL – Impacts to cultural resources would be unlikely due to developed nature of the site.	SMALL – Impacts to cultural resources would be unlikely due to developed nature of the site.	SMALL – Impacts to cultural resources would be unlikely due to developed nature of the site.	SMALL - Impacts to cultural resource of renewable portion and additional transmission infrastructure can be mitigated through placement. Placement to mitigate this impact may remove resources from availability.
Impacts of Accidents				
SMALL – Although the consequences of accidents could potentially be high, the overall risk of accidents is low given the low probability of an accident involving a significant release of radioactivity.	SMALL – Impacts of accidents in coal-fired plants are not applicable.	SMALL – Impacts of accidents in gas-fired plants are not applicable.	SMALL – Impacts of accidents in gas-fired plants and wind/solar are not applicable.	

TABLE 9.2-7

Impacts Comparison Detail

Proposed Action (EGC ESP)	Coal-Fired Generation	Gas-Fired Generation	Combination	
			Gas-fired	Renewable

[a] All total suspended particulates (TSP) for gas-fired alternative is PM10.

Notes: SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.

MODERATE – Environmental effects are sufficient to alter noticeably, but not destabilize, any important attribute of the resource.

LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

10 CFR 51, Subpart A, Appendix B, Table B-1, Footnote 3.

Btu = British thermal unit

MW = Megawatt

MWe = Megawatt electric

Ft^3 = cubic foot

NO_x = oxides of nitrogen

gal = gallon

PM_{10} = particulate matter having diameter less than 10 microns

GEIS = Generic Environmental Impact Statement (USNRC, 1996)

SHPO = State Historic Preservation Office

kWh = kilowatt-hour

SO_x = sulfur oxides

lb = pound

TSP = total suspended particulates

MM = million

yr = year

PV = photovoltaic

ROI = Region of Interest

TABLE 9.3-1
Illinois Nuclear Station Comparison – General Criteria for All Sites

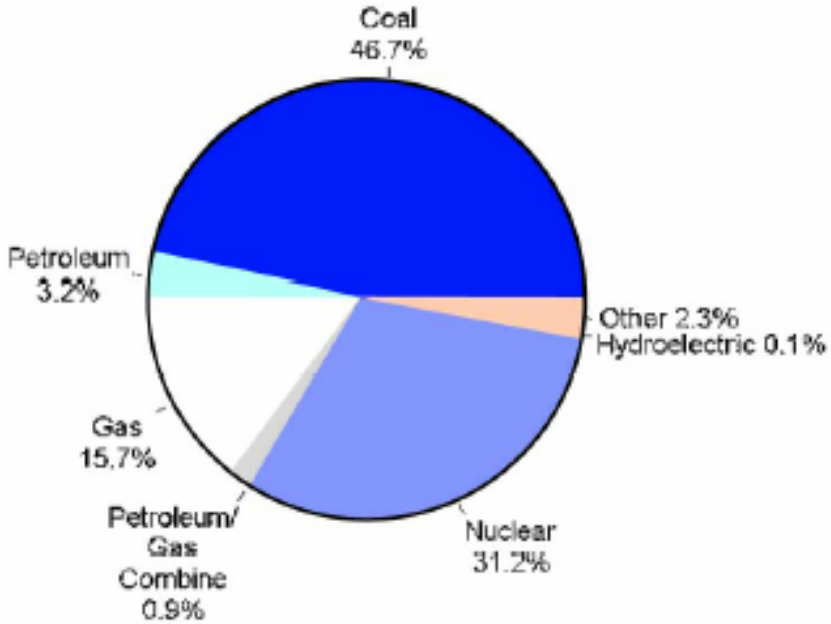
Site	Consumptive Use of Water	No Further Species Endangerment	Effects on Spawning Grounds	Effluent Discharge/ Water Quality	No Preemption or Adverse Impacts to Land Use	Potential Effects on Aquatic and Terrestrial Ecology	Population Characteristics
Braid-wood	Minor consumptive use	No record of endangered species on the site	No potential significant impacts noted	Discharges anticipated to be within current regulatory limits	No preemption or change to land use – site licensed for 4 units	Effects expected to be similar to current impacts	Meets 10 CFR 100 Site is within 50 mi of Chicago and in industrialized suburbs with potentially disproportionate environmental impacts
Byron	Consumptive groundwater use (for cooling and potable water)	No record of listed threatened or endangered species	No record of spawning grounds at the site	Discharges anticipated to be within current regulatory limits	Site licensed for 2 units; currently operating at license capacity – new construction would require additional area	Effects expected to be similar to current impacts	Meets 10 CFR 100
Clinton	Minor consumptive use	No record of listed threatened or endangered species	No record of spawning grounds at the site	Discharges anticipated to be within current regulatory limits	Site licensed for 2 units – 1 unit operating No preemption or additional land use	Effects expected to be similar to current impacts	Meets 10 CFR 100
Dresden	Minor consumptive use	No record of listed threatened or endanger species	No record of spawning grounds at site	Discharges anticipated to be within current regulatory limits	3 units, 2 units operating 1 unit not operational. No additional land available at the site	Effects expected to be similar to current impacts	Meets 10 CFR 100
LaSalle	Groundwater used for makeup, systems, and potable supply.	Occur in vicinity, but not at site	No record of spawning grounds at site	Discharges anticipated to be within current regulatory limits	2 units operating – licensed for 4 units. No additional land required.	Effects expected to be similar to current impacts	Meets 10 CFR 100
Quad Cities	Minor consumptive use	None at site-listed aquatic species present about 1.5 mi from site.	None at site – Essential Habitat and spawning area about 1.5 mi. from site	Discharges anticipated to be within current regulatory limits	Site licensed for 2 units; currently operating at license capacity – new construction would require additional area	Effects expected to similar to current operation; essential habitat may be affected	Meets 10 CFR 100

TABLE 9.3-1
Illinois Nuclear Station Comparison – General Criteria for All Sites

Site	Consumptive Use of Water	No Further Species Endangerment	Effects on Spawning Grounds	Effluent Discharge/ Water Quality	No Preemption or Adverse Impacts to Land Use	Potential Effects on Aquatic and Terrestrial Ecology	Population Characteristics
Zion	Minor consumptive use	No listed threatened or endangered species reported	No spawning grounds reported, but site presents characteristics common to inshore spawning grounds on Lake Michigan	Discharges anticipated to be within current regulatory limits	Current plant not operational. No expected preemption or adverse impacts to land use	Effects similar to operation of proposed EGC ESP Facility at the EGC ESP Site	Meets 10 CFR 100. Site is in an urbanized, industrial area with potentially disproportionate environmental impacts.

TABLE 9.3-2
Illinois Nuclear Station Comparison Alternatives

Site	Ability to Transmit to Demand Centers	Not Proximate to Population Centers	Ease of Construction	Comments
Braidwood	Medium	Medium	Medium/High	Braidwood is affected by the transmission bottleneck around the Chicago hub, and is also near population centers in Northeastern Illinois. Two licensed units are currently operational – Land is available for additional units.
Byron	Medium	High	Low	Byron is affected by the transmission bottleneck around the Chicago hub, despite its rural location. Both licensed units are currently operational – no additional land is available for new units.
Clinton	High	High	High	Clinton's rural location and low population in southern Illinois allows flexibility in transmission. The site was approved for two units. One unit was built, and the area reserved for the second unit is available for construction.
Dresden	Medium	High	Low	Dresden is affected by the transmission bottleneck around the Chicago hub, despite its rural location. The site meets 10 CFR 100. Two units are operational, and a third unit is a Nuclear Historic Landmark. There is no available land within site boundaries to colocate a new nuclear facility, and therefore the site scores low for ease of construction.
LaSalle	Medium	High	Medium/High	LaSalle's location meets 10 CFR 100 population requirements, but it is affected by the transmission bottleneck around the Chicago hub. Both units are currently operational. Land is available for construction of a new unit.
Quad Cities	Medium	Medium	Low	Quad Cities is affected by the transmission bottleneck around major metropolitan areas such as the Quad Cities, and is also near population centers in Northwestern Illinois. Both units are currently operational – there is no available land at the site for additional units.
Zion	Medium/High	Low	Medium/High	Zion is also affected by the transmission bottleneck around the Chicago hub, and is the most affected by Chicago's population. The units are not operational, and the facility is decommissioned. The two units were converted into a voltage stabilization facility to relieve pressure on Illinois Power lines during peak demand periods – the units would require dismantling for siting a new plant, and the stabilization function would probably be lost. Construction may require demolition of existing structures; otherwise ability to build is high.



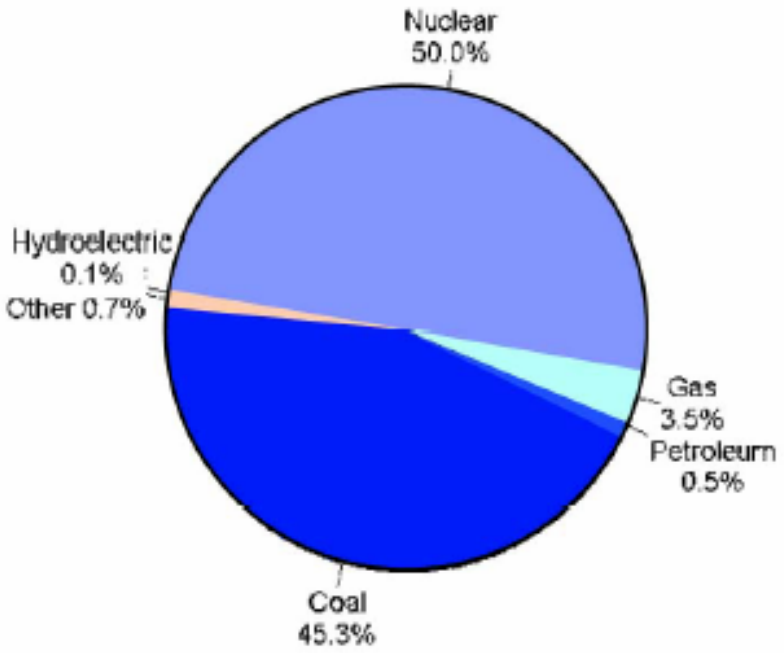
Environmental Report for the EGC Early Site Permit

Figure 9.2-1

Industry Generating Capacity in Illinois by Primary Energy Source, 1999

Legend

Not to Scale



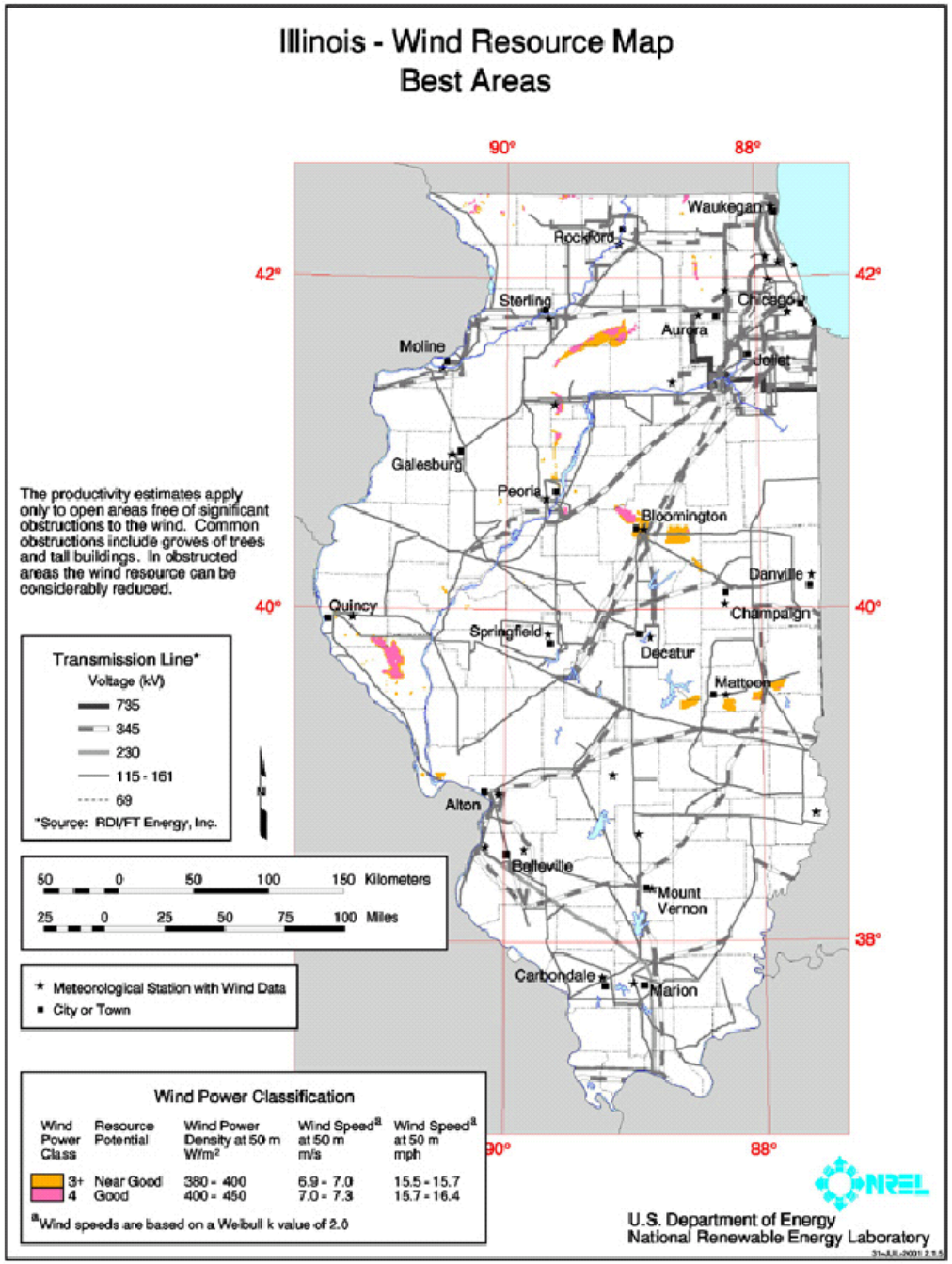
Environmental Report for the EGC Early Site Permit

Figure 9.2-2
Industry Generation Utilization in Illinois by Energy Source, 1999

Legend

Not to Scale

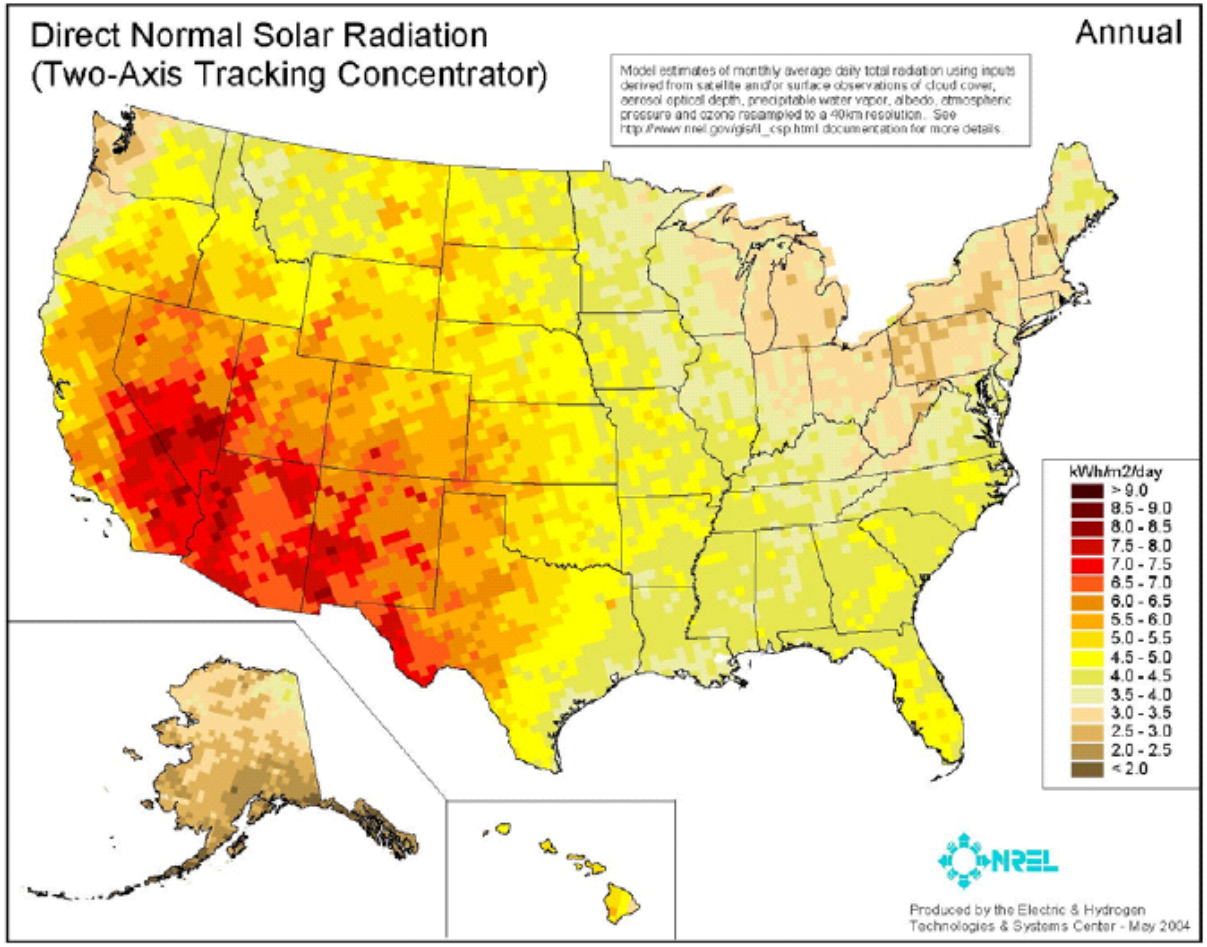
Figure 9.2-3
Illinois Wind Resource Map



Source: USDOE, 2004

Not to Scale

Figure 9.2-4
Direct Normal Solar Radiation Map



Source: USDOE, 2004

Not to Scale