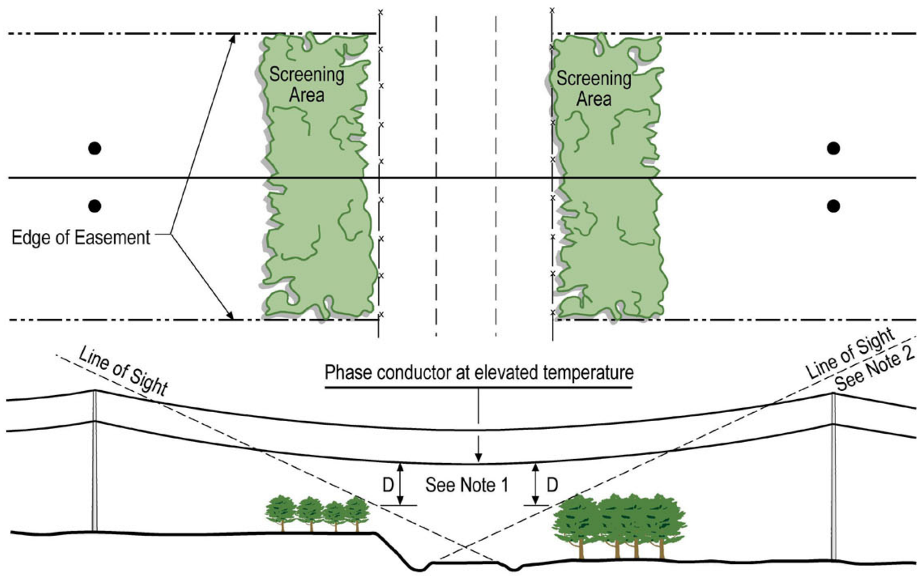
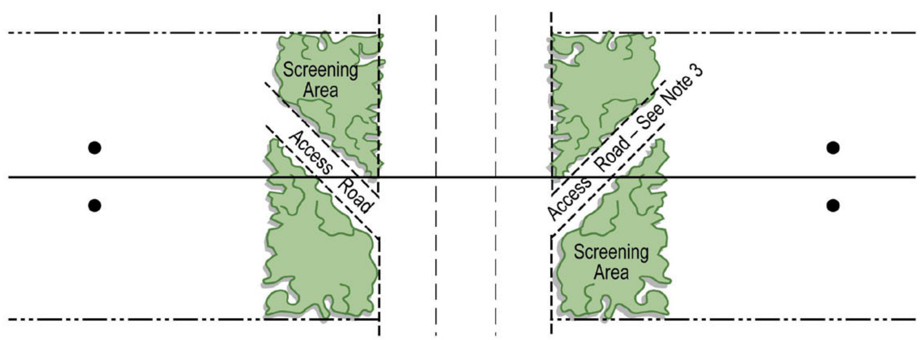
Figure 5.1-3
Screening Requirements

TRANSMISSION LINE SPECIFICATIONS
SCREENING DIAGRAMS



SCREENING REQUIREMENTS – TRANSMISSION LINE CROSSING ROAD



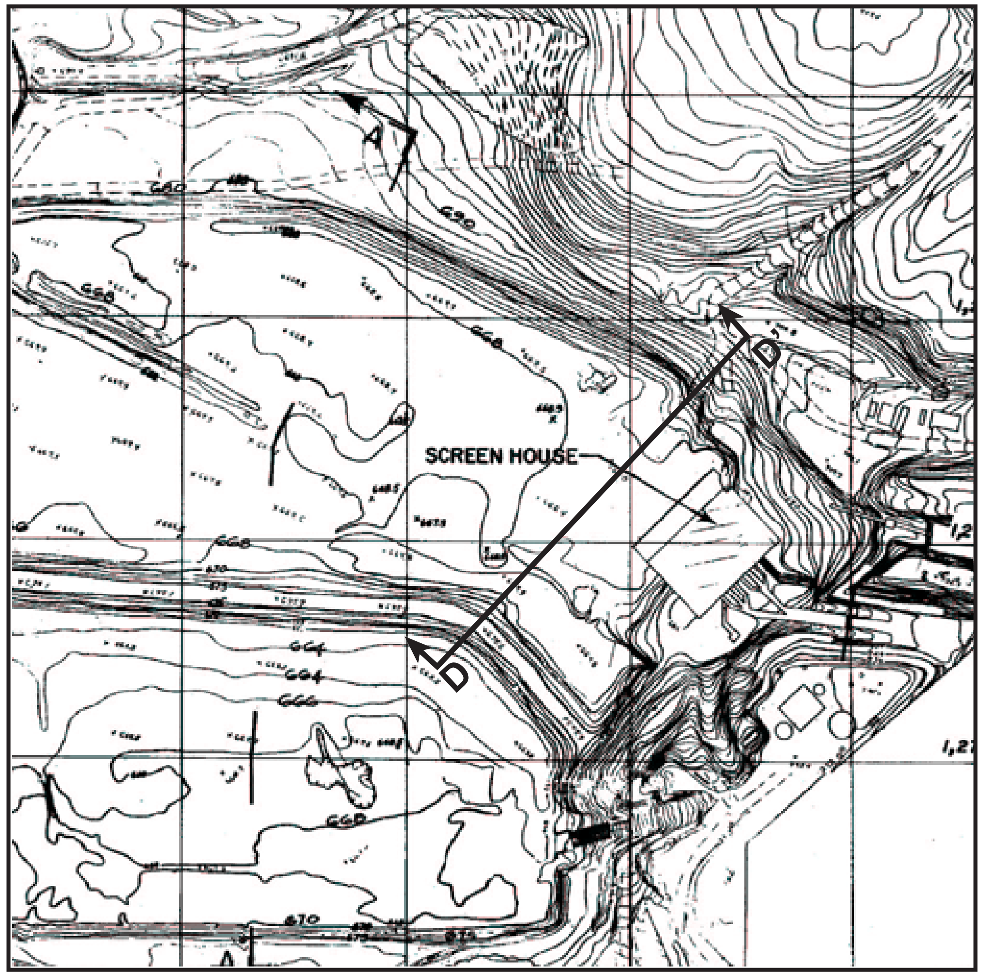
TYPICAL ACCESS ROAD THROUGH SCREENING AREA

Notes:

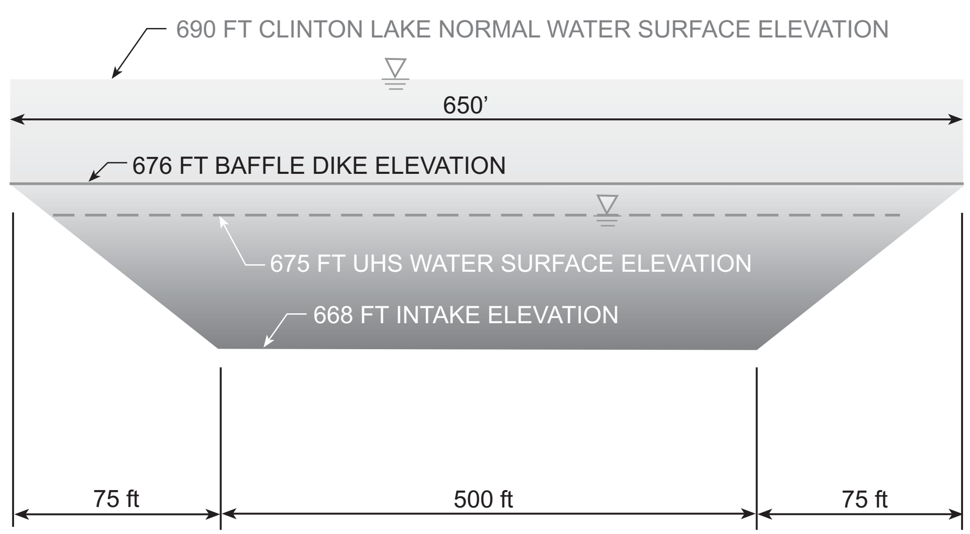
1. Dimension D shall be at least 19 ft for 345-kV lines.
2. Structures may extend above the line of sight, if the line of sight slopes upward at an angle of 15° or more.
3. The access road shall be located so that it does not expose the first structure or the cleared easement strip to view from the public road.

Not to Scale

Figure 5.3-1
Ultimate Heat Sink Plan and Section



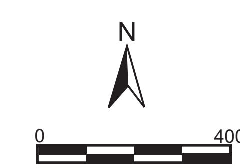
PLAN



INTAKE SECTION D-D'

(DIMENSIONS ARE APPROXIMATE)

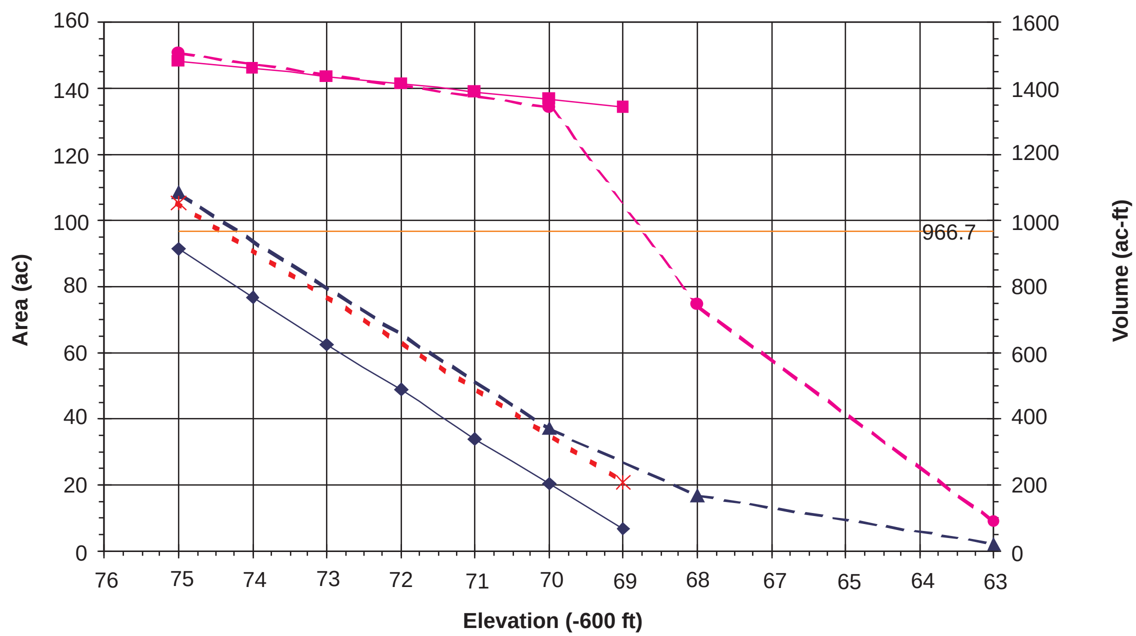
Data Source:
CPS, 2002



Scale in feet
Contour interval 2 feet

Environmental Report for the EGC Early Site Permit

Figure 5.3-2
Design and As-Built UHS Volumes and Areas



Legend

- Design Volume (September 1975)
- As-Built Volume (April 1985)
- Existing Volume (estimate)
- Volume Remaining after CT make-up
- Design Area (September 1975)
- As-Built Area (April 1985)

Not to Scale

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 minimum 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, Stronium-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, Stronium-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 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 of the 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 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

Section 6.1

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Section 6.7

None

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]) pH Total residual chlorine Total residual oxidant Temperature (average daily)	1/week 1/week 1/week 1/day Continuous
A02	Sewage Treatment Facility	Flow (mgd) pH BOD_5 Total suspended solids	1/week 1/week 1/week 1/week
B02	Radwaste Treatment System Effluent	Flow (mgd) Total suspended solids Oil and grease	Continuous 1/week 1/week
003	Water Treatment Works	Flow (mgd) pH Total suspended solids Total dissolved solids	1/week 1/week 1/week 1/week
C02 A03	Activated Carbon Treatment System Effluent	Flow (mgd) Oil and grease Benzene Ethyl benzene Toluene Xylenes (total) Priority pollutants PNAs	1/month 1/month 1/month 1/month 1/month 1/month 1/month
004	Transformer Area Oil-Water Separator	Flow (mgd) Oil and grease	1/month 1/month
005	Diesel Generator Area Oil-Water Separator	Flow (mgd) Oil and grease	1/month 1/month
006	Screen House Intake Discharges	Flow (mgd) Total residual chlorine	1/week 1/week
007	Safe Shutdown Service Water System	Flow (mgd) Total residual chlorine	1/week 1/week
008	Station Service Water	Flow (mgd) Total residual chlorine	Estimate 24-hour total Daily when discharging
015	Ultimate Heat Sink Dredge Pond Discharge	Flow (mgd) pH Total suspended solids	Continuous 1/week 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	Marsh McBirney Flowmeter (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	Marsh McBirney Flowmeter (or equivalent instrument)	Continuous
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

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

Category	Monitoring Location	Summary	Instrumentation Used	Sampling Frequency
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
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

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

Category	Monitoring Location	Summary	Instrumentation Used	Sampling Frequency
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 (Site 16)	Characterize background conditions in Salt Creek prior to point of discharge to the lake	Van Dorn, Kemmerer, or Beta type bottles YSI Multiprobe or Multiparamter Instrument	1+/month
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

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

Category	Monitoring Location	Summary	Instrumentation Used	Sampling Frequency
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.

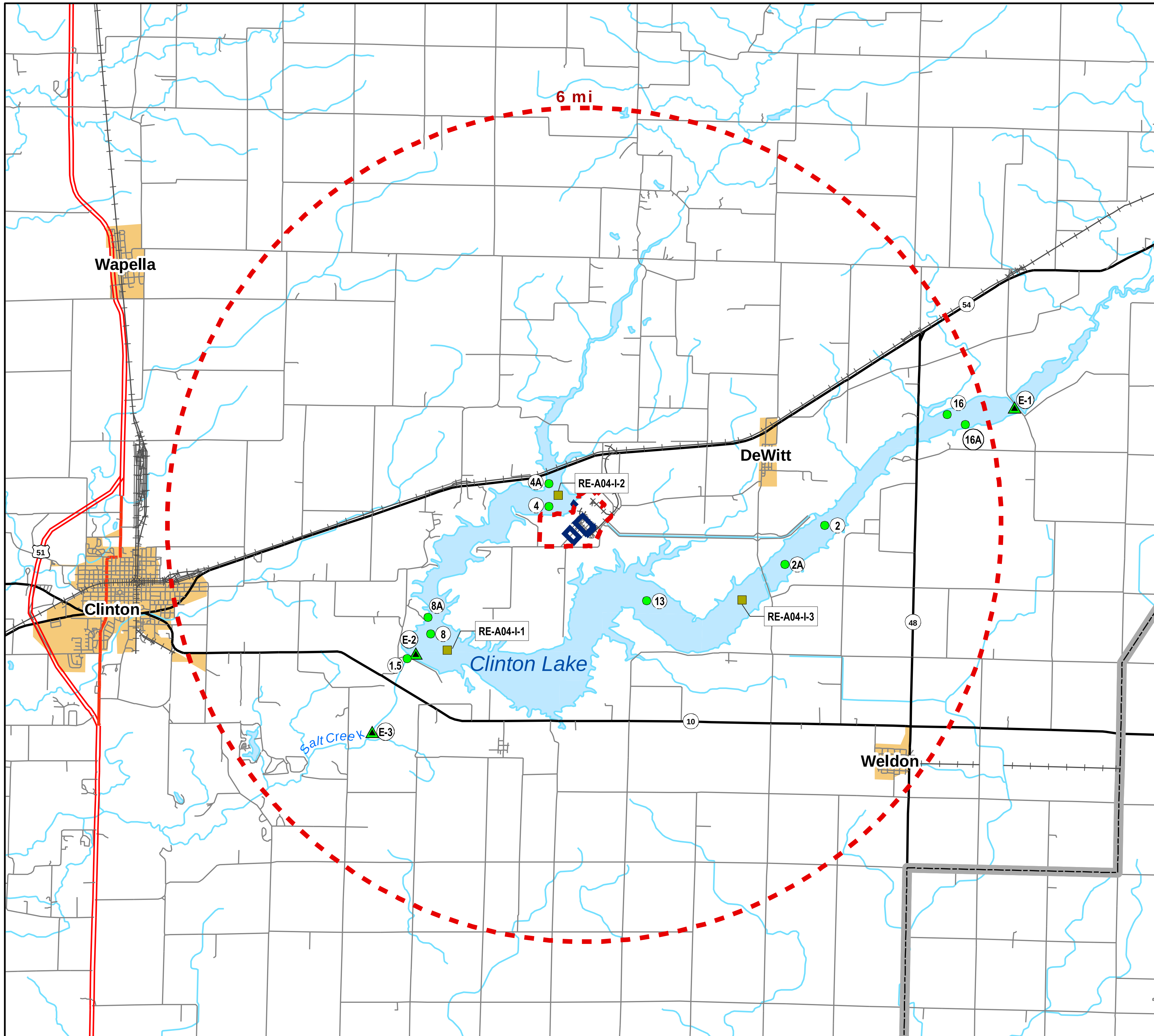
TABLE 6.7-2
Proposed Preoperational Monitoring Programs

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	YSI Multiprobe or Multiparameter 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.

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

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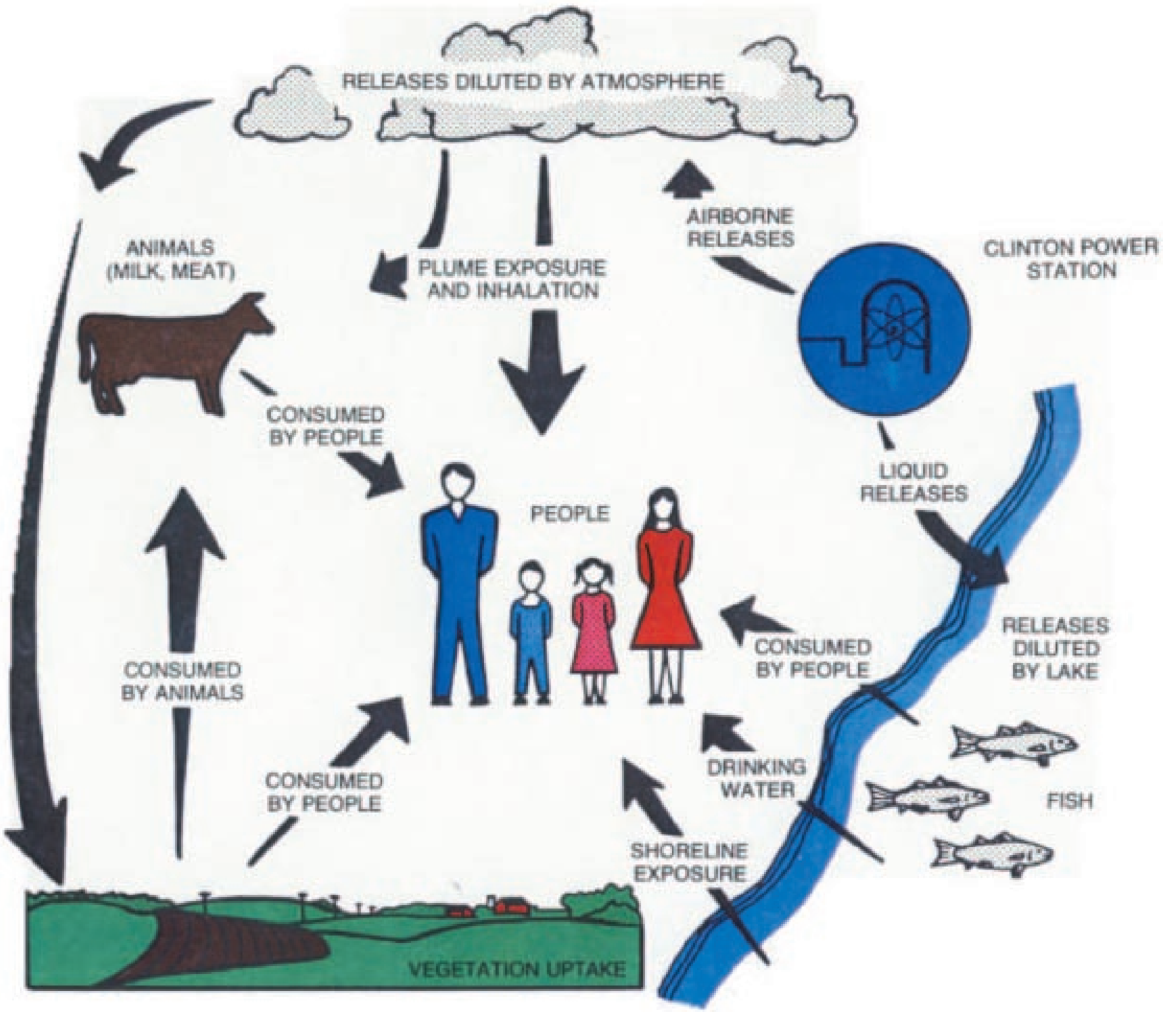
Figure 6.2-1

Basic Pathways for Gaseous and Liquid Radioactive Effluent Releases to the Public



Legend

Data Source:
Campbell, 2002

Not to Scale

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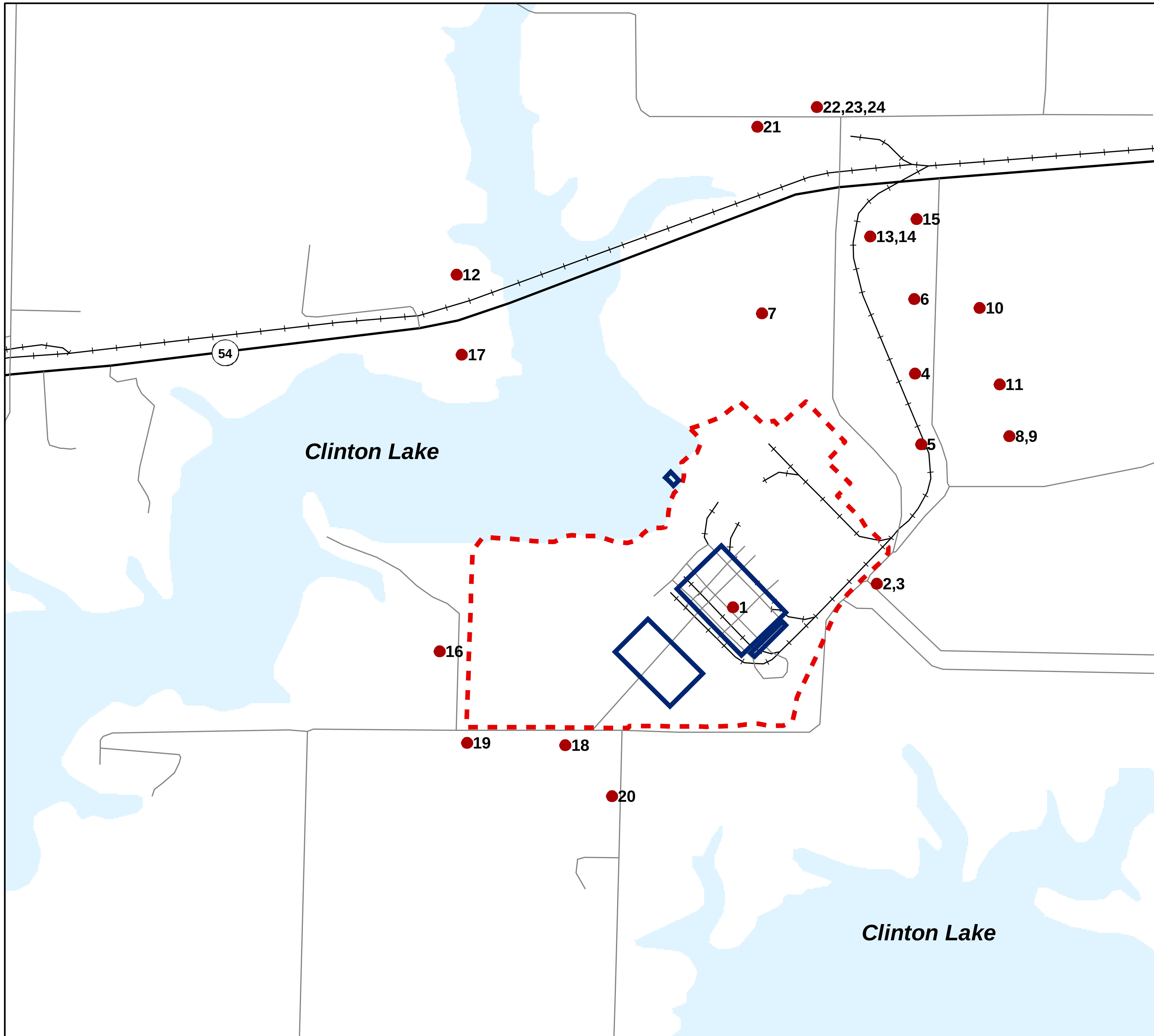
Figure 6.2-2
Proposed EMP Sample Locations within 1 mi



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

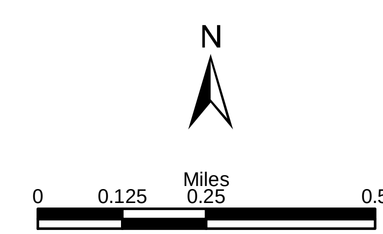
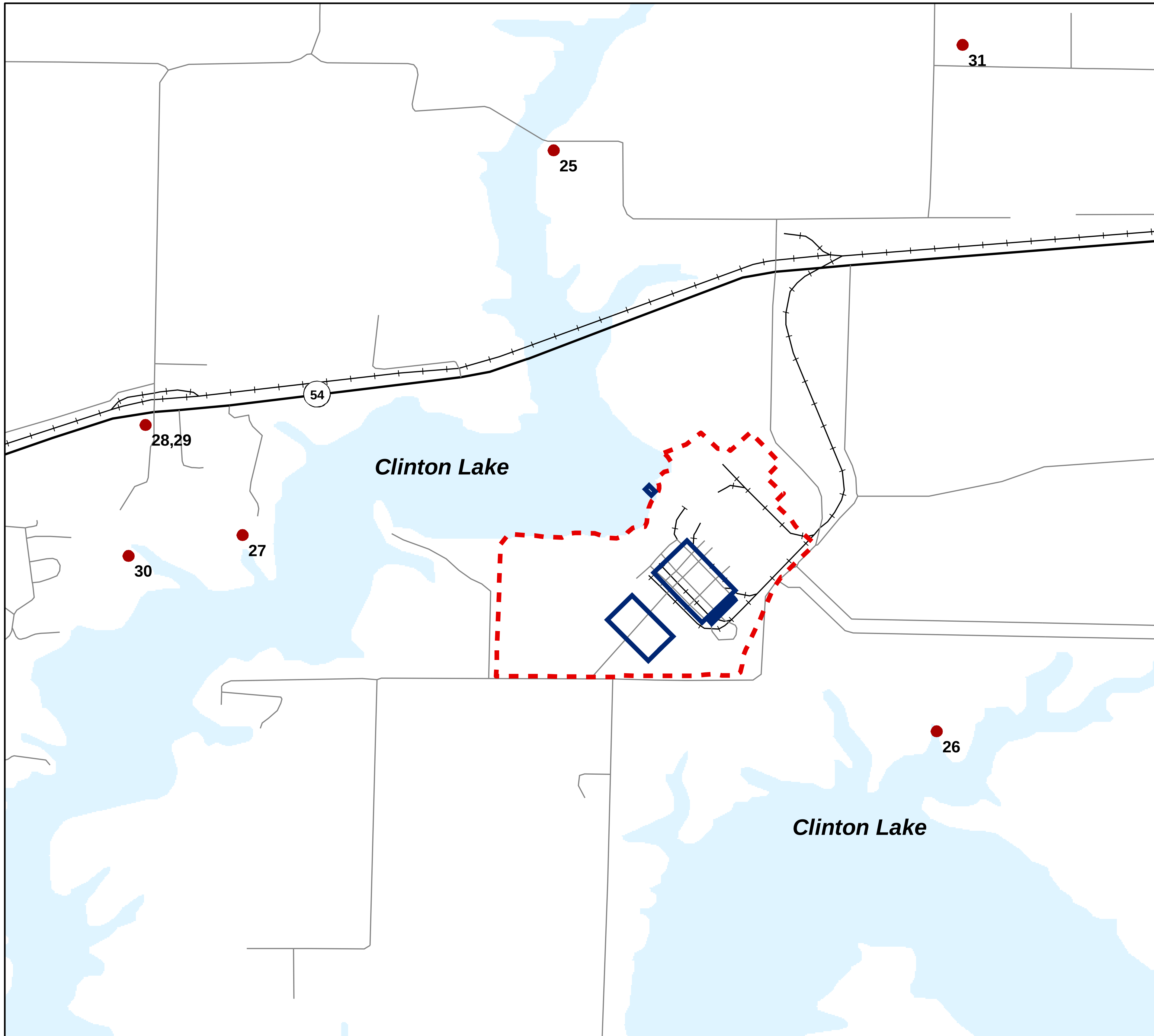


Figure 6.2-3
Proposed EMP Sample Locations from 1 to 2 mi



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

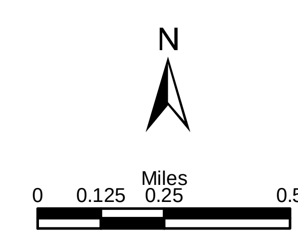


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Figure 6.2-4
Proposed EMP Sample Locations from 2 to 5 mi

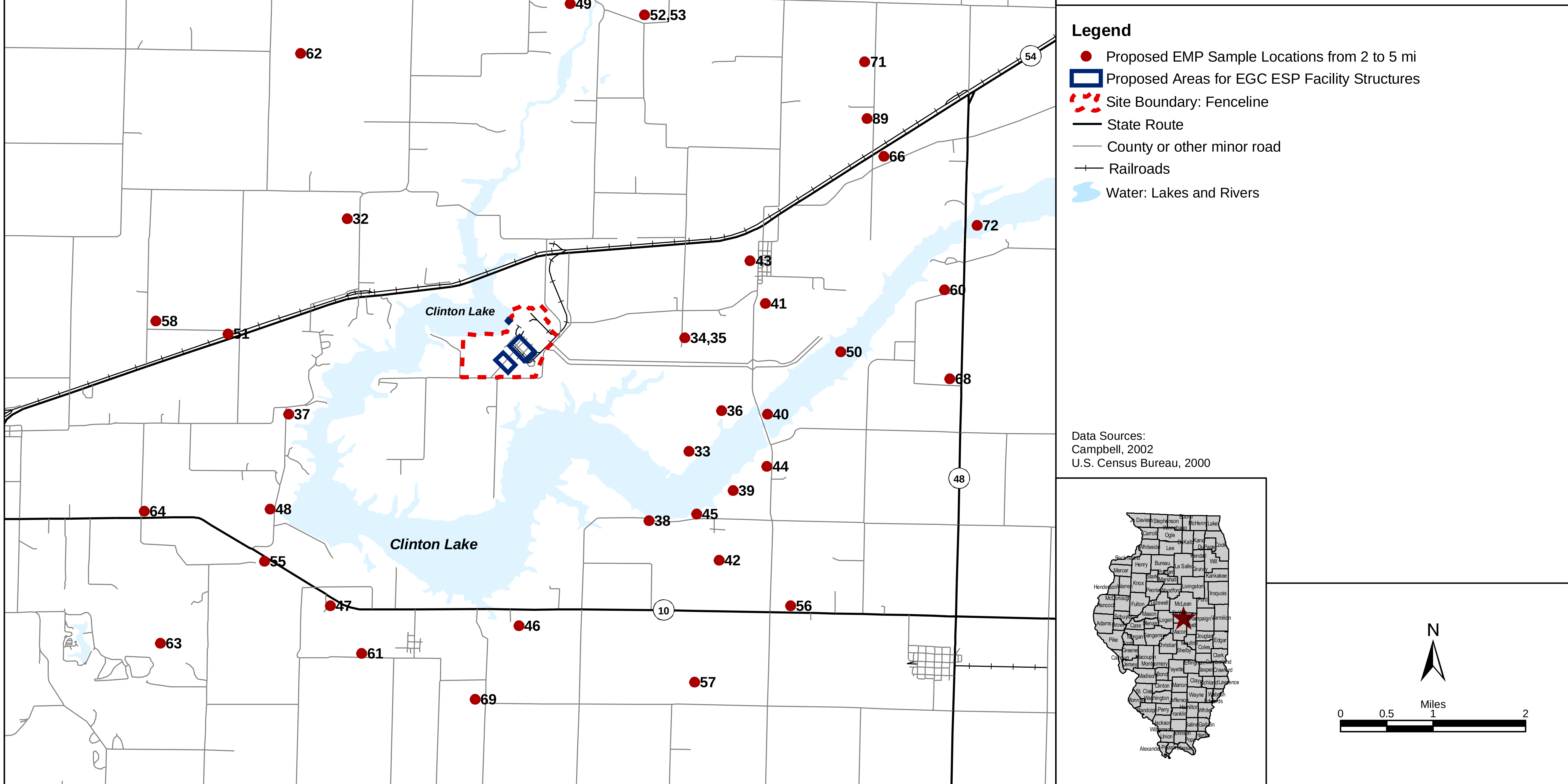

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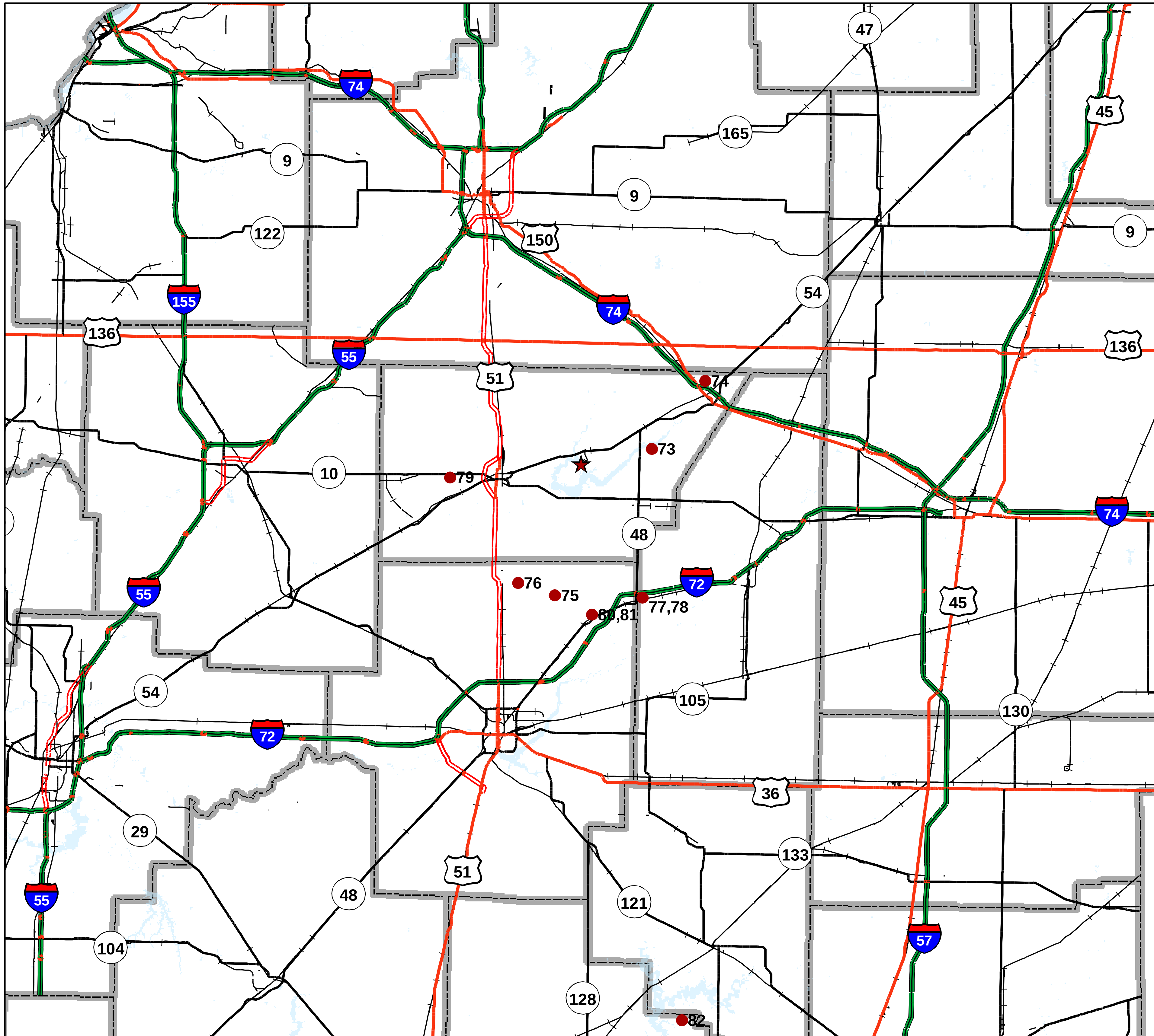
Figure 6.2-5
Proposed EMP Sample Locations Greater Than 5 mi



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

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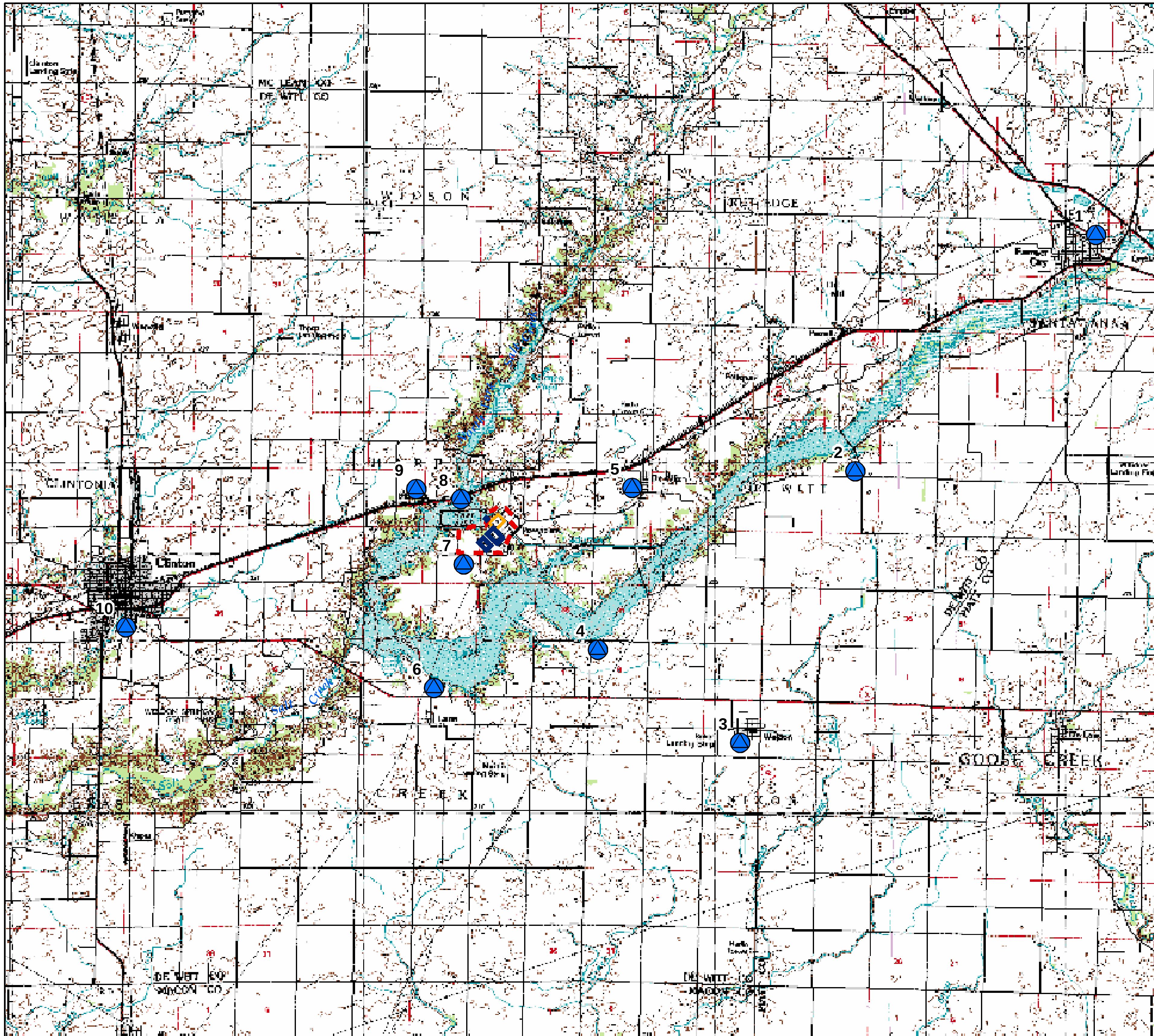
Figure 6.6-1
Groundwater Monitoring Well Locations



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

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 accident dose evaluations were performed using chi/Qs and activity releases for the following intervals:

- 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, 1993). The DDE is taken the same as the effective dose equivalent from external exposure and the dose conversions in Federal Guidance Report 12 (USEPA, 1993a) 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 DBAs, the resultant activity release paths, the important accident parameters and assumptions, and the credited mitigation features used in the site dose evaluations. An overall summary of the results of the evaluated accident doses is presented in Table 7.1-1 (USNRC, 2000 and USNRC, 1987). This table also compares the environmental doses to the recommended limits in Regulatory Guide 1.183 and NUREG-0800 Standard Review Plan. Table 7.1-2 shows that the evaluated dose consequences meet the accident-specific acceptance criteria invoked in Section 7.1.2.

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 (μCi/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 µCi/g dose equivalent Iodine-131
- Preexisting iodine spike – reactor coolant at 60 µCi/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 µCi/s referenced to a 30 minute decay
- Preexisting iodine spike – corresponding to an offgas release rate of 400,000 µCi/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 μCi/g dose equivalent Xe-133
- Preexisting iodine spike – reactor coolant at 60 μCi/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 μCi/g dose equivalent Xe-133
- Preexisting iodine spike – reactor coolant at 60 μCi/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 μCi/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 μCi/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 μCi/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 µCi/g dose equivalent Xe-133
- Reactor coolant equilibrium iodine activity - 1.0 µCi/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 µCi/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 µCi/g dose equivalent Xe-133
- Reactor coolant equilibrium iodine activity – 1.0 µCi/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

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

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Section 7.4

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	

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	
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

Accident	Reactor	EAB Dose TEDE (rem)	LPZ Dose TEDE (rem)	Guideline [a] TEDE (rem)
Main Steam Line Break				
Accident-initiated Iodine Spike	AP1000	4.7E-02	5.0E-02	2.5
Preexisting Iodine Spike	AP1000	4.2E-02	1.3E-02	25
Max Equilibrium Iodine Activity	ABWR	3.4E-03	3.3E-04	2.5
Preexisting Iodine Spike	ABWR	6.8E-02	6.5E-03	25
Reactor Coolant Pump Locked Rotor	AP1000	1.5E-01	1.5E-02	2.5
Control Rod Ejection Accident	AP1000	1.8E-01	4.5E-02	6.3
Control Rod Drop Accident	ABWR	Not Applicable [b]	Not Applicable [b]	6.3
Steam Generator Tube Rupture				
Accident-initiated Iodine Spike	AP1000	8.9E-02	6.6E-03	2.5
Preexisting Iodine Spike	AP1000	1.8E-01	8.8E-03	25
Small Line Break	AP1000	7.7E-02	7.6E-03	2.5
	ABWR	3.0E-03	5.7E-04	2.5
Loss of Coolant Accident	AP1000	1.5E+00	2.6E-01	25
	ABWR	2.3E-01	7.6E-01	25
	ESBWR	3.1E-01	4.7E-01	25
	ACR-700	3.8E-01	4.2E-01	25
Fuel Handling Accident	AP1000	1.4E-01	1.5E-02	6.3
	ABWR	8.0E-02	9.8E-03	6.3

[a] TEDE guidelines from Regulatory Guide 1.183. Small line break guideline based on NUREG-0800 Chapter 15.6.2 (USNRC, 2000 and 1987).

[b] Not applicable due to design of ABWR, see Section 7.1.4.5.

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

Time	Exclusion Area Boundary Dose TEDE (rem)	Low Population Zone Dose TEDE (rem)
0 to 2 hr	3.43E-03	--
0 to 8 hr	--	3.28E-04
8 to 24 hr	--	0
24 to 96 hr	--	0
96 to 720 hr	--	0
Total	3.43E-03	3.28E-04

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

Time	Exclusion Area Boundary Dose TEDE (rem)	Low Population Zone Dose TEDE (rem)
0 to 2 hr	6.85E-02	--
0 to 8 hr	--	6.54E-03
8 to 24 hr	--	0
24 to 96 hr	--	0
96 to 720 hr	--	0
Total	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 Containment

Time	Exclusion Area Boundary Dose TEDE (rem)	Low Population Zone Dose TEDE (rem)
0 to 2 hr	2.97E-03	--
0 to 8 hr	--	5.75E-04
8 to 24 hr	--	0
24 to 96 hr	--	0
96 to 720 hr	--	0
Total	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	2 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

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

Isotope	0 to 1 hr	2 to 3 hr	0 to 8 hr	8 to 24 hr	24 to 96 hr	96 to 720 hr
Te-127m	1.10E-01	2.58E+00	4.06E+00	9.83E-02	2.27E-03	1.77E-02
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

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

Isotope	0 to 1 hr	2 to 3 hr	0 to 8 hr	8 to 24 hr	24 to 96 hr	96 to 720 hr
Cerium Group						
Ce-141	1.37E-01	3.19E+00	5.02E+00	1.21E-01	2.71E-03	1.72E-02
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

Time	Exclusion Area Boundary Dose TEDE (rem)	Low Population Zone Dose TEDE (rem)
0 to 2 hr	2.35E-01	--
0 to 8 hr	--	3.78E-02
8 to 24 hr	--	3.20E-02
24 to 96 hr	--	1.65E-01
96 to 720 hr	--	5.29E-01
Total	2.35E-01	7.63E-01

Note: LOCA based on Regulatory Guide 1.3 and TID-14844 (USNRC, 2000 and 1983).

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

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-139	4.82E+00	1.21E+01	2.15E+01	5.00E-01	0	0
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

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-239	4.24E-05	1.95E-04	5.68E-04	1.09E-03	3.78E-03	6.16E-03
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

Time	Exclusion Area Boundary Dose Total Effective Dose Equivalent (rem)	Low Population Zone Dose Total Effective Dose Equivalent (rem)
0 to 2 hrs	8.04E-02	--
0 to 8 hrs	--	9.78E-03
8 to 24 hrs	--	0
24 to 96 hrs	--	0
96 to 720 hrs	--	0
Total	8.04E-02	9.78E-03

Note: LPZ dose includes contribution from activity remaining in reactor building, see Section 2.1.4.13.

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.