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DRAWINGS CITED IN THIS CHAPTER*

*The listed drawings are included as "General References" only; i.e., refer to the drawings to obtain additional detail or to obtain background information. These drawings are not part of the UFSAR. They are controlled by the Controlled Document Program.

DRAWINGS*	SUBJECT
M-1	Property Plan

2.1 GEOGRAPHY AND DEMOGRAPHY

2.1.1 Site Location and Description

2.1.1.1 Site Size and Location

The Dresden Nuclear Power Station site consists of approximately 953 acres located in the northeast quarter of the Morris 15' quadrangle (as designated by the United States Geological Survey [USGS]), Goose Lake Township, Grundy County, Illinois. The tract is situated in portions of Sections 25, 26, 27, 34, 35, and 36 of Township 34 North, Range 8 East of the third principal meridian. The site boundaries generally follow the Illinois River to the north, the Kankakee River to the east, a county road from Divine extended eastward to the Kankakee River on the south and the Elgin, Joliet and Eastern Railway right-of-way on the west, as shown in Figure 2.1-1.

A cooling lake, which was formed by constructing an impervious earth-fill dike, encompasses a storage area of approximately 1275 acres as shown on Figure 2.1-2. The lake extends north of Lorenzo Road from Dresden (Pequot) Road to the Santa Fe Railroad right-of-way to a line about 250 feet south of the Kankakee River. The lake is connected to the intake and discharge flumes of Units 2 and 3 by two canals (one intake and one discharge); each canal is about 11,000 feet long.

2.1.1.2 Location of the Units on the Site

Unit 1 is located in the northeast quadrant of the site with an intake canal extending west from the Kankakee River and a discharge canal extending north to the Illinois River. Unit 1 was officially retired on August 31, 1984, but its major structures are still present and intact. Unit 2 is located on the site directly west of and adjacent to Unit 1. The location of Unit 3 is directly west of and adjacent to Unit 2. At this location, the units are situated approximately 0.5 miles from the south boundary of the site, 0.5 miles south of the center of the navigation channel in the Illinois River, and approximately 1 mile from the western boundary of the site. Refer to Drawing M-1 for a plan view of the property.

2.1.1.3 Site Ownership

EGC is the sole owner of the entire 953-acre tract. This tract is subject only to an easement of the U.S. Government for an access road to the Dresden Island Lock and Dam, which is maintained and operated by the U.S. Army Corps of Engineers. The access road traverses the site from south to north approximately 0.8 miles west of the plant.

In addition to ownership of the tract and cooling lake, EGC also leases approximately 17 acres from the State of Illinois. This acreage is comprised of two narrow strips of river frontage located near the northeast corner of the site. The terms of the lease provide that these "buffer" strips shall remain idle. This parcel of property, which extends southeastward from the Dresden Lock and Dam, is not developed and is accessible only by foot. It is slightly depressed and provides drainage of the surrounding land. EGC does not exercise any control over this piece of property.

2.1.2 Exclusion Area Authority and Control

2.1.2.1 Exclusion Area

The exclusion area boundary (EAB), which is common for all three nuclear units, has a radius of 0.5 miles (800 meters) and is shown on Figure 2.1-1. Section 100.3(a) of 10 CFR 100 requires that a reactor licensee have the authority to determine all activities within the designated area, including the exclusion and removal of personnel and property. No public highways or railroads transverse the EAB.

Through direct ownership, including mineral rights or a lease agreement with the State of Illinois, the licensee has total control of the entire area within the EAB with the exception of control over the Des Plaines and Kankakee rivers. As a result of this exception, arrangements have been made with the U.S. Coast Guard, through the Illinois Emergency Management Agency (IEMA) and the Illinois Department of Nuclear Safety (IDNS) for control of the water traffic in event of a plant emergency. This arrangement is documented in the Emergency Plan (E-Plan).

2.1.2.2 Access to the Site

The units, including their intake and discharge canals, are completely enclosed by a security fence (see Drawing M-1) consisting of a 6-foot high chain link fencing surmounted by three strands of barbed wire. This fence also establishes the boundary for purposes of the Price-Anderson indemnity agreement and the nuclear liability insurance policies maintained. Access to the area is controlled at a security gate.

The frontage upon the Illinois and Kankakee rivers does permit access to the site by water. There are roads to both rivers which parallel the intake and discharge canals. A breakwater, ramp, and pier on the Illinois River are the only boat docking facilities. These facilities were used to bring in components for the nearby Braidwood Nuclear Station during its construction.

2.1.2.3 Other Activities on the Site

Portions of the 953-acre tract outside the area occupied by the station are leased to a neighboring farmer for grazing cattle and growing field crops. Approximately 150 acres are used for grazing with appropriate fencing provided to control the approximately 75 head of cattle that may be present during the pasturage season. Field crop cultivation generally occupies about 300 acres. The lease has been modified with a clause which allows EGC to have "sole authority to determine the right of access and the right to be present in the area covered by this lease" when the GSEP is in effect.

Hunting is permitted on the site outside of the security fenced areas during legally prescribed seasons.

A guyed, structural steel microwave relay tower belonging to the International Bell Telephone System is located on the site approximately 1000 feet west-southwest of the reactor building. The equipment installed on the tower and in the small adjacent control building is automatically controlled, thereby requiring infrequent visits to the facility by telephone company maintenance personnel.

A guyed, structural steel meteorological monitoring tower is located approximately 3000 feet west of the reactor building. The tower serves multiple purposes; it has meteorological monitoring equipment attached at various elevations, and it is also employed as a microwave communications tower for several functions. The communications uses include transmission of line and switchyard information to the load dispatcher and two-way communications between the station (control room) and emergency facilities such as the following: Technical Support Center (TSC), Dresden; Emergency Operations Facility (EOF), Downers Grove mobile units and environmental monitoring teams.

2.1.3 Population Distribution

2.1.3.1 Population Data

As part of the Systematic Evaluation Program (SEP) for Unit 2, a review has been conducted in accordance with Standard Review Plan (SRP), Section 2.1.3, "Population Distribution."

There is no resident population within the EAB. The transient population within the EAB of the nuclear station consists only of operating personnel, construction workers, visitors, and NRC inspectors. No changes are expected within the EAB.

The transient population in the vicinity of the station outside the EAB comprises workers employed by the various industries in the area and visitors to the many recreational facilities available.

The low population zone (LPZ) for the station is an area within an 8000-meter (4.97-mile) radius. The population within the 8000-meter radius area is approximately 12,000.

The nearest resident population within the LPZ is contained in a cluster of cottages along the west shore of the Kankakee River; the nearest line of cottages is just outside the EAB. The estimated population of this cluster of homes is approximately 400.

The other closest residences are widely separated in several directions from the station. A single residence is located approximately 0.6 miles southeast of the station on the east shore of the Kankakee River. To the northwest, approximately

0.8 miles from the station, are a temporary construction office trailer and two permanent residences for engineers at the Dresden Island Lock and Dam. At the confluence of the Des Plaines and Kankakee rivers there is a new residential development that includes six houses from 0.8 to 1.0 miles from the station. Three individual residences are located along the Kankakee Bluffs on the north shore of the Des Plaines and Illinois rivers approximately 0.8 miles to the north-northwest, northeast, and east of the station, respectively.

The closest significant residential concentration of over 1000 residents is 3 to 4 miles northeast of the station along the Illinois River.

The nearest incorporated municipality is Channahon with a 2000 census population of 7344 people, substantially more than the reported 1990 population of 4266. Channahon is actively expanding by annexing adjacent properties that have been recently developed for residential subdivisions. A large tract of vacant land extending 2 to 3 miles northeast of the station has been annexed by the village of Channahon but not yet developed. Future expansion, however, is probable as the area near the confluence of the Du Page and Des Plaines rivers is developed.

The next closest incorporated municipality, Minooka, has its closest border approximately 3.5 miles north-northeast of the station. It has also been expanding. The present population according to the 2000 census is 7295, substantially more than the 1990 population of 2561.

Other significant unincorporated residential developments have been expanding in the strip-mined areas 4 to 5 miles southwest of the station, in a residential complex across U.S. Highway 6 from the industrial center 3.5 miles northwest of the station and along Aux Sable Creek 4.5 miles northwest of the station.

The 1990 population of other municipalities, including the population centers (containing more than 25,000 residents) within 50 miles of the station based on 1990 census data, is compared with the population data shown in the Final Environmental Statement (FES) (see Table 2.1-1).

The criterion that the nearest major population center must be over one and one-third times the distance of the LPZ radius (5 miles) is still being met. These residential concentrations do not appreciably alter the permanent population distribution patterns reported previously, except that the growth of the rural communities was greater than projected in the FES, whereas the population of most large cities located further from the station have declined.

2.1.3.2 Land Use

The land to the north and west of the site is used principally for agriculture.

Adjacent to the site on the southwest side is the GE Morris Operations Facility (NRC Docket 50-268). It was originally planned as a spent fuel reprocessing facility but is now used for spent fuel storage. A description of the facility is presented in the application, as amended, and filed in the proceeding.

The nearest boundary of the large Joliet Ammunition Plant (36,000 acres) is located approximately 2 miles east of the site and adjacent to a recreational area of about 2500 acres owned by the State of Illinois.

There are additional private recreational facilities such as gun clubs and picnic grounds scattered throughout the strip-mined areas south of the station. A small unnamed public park is also located 1.5 miles east of the station on the Des Plaines River. Public access is available to the Dresden Lock and Dam, and a public path parallels the Illinois and Michigan Canal which is 0.7 miles north of the station at its closest point. The recreational facilities are apparently being actively expanded and improved, and data on daily use indicate a substantial increase in recreationists in recent years. Major recreation facilities are listed in Table 2.1-2.

South of the site are some agricultural operations and a large abandoned strip mine. For a more detailed description of nearby industrial, transportation, and military facilities refer to Section 2.2. The Illinois Plan for Radiological Accidents (IPRA) describes nearby institutional facilities.

2.1.3.3 Summary

The EAB of the Dresden Nuclear Power Station, as reported previously, has no permanent residents. Permanent population distribution around the station has not changed significantly; although, total 1990 census population within the 5-mile LPZ has increased to 8948 residents from 5090 reported in the FES. Industrial facilities and recreational facilities have also expanded, although their distribution is largely unchanged. The daily maximum transient population, including visitors to recreational facilities and workers employed by industries within 5 miles of the station is estimated to be approximately 15,200. The LPZ and population center distance specified for the site are in conformance with 10 CFR 100.

Table 2.1-1

POPULATION CENTERS SURROUNDING THE STATION

	1990 Population	2000 Population	Distance from Station (mi)	Direction from Station
Morris, IL	10,270	19,114	7.5	WSW
Coal City, IL	3,907	4,797	8	S
Braidwood, IL	3,584	5,203	9	SSE
Wilmington, IL	4,743	5,134	10	SE
Joliet, IL	76,836	106,221	15	NE
Aurora, IL	99,581	142,990	27	N
Kankakee, IL	27,575	27,491	30	SE
Chicago, IL	2,783,726	2,896,016	50	NE

Table 2.1-2

MAJOR RECREATIONAL FACILITIES NEAR THE STATION

	Distance from Station (mi)	Direction from Station
Illinois, Kankakee, and Des Plaines rivers	Adjacent	
Goose Lake State Park	1.0	SW
Collins Lake	2.0	W
Des Plaines Conservation Area	2.5	SE
Empress Riverboat Casino	8-9	NE
Lake Point Club	5-6	SSE

2.2 NEARBY INDUSTRIAL, TRANSPORTATION, AND MILITARY FACILITIES

A study was performed to identify and evaluate potential accidents which may occur at Dresden Station as a result of activities at nearby industrial, transportation, and military facilities. The evaluation was performed in accordance with the guidelines of NRC Standard Review Plans (SRPs) 2.2.1-2.2.2, 2.2.3, and 3.5.1.6.

This study identified potential accidents near Dresden Station as a result of activities at nearby industrial, transportation, and military facilities. Twelve sources of hazard were identified and evaluated with respect to their being considered design basis events. Table 2.2-1 summarizes these sources and the findings of this study.

Based on the summary given in Table 2.2-1, with the minor exception noted in the table, Dresden Station is considered to meet the safety requirements outlined in SRPs 2.2.1-2.2.2, 2.2.3, and 3.5.1.6.

2.2.1 Location

Figure 2.2-1[1] shows the locations of nearby military, industrial, and transportation facilities in relation to the Dresden site.

2.2.2 Descriptions

2.2.2.1 Description of Facilities

2.2.2.1.1 Military Facilities

The Joliet Army Ammunition Plant, whose nearest boundary is approximately 4 miles east of Dresden Station, is used for storage of explosive materials from other installations, transported by way of the Atchison, Topeka, and Santa Fe Railroad (AT&SF). No explosive materials are stored within 1 mile of the eastern property line of the ammunition plant.[2] Thus, the distance from Dresden Station to the storage area of the ammunition plant exceeds 5 miles. At this distance, an accidental explosion at the Joliet Army Ammunition Plant will not affect Dresden Station.

2.2.2.1.2 Highway Transportation

As shown in Figure 2.2-1, the major highways within 5 miles of the plant are Interstate 55, 4 miles east of the plant, and U.S. Route 6, 1.9 miles north of the plant.

The nearest secondary road is Collins (or Goose Lake) Road, approximately 0.5 miles south of the plant. The heaviest traffic is on Interstate 55, with a 24-hour annual average of 13,700 cars.[3] Collins Road has only light traffic and would not be used by heavy trucks carrying explosive materials.

2.2.2.1.3 Railway Transportation

There are four railroads within 5 miles of the plant. The Canadian National (CN) Railroad is approximately 1.5 miles west of and provides spur access to the plant. The AT&SF and the Chicago, Missouri, and Western (Amtrak) Railroads are approximately 3.9 miles southeast of the plant. The AT&SF carries explosive materials to and from the Joliet Army Ammunition Plant. The track used by the Iowa and Chessie Railroads is 3.7 miles northwest of the plant. A short EJ&E track approximately 2.5 miles northwest of the plant connects this track to the main EJ&E track.

2.2.2.2 Description of Products and Materials

Industries within 5 miles of the plant and the products they handle are listed in Table 2.2-2. Figure 2.2-1 shows the locations of a representative sample of industrial sites in the vicinity of Dresden Station. The industries listed in Table 2.2-2 are not licensed to store or use solid explosives (trinitrotoluene [TNT], dynamite, tetryl, etc.).[4] Based on available information, the following industries process, store, or transport flammable and/or explosive substances:

A. Reichhold Chemical Company,
B. Northern Illinois Gas Company,
C. Van Den Bergh Foods (formerly Glidden-Durkee),
D. Enron Liquids Pipeline, Inc.,
E. Mobil Chemical Company, and
F. Mobil Oil Corporation.

Reichhold Chemical Company is located 1.6 miles west of the plant. The largest amount of flammable and/or explosive substances stored onsite is a 1.5-million gallon tank of benzene.[5]

Benzene is transported to the site by barges with a maximum capacity of 400,000 gallons. Based on Regulatory Guide 1.91, the safe standoff distance for a 400,000-gallon barge of benzene is 1.63 miles. Since the loading and unloading point of the plant is 1.6 miles from the Dresden site, and since hazards from transportation on waterways have been ruled out (see Section 2.2.3.1.4), it is concluded that the transportation of benzene to Reichhold Chemical Company does not pose a design basis hazard to the Dresden Station.

The safe standoff distance for the 1.5-million gallon tank of benzene at Reichhold Chemical is 2.5 miles, which exceeds the 1.6-mile separation distance. However, the tank is vented to prevent the formation of an explosive vapor-air mixture.

The Northern Illinois Gas Company plant near the Dresden site mainly produced supplemental natural gas (SNG) from petroleum products. The existing SNG plant was capable of producing 4 million cubic feet of gas per hour; however, the plant was virtually non-operational as of 1981.[6]

The Van Den Bergh Foods facility located 3.2 miles northeast of the Dresden plant produces edible oil. One million cubic feet of liquid hydrogen is stored in a single tank at the Van Den Bergh site.[7] Using a hydrogen equivalency factor of 5.9 to calculate the equivalent weight of TNT, it was found that the corresponding safe standoff distance for which the detonation overpressure does not exceed 1.0 psi is 2.6 miles. Since the distance between Van Den Bergh and Dresden is greater than 2.6 miles, the stored hydrogen does not present a hazard to the plant.

Enron Liquids Pipeline, Inc., operates an above ground propane storage and underground ethane storage facility 4 miles from the plant.[8] The propane tanks are equipped with 250-psi pressure relief valves; the maximum capacity of any tank is 90,000 gallons. Based on Regulatory Guide 1.91, it was found that the corresponding safe standoff distance for which the overpressure does not exceed 1.0 psi is 0.8 miles. Since the separation distance is greater than 0.8 miles, the propane storage facility does not present a hazard to plant safety.

The Mobil Chemical site stores styrene monomer; this is the only flammable material stored in large quantities. The largest amount of styrene monomer stored in a tank or transported in a barge is 1.2 million gallons.[9] 1981 plans for expansion included the installation of a 3-million-gallon styrene tank on the site. Using the approach for hydrocarbons given in Regulatory Guide 1.91, it was found that the safe standoff distance for which the overpressure caused by the simultaneous detonation of 3 million gallons of styrene will not exceed 1.0 psi is 3.32 miles. Since the site is 4.1 miles from the plant, an accidental explosion at the existing or expanded storage facility does not present a hazard to the plant.

Mobil Oil Company's refinery is located on Interstate 55 approximately 4.5 miles northeast of Dresden Station. Although the refinery stores various petroleum products typical of such a facility, Mobil Oil Company has stated that information on the types and quantities of products stored is confidential and may not be released to any party without the prior written consent of the company. However, based on the information provided informally by Mobil Oil, it is concluded that a sufficient separation distance (based on Regulatory Guide 1.91) exists for all petroleum products stored at the facility, with one exception. The standoff distance for this one product slightly exceeds the available separation distances; however, the stored product has a high flash point, which eventually rules out the possibility of an explosion hazard from this source at a distance of 4.5 miles.

Data provided by the GE BWR Spent Fuel Storage and Alumax Mill Products[10] indicate that they do not process, store, use, or transport flammable and/or explosive materials.

2.2.2.3 Pipelines

Tables 2.2-3 and 2.2-8 summarize the size, operating pressure, and nearest distance for pipelines located within 5 miles of the plant.[8,11,12] The potential for a postulated accidental leak or rupture and consequent explosion has been evaluated for pipelines in the vicinity of the plant. The first eight pipelines listed in Tables 2.2-3, which are also contained in Table 2.2-8 pose the greatest potential hazard to the plant. The locations of these lines in relation to the Dresden site are shown in Figure 2.2-2. The other pipelines listed in Tables 2.2-3 and 2.2-8 do not pose significant hazards to the plant because their diameters are smaller and they are more than 2 miles from the plant.

Because of the proximity of the first seven pipelines to the Dresden safety-related structures, it is not possible to conclude that the peak overpressure would not exceed 1 psi. Therefore, the probability of exposure to pressure in excess of 1 psi was estimated, per Regulatory Guide 1.91.

The method of analysis used to calculate the probability of the first six pipelines follows the guidelines of the study presented in the Safety Evaluation Report (SER) for Hartsville Nuclear Plant.[13] Briefly, the factors included in this analysis were the break size and location, the gas release rate following the break, the plume rise and dispersion of the gas cloud under various meteorological conditions, the time from rupture to ignition, and the possibility of deflagration and explosion of the gas cloud. Conservatism was ensured in determining the size of the resulting gas cloud by assuming 200% ruptures (i.e., double-ended flow), with the pipeline operating at maximum capacity.

The flowrate from a ruptured pipe versus the time from the start of gas release was obtained by prorating the previously calculated flowrate for a 22-inch diameter pipeline. The flowrate for the 22-inch pipeline was computed using the GASUS computer program for pipeline transients.[14]

This flowrate was proportionately increased for the areas and pressures of the pipes being analyzed. Independent calculations of steady state flow rates were made to validate the calculated flowrates.

It was found that as a result of a rupture anywhere on the six gas pipelines within 5 miles of the plant, the probability of exceeding 1-psi blast overpressure is approximately 6.2 x 10^{-6} per year. If the release rate were computed using the GASUS program for each pipeline, lower release rates and lower probabilities of damage to the plant would have been obtained.

The method of analysis used for the seventh (NICOR) pipeline involves the identification of potential leakage locations, leak size/rate considerations, and determining the most conservative scenarios which result in the greatest potential hazard to the plant. Only scenarios involving aboveground piping are evaluated as the effects of releases from the buried portions of the pipeline on SSC important to safety are bounded by the evaluations of releases from aboveground portions of the piping. Five scenarios are identified (Reference 30):

(1) Large isolated leak with methane release and explosion at Pipe Bridge,
(2) Large isolated leak at Pipe Bridge with methane release and dispersion,
(3) Smaller unisolated leak with methane release and dispersion from the pipe bridge location,
(4) Smaller unisolated leak with methane release and explosion at the pipe bridge location, and
(5) Leakage in the Boiler House. Potential release rates from natural gas line breaks were determined taking into account design features provided for the pipeline. A probabilistic based evaluation for the frequency of a natural gas explosion that damages safety-related SSCs.

An excess flow check valve is provided at the metering station and at the entry to the heating boiler house to protect the pipelines downstream. The setpoint for the excess flow check valve is factory set to 10% above the total flow required for two boilers. Excess flow protection devices are simple and very reliable. The probabilities of an unisolated break above the setpoint are well below the 10^{-6} per year threshold for credibility (from Regulatory Guide 1.78, Rev. 1).

For the first scenario, all of the methane contained within the pipeline, plus the mass that continues to flow until an excess flow device actuates is considered. For this explosion, the distance from the point of the explosion to the point with a 1 psig overpressure is 207 feet (nearest safety-related structure is the Reactor Building, which is 600 feet away). Therefore, all safety-related structures are protected from this event by distance.

The second scenario is similar to the first event, except that the methane cloud is assumed to travel downwind without immediately detonating. This release is analyzed using the HABIT computer program (referenced in Regulatory Guide 1.78, Rev. 1) for the dispersion analysis. Atmospheric conditions assumed in the analysis include a 1 meter/second wind speed, "G" stability class, 0 release height and 0 intake height. The resulting concentration at the nearest corner of the Turbine Building at a distance of 127 meters (approximately 417 feet) is 533 ppm by mass, or 966 ppm by volume. This is well below the 50,000 ppm lower flammability limit. The Turbine Building is the nearest major plant structure to the release point, and is closer than the nearest safety-related structure, the Reactor Building. Therefore, all safety-related plant structures are protected from this event by distance.

The third scenario is analyzed using the ALOHA computer program. Atmospheric data used in the analysis includes wind direction towards the closest safety related structure, a wind speed of 2 miles/hour, and stability class F. The release plume quickly reaches steady state conditions. Under these conditions, the lower flammability limit boundary within the plume just reaches the Turbine Building, the closest major plant structure. Therefore, all safety related structures are protected by distance from this postulated event.

The fourth scenario is also analyzed using the ALOHA computer program. Here the portion of the plume where the concentration of methane reaches the lower explosive limit (LEL) occurs 128 yards downstream of the release point. The distance from the point of the explosion to the point with a 1 psig overpressure is 166 feet. The nearest safety-related structure, the Reactor Building, is more than 166 feet from the point of the explosion. Therefore, all safety-related structures are protected from this event by distance.

The fifth scenario is analyzed to estimate the frequency of damage to SSCs important to safety from an on-site natural gas leak and explosion. The following analyses are performed to estimate the frequency of damage using a fault tree of a hazardous explosion.

- <u>Gas Release Analysis</u> – To evaluate the gas release rate for leaks both inside and outside of the Boiler House, a hydraulic model of the gas line is created using RELAP5. Transient release rates are determined for both isolated and unisolated leaks as it is required to support the risk analysis. The maximum calculated release rates are approximately 48 lbm/s outside the Boiler House, 10 lbm/s in the valve vault, and 7.5 lbm/s in the Boiler House.

- <u>Gas Accumulation Analysis</u> – Based on the output from the gas release rate scenarios from the RELAP5 model, gas accumulation analysis is performed for releases inside the Boiler House using GOTHIC model of the Boiler House. The use of GOTHIC model of the boiler House provides a basis for the amount of mixing in the building demonstrating when gas detectors will identify a gas leak.

- <u>Gas Dispersion Analysis</u> – Based on the output from the transient gas release scenarios from the RELAP5 model, gas dispersion analysis is performed for releases outside the Boiler House using MathCad hand-calculations based on the methodology in NUREG-0570.

- Fault Tree Analysis – The fault tree analysis is performed using the Computer Aided Fault Tree Analysis System (CAFTA) and Uncertainty Analysis Software (UNCERT), using results from the gas release, gas dispersion, and gas accumulation analyses to quantify the risk of a gas pipeline rupture on-site that is consistent with the approach used in the Safety Evaluation Report, Hartsville Nuclear Power Plant referenced in UFSAR Section 2.2.2.3.

  The fault tree analysis is the overall estimate of the frequency of an explosion that damages Safety-Related SSCs of 3.31 x 10^{-8} per year. This estimated frequency satisfies the frequency of a radiological release to the public that is less than 10^{-7} per year as per the NUREG-0800 and the exposure rate due to an explosion threat that is less than 10^{-7} events per year as per Regulatory Guide 1.91.

The use of natural gas as the heating boiler primary fuel was implemented per EC 388091, "Install New Natural Gas Line for Heating Steam Boilers" and EC 387722, Install New Heating Boilers 2A/2B". The natural gas fuel was assessed per 10 CFR 50.59 Evaluation No.: 2014-09-001, Revision 002. 10 CFR 50.59 Evaluation No.: 2014-09-001, Revision 002 input was based on Dresden Gas Line Explosion Risk Assessment, Evaluation No. 2015-02412, Revision 01, which provided the basis for using natural gas as the Heating Boiler fuel via 10 CFR 50.59. The evaluation is incorporated in calculation DRE12-0036, Revision 02 as an Attachment H. Limitations defined on system operation listed in Risk Assessment Evaluation No.: 2015-02412, Revision 01 (documented with Calculation DRE12-0036, Revision 02) must be met to ensure compliance with the evaluation.

For the eighth (Alliance Pipeline) pipeline, the impacts of a potential explosion, heat loads from a potential jet fire, and habitability impacts on the Control Room operators due to a postulated rupture are evaluated (Reference 37). The impacts due to an explosion or jet fire are evaluated for the meteorological tower (at 1,250 ft), the Control Room (at 3,700 ft), and the nearest plant structure (at 3,300 ft). The break is assumed to occur at the closest point to each structure. The scenarios are evaluated using the ALOHA computer program. Atmospheric data used in the analysis includes wind direction towards each structure, a wind speed of 2.31 miles/hour, and stability class F.

For the potential explosion, the overpressure is less than 1 psi at each of the structures. For the heat load from a potential jet fire, the radius of the lowest ALOHA heat zone (> 2.0 kW/m^2) is 511 yards which will not reach the site at 3,300 ft (1,100 yards). While the jet fire heat load would reach the meteorological tower, the heat load of approximately 3.0 kW/m^2 would not compromise the structural integrity of the tower. The maximum methane concentration inside the Control Room was determined to remain below the PAC-1 limit for the duration of the accident. Therefore, the Alliance pipeline does not pose a significant hazard to the plant.

2.2.2.4 Waterway Transportation

The major rivers within 5 miles of the plant are the Illinois, Des Plaines, and Kankakee rivers. The Kankakee River joins the Des Plaines River east of the plant to form the Illinois River, which extends along the north boundary of the site. The closest navigational channel is on the Illinois River, located approximately 0.5 miles north of the plant. The closest river lock is the Dresden Island Lock, approximately 1 mile northwest of the plant.

The river traffic passing by the site consists mainly of cargo barges. No TNT is shipped on the Illinois River near the plant site.[15] The commodities that passed through the Dresden Island Lock over a period of 6 years consisted mainly of coal, petroleum, steel, sludge, and agricultural products.[16]

2.2.2.5 Airports

The airports within 10 miles of the plant and the data required for hazard analysis of these airports are given in Table 2.2-4.[17,18,29]

Using the guidelines given in SRP 3.5.1.6, it was found that an evaluation of the probability of aircraft impact was required for Fromm, Morris, and Joliet Airports and for Adelmann Airstrip.

O'Hare International Airport has the heaviest traffic of any local airport but is outside the 10-mile radius. According to available maps, O'Hare is 46 miles north-northeast of the plant and had 734,555 operations in the 1980 fiscal year.[19] The projected number of operations at this airport for the year 2010 is calculated as 1,183,000.[20] This level of operation is lower than the 2,116,000 operations per year calculated using the 1000 d^2 criterion given in SRP 3.5.1.6, where d is the distance from the plant in miles. The probability of aircraft strike is calculated in Section 3.5.

Four low-altitude federal airways have their nearest edge within 2 miles of the station: V69, V38, V171, and V429.

According to the Air Route Traffic Control Center,[21] peak daily instrument flight rules (IFR) traffic within 10 nautical miles of Dresden for 1981 before the Professional Air Traffic Controllers Organization (PATCO) strike was 327 aircraft traversing the area. The amount of visual flight rules (VFR) traffic is not available since the traffic control centers have no control over these flights. The VFR traffic is therefore estimated to be equal to the amount of IFR traffic.

2.2.2.6 Growth Projections

The industries that responded to CECo's requests for information indicated that they have no plans for expansion, except for Mobil Chemical Company, whose expansion plans were described above and found to pose no hazard to plant safety.

2.2.3 Evaluation of Potential Accidents

Table 2.2-1 summarizes the assessments for 12 types of hazards posed by nearby industrial, transportation, and military facilities. It was determined that the potential effects of hazards 1 through 12 would not result in a design basis event for Dresden Station.

2.2.3.1 Hazards from Explosion

2.2.3.1.1 Nearby Industrial and Military Facilities

Explosion hazards associated with nearby industrial and military facilities, including pipelines, are discussed in Sections 2.2.2.1.1, 2.2.2.2 and 2.2.2.3.

2.2.3.1.2 Highway Transportation

Highway transportation facilities are described in Section 2.2.2.1.2. The worst event postulated according to Regulatory Guide 1.91 is the explosion of a truck carrying 50,000 pounds of TNT on the nearest road. It was found that the corresponding safe standoff distance for which blast overpressure does not exceed 1.0 psi is 1660 feet. Since the closest road is more than 1660 feet from the Class 1 structures of the plant, the transport of explosive materials on nearby roads does not present a hazard to plant safety.

2.2.3.1.3 Railway Transportation

Railway transportation facilities are described in Section 2.2.2.1.3. An accident postulated in Regulatory Guide 1.91 is the simultaneous explosion of three boxcar-loads of TNT (396,000 pounds) on the nearest railroad. It was found that the corresponding safe standoff distance for which blast overpressure will not exceed 1.0 psi is 0.63 miles. Since the nearest railroad is more than 0.63 miles from the Class 1 structures of the plant, the transport of explosive materials on nearby railroads does not present a hazard to plant safety.

2.2.3.1.4 Waterway Transportation

Waterway transportation facilities are described in Section 2.2.2.4. A review of the materials passing by the site area indicates that the worst event would be the explosion of an empty petroleum barge (one containing the vapors of the previous cargo) on the river 0.5 miles from the plant. For such an explosion to occur, it is assumed that the empty tank contains an adequate vapor-air mixture and that a proper detonating stimulus is applied to this mixture.

Under these assumptions, the fuel vapor mass contained in a jumbo size (300 ft x 50 ft x 12 ft) tank would be approximately 1000 pounds. The corresponding distance at which the blast overpressure attenuates to 1.0 psi is approximately 600 feet, as determined using Regulatory Guide 1.91. Conservatisms in these calculations include the consideration of the largest volume tank and the use of a TNT equivalency factor of 240% for the mixture. Since the closest Class 1 structure (crib house) is more than 600 feet from the Illinois River, empty fuel barges do not present a hazard to plant safety.

2.2.3.2 Hazards from Vapor Clouds and Fires

Barge shipments of flammable and/or potentially explosive liquefied gases on the Des Plaines and Illinois rivers may result in the formation of vapor clouds with consequent fire and/or explosion.

The Dresden safety-related structures are not at a safe distance from the river to ensure that the 1-psi peak overpressure will not be exceeded if an accident occurs in the vicinity of the plant. Since the safe distance criterion is not satisfied, Regulatory Guide 1.91 requires that the probability of exposure to pressure in excess of 1 psi be estimated.

The method of analysis used to calculate this probability is presented in "Evaluation of the Risks to the Marble Hill Nuclear Generating Station from Traffic on the Ohio River."[22] The input information required to perform the analysis consists of traffic, casualty, and spill statistics for the Illinois River. These statistics are presented in Tables 2.2-5[15,16] and 2.2-6.[28] Where the casualty and spill statistics available for the Illinois River were not sufficient, statistics from western rivers were used in the evaluation. The probability of exposure to fire/explosion from liquefied gas traffic on the river near the Dresden plant is calculated to be 4.0 x 10^{-7} per year. Based on this low probability, it is concluded that plant safety will not be affected by liquefied gas shipments on the Illinois, Des Plaines, and Kankakee rivers.

2.2.3.3 Hazards From Toxic Chemicals

A survey for potentially toxic chemicals stored or transported onsite or within a 5-mile radius offsite of Dresden Station was conducted in accordance with the criteria outlined in NUREG-0737, Item III.D.3.4. The study was performed to ensure compliance with 10 CFR 50, Appendix A, "General Design Criteria for Nuclear Power Plants," Criterion 19, "Control Room."[23,24] Control room habitability, including toxic chemical protection, is discussed in Section 6.4.

2.2.3.3.1 Onsite Survey Methodology

The onsite survey was conducted to identify chemicals stored within the plant boundary in quantities greater than 100 pounds in any given container. A list of potentially toxic onsite chemicals is provided in Table 2.2-7. The results of the onsite survey analysis are provided in Section 6.4.4.2.2.

2.2.3.3.2 Offsite Survey Methodology

The offsite survey was conducted to identify chemicals stored or transported within a 5-mile radius of the Dresden site. Fixed industrial, municipal, and bulk storage facilities, as well as pipeline companies, local farms, and businesses, were contacted regarding the chemicals they stored. Chemicals transported by barge, rail, and highway were also addressed. For Dresden, commodities transported on the

Illinois River; Canadian National (CN); AT&SF Railroad; Iowa Railroad; and the I-55 and I-80 interstate highways were considered. In accordance with Regulatory Guide 1.78, only chemicals transported with a minimum shipment frequency of 10 per year by highway, 30 per year by rail, and 50 per year by barge were considered.

A survey of chemicals stored at, or transported to or from, fixed facilities was conducted by individually contacting each facility. A listing of the firms contacted and the associated potentially toxic chemicals they transported or stored is provided in Table 2.2-8.

A survey of barge traffic on the Illinois River was performed using established methodology.[25,26] This survey provides a record of yearly tonnage of a given commodity category shipped from the mouth of the Illinois River to Lockport, Illinois, and through Lock 4/1 in the vicinity of Dresden Station. Shipment frequency was determined by dividing the yearly tonnage by the number of barges. This methodology is conservative because it assumes only one barge per shipment, while normal shipments may contain as many as four barges. Table 2.2-9 lists the chemicals.

Unlike the information on barge traffic,[24,26] there is no centralized source of meaningful data on railway and highway commodity traffic which is applicable to this survey. Data on railway traffic was obtained by individually contacting each of the railroads discussed. As noted on the tables, some information on commodity traffic by rail was not available. Data on highway commodity traffic was obtained by requesting information on chemicals transported to or from facilities within or near the 5-mile radius. These facilities include chemical users and producers. While these sources cannot provide a complete listing of the regional highway traffic, they are the only known sources of information and, therefore, the only data available for evaluation. Tables 2.2-10 and 2.2-11 provide a listing of potentially toxic chemicals transported by railway and highway, respectively.

2.2.3.4 Hazards from Collision with the Intake Structure

Cooling water for the station is provided through intake canals from the Des Plaines and Kankakee rivers and from an existing cooling lake. There is no commercial or recreational water traffic on the cooling lake. Thus, there is no potential for collision of vessels with the intake canals of the cooling lake. The crib house is approximately 2000 feet from the navigational channels. Thus, there is no potential for collision of river traffic with the crib house.

An event which has been postulated is the collision of a barge on the river with the intake canal, causing failure of the canal. Since water would be available from the cooling lake, this type of failure would not adversely affect plant safety.

2.2.3.5 Hazard from Liquid Spills

The accidental release of corrosive, coagulant, or cryogenic liquids into the Des Plaines, Kankakee, or Illinois rivers near the site is not a potential hazard to plant safety, because the service water and circulating water systems can be supplied by the cooling lake in the event of a spill. The potential intake of highly polluted water from the rivers as a result of a major spill is highly improbable for the following reasons:

A. The river water is tested weekly to detect any potential releases of corrosive, coagulant, or cryogenic liquids; and

B. The Illinois, Des Plaines, and Kankakee rivers in the vicinity of the plant were reclassified in 1972 as "Public and Food Processing Supplies," which implies that the upstream pollution is continuously abated by pollution control activities.[27]

2.2.4 References

1. Final Environmental Statement, Dresden Nuclear Power Station, Units 2 and 3, November 1973, USAEC.

2. Telephone conversation between J.A. Wilson of Sargent & Lundy and Mr. Hurley of Uniroyal Company, speaking for the Joliet Army Ammunition Plant, October 27, 1981.

3. Braidwood Station FSAR, Section 2.2.

4. Illinois Department of Mines and Minerals, Explosives Division, Benton, Illinois, "Certificate of Compliance for Explosive Storage," 1981-1982.

5. Telephone conversations between J. Beard, Plant Manager, Reichhold Chemical Company, and J.A. Wilson, Environmental Coordinator, Sargent & Lundy, January 20 and April 21, 1982.

6. Telephone conversation between J. Becia of Northern Illinois Gas and J.A. Wilson, Sargent & Lundy, October 1981.

7. Written response from Durkee-SCM Chemical Company (now Van Den Bergh Foods) to J.A. Wilson, Environmental Coordinator, Sargent & Lundy, January 22, 1982.

8. Telephone conversations between G. Warner, Hydro-Carbon Transportation, Inc., and J.A. Wilson, Sargent & Lundy, October and November 1981.

9. "Waterborne Commerce of the United States, 1973-1978," and telephone conversations between B.K. Lemba, U.S. Army Corps of Engineers, and J.A. Wilson, Sargent & Lundy, November 6, 1981.

10. Written response from G. Melhorn, General Manager, Alumax Mill Products, Inc. to J.A. Wilson, Environmental Coordinator, Sargent & Lundy, dated December 3, 1981.

11. Telephone and personal conversations between M. Harbach, Natural Gas Pipeline Co. of America, and J.A. Wilson, Sargent & Lundy, October and November 1981.

12. Oil & Gas Industry in Illinois Map, 1977.

13. Safety Evaluation Report, Hartsville Nuclear Plant, March 1976.

14. User's Guide for GASUS Computer Program for Transient Flow Behavior in Natural Gas Pipelines, Stone & Associates, Inc., Carlisle, Pennsylvania.

15. Department of the Army, Corps of Engineers, "Waterborne Commerce of the US," 1978.

16. Lockage Statistics, Chicago District Corps of Engineers, Department of the Army, 1973-1978.

17. Chicago Aeronautical Chart, May 14, 1981.

18. Telephone conversation between Owen Leander of the Federal Aviation Administration and J.A. Wilson of Sargent & Lundy, February 5, 1982.

19. Telephone conversation between J. Bueler, Federal Aviation Administration, and J. Wilson, Sargent & Lundy, October 6, 1981.

20. FAA Aviation Forecasts, 1981-1992.

21. Letter from G.C. Gunter, Chicago ARTCC, February 25, 1982.

22. "Evaluation of the Risks to the Marble Hill Nuclear Generating Station from Traffic on the Ohio River," IIT Research Institute, February 21, 1979.

23. Letter from E.D. Swartz (CECo-NLA) to D.G. Eisenhut (NRC), December 17, 1981, "Dresden Units 2 and 3, Quad Cities Station Units 1 and 2, Zion Station Units 1 and 2, Supplemental Response to NUREG-0737, Item III. D.3.4."

24. Control Room Habitability Study Update for Dresden Units 2 and 3, July 1992, Halliburton NUS Environmental Corporation.

25. Waterborne Commerce of the United States, 1989, U.S. Army Corps of Engineers, Document WRSC-WCUS-89-3.

26. Waterways Traffic Report, Illinois Lock 4/1 for 1991, U.S. Army Corps of Engineers, Rock Island District.

27. Telephone conversation between B. Burdick and R. MacLauchlin, U.S. Army Corps of Engineers, dated September 14, 1981 (3320).

28. "Analysis of Risk in the Water Transportation of Hazardous Materials," National Academy of Sciences, 1976.

29. FAA Form 5010-1, Airport Master Record.

30. "Control Room Habitability Study Update for Dresden Units 2 and 3, Enercon 2015, Calc DRE 15-013, EC 401597."

31. Calculation DRE12-0036, Revision 02 "Hazard Evaluation for Heating Boiler Natural Gas Fuel," February 22, 2016 including Attachment H, "Natural Gas line Risk Assessment."

32. US NRC Standard Review Plan NUREG 0800, Section 2.2.3, Rev 03, "Evaluation of Potential Accidents."

33. US NRC Regulatory Guide 1.91, "Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants," Rev 1.

34. GOTHIC Thermal Hydraulic Analysis Package User Manual, Version 8.1 (QA), Electric Power Research Institute (EPRI), Palo Alto, CA 2014.

35. RELAP/MOD3.3 Code Manual Volume I, October 2010 Information Systems Laboratories, Inc. Prepared for the Division of Systems Research, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

36. Final Safety Evaluation for Westinghouse Electric Company Topical Report (TR) WCAP-16608-P, Revision 0, Westinghouse Containment Analysis Methodology and Appendix A Generation of Thermal Hydraulic Information For Containment. (GOTHIC), ADAMS Accession Number ML090230143.

37 Calculation DRE22-0002, Revision 0 “Dresden Buried Pipe Blast and Gas leak Analysis.”

Table 2.2-1

ASSESSMENT SUMMARY

Hazard Number	Source of Potential Hazard	UFSAR Section	Design Basis Event?
	Explosion from:		
1	Industrial facilities(1)	2.2.2.2, 2.2.2.3	No, based on adequate separation distance(2)
2	Highway transportation	2.2.3.1.2	No, based on adequate separation distance
3	Railway transportation	2.2.3.1.3	No, based on adequate separation distance
4	Waterway transportation	2.2.3.1.4	No, based on adequate separation distance
5	Military facilities	2.2.2..1.1	No, based on adequate separation distance
6	Pipelines	2.2.2.3	No, based on frequency of 6 x 10^{-6}/yr using conservative assumptions
7	Vapor cloud explosion and fire from waterway transportation	2.2.3.2	No, based on frequency of 4 x 10^{-7}/yr
8	Toxic chemicals	2.2.3.3	No, based on physical considerations and PRA
9	Collision with intake structure	2.2.3.4	No, based on physical considerations
10	Liquid spills	2.2.3.5	No, based on physical considerations

Table 2.2-1

ASSESSMENT SUMMARY

Hazard Number	Source of Potential Hazard	UFSAR Section	Design Basis Event?
	Aircraft impact from:		
11	Airports	3.5	No, based on frequency of 3.24 x 10^{-7}/year
12	Airways	3.5	No, based on frequency of 0.93 x 10^{-7}/year

Notes:

1. Data for facilities which responded to the questionnaire.
2. There is one exception to this conclusion – the benzene storage tank on the Reichhold Chemical site.

Table 2.2-2

INDUSTRIES WITHIN 5 MILES OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-2 (Continued)

INDUSTRIES WITHIN 5 MILES OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-3

PIPELINES WITHIN 5 MILES OF DRESDEN STATION

Pipeline Company	Pipe Size (in.)	Material Carried	Operating Pressure (psi)	Closest Distance to the Plant (mi)
Natural Gas Pipeline Co.	36	Natural Gas	858	1.75
	36	Natural Gas	858	1.70
	30	Natural Gas	858	1.60
	36	Natural Gas	650	1.25
	30	Natural Gas	858	1.70
	30	Natural Gas	858	1.60
Nicor	8	Natural Gas	75	Onsite
Alliance Pipeline	20	Natural Gas	1208	0.62
Enron Liquids Pipeline, Inc.	10	Propane, Natural Gas	2100	4.0
	10	Propane, Natural Gas	2100	4.0
	6	Propane, Butane	500	2.0
Northern Illinois Gas	36	Natural Gas	740	2.5
	10	Out of Operation	---	2.5
	4	Natural Gas	Unknown	3.0

Table 2.2-3 (Continued)

PIPELINES WITHIN 5 MILES OF DRESDEN STATION

Pipeline Company	Pipe Size (in.)	Material Carried	Operating Pressure (psi)	Closest Distance to the Plant (mi)
Amoco	10	Crude Oil	---	3.0
	12	Crude Oil	---	3.0
	22	Crude Oil	---	3.0

Table 2.2-4

DATA ON AIRPORTS WITHIN 10 MILES OF DRESDEN STATION

Airport	Type	Approximate Distance from Station (mi)	Direction from Station	Number of Operations	Length of Runway (ft)	Width of Runway (ft)	Type of Runway	Orientation of Runway
Fromm	Private	4.5	E	50[1]	2773	100	Turf	NNE/SSW
Morris	Private	8	WNW	1942[1]	2400 2987	135 60	Turf Asphalt	E/W N/S
Rossi	Private	9	N	50[2]	2400	70	Turf	E/W
Bushby	Private	9.9	NNE	45[2]	1800	100	Turf	N/S
Joliet	Public	10	NNE	10,000[1]	3452 2970	125 100	Turf Asphalt	NE/SW NW/SE
Adelmann	Private	1	NE	20[2]	1600	70	Turf	SE/NW

Notes:

1. Total peak month, from FAA supplied documents.

2. Number per month, as supplied by owner of airport.

Table 2.2-5

DRESDEN ISLAND TRAFFIC STATISTICS
FISCAL YEARS 1973 THROUGH 1978[15,16]

Commodity Type	Fiscal Year						
	1973	1974	1975	1976	1977	1978	Average
Total commodities, tons x 10^6	28.476	30.853	27.808	25.882	23.452	19.521	26.0
Hazardous materials,(1) tons x 10^6	5.653	6.073	5.358	5.059	4.093	3.658	5.0
Liquified gases,(2) Tons	0.0	0.0	0.0	17,992	0.0	0.0	3000.0

Notes:

1. Hazardous materials are defined as all materials listed under the category of petroleum products in the lock statistics.

2. Liquefied gases shown are the amounts transported on the entire navigable length of the Illinois River.

Table 2.2-6

CASUALTY AND SPILL STATISTICS – FISCAL YEARS 1969 THROUGH 1972

Casualty/Spill	Illinois Rivers	Western Rivers[1]
Casualties[2]	178	2831
Casualties of hazardous material barges[3]	40	508
Spills from hazardous material barges	1	69
Casualties of liquefied gas barges	---	9
Spills from double-skinned vessels	---	7
Total length of waterway (mi)	333	3137

Notes:

1. Lower Mississippi, Upper Mississippi, Ohio, and Illinois rivers; casualties from these rivers constitute 97% of the casualties on western rivers.

2. Casualties which result in any of the following: loss of life, damage to cargo in excess of $1500, or release of cargo.

3. Hazardous material barges are generic type 17, 18, and 29 vessels.[28]

Table 2.2-7

POTENTIALLY TOXIC CHEMICALS STORED WITHIN
THE DRESDEN SITE BOUNDARY

Information Withheld Under 10 CFR 2.390

Table 2.2-7 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED WITHIN
THE DRESDEN SITE BOUNDARY

Information Withheld Under 10 CFR 2.390

Table 2.2-7 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED WITHIN
THE DRESDEN SITE BOUNDARY

Information Withheld Under 10 CFR 2.390

Table 2.2-7 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED WITHIN
THE DRESDEN SITE BOUNDARY

Information Withheld Under 10 CFR 2.390

Table 2.2-8

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-8 (Continued)

POTENTIALLY TOXIC CHEMICALS STORED AT FIXED FACILITIES
WITHIN A 5-MILE RADIUS OF DRESDEN STATION

Information Withheld Under 10 CFR 2.390

Table 2.2-9

POTENTIALLY TOXIC CHEMICALS TRANSPORTED ON BARGES
WITHIN A 5-MILE RADIUS OF DRESDEN

Potentially Toxic Chemical	Tons Shipped per Year	Tons per Barge[3]	Number of Barges
Sodium hydroxide[2]	353,606	1580	224
Chemicals and related products[2]	2,157,143	1580	1363
Alcohols[2]	769,832	1580	487
Organic industrial chemicals[1]	422,152	1580	267
Benzene and toluene[2]	69,745	1580	55
Synthetics[1]	106,565	1580	67
Nitrogenous chemical fertilizers[1]	39,700	1580	25
Other basic chemicals[1]	37,900	1580	24
Naphtha, petroleum solvents[2]	206,618	1580	130
Petroleum and petroleum-related products[1]	1,089,823	1580	695

Note:

1. Illinois River at Lock 4/1, U.S. Army Corps of Engineers, Rock Island District for 1990.

2. River traffic from the mouth of the Illinois River at Grafton, Illinois, to Lockport, Illinois, 291 miles. From Waterborne Commerce of the United States, U.S. Army Corps of Engineers, 1989.

3. Average barge size from Note 1.

Table 2.2-10

POTENTIALLY TOXIC CHEMICALS TRANSPORTED ON RAILROADS WITHIN A 5-MILE RADIUS OF DRESDEN

☐

Potentially Toxic Compound	Railroad					Total
	Burlington Northern Santa Fe (BNSF)	Iowa	Canadian National (CN)	Canadian National (CN)	Chessie[(2)]	
	Closest Distance to Dresden Station (mi)					
	3.9	3.7	2.45	1.45	3.7	
	Number of Tank Cars Shipped Per Year					
Acrylonitrile	8		6			14
Anhydrous ammonia	3		48			51
Butene	17		480	1.2		498.2
Carbon dioxide	219	80				299
Ethyl chloride	1					1
Ethylene dichloride	1					1
Ehylene oxide	1		132			133
Helium	16					16
Sulfuric acid	72					72
Vinyl chloride	1					1
Xylene	10	4[(1)]				14
Methanol	1					1
Nitrogen	1					1
Denatured alcohol		124[(1)]				124
Chlorosulfuric acid		52[(1)]				52

(Sheet 1 of 3)

Table 2.2-10 (Continued)

POTENTIALLY TOXIC CHEMICALS TRANSPORTED ON RAILROADS
WITHIN A 5-MILE RADIUS OF DRESDEN

Potentially Toxic Compound	Railroad					Total
	Burlington Northern Santa Fe (BNSF)	Iowa	Canadian National (CN)	Canadian National (CN)	Chessie[(2)]	
	Closest Distance to Dresden Station (mi)					
	3.9	3.7	2.45	1.45	3.7	
	Number of Tank Cars Shipped Per Year					
Chlorine		15 – 20[(1)]				
Aniline oil		32[(1)]				32
Phosphoric acid		140[(1)]				140
Heptane		4[(1)]				4
Hydrochloric acid		192[(1)]	3.6			195.6
Liquified petroleum gas			720			720
Propylene			672			672
Ethylene			156			156
Petroleum naptha			84			84
Methyl chloride			24			24
Vinyl acetate			12	84		96
Isopropanol			4.8			4.8
Diethyl sulfate			3.6			3.6
Propyl aldehyde			3.6			3.6

Table 2.2-10 (Continued)

POTENTIALLY TOXIC CHEMICALS TRANSPORTED ON RAILROADS
WITHIN A 5-MILE RADIUS OF DRESDEN

Potentially Toxic Compound	Railroad					Total
	Burlington Northern Santa Fe (BNSF)	Iowa	Canadian National (CN)	Canadian National (CN)	Chessie[2]	
	Closest Distance to Dresden Station (mi)					
	3.9	3.7	2.45	1.45	3.7	
	Number of Tank Cars Shipped Per Year					
Caustic soda			3.6			3.6
Hexane			2.4			2.4
Argon gas			2.4			2.4
Styrene monomer (inhibited)				108		108
Resin solution				48		48
Butyl acrylate				36		36
Phthalic anhydride				8.4		8.4
Dicyclopentadiene				4.8		4.8

Notes:

1. Based on 3 months' data scaled up to 1 year by a factor of four.
2. Chessie did not respond.

Table 2.2-11

POTENTIALLY TOXIC CHEMICALS TRANSPORTED ON HIGHWAYS WITHIN A 5-MILE RADIUS OF DRESDEN

Highway	Distance (mi)	Chemical	Quantity
Arsenal Road	4	Gasoline Diesel fuel Heating oil	11 shipments 4 shipments 2 shipments
Route 6	2	n-Butane Natural gas Propane	2900 1700 5900
Routes I-55 and I-80	4	Ammonia, anhydrous Hydrofluoric acid 4-Methyl, 2-Penanone Methyl ethyl ketone 3,5,5-Trimethyl, 2-Cyclohexene Secondary butyl alcohol Acetic acid esters Acetone Isopropyl alcohol Polyester resin styrene Acrylonitrile Formaldehyde Methyl alcohol Sulfuric acid Methyl chloride Propane Diethylene Glycol Dipropylene Glycol Ethylene Glycol Methyl Methacrylate Phthalic Anhydride Hydrogen Fluoride	Greater than 10 trucks per year (for each chemical listed).

2.3 METEOROLOGY

This section provides a meteorological description of the site and its surrounding areas, including a description of the general climate, local meteorological conditions, the onsite meteorological measurement program, and the radiological environmental monitoring program (REMP).

2.3.1 Regional Climatology

The regional meteorological characteristics of the Dresden site were studied by Murray and Trettel, Certified Consulting Meteorologists, from Northfield, Illinois. Their report is published in the Unit 2 Plant Design and Analysis Report (Docket 50-237).

The site is located in rolling prairie terrain typical of much of Illinois. Lake Michigan is the only topographical feature which could have some effect on the local meteorology. However, since the lake is about 45 miles to the northeast, this large body of water is considered to have an insignificant effect on the dispersive characteristics around the site.

2.3.1.1 Tornadoes

A typical tornado covers an area of about 8 square miles once it touches down. Widths of tornado paths range from about 100 feet to a maximum of about 4 miles. Tornadoes are known to touch down repetitively in erratic patterns. Path lengths, however, range from about 1 mile to the longest recorded, 163 miles.

Tornado occurrence data was compiled under Topic II-2.A of the systematic evaluation program (SEP) performed by the NRC and is summarized as follows. There were 233 tornadoes reported within an approximate 60-mile radius from the Dresden site, excluding the water area over Lake Michigan, during 1950 - 1977. On the average, eight tornadoes are expected to occur in the vicinity of the Dresden site every year. Based on the path length and width data from tornadoes occurring in the site region, the recurrence interval for a tornado at the site is calculated to be approximately 870 years.

Two tornadoes have been reported near the Dresden site since 1965. On November 12, 1965, a tornado moving east-northeast at approximately 70 mph passed 4 miles west of the site. Several electrical transmission lines to the site were interrupted, and, as a result, Unit 1 was shut down for about 24 hours. The second tornado, on May 24, 1966, passed near the site, resulting in the loss of one transmission line. However, the load was carried by other electrical transmission lines allowing Unit 1 to operate normally.

Even though the occurrence of a tornado touching down at the Dresden site may be considered very remote, each unit at Dresden Station is designed so that it can be shut down and maintained in a safe shutdown condition if such an event were to occur. For a discussion of the design considerations for tornado protection refer to Section 3.3.2.

2.3.2 Local Meteorology

At the time of original plant licensing, the normal annual precipitation in the area was 33.18 inches. A 24-hour maximum rainfall of 6.24 inches had been recorded. The average annual snowfall since 1929 was 37.1 inches. The maximum snowfall from 1929 through mid-1967 was 66.4 inches, recorded in the winter of 1951-1952.

Thunderstorms occur an average of 49 days per year in the site region. Based on the annual number of thunderstorm days, the calculated annual flash density of ground lightning strikes is five flashes per square kilometer. A structure with the approximate dimensions of the Dresden reactor buildings can be expected to be subjected to an average of one strike every 5 years.

On the average, hail storms occur about 2 days per year, and freezing rain occurs approximately 12 days per year. The maximum radial thickness of ice expected in the site region is about 1 inch.

Fogging and icing from the Dresden cooling lake are not expected to adversely affect the surrounding area except for an increased hazard on County Line and Dresden roads. Warning signs with flashing lights are installed to alert traffic to fog conditions. Additionally, a fog fence and a lighted, covered bridge were constructed on County Line Road to further assure traffic safety.

In SEP Topic II-2.A, the NRC concluded that the extreme maximum and minimum temperatures appropriate at the Dresden site for general plant design (i.e., HVAC systems) are 94°F (equalled or exceeded 1% of the time), and -5°F (equalled or exceeded 99% of the time). As described in UFSAR Section 9.4, the design of most HVAC systems is based on outside air temperatures varying between -6°F and +93°F. The review of HVAC systems was performed under SEP Topic IX-5 "Ventilation Systems".

Annual wind frequencies show a rather uniform distribution of wind direction which is typical of mid-continent locations. The most frequent wind directions are from the west and south sectors. (A sector is defined as 22½°.) The highest velocity of wind officially reported at various locations around the site area is 87 mph at Chicago and 75 mph at Peoria. Higher gusts are reported unofficially, up to 109 mph during heavy thunderstorms and scattered tornadic activity. Thus, the design criterion that structures be capable of withstanding wind loadings of 110 mph is considered appropriate for withstanding the anticipated sustained winds.

Hourly wind direction variability at the site shows that an average direction range (angular change in direction) is 120° in a 1-hour period, for all wind speed conditions combined. During 0 - 3 mph wind speeds, the average range in direction is 100°. Approximately 87% of the time when the wind speed is 0 - 3 mph (or 98.3% of all wind speeds) the wind direction range is 60° or more, which corresponds to a value of the diffusion parameter of 20 degree-mph or 0.16 radian-m/s.

2.3.3 Onsite Meteorological Measurements Program

The meteorological measurements program at the Dresden site consists of monitoring wind direction, wind speed, temperature, and precipitation. Two methods of determining atmospheric stability are used: delta T (vertical temperature difference) is the principal methods; sigma theta (standard deviation of the horizontal WD) is available for use when delta T is not available. These data, referenced in ANSI/AND 2.5 (1984), are used to determine the meteorological conditions prevailing at the plant site. Site-specific information on instrumentation, calibration procedures, as well as the meteorological measurements program during a disaster can be found in the Emergency Plan (E-Plan) annex.

The meteorological tower is equipped with instrumentation that conforms with the system accuracy recommendations of Regulatory Guide 1.23 and ANSI/ANS 2.5 (1984). The equipment is placed on booms oriented into the generally prevailing wind at the site. Equipment signals are brought to an instrument shack with controlled environmental conditions. The shack at the base of the tower houses the recording equipment, signal conditioners, etc., used to process and retransmit the data to the end-point users.

Recorded meteorological data are used to generate wind roses and to provide estimates of airborne concentrations of gaseous effluents and projected offsite radiation dose. Instrument calibrations and data consistency evaluations are performed routinely to ensure maximum data integrity. Data recovery objective is to attain better than 90% from each measuring and recording system. Data storage and record retention are also maintained in compliance with ANSI/ANS 2.5 (1984).

2.3.4 Radiological Environmental Monitoring Program

The REMP being conducted in the vicinity of the station has the following objectives:

A. To provide data on measurable levels of radiation and radioactivity in the environment and relate these data to radioactive emissions;

B. To identify changes in the use of nearby offsite areas to assure adequate surveillance and evaluation of doses to individuals from principal pathways of exposure;

C. To provide environmental surveillance in case of an unplanned release; and

D. To provide year round monitoring of principal pathways of exposure.

The REMP provides representative measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides that lead to the highest potential radiation exposures of members of the public resulting from the station operation. The REMP implements Section IV.b.2 of Appendix I to 10 CFR 50 and thereby supplements the radiological effluent monitoring program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of effluent measurements and the modeling of the environmental exposure pathways.

A description of the current REMP parameters can be found in the Dresden Annual Radiological Environmental Operating Report and the Dresden offsite dose calculation manual (ODCM).

Current summaries of wind speed, wind direction, and atmospheric stability are published in the Dresden Annual Radiological Environmental Operating Report. Classification of stability based on lapse rate is given in Table 2.3-1.

Table 2.3-2 provides the distance from each of the three points of airborne effluent on the Dresden site to various points near the site.

2.3.5 Short-Term Diffusion Estimates (Original Licensing χ/Q Analysis)

From a meteorological standpoint the site is suitable for the combined operation of Units 1, 2, and 3. The environmental surveys of the site and surrounding areas conducted by CECo, Argonne National Laboratory, and the State of Illinois demonstrate that meteorological diffusion characteristics provide a means for dispersion of gaseous wastes emitted during normal operation to a degree that they are almost undetectable in the environs of the site. There is nothing in the meteorological or topographical data which indicates that the diffusion mechanism would not be operative during assumed hypothetical accident conditions. The hourly wind direction variability of 60° for more than 98.3% of the time at all wind speeds provides evidence that the concentration of any accidental release of radioactive gaseous products would be rapidly diluted and dispersed.

2.3.5.1 Short-term (Accident) Diffusion Estimates (Alternative Source Term χ/Q Analysis)

2.3.5.1.1 Calculation of χ/Q at the EAB and LPZ

Estimates of atmospheric diffusion (χ/Q) at the Exclusion Area Boundary (EAB), the outer boundary of the Low Population Zone (LPZ) and the Control Room Intakes are calculated for the regulated short-term (accident) time-averaging periods of 0-2 hrs, 2-8 hrs, 1-4 days and 4-30 days. χ/Q was calculated at the EAB (800 m) and LPZ (8000 m) for releases from the Unit 2 and 3 MSIV, the Station Chimney, and the Reactor Building Vent Exhaust Stack, using the NRC-recommended model PAVAN (Ref. 1), in accordance with Regulatory Guide 1.145 (Ref. 2).

2.3.5.1.1.1 PAVAN Model Analysis

For elevated releases during non-fumigation conditions, the equation for ground-level relative concentration at the plume centerline is:

$$\chi / Q = \frac{1}{\pi \overline{U}_h \sigma_y \sigma_z} \exp\left[\frac{-h_e{}^2}{2\sigma_z{}^2}\right]$$

χ / Q is relative concentration, in sec/m³.

$\overline{U_h}$ is windspeed representing conditions at the release height, in m/sec.

σ_y is lateral plume spread, in meters, a function of atmospheric stability and distance.

σ_z is vertical plume spread, in meters, a function of atmospheric stability and distance.

π is 3.14159.

h_e is effective stack height, in meters: $h_e = h_s - h_t$

h_s is the initial height of the plume (usually the stack height) above plant grade, in meters.

h_t is the maximum terrain height above plant grade between the release point and the point for which the calculation is made, in meters. If h_t is greater than h_s then $h_e = 0$.

For elevated release during fumigation conditions, the equation for ground-level relative concentration at the plume centerline is:

$$\chi / Q = \frac{1}{(2\pi)^{1/2} \overline{U}_{h_e} \sigma_y h_e}, h_e > 0 \qquad (2.3.5.1\text{-}2)$$

$\overline{U_{h_e}}$ is windspeed representative of the fumigation layer of depth h_e, in m/sec; a value of 2 m/sec is assumed in accordance with NRC staff consideration as a reasonably conservative assumption for h_e of about 100m.

σ_y is the lateral plume spread, in meters, that is representative of the layer at a given distance; a moderately stable (F) atmospheric stability condition is assumed.

For the fumigation case that assumes F stability and a windspeed of 2 m/s, Equation 2.3.5.1-1 is used instead of 2.3.5.1-2 at distances greater that the distance at which the χ/Q values determined using Equation 2.3.5.1-1 with $h_e = 0$ and Equation 2.3.5.1-2 are equal.

For ground-level releases, calculation χ/Q for the 2 hours following the accident is based on the following equations:

$$\chi / Q = \frac{1}{\bar{U}_{10}(\pi \sigma_y \sigma_z + A/2)} \qquad (2.3.5.1\text{-}3)$$

$$\chi / Q = \frac{1}{\bar{U}_{10}(3\pi \sigma_y \sigma_z)} \qquad (2.3.5.1\text{-}4)$$

$$\chi / Q = \frac{1}{\bar{U}_{10}\pi \Sigma_y \sigma_z} \qquad (2.3.5.1\text{-}5)$$

where:

χ / Q is relative concentration, in sec/m3.

π is 3.14159.

$\bar{U}_{10}$ is wind speed at 10 meters above grade, in m/sec.

σ_y is lateral plume spread, in meters of atmospheric stability and distance.

σ_z is vertical plume spread, in meters, a function of atmospheric stability and distance.

Σ_y is lateral spread, in meters, with meander and building wake effects (in meters), a function of atmospheric stability, wind speed, and distance [for distances or 800 m or less, $\Sigma_y = M\sigma_y$, where M is determined from Reg. Guide 1.145 Fig. 3; for greater than 800 m $\Sigma_y = (M-1)\ \sigma_{y800m} + \sigma_y$.

A is the smallest vertical-plane cross-sectional area of the reactor building, in square meters. (Other structures or a directional consideration may be justified when appropriate.)

Plume meander is only considered during neutral (D) or stable (E, F or G) atmospheric stability conditions. For such, the higher of the values resulting from Equations 2.3.5.1-3 and 2.3.5.1-4 is compared to the value of equation 2.3.5.1-5 for meander, and the lower value is selected. For all other conditions (stability classes A, B, or C), meander is not considered and the higher χ/Q value of equations 2.3.5.1-3 and 2.3.5.1-4 is selected.

The χ/Q values calculated at the EAB based on meteorological data representing a 1-hour average are assumed to apply for the entire 2-hour period.

To determine the maximum sector χ/Q value at the EAB, a cumulative frequency probability distribution (probabilities of a given χ/Q value being exceeded in that sector during the total time) is constructed for each of the 16 sectors using χ/Q values calculated for each hour of data. This probability is then plotted versus the χ/Q values and a smooth curve is drawn to form an upper bound of the computed points. For each of the 16 curves, the χ/Q value that is exceeded 0.5 percent of the total hours is selected and designated as the sector χ/Q value. The highest of the 16 sector χ/Q values is the maximum sector χ/Q.

Per RG 1.145, Dresden is classified as an inland site (i.e, more than 3.2 km from large bodies of water such as oceans or Great Lakes); therefore, the maximum sector χ/Q value at the EAB is determined by comparison of the sector fumigation and non-fumigation (as determined in the above paragraph) χ/Q values. If the fumigation value is greater, then it is used for the 0 – ½ hour time period and the non-fumigation value is used for the ½ – 2 hour time period. Otherwise, the non-fumigation sector value is used for the entire 0 – 2 hour time period. The maximum sector χ/Q at the LPZ for stack releases during fumigation conditions at in land sites are determined in the same manner as the EAB.

Determination of the LPZ maximum sector χ/Q is based on a logarithmic interpolation between the 2-hour sector χ/Q and the annual average χ/Q for the same sector. For each time period, the highest of these 16 sector •/Q values is identified as the maximum sector χ/Q value. The maximum sector χ/Q values will, in most cases, occur in the same sector. If they do not occur in the same sector, all 16 sets of values are used in dose assessment requiring time-integrated concentration considerations. The set that results in the highest time-integrated dose within a sector is considered the maximum sector χ/Q.

The 5% overall site χ/Q value for the EAB and PZ is determined by constructing an overall cumulative probability distribution for all directions. The value of χ/Q is plotted versus the probability of it being exceeded, and an upper bound curve is drawn. From this curve, the 2-hour χ/Q value that is exceeded 5% of the time is found. The 5% overall site χ/Q at the LPZ for intermediate time periods is determined by logarithmic interpolation of the maximum of the 16 annual average χ/Q values and the 5% 2-hour χ/Q values.

2.3.5.1.1.1.1 PAVAN Meteorological Database

1995-1999 hourly meteorological tower data was utilized for the EAB and LPZ χ/Q calculations. Wind measurements were taken at 35 ft, 150 ft, and 300 ft and the vertical temperature difference (i.e., delta T) was measured between 150 ft and 35 ft and between 300 ft and 35 ft. The most representative wind measurement level and delta T measurement were utilized for each scenario as follows:

Scenario	PAVAN Release Mode	Wind Level	Delta T Stability Class Layer
Unit 2 and 3 MSIV to EAB and LPZ	Ground	35 ft	150-35 ft
Station Chimney to EAB and LPZ	Elevated	300 ft	300-35 ft
Reactor Building Vent Exhaust Stack to EAB and LPZ	Ground	35 ft	150-35 ft

2.3.5.1.1.1.2 PAVAN Input Parameters

The MSIV release points and the Reactor Building Vent Exhaust Stack releases were executed by PAVAN as "ground" type releases and the Station Chimney was executed as an elevated release.

The EAB and LPZ terrain heights shown in the tables below were utilized in PAVAN in accordance with Regulatory Guide 1.145 for the Station Chimney scenario.

Regulatory Guide 1.145 requires setting the terrain elevation equal to the "maximum terrain height above plant grade between the release point and the point for which the calculation is made"; however, for conservatism, the 100 ft bluff located well outside the EAB at 1300 m in the north through east sectors (i.e., the only historically considered significant terrain feature located in the immediate vicinity of the Station) was also conservatively incorporated as PAVAN enables into the EAB χ/Q computation.

Terrain elevation to the LPZ boundary distance in all direction sectors was very conservatively assumed to be equal to the height of the stack (i.e. 95 m), as shown below.

PAVAN EAB Terrain Heights Station Chimney Scenario																
Downwind Sector	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**
Terrain Height (m)	0	0	0	0	0	0	0	0	31	31	31	31	31	0	0	0
Distance at which terrain height occurs (m)	800	800	800	800	800	800	800	800	1300	1300	1300	1300	1300	800	800	800

PAVAN LPZ Terrain Heights Station Chimney Scenario																
Downwind Sector	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**
Terrain Height (m)	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95
Distance at which terrain height occurs (m)	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000

No terrain elevations were used for the Unit 2 and 3 MSIV and Reactor Building Vent Exhaust Stack ground-level release scenarios. The maximum ground-level release EAB and LPZ χ/Q values are predicted by PAVAN to occur at the minimum EAB and LPZ distances.

2.3.5.1.1.1.3 PAVAN EAB and LPZ χ/Q

Atmospheric χ/Q diffusion factors predicated by PAVAN at the EAB and LPZ are summarized below.

PAVAN Stack χ/Q Results EAB and LPZ								
Scenario		χ/Q (sec/m^3) (1)						
Receptor	Source	0-0.5 hour (max fumigation	0-2 hrs(2)	0-8 hrs	8-24 hrs	1-4 days	4-30 days
EAB (800 m)	Unit 2 and 3 MSIV	N/A	2.51E-04 (NE)	1.21E-04 (NE)	8.43E-05 (NE)	3.83E-05 (NE)	1.29E-05 (SE)
	Station Chimney	8.74E-05 (N through E)	6.74E-06 (ENE)	3.06E-06 (ENE)	2.06E-06 (ENE)	8.75E-07 (ENE)	2.56E-07 (E)
	Reactor Building Vent Exhaust Stack	N/A	2.51E-04 (NE)	1.21E-04 (NE)	8.43E-05 (NE)	3.83E-05 (NE)	1.29E-05 (SE)
LPZ (800 m)	Unit 2 and 3 MSIV	N/A	2.63E-05 (SE)	1.09E-05 (SE)	7.02E-06 (SE)	2.70E-06(SE)	6.86E-07 (SE)
	Station Chimney	1.55E-05 (All Sectors)	8.30E-06	3.57E-06	2.34E-06	9.39E-07	2.53E-07
	Reactor Building Vent Exhaust Stack	N/A	2.63E-05 (SE)	1.09E-05 (SE)	7.02E-06 (SE)	2.70E-06 (SE)	6.86E-07 (SE)

(1) χ/Q values are the higher of the Direction-Specific Max (wind direction specified) and Site Limit (direction independent)
(2) When a 0-0.5 hour fumigation value is listed, the 0-2 hr time period represents a 0.5-2 hour time period.

2.3.5.1.2 Calculation of χ/Q at the Control Room Intake

Estimates of atmospheric diffusion (χ/Q) are made for the Control Room Intake for releases from the Unit 2 MSIV, Unit 3 MSIV, the Station Chimney and the Reactor Building Vent Exhaust Stack. The NRC-sponsored computer codes ARCON96 (Reference 3) and PAVAN are utilized consistent with the procedures in Regulatory Guide 1.194 (Reference 4).

2.3.5.1.2.1 ARCON96 Model Analysis

ARCON96 is utilized in both elevated release mode and ground-level release mode for calculation of Control Room χ/Q at the Dresden Station. Its technical basis is described as follows, per Reference 3.

For elevated releases, the relative concentration is given by:

$$\frac{\chi}{Q} = \frac{1}{\pi \sigma_y \sigma_z U} \exp\left[-0.5\left(\frac{y}{\sigma_y}\right)^2\right] \exp\left[-0.5\left(\frac{h_e - h_i}{\sigma_z}\right)^2\right] \quad (2.3.5.1\text{-}6)$$

where h_e is the effective stack height and h_i is the height of the intake. Wake corrections are not made to diffusion coefficients used in calculating concentrations in elevated plumes. Effective stack height is determined from the actual stack height (h_s), the difference in terrain elevation between the stack and intake locations ($t_s - t_i$), and stack downwash (•h_d) by

$$h_e = h_s + (t_s - t_i) + \Delta h_d \quad (2.3.5.1\text{-}7)$$

Where the stack downwash is computed as

$$\Delta h_d = 4 r_s \left[\frac{w_o}{U(h_s)} - 1.5\right] \quad (2.3.5.1\text{-}8)$$

and r_s is the radius of the stack, w_o is the vertical velocity of the effluent, and $U(h_s)$ is the wind speed at stack height. A release is considered elevated if the actual stack height is more than 2.5 times the height of structures in the immediate vicinity of the stack. Plume rise is not considered in calculating effective stack height in ARCON96. If consideration of plume rise is desired, the plume rise must be calculated manually and added to the release height before the release height is entered.

The sector-average model is used in calculating relative concentrations for elevated releases for averaging period longer than 8 hours. The sector-average plume model for elevated releases may be derived in the same manner as the sector-average plume model for ground-level releases. It is

$$\frac{\chi}{Q} = \frac{2}{(2\pi)^{1/2} W_s \sigma_z U} \exp\left[-.05\left(\frac{h_e - h_i}{\sigma_z}\right)^2\right] \quad (2.3.5.1\text{-}9)$$

The use of the elevated plume models can lead to unrealistically low concentrations at control room intakes. Near the base of stacks the highest concentrations are likely to occur during low wind speed conditions when there may be reversals in the wind direction. In accordance with Regulatory Guide

1.194, the methodology of Regulatory Guide 1.145 is used to estimate potential control room intake concentrations during low wind speed conditions (See PAVAN modeling analysis in Section 2.3.5.1.1).

The basic model for a ground-level release is as follows:

$$\frac{\chi}{Q} = \frac{1}{\pi \sigma_y \sigma_z U} \exp\left[-.05 \left(\frac{y}{\sigma_z} \right)^2 \right] \qquad (2.3.5.1\text{-}10)$$

where:

χ/Q = relative concentration (concentration divided by release rate) [{ci/m³)/(ci/s)]

$\sigma_{y^3}\ \sigma_z$ = diffusion coefficients (m)

U = wind speed (m/s)

y = distance from the center of the plume (m)

This equation assumes that the release is continuous, constant, and of sufficient duration to establish a representative mean concentration. It also assumes that the material being released is reflected by the ground. Diffusion coefficients are typically determined from atmospheric stability and distance from the release point using empirical relationships. A diffusion coefficient parameterization from the NRC PAVAN and XOQDOQ (Reference 5) code is used for σ_y and σ_z

The diffusion coefficients have the general form

$$\sigma = a\, x^b + c$$

where x is the distance from the release point, in meters, and a, b, and c are parameters that are functions of stability. The parameters are defined for 3 distance ranges – 0 to 100 m, 100 to 1000 m, and greater than 1000 m. The parameter values may be found in the listing of Subroutine NSIGMA1 in Appendix A of NUREG/CR-6331 Rev. 1.

Diffusion coefficient adjustments for wakes and low wind speeds are incorporated as follows:

To estimate diffusion in building wakes, composite wake diffusion coefficients, • $_y$ and • $_{z3}$replace σ_y and σ_z. The composite wake diffusion coefficients are defined by

$$\Sigma_y = \left(\sigma_y^2 + \Delta\sigma_{y1}^2 + \Delta\sigma_{y2}^2 \right)^{1/2} \qquad (2.3.5.1\text{-}11)$$

$$\Sigma_z = \left(\sigma_z^2 + \Delta\sigma_{z1}^2 + \Delta\sigma_{z2}^2 \right)^{1/2} \qquad (2.3.5.1\text{-}12)$$

The variables σ_y and σ_z are the normal atmospheric diffusion coefficients, • σ_{y1} and • σ_{z1} are the low wind speed corrections, and σ_{y2} and σ_{z2} are the building wake corrections. These corrections are described and evaluated in Ramsdall and Fosmire (Reference 6). The low wind speed corrections are:

$$\Delta\sigma_{y1}^2 = 9.13 \times 10^5 \left[1 - \left(1 + \frac{x}{1000U} \right) \exp\left(\frac{-x}{1000U} \right) \right] \qquad (2.3.5.1\text{-}13)$$

$$\Delta\sigma_{z1}{}^2 = 6.67 \times 10^2 \left[1 - \left(1 + \frac{x}{100U} \right) \exp\left(\frac{-x}{100U} \right) \right] \tag{2.3.5.1-14}$$

The variable, x, is the distance from the release point to the receptor, in meters, and U is the wind speed in meters per second. It is appropriate to use the slant range distance for x because these corrections are made only when the release is assumed to be at the ground level and the receptor is assumed to be on the axis of the plume.

The diffusion coefficients corrections that account for enhanced diffusion in the wake have a similar form. These corrections are:

$$\Delta\sigma_{y2}{}^2 = 5.24 \times 10^{-2}\, U^2 A \left[1 - \left(1 + \frac{x}{10\sqrt{A}} \right) \exp\left(\frac{-x}{10\sqrt{A}} \right) \right] \tag{2.3.5.1-15}$$

$$\Delta\sigma_{z2}{}^2 = 1.17 \times 10^{-2}\, U^2 A \left[1 - \left(1 + \frac{x}{10\sqrt{A}} \right) \exp\left(\frac{-x}{10\sqrt{A}} \right) \right] \tag{2.3.5.1-16}$$

The constant, A, is the cross-sectional area of the building.

An upper limit is placed on $\sum_y$ as a conservative measure. This limit is the standard deviation associated with a concentration uniformly distributed across a sector of width equal to the circumference of a circle with radius to the distance between the source and receptor. This value is

$$\begin{aligned} \textstyle\sum_{y\,max} &= \frac{2\pi x}{\sqrt{12}} \\ &\approx 1.81x \end{aligned} \tag{2.3.5.1-17}$$

2.3.5.1.2.1.1 ARCON96 Meteorological Database

The Dresden meteorological tower data for the five-year period, 1995-1999, were applied in the ARCON96 modeling analyses. Wind measurements were taken at 35 ft, 150 ft, and 300 ft. The vertical temperature difference (i.e., delta T) was measured between 150 ft and 35 ft and between 300 ft and 35 ft. The most representative wind and delta T measurement levels were then selected to be utilized in ARCON96 for each of the source/Control Room Intake scenarios as shown below:

Scenario	**Lower Level Wind**	**Upper Level Wind**	**Delta T Stability Class Levels**
Unit 2MSIV	35 ft	150 ft	150-35 ft
Unit 3 MSIV	35 ft	150 ft	150-35 ft
Station Chimney	35 ft	300 ft	300-35 ft
Reactor Building Vent Exhaust Stack	35 ft	150 ft	150-35 ft

2.3.5.1.2.1.2 ARCON96 Input Parameters

There are four (4) release points identified for Dresden: the Unit 2 MSIV, the Unit 3 MSIV, the Station Chimney and the Reactor Building Vent Exhaust Stack. The Unit 2 MSIV, Unit 3 MSIV and the Reactor Building Vent Station licensing as document in the Dresden SER, the Station Chimney (although somewhat less than 2.5 times the height of its adjacent building) is treated as an elevated release. The effects of stack downwash were considered for the Station Chimney scenario.

2.3.5.1.2.1.3 ARCON96 Control Room Intake χ/Q

The χ/Q values resulting from the ARCON96 modeling analysis of each Source/Control Room Intake scenario are presented below:

TABLE 2-1

ARCON96 Analysis χ/Q Results: Control Room Intakes							
Scenario			χ/Q (sec/m^3)				
Receptor	Source	Type of Release	0-2 hrs	2-8 hrs	8-24 hrs	1-4 days	4-30 days
Control Room Intake	Unit 2 MSIV	Ground	1.30E-03	1.06E-03	4.49E-04	2.96E-04	2.44E-04
	Unit 3 MSIV	Ground	4.48E-04	3.74E-04	1.57E-04	1.04E-04	8.42E-05
	Station Chimney	Elevated	1.00E-15	1.00E-15	1.84E-13	5.95E-14	3.82E-14
	Reactor Building Vent Exhaust Stack	Ground	6.44E-04	4.91E-04	2.02E-04	1.36E-04	1.05E-04

2.3.5.1.2.2 PAVAN Model Anlaysis

A PAVAN modeling analysis was also performed to determine χ/Q values at the Control Room Intake for releases from the Stack. For this PAVAN analysis, which supplements the ARCON96 modeling analysis results for the 0-2 hour, 1-4 day, and 4-30 day χ/Q time intervals, maximum PAVAN χ/Q are utilized irrespective of Station Chimney to Control Room Intake direction.

PAVAN was executed in stack release mode utilizing the equations outlined above in Section 2.3.5.1.1.

2.3.5.1.2.2.1 PAVAN Meteorological Database

The 300 ft wind and 300-35 ft delta T stability class for the five-year period 1995-1999, was utilized in PAVAN for the Control Room Intake χ/Q calculations.

2.3.5.1.2.2.2 PAVAN Input Parameters

PAVAN was executed in elevated release mode. Following the execution of PAVAN for the distance from the Station Chimney to the Control Room Intake, a review of this output was performed in accordance with RG 1.194 guidance to estimate an approximate distance range within which the actual maximum 0-2 hour χ/Q would be predicted to occur in each given downwind sector. An additional set of PAVAN runs was then modeled for several distances in this range to determine the actual maximum χ/Q.

Terrain was not considered for the Station Chimney to Control Room Intake scenario because the distance from intake to source is so small that the terrain would not be expected to have a significant effect on the χ/Q values.

2.3.5.1.2.2.3 PAVAN Control Room Intake χ/Q

PAVAN Analysis χ/Q Results Station Chimney to Control Room Intake				
χ/Q (sec/m^3)*				
0-2 hours	**0-8 hours**	**8-24 hours**	**1-4 days**	**4-30 days**
6.42E-06	2.87E-06	1.93E-06	8.18E-07	2.38E-07

*χ/Q value represents maximum occurrence calculated between 75 m and 3000 m.

2.3.5.1.2.3 Control Room χ/Q Results (In accordance with RG 1.194)

The table below shows the final Control Room Intake χ/Q results in accordance with RG 1.194, as derived based on the ARCON96 and PAVAN analysis χ/Q values.

Control Room Intake χ/Q Results (in accordance with RG 1.194)					
Scenario	χ/Q (sec/m^3)				
	0-2 hrs	**2-8 hrs**	**8-24 hrs**	**1-4 days**	**4-30 days**
Unit 2 MSIV	1.30E-03	1.06E-03	4.49E-04	2.96E-04	2.44E-04
Unit 3 MSIV	4.48E-04	3.74E-04	1.57E-04	1.04E-04	8.42E-05
Reactor Building Vent Exhaust Stack	6.44E-04	4.91E-04	2.02E-04	1.36E-04	1.05E-04
Station Chimney to Control Room Intake	6.42E-06	1.00E-15	1.84E-13	3.41E-08	1.00E-08

2.3.6 Long-Term Diffusion Estimates

For information on the data and methodology used to calculated the distribution of relative concentrations refer to the ODCM.

2.3.7 References

1. *Atmospheric Dispersion Code System for Evaluating Accidental Radioactivity Releases from Nuclear Power Stations;* PAVAN, Version 2; Oak Ridge National Laboratory; U.S. Nuclear Regulatory Commission; December 1997.

2. *Regulatory Guide 1.145; Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants (Revsion 1)*; U.S. Nuclear Regulatory Commission; November 1982.

3. *Atmospheric Relative Concentrations in Building Wakes;* NUREG/CR-6331, PNNL-10521, Rev. 1; prepared by J. V. Ramsdell, Jr., C. A. Simmons, Pacific Northwest National Laboratory; prepared for U.S. Nuclear Regulatory Commision; May 1997 (Erratra, July 1997).

4. *Regulatory Guide 1.194; Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at nuclear Power Plants;* U.S. Nuclear Regualtory Commission; June 2003.

5. *XOQDOQ; Computer Program for the Meteorological Evaluation of Routine Releases at Nuclear Power Stations;* NUREG/CR-2919; J. F. Sagendorf, J. T. Goll, and W. F. Sandusky, U.S. Nuclear Regulatory Commission; Washington, D.C; 1982.

6. *Atmospheric Dispersion Estimates in the Vicinity of Buildings;* J. V. Ramsdell and C. J. Fosmire, Pacific Northwest Laboratory; 1995

Table 2.3-1

CLASSIFICATION OF STABILITY BASED ON LAPSE RATE

Index	Pasquill Class[1]	Stability Class [1]	Rate of Temperature Change, Delta-T, (°F/1000 ft)
1	A	Extremely unstable	Delta-T < -10.3
2	B	Moderately unstable	-10.3 <= Delta-T < -9.3
3	C	Slightly unstable	-9.3 <= Delta-T < -8.3
4	D	Neutral	-8.3 <= Delta-T < -2.6
5	E	Slightly stable	-2.6 <= Delta-T < 8.9
6	F	Moderately stable	8.9 <= Delta-T < 20.4
7	G	Extremely stable	20.4 <= Delta-T

The unstable category (Pasquill Classes A, B, and C) correspond to stability indexes 1 through 3; the neutral category corresponds to stability index 4 (Pasquill Class D); and the stable category (Pasquill Classes E, F, and G) encompasses stability indexes 5, 6 and 7.

Notes:

1. As noted in Offsite Dose Calculational Manual.

Table 2.3-2

DISTANCES (feet) FROM RELEASE POINTS TO VARIOUS POINTS NEAR SITE

	South Boundary	Northwest Boundary	Thorsen Farm	Edge of Bluff
Unit 2/3 (Chimney)	2900	2250	2910	4100
Unit 2/3 (Ventilation Stack)	2650	2450	2670	4250
Unit 1 Chemical Cleaning Building (Ventilation Stack)	2670	3020	2670	3650

2.4 HYDROLOGIC ENGINEERING

2.4.1 Hydrologic Description

The Harza Engineering Company, a consulting firm from Chicago, made a study in 1965 of the characteristics of the river systems of interest, and its report was set forth in Volume III of the Unit 2 Plant Design and Analysis Report (PDAR).

The Dresden site at the confluence of the Des Plaines and Kankakee rivers is at the location considered to divide the upper and lower parts of the Illinois River system. The normal river pool elevation controlled at the adjacent Dresden Island Lock and Dam is nominally 505 feet. In December 1982, the Dresden site was subjected to flood waters that exceeded 509 feet establishing a maximum historical flood elevation. Nominal ground elevation is about 516 feet at the location of the principal structures of Units 2 and 3, and design plant grade is 517 feet. Consequently the probability of flooding critical areas of the site is remote. Pertinent hydrologic design bases elevations are provided in Table 2.4-1.

Spillway capacity at the Dresden Island Lock and Dam is well in excess of the estimated maximum instantaneous flow of the Illinois River (100,000 ft^3/s based on the assumption that maximum flows for all contributory streams occur simultaneously). The site elevation is well above the vast valley storage area upstream from the dam.

River system flow data applicable to the site for the years 1961-1964 show that river flow exceeds 3000 ft^3/s on 98% of the days, 3600 ft^3/s on 93% of the days, 4000 ft^3/s on 87% of the days, 5000 ft^3/s on 63% of the days, and 6000 ft^3/s on 48% of the days. Such flows are more than adequate to meet the cooling water requirements of the two operating units, to assure the availability of sufficient quantities of water for dilution of all radioactive liquid wastes discharged into the Illinois River within the limits in 10 CFR 20, and to reduce concentrations to approximately one one-thousandth of the maximum permissible concentration in the river below the point of discharge from the station.

The closest point downstream of the station where the Illinois River is used as a source of domestic water is Peoria which is 100 miles downstream. At this point the combined effects of dilution, mixing, radioactive decay, and deposition of radioactivity on the river bottom will have rendered the contribution of radioactivity by the station negligible in relation to that present in the Illinois River from other sources.

The principal uses of the water of the Des Plaines and Illinois rivers are navigation, sewage disposal and dilution, and condenser cooling water for power plants. The Kankakee River, upstream from the station, is not navigable and is used for domestic supply and recreation.

2.4.2 Effects of Local Intense Precipitation on Roof Structures

The NRC concluded in the Systematic Evaluation Program (SEP) Topic II-3.B that the roofs of certain safety-related buildings were not designed to sustain loadings from the probable maximum precipitation (PMP). The existing drainage was insufficient, and as a result, the actual roof loading would exceed the original design live loads. To resolve the concern CECo installed scuppers in the roof parapets of the turbine building, reactor building, and the crib house.

2.4.3 Probable Maximum Flood on Streams and Rivers

The NRC concluded in SEP Topic II-3.B that a flow of 490,000 ft^3/s in the Illinois River would result in a stillwater flood elevation of 525'-0". Adding wave runup to the stillwater flood elevation yields a site probable maximum flood (PMF) elevation of 528'-0". Since the PMF is above the plant grade (elevation 517'-0") and above the lowest opening leading to safety-related equipment (elevation 510'-4"), the safe operation of the plant during the PMF is accomplished via implementation of the flood emergency procedures as discussed in Section 3.4.

The NRC also concluded that the expected 100-year flood would occur at elevation 509.8', and the standard project flood would occur between elevations 512'-0" and 516'-0". The NRC further concluded that neither of these floods will inundate the site, but they would flood the service water pump motors.

Additionally, the NRC stated that local flooding due to the occurrence of a localized PMP event will not affect safety-related equipment at the site.

The PMP for Dresden Station was determined based upon U.S. National Weather Service reports as follows:

A. 26 inches within 10 square miles over a 24-hour period; or

B. 17.8 inches within 1 square mile over a 1-hour period.

2.4.4 Potential Dike and Dam Failures, Seismically Induced

2.4.4.1 Cooling Lake Dike Failure

Instantaneous dike losses on the north, south, or west sides of the cooling lake (there is no dike on the east side of the lake) would not affect plant operation and safety.

An earth dam of the type specified usually does not collapse in its entirety. A break occurs and widens as the water washes through the break. This tends to prolong the time it would take to empty the lake; nevertheless, instantaneous dike losses have been considered since the dikes are not constructed to Class I criteria.

The flood plain area into which the lake water would drain is approximately 4000 acres. Therefore, if the entire lake instantly drained into the flood plain of the Kankakee River, the water level of the river could rise 3.2 feet for a short period of time. The rise would not affect plant operation or safety since the plant grade is at elevation 517'-0", 12 feet above normal river elevation at the station (nominally 505'-0"). The time interval required for the lake to empty, coupled with the flow of the river which would carry this excess water past the plant site, would result in an actual rise of the river to below the 3.2 feet noted above.

In the event of a complete loss of the dike on the south or west side of the lake, the water would flood an area along Lorenzo Road and the south portion of Dresden (Pequot) Road, including low areas where inactive strip mines are located. This water would drain off to the river and would not approach the plant which is more than 1½ miles away.

2.4.4.2 Dresden Lock and Dam Failure

The Dresden lock and dam are concrete structures that are operated and maintained by the U.S. Army Corps of Engineers. The dam is subject to inspection and evaluation by the Corps of Engineers under the National Dam Inspection Act. The evaluation criteria and inspection assure that the dam is safe with regard to prevention of loss of life and property.

The NRC safety evaluation for SEP Topic II-4.E concluded that the plant is designed so that it can be safely shut down in the event of failure of the Dresden dam and loss of the pool impounded by it. Part of the basis for this conclusion was that there is enough water impounded in the intake and discharge canals below their high point elevations to allow a safe shutdown of Dresden Units 2 and 3. Refer to Section 2.4.8.1 for further information on the dam pool, intake canal, and discharge canal elevations.

The analysis of failure of the Dresden dam, with the addition of the cooling lake, does not change from that described in Section 9.2.5 because the same amount of water remains impounded for cooling in the intake and discharge canals.

2.4.5 Probable Maximum Surge and Seiche Flooding

Flooding due to surges or seiches is not applicable to Dresden Station.

2.4.6 Probable Maximum Tsunami Flooding

Flooding due to tsunamis is not applicable to Dresden Station.

2.4.7 Ice Effects

An 8-foot diameter deicing line connects the discharge canal headworks and the crib house forebay. Its high point is in the headworks at elevation 495'-0" and its low point is in the forebay at elevation 489'-0". A slide gate valve is used to isolate the deicing line when not in use.

2.4.8 Cooling Water Canals and Reservoirs

2.4.8.1 Dresden Lock and Dam

The normal pool water level above the Dresden Island Lock and Dam is nominally 505'-0". The pool level can vary from a low of 503'-0" to a high of 506'-5". The pool level below the Dresden dam is 483'-4". The top of the next downstream dam, located at Marseilles (approximately 25 miles from Dresden), is 486'-6" (see Figure 2.4-1).

Units 2 and 3 share a common intake canal, approximately 1800 feet long. Unit 1 has a separate intake canal of the same length. The high point on the floor of the Unit 2 and 3 intake canal is 494.2 feet. The high point on the floor of the Unit 1 intake canal is 495'-0". The high points are located 123 feet downstream of the floating booms which protect the entrance to both canals from floating debris. The intake canal floors then decrease in elevation until a low point of 482'-6" is reached at the forebay of the crib houses.

There are two discharge canals approximately 2000 feet in length. One canal serves Unit 1 and the second serves both Units 2 and 3. The high point of 498'-0" on the floor of the discharge canals is located near the point where the canals join the river. Between this high point and the discharge headworks, the floor of each canal decreases to elevation 489'-0".

2.4.8.2 Cooling Lake

The cooling lake has an area of 1284 acres with an average depth of 8 feet; thus, the lake contains a maximum volume of 14,590 acre-feet. The purpose of the cooling lake is to provide adequate cooling of the circulating and service water before discharge to the Illinois River. The water discharged to the river must meet the National Pollutant Discharge Eliminiation System (NPDES) Permit (NPDES Permit No. IL0002224) requirements:

The state requirements are subject to review and change every five years.

The lake is normally operated in a closed cycle. However, indirect open-cycle operation is allowed during the summer so that the cooler river water may be used to decrease the turbine back-pressure, yielding a higher plant efficiency.

Items which may be considered by the state in determining the discharge requirements include:

A. Effects on the cooling lake as a fish hatchery;

B. Effects on fish in the river; and

C. Effects on ice formation in the lake and river.

The lake is connected to the intake and discharge canals for Units 2 and 3 by two canals (the "hot" and "cold" canals), each about 11,000 feet long. The hot canal is connected to the discharge canal. Water is pumped from the hot canal into the lake by a set of six pumps located in a lift station between the hot canal and the north end of the lake. The number of lift pumps that must be used varies with the number of circulating water pumps in operation and the position of the flow regulator which controls the distribution of lake discharge water to the intake canal and the Illinois River. An equalizing gate between the hot and cold canals, near the lift station, can be cracked open to allow some short-circuiting of the flow. This prevents cycling of a lift pump when fractional capacity of that pump is needed. The level of the lake is maintained by a concrete spillway located adjacent to the lift station and between the cold canal and the north end of the lake. The spillway is equipped with weir gates which can be lowered to block some of the spillover to maintain the level of the lake. The water returns from the lake, via the cold canal which is connected to both the intake and discharge canals at a three-way junction (see Figures 2.4-2 and 2.4-3).

A flow-regulating station at the junction distributes water returning from the lake to the river (indirect open-cycle operation), to the intake flume to the crib house (closed cycle operation), or to a combination of both. Failure of the flow regulation station would not affect plant safety since operation can continue in the current mode (i.e., open or closed cycle). In addition, safe shutdown can be accomplished in either mode of operation.

The regulating structure is a concrete structure, shown schematically on Figure 2.1-2. Water once diverted to the intake canal is controlled by the pumps in the crib house. Any surplus of water that cannot be handled by the pumps in the crib house will back up to the river and be carried downstream. A spillway between the cold canal and the discharge canal, next to the flow regulating station, allows water to spill over to the river bypassing the flow regulating station, if the cold canal level gets too high.

If all the gates are inadvertently closed, plant safety will not be affected. Water would continue to be drawn in from the river in a normal manner. The closed gates would cause the level in the cold canal to rise. The resulting flooding caused by the overflow would be no worse than that for collapse of the discharge spillway or structural failure of the lift station described below.

The collapse of the discharge spillway or structural failure of the lift station would not effect plant operation or safety. The contents of the lake would eventually be released to the cold canal in the case of the spillway failure or the hot canal in the case of the lift station failure.

The water level in either canal would rise to the top of the canal, elevation 513.0 feet and then flow over the top of the dikes on both sides of the canal. The water would then spread out as in the case of the dike failure discussed in Section 2.4.4.1. The plant grade is 4.0 feet above the top of the canal. Some of the water in the canals would be released to the Des Plaines River through the intake and/or discharge canals depending on the gate settings in the flow-regulating station. The water in the river could rise to a maximum elevation of 508.2 feet, assuming no flow over the Dresden dam.

Improper operation of the flow-regulating station likewise would not affect plant operation or safety.

2.4.8.3 Canal Cooling Tower Systems

The purpose of the canal cooling tower systems is to provide supplemental cooling capacity to the Dresden cooling lake. This augmented capacity provides for higher plant efficiency during both Closed-cycle and Indirect open-cycle operation.

The canal cooling tower systems are once-through systems and are comprised of two sub systems: the hot canal cooling towers and the cold canal cooling tower. The hot canal cooling towers take suction from the hot canal, cools the water via a counter flow of air, and discharges back into the hot canal down stream of the suction supply. The cold canal system takes suction from the cold canal, cools the water via a counter flow of air and discharges back to the cold canal down stream of the suction supply. The cooling tower systems are subdivided into cells. A cell is defined as an enclosed area that contains a fan, gearbox, and motor assembly that is supplied water to cool. These cells can be operated independently as desired to provide enough augmented capacity to maximize plant efficiency.

The failure of either or both cooling tower systems would not affect safe plant operation.

2.4.9 Channel Diversions

The authority to control the Dresden Island Lock and Dam, and therefore, the level of the pool impounded by it, is vested in the U.S. Army Corps of Engineers. Should the dam become damaged, one method of maintaining the pool level would be through the use of increased water diversion from Lake Michigan. This would be accomplished with the permission of the U.S. Supreme Court. For a discussion of the analysis performed for a failure of the dam refer to Section 9.2.5.

2.4.10 Flooding Protection Requirements

External flood protection is discussed in Section 3.4.

2.4.11 Low Water Considerations

A discussion of Illinois waterway flowrate fluctuations and the 10-year low flowrate data used for the application for the Full-Term Operational Licenses at Dresden is contained in the Final Environmental Statement. For a discussion of the Ultimate Heat Sink that is available during low water conditions, such as loss of the Dresden dam, see Section 9.2.5.

2.4.12 Releases of Liquid Effluents in Surface Waters

Information regarding radioactive liquid effluents released to surface waters from Dresden Station is contained within Section 11.2.

2.4.13 Groundwater

A discussion of the groundwater resources and aquifers in the vicinity of Dresden Station is discussed in the Final Environmental Statement.

Table 2.4-1

PERTINENT HYDROLOGIC ELEVATIONS

Location	Elevation
Plant grade	517'-0"
Normal pool level at Dresden Dam	505'-0"
Cooling lake	
Normal water level	522'-0"
Top of dikes	527'-0"
Lake bottom	507'-0" to 517'-0"; average 514'-0"
Morris operations facility	525'-0" to 550'-0"

2.5 GEOLOGY, SEISMOLOGY, AND GEOTECHNICAL ENGINEERING

2.5.1 Basic Geologic and Seismic Information

2.5.1.1 Geology

A study of the geology of the Dresden site was made in 1965 by Dames and Moore, consultants in applied earth sciences, soil mechanics, engineering geology, and geophysics. The study was reported in Volume III, Section 4, of the Dresden Unit 2 Plant Design and Analysis Report (PDAR). The NRC reviewed the 1965 study as part of the Systematic Evaluation Program (SEP) Topic II-4.

The geological characteristics of the site, which were previously studied and determined to be suitable for Dresden Unit 1, were confirmed by the 1965 study. The load-bearing capability of the rock formation is significantly in excess of that necessary for the support of the units. The topographic (elevations) characteristics of the Dresden Station, particularly those for the location of Units 2 and 3, preclude possible movements (slides) of the plant structures into the Illinois River or earth slides from adjacent higher elevations on to the units.

The site is located just west of the area where the Des Plaines and Kankakee rivers flow together to form the Illinois River. The terrain is slightly hilly with a maximum relief at the site of about 25 feet. Regional relief is on the order of 200 feet. The site area is within the Central Lowland Physiographic Provence.

A thin (less than 10-foot) mantle of soil, mostly glacial drift, overlies bedrock at the site. The upper unit of bedrock is the Spoon formation of the Pennsylvanian age (300 million years before present [MYBP]). The Spoon is a sandstone that varies in thickness beneath the site from 0 to 45 feet. A thin soil horizon is present below the Spoon overlying rocks of the Upper Ordovician (450 to 430 MYBP) Marquoketa formation. The Marquoketa consists of a 20- to 45-foot thick upper limestone member, the Fort Atkinson limestone, and a 70-foot thick lower shale member, the Scales shale. Below the Marquoketa formation are approximately 1000 feet of limestone, dolomites, and sandstones ranging in age from Middle Ordovician (450 MYBP) to Cambrian (570 MYBP). These rocks lie on the Precambrian crystalline basement.

The Dresden site lies within the Central Stable Region of the North American Continent. This region extends from the Rocky Mountains to the Appalachian Plateaus and is relatively undeformed tectonically. It is characterized by a pattern of large basins, domes, and arches which formed throughout the Paleozoic Era (570 to 225 MYBP). The site is located on the northeast flank of one of these structures, the Illinois Basin. The north-northwest striking LaSalle anticlinal belt, a major structural element within the Illinois Basin, lies a few miles west of the site. The LaSalle anticline is a band of en echelon folds which formed during the Mississippian and Pennsylvanian periods (345 to 280 MYBP).

The northwest trending Kankakee Arch forms the northeastern boundary of the Illinois Basin and intersects the Wisconsin Arch to the North

2.5.1.2 Seismology

The Dresden site area is placed in Zone 1 (zone of minor damage) on the seismic probability map of the 1958 Uniform Building Code. The August 1958 Seismic Regionalization map by Richter gives general predictions of probable maximum earthquake intensity and, recognizing that lines between the areas of differing intensity are approximations only, shows the Dresden region as Modified Mercalli Intensity (MMI) VII to VIII.

Only a few earthquakes of significant intensity in Northern Illinois have been reported since 1800, and none has been accompanied by clear-cut surface faulting. A quake on May 26, 1909, caused moderate damage in Aurora, Bloomington, Chicago, and Joliet, and may have been of intensity MMI VII in the Dresden area. A quake on January 2, 1912, had a reported intensity of MMI VI at Aurora, Yorkville, and Morris, and probably was of similar intensity at the Dresden site location.

The engineering consulting firm of John A. Blume and Associates, San Francisco, was retained for advice on seismology; they consulted Dr. Perry Byerly, Oakland, California on the seismicity of the site region. The seismological studies indicated that the area of Northern Illinois and the actual Dresden site are seismically suitable. Nevertheless, it was considered appropriate to adopt a design approach which would assure the safety of Units 2 and 3 by preserving the ability to maintain the units in a safe shutdown condition in the event of a strong earthquake having a ground acceleration of 0.2 g. Seismic design motion is discussed further in Section 3.7.1.

2.5.2 Vibratory Ground Motion

Studies were conducted to determine the effects at the site of possible significant seismic events. The studies considered local and regional geology, seismology, and seismic history. The design basis is derived from the seismic design report of John A. Blume and Associates and is discussed further in Section 3.7.1.

2.5.3 Surface Faulting

The Sandwich Fault zone is the largest fault in the site region. It is located on the north flank of the Ashton Arch, which merges to the north with the LaSalle anticlinal belt described in Section 2.5.1.1. The Sandwich Fault is oriented west-northwest and is about 90 miles long. It passes 6 miles north of the station. The fault zone is approximately 100 feet wide, dips nearly vertically, and rocks to the north of it are down-thrown with respect to rocks to the south. A maximum displacement of 900 feet is found 20 to 30 miles west of Chicago. This displacement decreases to 0 within 18 miles of Chicago.

Another fault which is interpreted to be a continuation of the Sandwich Fault zone carries the trend farther eastward but with the south side down with respect to the north side. The offset increases from 0 to as much as 100 feet to the east. The two faults have a scissor-like relationship to one another. The Sandwich Fault zone is post-Silurian in age (younger than 395 MYBP) because Silurian rocks are offset. Rocks younger than Silurian have been eroded from the fault zone. Minor folds, faults, and evidence of warping of Pennsylvanian rocks within the region suggest some post-Pennsylvanian (younger than 280 MYBP) tectonic activity. Pleistocene drift has not been deformed by the fault, thus indicating no movement for at least the last several tens of thousand years. Minor faults found at the site have similar trends and senses of movement and are most likely related to the Sandwich Fault zone with similar time spans since the last movement.

2.5.4 Stability of Subsurface Material and Foundations

Examination of cores from borings at the site and excavation for the construction of Units 1 and 2 show that all footings for major structures have a foundation of sound rock which eliminates the potential problems of soil consolidation and differential settlement. A very extensive survey and study of the underlying soil and rock was made prior to the construction of Unit 1, and an additional study was completed in 1965 for the application of Unit 2.

The generalized geologic column for the site consists of an upper layer of Pennsylvanian Pottsville sandstone of variable thickness of 40 to 50 feet. The next layer below is about 15 to 35 feet of Ordovician Marquoketa Divine limestone based on a 65-foot layer of Marquoketa dolomitic shale. The Ordovician system has a total thickness approaching 1000 feet, with the Cambrian system next below. Brecciated rock is found on some cross sections and is indicative of ancient faulting. The geologic evidence indicates that these faults are inactive.

Laboratory tests showed that unconfined ultimate compressive strength on boring samples ranged from 2000 to 15,000 psi on most samples. Laboratory wave velocity propagation tests showed 4000 to 15,000 ft/s.

In summary the geological characteristics of the site are suitable for Dresden Station. The load-bearing capacity of the rock formation foundation is significantly in excess of that necessary for the support of the plant structures.

2.5.5 Stability of Slopes

The only slopes at the Dresden plant considered critical with regard to slope stability are those of the intake canal from the river to the crib house and of the discharge canal from the plant to the river.

The intake and discharge canals are about 56 feet wide and are cut into sandstone rock on an average of 13 feet to 25 feet, with near vertical side slopes. The rock top varies from elevation 508' to greater than 510'. The maximum height of soil above rock along the canals is about 6 feet. The overburden slopes are inclined at 3 feet horizontal to 1 foot vertical. The normal pool level in the canals is at elevation 505'; the maximum historic flood level prior to plant operation was at elevation 506.6'. In December 1982, the Dresden site was subjected to flood waters that exceeded 509 feet. The overburden slopes are above the canal water level and also lie above the water table (normal groundwater level between elevations +505 feet and 508 feet) and are thus normally dry.

A "sliding wedge" slope stability analysis under safe shutdown earthquake (0.2 g horizontal acceleration) loading indicates a minimum factor of safety of 1.5 against failure of the intake or discharge canals. However, even if the overburdened slopes failed and this material moved into the canal, there would still be an ample water supply in the intake canal for use in station operation.

The rock into which the canals are cut is sound and capable of maintaining a stable vertical cut under earthquakes or other events. The rock, locally referred to as the Pottsville sandstone, is composed predominantly of cemented sub-angular fine-to- medium grains of quartz containing varying amounts of mica. No evidence of faulting exists in the sandstone at the site, but there are occasional vertical joints. Laboratory compressive strength tests on the sandstone indicate strengths of the rock in excess of 3000 psi.

Therefore, slope stability is not a safety concern for Dresden Station.

2.5.6 Embankments and Dams

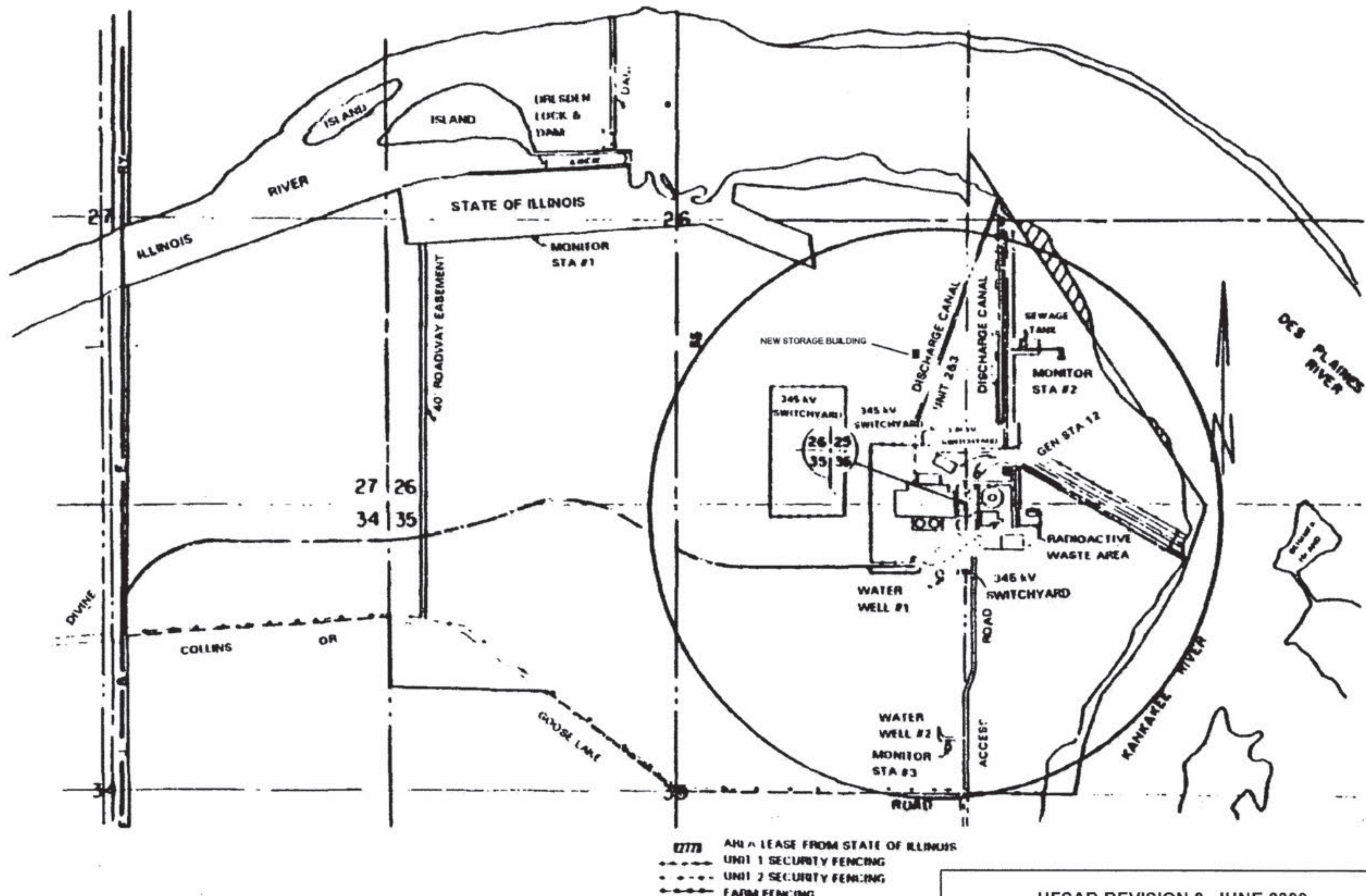
2.5.6.1 Dresden Lock and Dam

The Dresden Lock and Dam is maintained and operated by U.S. Army Corps of Engineers as part of the Illinois River Waterway. The design of the lock and dam was started following World War I by the State of Illinois. The Dresden Lock and Dam was to be the first of a series of dams and locks to permit navigation on the Illinois River. Construction was started in 1925; however, the state's funds were soon depleted. The federal government assumed responsibility and construction was completed in 1932.

In discussions with the Corps of Engineers, the design of the dam and lock was not based on any seismic criteria as is used today. The dam and lock were designed to withstand the large forces due to the mass movement of ice flows from the Des Plaines and Kankakee rivers, floods during periods of heavy runoff, and the impact forces of runaway tows. It should be remembered that the problems of the large movement of ice were of real concern in the 1920's, prior to the industrialization of the waterway above the dam.

The dam consists of 11 heavily reinforced concrete piers 10 ft. x 45 ft. at the top and 10 ft. x 60 ft. at the bottom with the taper on the downstream side. Each pier is socketed 5 feet into bedrock and anchored. Between the piers are concrete gravity section rollaways. Above these are Tainter Gates, which control pool level, supported from the piers. The dam is anchored to the rock rising to the Kankakee Bluffs at the north end and the lock structure on the south. The lock walls are 10 feet wide at the top, 20 feet wide at the bottom, and 800 feet long. The lock width is 110 feet.

Since the dam and lock are of major importance to the Chicago region, and its function is the responsibility of the Corps of Engineers, an evaluation of its adequacy to seismic activity could only be made by the corps. Commonwealth Edison does not have access to the detailed drawings or design calculations. However, the design of Dresden Station accounts for the potential catastrophic failure of the dam and lock, as described in Section 9.2.5.3.



UFSAR REVISION 8, JUNE 2009

DRESDEN STATION
UNITS 2 & 3

STATION PROPERTY PLAN

FIGURE 2.1-1

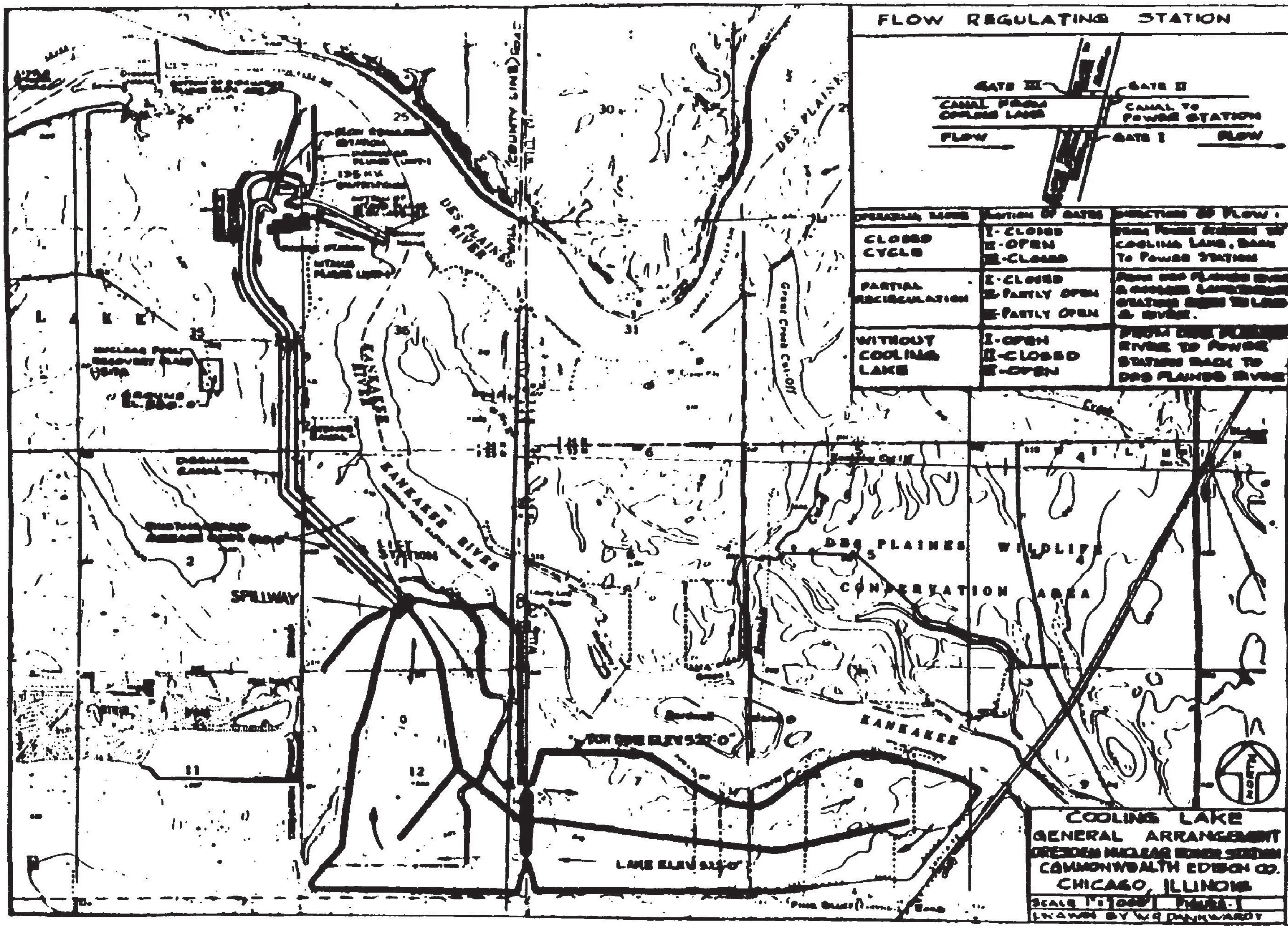
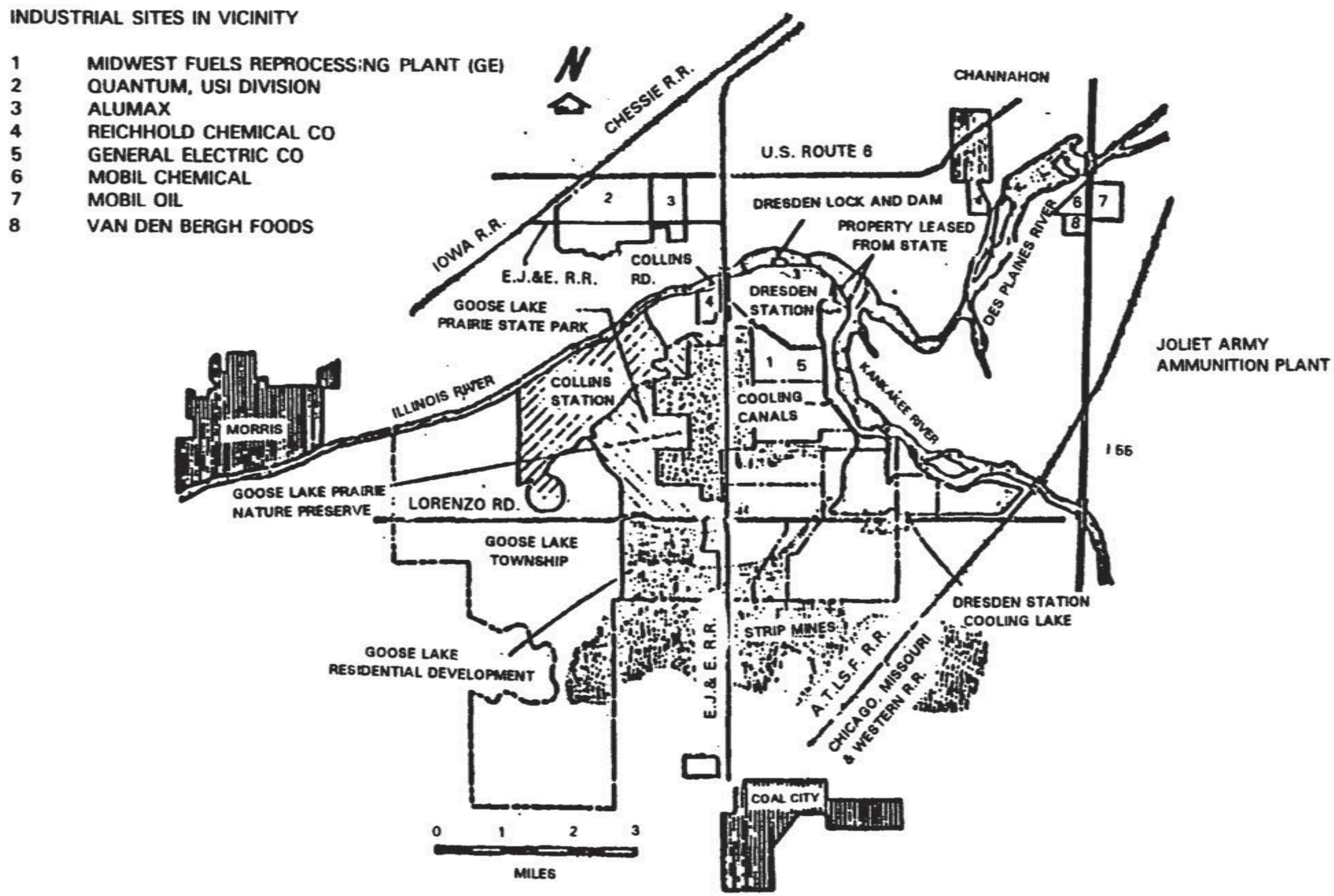

FLOW REGULATING STATION
GATE III
GATE II
GATE I
CANAL FROM COOLING LAKE
CANAL TO POWER STATION
FLOW
CLOSED CYCLE
I-CLOSED
II-OPEN
III-CLOSED
PARTIAL RECIRCULATION
I-CLOSED
II-PARTLY OPEN
III-PARTLY OPEN
WITHOUT COOLING LAKE
I-OPEN
II-CLOSED
III-OPEN
FROM DES PLAINES RIVER TO POWER STATION BACK TO DES PLAINES RIVER
DES PLAINES RIVER
KANKAKEE RIVER
COUNTY LINE ROAD
L A K E
DISCHARGE CANAL
SPILLWAY
DES PLAINES WILDLIFE CONSERVATION AREA
KANKAKEE
LAKE ELEV 512.0'
NORTH
COOLING LAKE
GENERAL ARRANGEMENT
DRESDEN NUCLEAR POWER STATION
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS

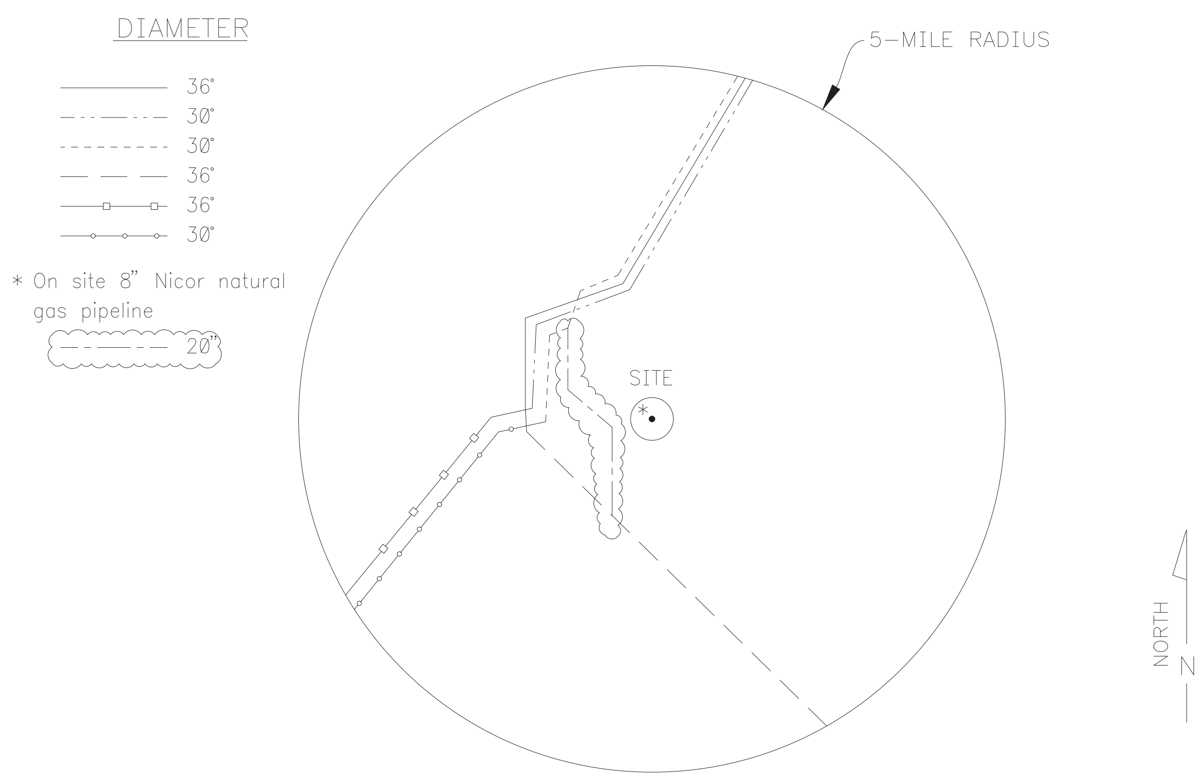
FIGURE 2.1-2



DRESDEN STATION
UNITS 2 & 3

DRESDEN NUCLEAR POWER STATION AREA MAP

FIGURE 2.2-1



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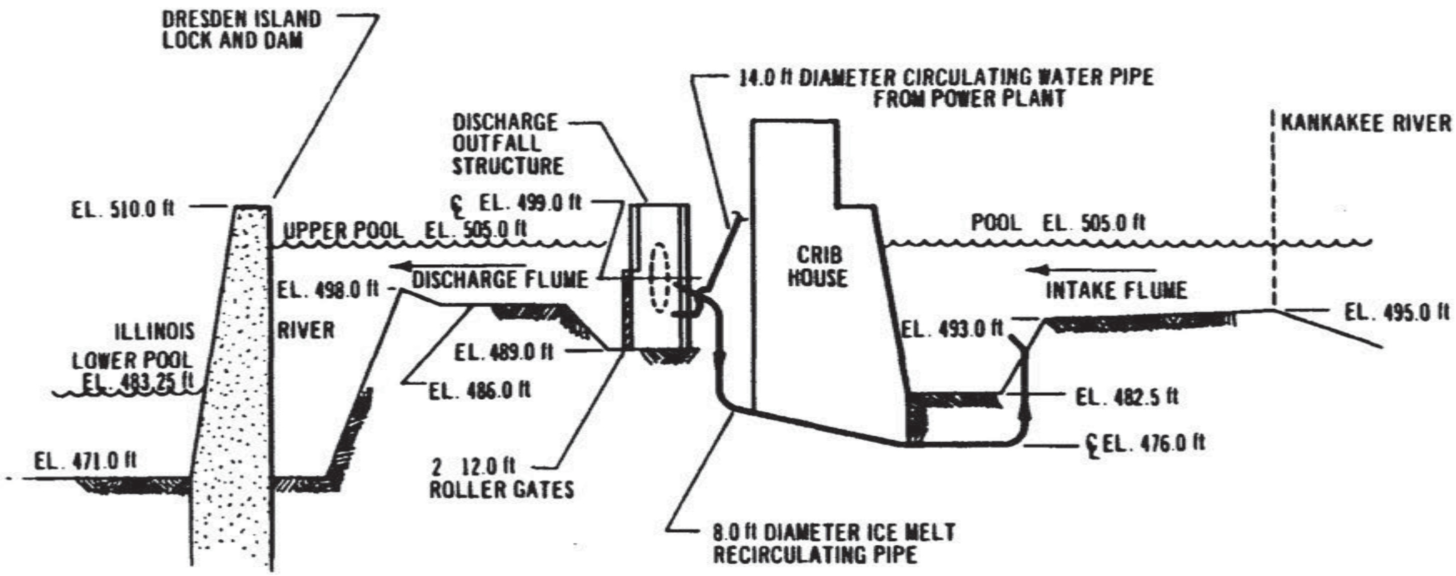
DRESDEN STATION
UNITS 2 & 3

PIPELINES CONSIDERED IN THE EVALUATION OF HAZARD FROM EXPLOSION

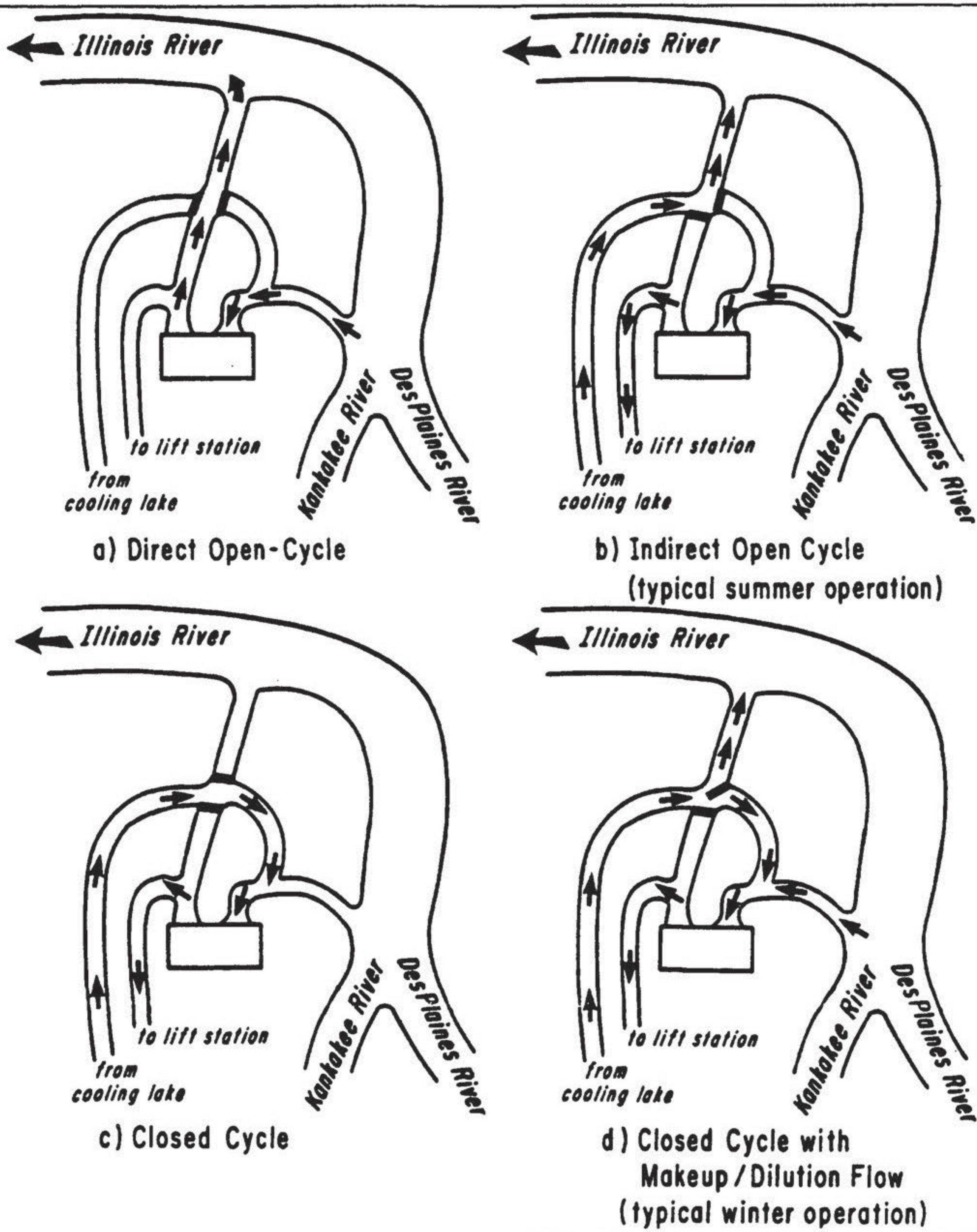
FIGURE 2.2-2



DRESDEN STATION
UNITS 2 & 3

SITE FLOW DIAGRAM AT ILLINOIS RIVER
ABOVE THE DRESDEN ISLAND LOCK AND DAM

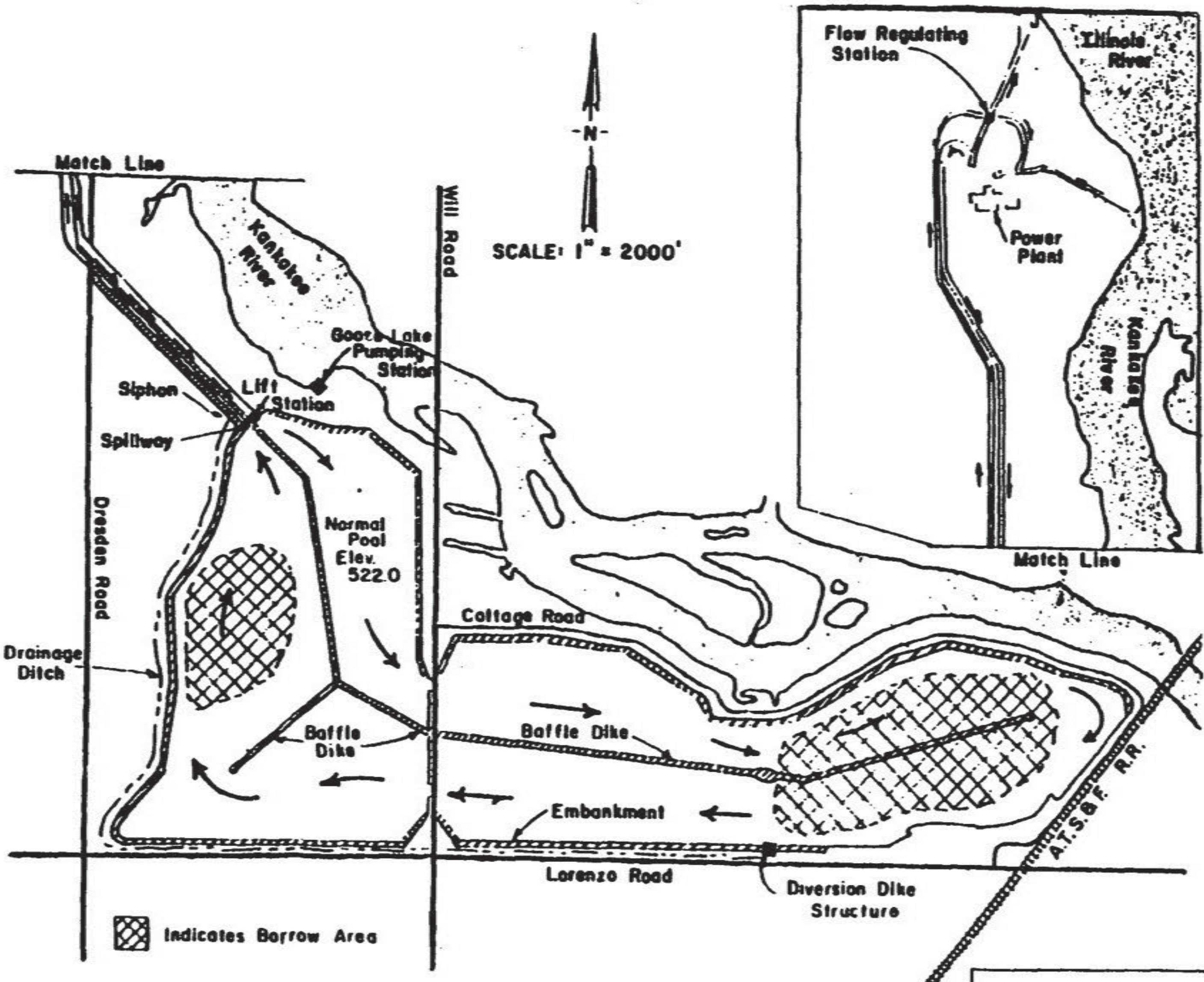
FIGURE 2.4-1



DRESDEN STATION
UNITS 2 & 3

COOLING WATER FLOW DIAGRAM - UNITS 2 AND 3 (UNIT 1 NOT SHOWN)

FIGURE 2.4-2



DRESDEN STATION
UNITS 2 & 3

DRESDEN COOLING LAKE,
GRUNDY COUNTY, ILLINOIS
IL. I.D. NO. 00439

FIGURE 2.4-3