INSERTION INSTRUCTIONS

Correction pages to the Haven Site Addendum (Volumes 1-5) are identified by "Amendment 20, 2/79."

Change bars (vertical bars in the margin of corrected text and tables) indicate the location of additions, deletions, and changes originating with this amendment. Change bars from previous amendments have been dropped from corrected pages. Figures do not have change bars, but are identified by "Amendment 20" under the title block.

Entries herein beginning with T or F designate tables and figures, respectively. All other entries are page numbers.

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	VOLUME 1	
-	WE Letter to Harold Denton for Amendment 20/blank	Before WE Letter to Harold Denton Amendment 19
-	USNRC Attachment - Amendment 20, Haven Site Addendum/blank	
-	Sol Burstein Affidavit/ blank	
MEP-1/MEP-2	MEP-1/MEP-2	Before Volume 1 Title Page
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	CHAPTER 1	
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1.1-1/1.2-1	1.1-1/1.2-1	
-	F1.2-1	After p. 1.2-1

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Tab NRC Letter 8/3/78 (discard)	-	Before Tab 312.0 (Accident Analysis Branch)

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		Relocate the following material before Tab 360.0 (Geology/ Seismology): Tab 312.0 (Accident Analysis Branch) and Q312.3-1 thru Q312.8-1/blank Tab 321.0 (Hydrology) and Q321.1-1 and Q321.2-1/blank
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Q361.10-1/blank	Q361.10-1/blank	After Tab 361.0 (Geology/ Seismology)

HAVEN SITE ADDENDUM

MASTER LIST OF EFFECTIVE PAGES

The Lists of Effective Pages for the Site Addendum are compiled for each chapter and appendix in Volumes 1 through 4 and the NRC Questions and Responses in Volume 5.

The Master List of Effective Pages presents the dates of issue for each amendment, and the revision number of the General Table of Contents (found at the front of each volume), and each List of Effective Pages (found immediately after the respective tab).

Issue	Date	Issue	Date
Amendment 15	12/16/77	Amendment 18	9/22/78
Amendment 16	3/24/78	Amendment 19	11//78
Amendment 17	5/26/78	Amendment 20	2/79

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GENERAL TABLE OF CONTENTS (CONT'D)

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HAVEN SITE ADDENDUM

LIST OF EFFECTIVE PAGES

CHAPTER 1

CHAPTER 1

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CHAPTER 1

LIST OF FIGURES

1.1 INTRODUCTION

By application filed with the Wisconsin Utilities Project Preliminary Safety Analysis Report (PSAR), the Applicants seek a construction permit to build standardized nuclear power plants located on one or more sites in the central and southern half of the State of Wisconsin, under the Atomic Energy Commission Act of 1954 as amended, and the Regulations of the Atomic Energy Commission set forth in Title 10, Part 50 of the Code of Federal Regulations (10CFR50) as amended. By this Site Addendum to the Wisconsin Utilities Project PSAR, the Applicants seek to locate such a plant, the Haven Nuclear Plant, Units 1 and 2, consisting of two electric generating units, on a site approximately 5 miles north of Sheboygan, Wisconsin on the western shore of Lake Michigan.

These two units were originally proposed to be located at the Koshkonong site in Jefferson County, Wisconsin. The Site Addendum for the Koshkonong site has been reviewed by the NRC and was the subject, along with the Wisconsin Utilities Project Standard PSAR, of a Staff Safety Evaluation Report in October 1975, supplemented in April 1976 and July 1976. In early 1978 this Haven Site Addendum will be amended to include the commitments made by the Applicants in the course of the NRC Staff review of the Koshkonong site as they relate to Haven. For example, the maximum horizontal ground acceleration in the bedrock for the Safe Shutdown Earthquake (SSE), and Operational Basis Earthquake (OBE) agreed upon for the Koshkonong site will also apply to the Haven site.

This Site Addendum for the Haven Nuclear Plant is submitted in support of the Wisconsin Utilities Project PSAR and is based on the guidelines provided in proposed Appendix N to 10CFR50, "Standardization of Nuclear Power Plant Designs; Licenses to Construct and Operate Nuclear Power Reactors of Duplicate Designs at Multiple Sites."

Presented herein are descriptions of site specific aspects of design and demonstration that actual site parameters are consistent with the design basis site parameters as described in the Wisconsin Utilities Project Standard PSAR.

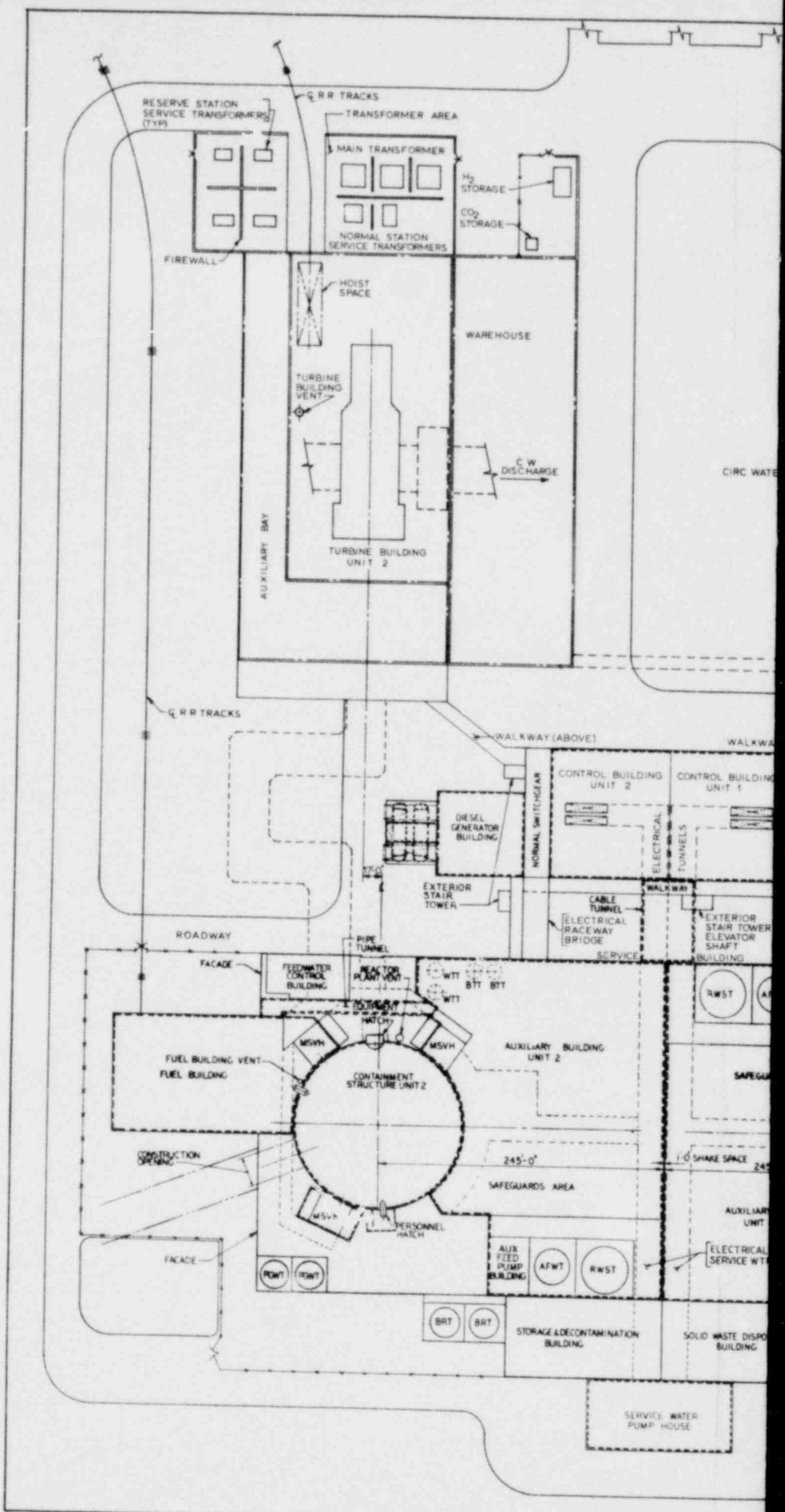
The project schedule is based upon Unit No. 1 fuel loading in March 1987 and commercial operation in June 1987. Unit No. 2 is scheduled for fuel loading in March 1989 and commercial operation in June 1989.

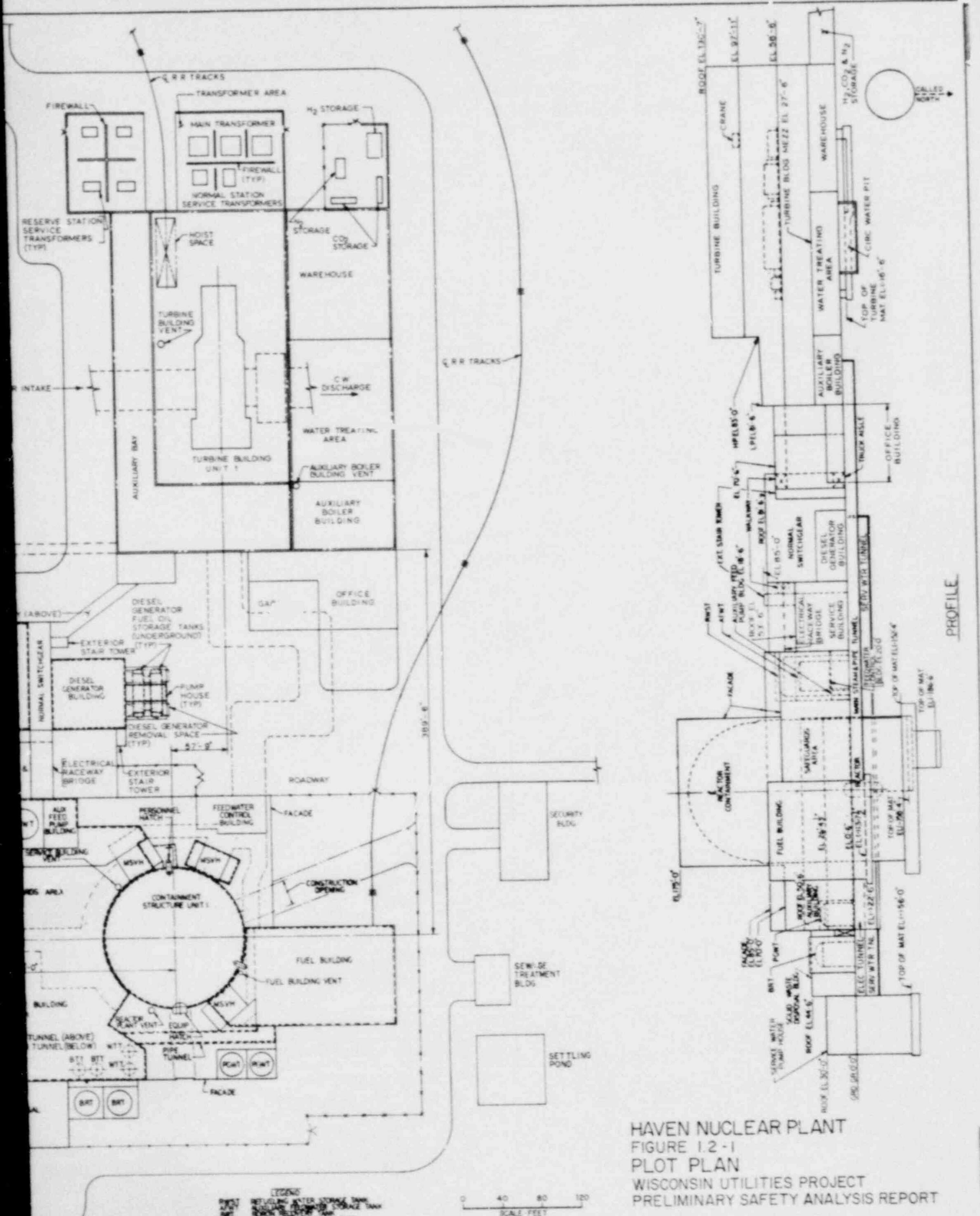
1.2 GENERAL PLANT DESCRIPTION

A general description of site unrelated aspects of plant design is provided in Section 1.2 of the Standard PSAR. The general arrangement of the Haven Nuclear Plant is shown in the plot plan, Figure 1.2-1 of this Site Addendum. A general description of site characteristics is presented in Section 1.2.2 below.

1.2.2 Site Characteristics

The Haven Nuclear Plant is located along the western shore of Lake Michigan in Sheboygan County. The site is approximately 625 acres, is about 5 miles north of Sheboygan, 56 miles north of Milwaukee, and 18 miles south of Manitowoc. The surrounding area is quite flat and is primarily farmland. Refer to Section 2.1 for additional information on site characteristics.


RESERVE STATION SERVICE TRANSFORMERS (TYP)
℄ R R TRACKS
TRANSFORMER AREA
MAIN TRANSFORMER
H_2 STORAGE
CO_2 STORAGE
NORMAL STATION SERVICE TRANSFORMERS
FIREWALL
HOIST SPACE
WAREHOUSE
TURBINE BUILDING VENT
C W DISCHARGE
CIRC WATE
AUXILIARY BAY
TURBINE BUILDING UNIT 2
℄ R R TRACKS
WALKWAY (ABOVE)
WALKWA
CONTROL BUILDING UNIT 2
CONTROL BUILDING UNIT 1
DIESEL GENERATOR BUILDING
NORMAL SWITCHGEAR
ELECTRICAL TUNNELS
EXTERIOR STAIR TOWER
CABLE TUNNEL
ELECTRICAL RACEWAY BRIDGE
WALKWAY
EXTERIOR STAIR TOWER ELEVATOR SHAFT
SERVICE
BUILDING
ROADWAY
PIPE TUNNEL
FACADE
FEEDWATER CONTROL BUILDING
REACTOR PLANT VENT
WTT
BTT BTT
EQUIPMENT HATCH
RWST
MSVH
MSVH
FUEL BUILDING VENT
FUEL BUILDING
CONTAINMENT STRUCTURE UNIT 2
AUXILIARY BUILDING UNIT 2
SAFEGUA
CONSTRUCTION OPENING
245'-0"
SAFEGUARDS AREA
1'-0 SHAKE SPACE
MSVH
PERSONNEL HATCH
AUXILIARY UNIT
FACADE
AUX FEED PUMP BUILDING
AFWT
RWST
ELECTRICAL SERVICE WT
BRT
BRT
STORAGE & DECONTAMINATION BUILDING
SOLID WASTE DISPO BUILDING
SERVICE WATER PUMP HOUSE



HAVEN NUCLEAR PLANT
FIGURE 1.2-1
PLOT PLAN
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

AMENDMENT 20

HAVEN SITE ADDENDUM

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SECTION 2.2

NEARBY INDUSTRIAL TRANSPORTATION AND MILITARY FACILITIES

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SECTION 2.2

NEARBY INDUSTRIAL TRANSPORTATION AND MILITARY FACILITIES

2.2.1 Locations and Routes

Industrial and manufacturing facilities within a 10 mile radius of the Haven Nuclear Plant are located primarily in the Sheboygan urbanized area. The largest manufacturer in the area is the Kohler Company, located approximately 8 miles south-southwest of the plant in the village of Kohler[1].

Industrial and manufacturing facilities and pipelines within a 10 mile radius of the Haven Nuclear Plant are shown on Figure 2.2.1-1. Pipelines within the site area are shown on Figure 2.2.1-2.

Transportation facilities within a 10 mile radius of the Haven Nuclear Plant are shown on Figure 2.2.1-3.

Apart from various armed forces recruiting stations, there are no military facilities within a 10 mile radius of the Haven Nuclear Plant.

2.2.1.1 Surface Transportation

A natural gas transmission system operated by the Michigan Wisconsin Pipeline Company, consisting of one 10-inch and two 6-inch lines carrying 114.5 million cu ft/day at pressures ranging from 400 to 975 psi, passes within 4.8 miles of the plant. An 8-inch line operated by Wisconsin Public Service Corporation carrying 400,000 cu ft/hr of natural gas at 60 psig passes 3.7 miles southwest of the plant. No propane is carried or is anticipated to be carried in either of these lines.

Sheboygan Harbor, approximately 7 miles south of the plant, accommodates both foreign and domestic cargo ships carrying materials such as coal, stone, clay, petroleum products, lumber, and fish.

One municipal and two private terminals are together capable of handling three ships. The harbor has a channel 21 ft deep that is navigable for 5,000 ft, with a 25 ft deep turn basin. Approximately 265,000 sq ft of open cargo storage are now being utilized. The following terminal facilities are available at the Sheboygan port:

1. The Municipal Wharf - 125,000 sq ft open storage, 740 ft wharf, 21 ft water depth.

2. Sheboygan Port and Warehouse Terminal Limited - 38,750 sq ft transit shed, open storage of 75,000 sq ft, 1,800 ft wharf, 21 ft water depth.

3. C. Reiss Coal Company - 65,000 sq ft open storage, 21 ft water depth, railroad siding.

Additional port facilities are available approximately 18 miles north of the plant in the city of Manitowoc.

Rail service in the area is provided by the Chicago and North-western Railroad (C&NW). The railroad line passes along the western plant boundary approximately 4,200 ft from the containment structures[2].

US Highway 141 and State Routes 23, 28, 32, and 42, and the city of Sheboygan are located within 10 miles of the plant. US Highway 141, with a heavy duty classification, crosses north-south approximately 1-1/2 miles west of the plant. County Highway LS carries a light volume of traffic within the western plant boundary. Heavily travelled State Route 42 approaches within 4 miles to the west[2]. The extension of I-43, under construction approximately 1/2 mile west of 141 (about 2 miles west of the plant), is expected to be completed in the early 1980's.

2.2.1.2 Air Transportation

2.2.1.2.1 Airports

No airport beyond 10 miles from the plant is significant to plant safety as defined by the criteria of USNRC Regulatory Guide 1.70[3]. Table 2.2.1-1 lists the largest regional airports, their distance from Haven, and the operations levels.

There are two airports within a 10 mile radius of the plant. Bell's Airport is 2.7 miles south-southwest at 43°48'43"N, 87°45'20"W[4]. Sheboygan County Memorial Airport is 8.1 miles southwest at 43°46'10"N, 87°51'05"W[5]. These are shown on Figure 2.2.1-4. A small landing strip now located on the northern portion of the Applicants' property will be closed at the time of plant operation. Seaplane operations on Lake Michigan are rare in Sheboygan County, with an estimated 10 annual operations along the approximately 25 miles of shoreline. There are no operations reported on Sheybogan Lake or Elkhart Lake[6].

Bell's Airport is a privately owned, nonpublic-use facility[7] with a 2,500 ft runway with no lights, instrument approaches to the airport, or services, such as fuel or maintenance, at the field[5]. Based on reports to the State of Wisconsin[8], three locally based aircraft weighing under 2,000 lb conduct about 750 operations per year. A formula used by the State of Wisconsin[9] would estimate 520 nonbased (transient) operations if the facility were public. A nonpublic facility would have substantially fewer operations; but, for conservatism, it is assumed that there are 375 transient operations per year. The total number of operations is then 1,125 per year.

No growth in operations is projected for Bell's Airport. It is assumed that it will continue to serve only its immediate neighbors, and that it will continue to be operated in its current manner by the present or future property owners.

Sheboygan County Memorial Airport is a public airport operated by Chaplin Aviation and is the nearest public airport to the site. This facility has two paved runways 3,600 and 5,000 ft in length. The layout is shown on Figures 2.2.1-4 and 2.2.1-5. It is attended for 11 hours on Sundays and 13 hours other days, with pilot controlled night lighting[10]. According to reports to the State of Wisconsin[8], there are 58 aircraft based at the airport, including three twin-engine turbojet aircraft, seven twin-engine piston aircraft, and 48 single-engine piston aircraft. The largest based aircraft has an empty weight of 7,329 lb. The empty weights of seven aircraft exceed 3,000 lb and 40 are under 2,000 lb. The airport is served by Midstate Airline which flies Swearingen Metroliners, with a maximum gross weight of 12,500 lb[11], from Sturgeon Bay to Sheboygan to Chicago and return, for a total of 104 operations per week at Sheboygan[12]. The total number of aircraft operations of all kinds at Sheboygan in 1977 was estimated by the state to be 42,500[6].

The airport has a practical annual capacity (PANCAP) of 181,600 operations annually and a practical hourly capacity (PHOCAP) of 104 operations under Visual Flight Rules (VFR) or 10 operations under Instrument Flight Rules (IFR).

Planned airport improvements over the next 20 years include a 400 ft extension to the northeast end of the 5,000 ft runway, followed by a 400 ft extension to the northwest end of the 3,600 ft runway[4]. In addition, an instrument landing system (ILS) and an approach lighting system (ALS) are proposed to be installed to enable aircraft to use the airport during lower cloud ceiling and visibility conditions than is now possible. These improvements should increase the safety of flight operations as well as the reliability of scheduled and nonscheduled service. The 5,400 ft primary runway will provide more adequate runway length for business jets as well as most commuter service aircraft, such as the Swearingen Metroliner[4]. It is believed that no significant change in the PANCAP will be associated with these improvements.

The level of future Sheboygan airport operations has been predicted to 19 7 by the FAA (Table 2.2.1-2), and an independent prediction to 995 was prepared for the Airport Master Plan

(Table 2.2.1-3). These predictions and Wisconsin Department of Transportation data on present and past operations have been used as a basis for extrapolating projected operations at the facility into the 21st century. Operation levels projected that far in the future are extremely tentative due to economic uncertainties. However, if it is assumed that the present PANCAP will remain unchanged throughout the life of the Haven Nuclear Plant, the growth in total operations at Sheboygan County Memorial Airport would be as shown on Figure 2.2.1-6. A limit of 181,600 operations would be reached by approximately 2029 following some leveling off of growth as present capacity is approached. Aircraft crash probability calculations have been based on aircraft operations expected through 2029.

2.2.1.2.2 Instrument Approaches

There are three instrument approaches(13) to the Sheboygan airport currently published by the National Oceanic and Atmospheric Administration (NOAA) (see Figure 2.2.1-5). Two utilize the Sheboygan Falls VOR radio navigational facility as the starting point for the instrument approaches to runways 21 and 3, and are accordingly designated VOR RWY 21 and VOR RWY 3, respectively. The third approach utilizes the Sheboygan Non-Directional Beacon (NDB), another radio navigational facility, as the starting point for the instrument approach to runway 21, and is designated NDB RWY 21. The approaches shown on Figure 2.2.1-5 are more fully described below.

Description of the VOR RWY 21 Approach to Sheboygan

Upon arrival over the VOR, which is 7.9 miles southwest of the Haven site and located at the Sheboygan airport, at or above 2,700 ft above mean sea level (msl), the pilot intercepts the 023 deg radial outbound from the VOR. After 1 minute the pilot begins a "procedure turn" to the left (west).

The purpose of the procedure turn is to redirect the airplane to head toward the VOR along the same radial but headed inbound, staying west of that radial at all times. It can take different forms; the usual form is:

1. Turn 45 deg to the left. Heading = 338 deg

2. Proceed for 1 minute in that direction.

3. Turn 180 deg to the right. Heading = 158 deg

4. Re-intercept the 023 deg radial and track inbound to the VOR. Heading = 203 deg

At this point the pilot has maintained an altitude at or above 2,700 ft msl. Once re-established on the 023 deg radial inbound (heading = 203 deg), descent to the "minimum descent altitude"

(MDA) can begin. The MDA is a function of the airplane's maximum certified landing weight and its approach speed. At Sheboygan, the MDA is 1,200 ft msl or 454 ft above the airport for all categories of aircraft likely to use the airport. If the pilot can see the runway environment and is in a position, after reaching the MDA, to make a normal landing, the landing proceeds. If these conditions are not met, flying at or above the MDA, the pilot proceeds to the "missed approach point" (MAP), which is over the VOR, and executes a "missed approach" maneuver turning right to intercept the 223 deg radial from the VOR and climbing to 2,700 ft msl. Once at 2,700 ft and established on the 223 deg radial, the pilot executes a left turn and proceeds directly to the VOR. The Chicago Air Route Traffic Control Center will then provide further instructions, usually to proceed to his alternate airport or begin another approach to Sheboygan.

Error Limits

Positional information is displayed to the pilot in terms of angular deviation from the selected course by the course deviation indicator (CDI). The correct procedure is to maintain a centered CDI or "on-course" indication when not in a procedure turn. Experienced pilots maintain this with little deviation. A full scale deviation of 10 deg would disqualify an applicant for an instrument rating should it occur on the test flight.

Although the maximum permissible instrument error is 6 deg, an error of over 2 deg to 3 deg would be unusual due to frequent checks of the aircraft's VOR receiver required by Federal Aviation Administration regulations.

The altimeter must be calibrated within 2 years preceding any instrument flight. The maximum permissible instrument error is 35 ft at 3,500 ft indicated. As such it is very small and can be considered negligible. The pilot is expected to remain at or above the assigned floor. Thus, when the floor altitude is 2,700 ft msl, the actual altitude is at least 2,665 ft msl.

The VOR RWY 21 approach course is more than 3.0 miles from the plant. When closest to the site, the altitude would be over 2,665 ft msl (2,055 ft above the plant grade). On final approach, at or above 1,165 ft msl, the aircraft is headed away from the plant. A total error of 6 deg in the course, which is an occurrence of low probability, would have its closest point of approach 2.3 miles from the plant.

Description of the VOR RWY 3 Approach to Sheboygan

The VOR RWY 3 approach is analogous to the VOR RWY 21 except that the approach is executed to the southwest side of the airport along the 223 deg radial instead of the 023 deg radial. This can be seen by comparing sheets 1 and 2 of Figure 2.2.1-5. The MDA for this approach is 1,480 ft msl, 280 ft higher than for VOR RWY

21. Until the MAP is reached at the center of the runway, all maneuvers are southwest of the airport, and can present no possible hazard to the airport.

If the pilot executes a missed approach, a left turn is made to intercept the 023 deg radial outbound from VOR, while climbing to 2,700 ft. Once established on the 023 deg radial and at 2,700 ft msl, the pilot turns left and proceeds directly to the VOR. The Chicago Air Route Traffic Control Center provides further instructions.

Error Limits

The missed approach procedure is performed along the same 023 deg radial used for VOR RWY 21. The 2,700 ft msl minimum altitude used for the procedure turn is also identical. Consequently, the statements on errors and closeness to the plant made for the VOR RWY 21 approach apply to the missed approach portion of the VOR RWY 3 approach.

Description of the NDB RWY 21 Approach to Sheboygan

Upon arrival over the Sheboygan NDB, 8.1 miles southwest of the Haven site, at Sheboygan airport at or above 2,700 ft msl, the pilot intercepts and tracks along the 025 deg radial outbound. After 1 minute, the pilot begins a procedure turn to the left (west). This is exactly analogous to the turn made in the VOR RWY 21 approach, except the intent is now to be inbound on the 025 deg radial to the NDB (heading = 205 deg). Once on the radial, the pilot may descend to the MDA, which for this approach is 1,240 ft msl (494 ft above the runway). The pilot then proceeds toward the MAP, which is over the NDB, near the intersection of the two runways.

If the pilot cannot make a normal landing, the missed approach maneuver is to continue on the 205 deg heading from the NDB, climbing to 2,700 ft msl. Once at 2,700 ft msl, the pilot executes a left turn and proceeds back to the NDB for further instructions.

Error Limits

The approach course passes more than 2.8 miles from the plant. A 6 deg error east of the approach course would still miss the plant by 2.1 miles.

2.2.1.2.3 High and Low Altitude Airways

The charted airways which are closest to the plant are indicated on Figure 2.2.1-7. In addition, there is an uncharted direct route "near V217"(14) which is believed to be along the east shore of Lake Winnebago. This is a more direct route for flights south out of Appleton. The centerlines of none of these routes are within 10 miles of the plant. The low altitude airways extend 4 nautical miles on each side of their centerlines.

The high altitude jet route, J101, Green Bay to Milwaukee, is 25.4 miles west of the plant with a minimum altitude of 18,000 ft. This route had a peak day of eight flights in 1977.

Airway V217 is directly below J101, 25.4 miles west of the plant. It had a peak day of 45 flights in 1977.

Airway V7 is located 11.0 miles west-southwest of the plant and carried 30 flights on its busiest day in 1977.

Airway V450, connecting Green Bay and Muskegon, is 22.2 miles northeast of the site. The peak 1977 day had 29 flights.

The direct route near V217 is estimated to be 29 miles west of the plant, and it carried seven flights on its peak day in 1977.

2.2.1.3 Military Air Traffic

There is no scheduled military air traffic within 10 miles of the plant. Occasionally, National Guard helicopters land at Sheboygan County Memorial Airport[12].

There are no known military training routes within 50 miles of the plant[15,16]. Two military jets were included in the data on peak daily traffic for the high and low altitude airways[14].

There is a military operations area (MOA) designated MINNOW MOA over Lake Michigan offshore from the plant. At its nearest point, it is 8 miles from the plant. According to information informally supplied by the FAA, the area is used for air combat gunnery practice, air to air refueling, air counter measures missions (e.g., flak drops), etc. Electronic simulation is used for 99 percent of practices. There are about 142 aircraft believed to be using the area from time to time. The space was reported occupied by one or more aircraft for 564 hours in 1977 with an average of 2.48 hours per day of usage. The aircraft using MINNOW MOA are believed to be based at K.I. Sawyer A.F.B. on Michigan's Upper Peninsula, Glenview N.A.S. near Chicago, and at Selfridge A.N.G.B. near Detroit. Therefore, access to the MOA should not be near Haven.

2.2.2 Storage and Transportation of Hazardous Materials

Within an approximately 10 mile radius of the Haven site, a survey was made to locate potentially toxic or hazardous chemicals used by industry or transported in this area. The industries contacted and chemicals used are listed in Table 2.2.2-1[17]. Using Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room during a Postulated Hazardous Chemical Release" as a guide, the storage and shipment of potentially hazardous chemicals are discussed below.

Storage of Potentially Hazardous Chemicals

There is no offsite storage of any hazardous chemicals within a 5 mile radius. Onsite storage of chemicals is described in Section 9.5.8.2 of the PSAR.

Shipments of Potentially Hazardous Chemicals

The majority of the industries surveyed are outside a 5 mile radius of the plant site and are predominantly in Sheboygan and Sheboygan Falls. Shipments for these industries appear to arrive from the south (Chicago and Milwaukee areas) or into the port of Sheboygan. The port of Sheboygan receives barge and tanker traffic of methanol and fuel oil. The low frequency of shipments, and the fact that most traffic on Lake Michigan generally comes from the south, diminishes the need for concern for this type of traffic.

Rail traffic on the Chicago and Northwestern line from Sheboygan through Manitowoc passes within 4,200 ft of the containment structures. Based upon survey information from the Chicago and Northwestern Railroad, the only hazardous chemicals shipped past the site at a frequency of greater than 30 shipments per year are chlorine and anhydrous ammonia. There are no TNT shipments.

A survey of the industries in the Manitowoc area was also performed to determine possible traffic through the site from the south. The Heresite Chemical Company of Manitowoc is the only industry in this area that uses hazardous chemicals. Heresite Chemical Co. presently receives phenol in 55 gallon drums. Shipments of phenol are assumed to be transported on Route 141 passing approximately 1 mile west of the site. Due to increased steel costs, the drums have become uneconomical as a shipment container and a large tank is presently being constructed to provide storage. This new arrangement will require only four to five rail shipments per year, also within limits for infrequent shipments as defined in Regulatory Guide 1.78.

Chemicals used by industrial facilities in the area are provided in Table 2.2.2-1. A list of potentially hazardous chemicals with quantity, mode, and frequency of delivery is provided in Table 2.2.2-2.

2.2.3 Evaluation of Potential Accidents

Potential accidents at the routes and locations discussed in Sections 2.2.1 and 2.2.2 do not present a hazard to the site. The consequences of postulated explosions, flammable vapor clouds (delayed ignition), and fires neither exceed plant design bases nor approach the site.

The Chicago and Northwestern Railroad[18] has stated that 65 ton rail shipments of chlorine pass the site at a frequency of greater than 30 shipments per year. Analysis of postulated rail accidents involving chlorine shipments of this size revealed that redundant QA Category I chlorine detectors would be necessary. Upon reaching chlorine levels at or above 5 ppm, these detectors will alarm and automatically isolate the air intake for the normal control room ventilation system and start the emergency ventilation system (Section 9.4.1) in the recirculation mode. This action and the chlorine alarm allow the operator to perform protective actions which include the donning of self-contained portable breathing apparatus. One and one half to 2 minutes is sufficient time for trained operators to begin operating the breathing apparatus.

Sax[19] and the Technical Services Bulletin for Chlorine[20] state that short term exposures to concentrations of 15 ppm chlorine cause irritation of the throat; the Technical Services Bulletin[20] states that short term exposures to concentrations of 30 ppm chlorine are required to cause coughing, while exposure to 40 to 60 ppm is considered dangerous if breathed over 30 minutes. The American Conference of Government Industrial Hygienists[21] documents a case of chronic poisoning when 15 ppm chlorine are breathed, but over a period of years. From the analysis described in Section 2.2.3.1.3 and results presented in Table 2.2.3-1, automatic chlorine detection equipment, along with the portable breathing apparatus, adequately protects control room operators.

Consideration was given to the possibility that future shipments may be in excess of 65 tons. However, a probability analysis of an accident resulting in concentrations which would exceed 15 to 20 ppm within 2 minutes results in probabilities of 10^{-8} to 10^{-9} events per year and, hence, does not constitute a basis for any additional modifications to the control room.

Accidents involving detonations of liquid and gaseous fuels are evaluated using the TNT equivalence of the hazard under consideration and acceptable relationships of blast overpressure versus distance.

Table 2.2.3-2 summarizes the site hazards analyses.

2.2.3.1 Potential Accidents

Design basis events external to the nuclear plant are defined as those accidents which have a probability of occurrence of greater than or equal to 10^{-7} per year and have potential consequences serious enough to affect the safety of the plant to the extent that 10CFR100 guidelines could be exceeded.

A number of accident categories have been considered to determine if they could be design basis events for the site. Each accident was analyzed to determine if the effects of the postulated accident were severe enough to be considered as a design basis event. The evaluation has shown that the effects of postulated accidents are not limiting and they are not design bases for this site; therefore, no additional probability studies are required. The basis for this conclusion is described for each of the following categories of events and is summarized in Tables 2.2.3-1, 2.2.3-3, and 2.2.3-4.

2.2.3.1.1 <u>Explosions</u>

Accidents involving detonations of liquid and gaseous fuels are considered along waterways, roads, railways, airports, and at nearby industrial facilities.

<u>Water Transportation</u>

The internal traffic patterns of shipping to and from Wisconsin's ports shows that traffic is navigated in the central portion of the lake at considerable distances offshore[22]. The immediate shore area in the vicinity of the site is listed as a caution area even for local anglers[17].

However, a hypothetical accident which considers the explosion of gasoline vapor has been performed. The St. Lawrence Seaway allows the use of oceangoing ships on the Great Lakes. For evaluation purposes, a tanker approximately 750 ft long and 34,000 tons (dead weight) has been assumed. Normally, tankers this size carry heavy fuel oil. Tankers of the 34,000 ton classification draw 34 to 38 ft when loaded. The tankers are constructed with three rows of tanks across and 7 to 10 tanks in each row depending on the capacity and range from 16,000 to 46,000 tons (dead weight) capacity.

The tanks in the center row are the largest and have twice the capacity of the side (wing) tanks[23]. The largest center tanks are found in current designs and contain 74,000 cu ft[23,24]. A loaded tanker could not approach the shore as close as an unloaded tanker due to the shallow water near the site. Due to the explosive limits of gasoline vapor, the maximum hazard would occur if a tanker failed to properly purge and inert its tanks after unloading its cargo and had an accident while passing the plant. The tanker was assumed to ground and explode in 20 to 30 ft of water at a distance of approximately 4,300 ft from the safety-related structures located on shore.

Explosive concentrations of gasoline vapors in air range from 1.3 to 7.5 percent by volume[19,25]. Using a 5 percent gasoline vapor (butane) in air mixture, the TNT equivalent is 800 lb TNT for approximately 10,000 cu ft of vapor/air mix. Assuming the largest tank (74,000 cu ft) detonates, the TNT equivalent would be about 5,920 lb.

An explosion of this magnitude would result in an ambient peak overpressure of 1 psi at about 800 ft from the tanker using the methodology and equations in Regulatory Guide 1.91, Rev. 1. The design basis of safety-related structures (PSAR Section 3.3) is such that the postulated tank explosion will not impair the capability for a safe and orderly shutdown of the plant.

Overland Transportation

As discussed in Section 2.2.1, there are several highways in the area; the nearest is County Highway LS, passing 2,900 ft west of the containment structures, which has the potential to be used by propane trucks. Another road, State Route 141, with a heavy duty classification, passes about 1.5 miles west of the containment structures. The extension of I-43, approximately 2 miles west, which is expected to be completed in the early 1980's, should carry the majority of the traffic presently on Route 141. A rail line (Chicago and Northwestern) passes within 4,200 ft of the containment structures. The plant is sufficiently isolated from public highway facilities so that any blast wave created by a maximum probable explosive hazardous cargo for a single truck or for a single rail car would be less than the tornado design pressure (PSAR Section 3.3) for the region, even if such explosives were assumed to be transported near the site. Based on survey information received from the Chicago and Northwestern Railroad, there are no TNT rail shipments past the site. Also, any fires and related incidents, if they were to occur, would not interfere with the capability to safely shut down the plant because of the separation distance from public highways.

A hypothetical propane truck spill along County Highway LS with instantaneous and subsequent delayed explosions is evaluated in Section 2.2.3.1.2.

2.2.3.1.2 Flammable Vapor Clouds (Delayed Ignition)

Accidental release of natural gas from the Michigan Wisconsin Pipeline Company and the Wisconsin Public Service Corporation gas lines have been hypothesized to form unconfined vapor clouds. After a postulated rupture, it is assumed that natural gas is released at a rate equal to the peak capacity of the pipeline. It is further assumed that there is not an immediate explosion since the delayed ignition of a large cloud of the gas results in the worst case energy release. The natural gas in the pipelines is approximately 90 percent methane which, if released, would rise rapidly due to its buoyancy. However, in order to determine the worst case effect of such a break, it is assumed that the gas is as dense as air and forms a flammable cloud which is blown towards the site. This cloud is assumed to be entirely methane. Meteorological conditions of Pasquill Stability Class F and a wind speed of 1 m/sec were chosen to maximize the extent of the cloud, consistent with Regulatory Guide 1.3 and 1.4 design basis meteorological parameters. Flammable vapor clouds are evaluated using U.S. Bureau of Mines methods[26]. The extent and incident overpressures and distance are provided in Table 2.2.3-3. Under these conditions the flammable cloud does not reach the site, and the overpressures resulting from a delayed ignition event are less than the dynamic wind pressure associated with the design basis tornado. Therefore, natural gas line breaks do not constitute a hazard to the site.

A spill of a 9,000 gal propane truck along County Highway LS west of the site has also been considered. In the analysis it is assumed that the entire amount of propane is available to continuously leak over a period of 24,000 seconds (6.67 hours). The resulting release is assumed to form an unconfined cloud in the direction of the site. The cloud is conservatively assumed to detonate once it is fully developed using the methods in Burgess and Zabetakis[26] and the meteorological assumptions described above. Results are presented in Tables 2.2.3-2 and 2.2.3-3.

Under the stated conditions the flammable cloud does not reach the site, and the overpressure resulting from a delayed ignition event is less than the dynamic wind pressure associated with the design basis tornado. Therefore, a spill of a 9,000 gal propane truck along the county highway does not constitute a hazard to the site.

Using the methods and equations of Regulatory Guide 1.91, Rev. 1, the instantaneous release and detonation of the contents of a propane truck (9,000 gal) were conservatively analyzed. The 1 psi peak positive incident overpressure distance was calculated to be 2,029 ft. Since Highway LS is 2,900 ft from the nearest Category I structure, plant safety is unaffected by such an accident. This potential hazard has been conservatively overestimated since, in actuality, only about one-third of the liquid propane will flash-vaporize, and any subsequent explosion would ignite the remaining spilled propane producing a fire rather than a detonation.

Based on survey information from the Chicago and Northwestern Railroad, the frequency of liquid propane gas passing the site is less than that which warrants further evaluation by Regulatory Guide 1.78. However, the potential for delayed ignition of a flammable gas cloud from railcars was analyzed using the method developed by the U.S. Bureau of Mines[26]. For the analysis, a continuous release of flammable gas is assumed. The assumed release rates are the same as considered in the evaluation for toxic gases (Section 2.2.3.1.3). The resulting peak incident overpressures developed from such a delayed ignition are all less than 1.0 psi at the plant and do not exceed the design basis for the plant (PSAR Section 3.3).

Using the equations and methodology of Regulatory Guide 1.91, Rev. 1, the instantaneous release and detonation of the contents of a propane railroad tank car (34,500 gallons) were conservatively analyzed. The 1 psi peak positive incident overpressure distance was calculated to be 3,175 feet. Since all Category I structures are beyond this distance, the plant would be unaffected by this postulated accident. This hazard has been conservatively overestimated since, in actuality, only about one-third of the liquid propane will flash-vaporize, and any subsequent explosion would ignite rather than detonate the remaining spilled propane.

The Bureau of Explosives has developed recommended practices for handling fires or spills and other dangerous articles in transportation. In cases where evacuation is recommended, the evacuation radius is less than the 4,200 ft separation distance available and evacuation is only recommended if large quantities of material are involved or if a fire becomes uncontrollable.

2.2.3.1.3 Toxic Chemical Releases

In order to evaluate the potential effects of maximum concentration and maximum concentration-duration accidents on control room habitability as identified in Regulatory Guide 1.78[27] toxic chemical releases from frequent shipments along the Chicago and Northwestern Railroad were evaluated. The materials in Regulatory Guide 1.78[27] that were considered (see Tables 2.2.2-2 and 2.2.3-4) and that were transported at a frequency which warranted further evaluation[18,27] were anhydrous ammonia (NH_3) and chlorine (Cl_2). The only onsite source that required evaluation was the fire protection system carbon dioxide (CO_2) containers (Section 9.5.1). Table 2.2.3-4 also summarizes the results of the CO_2 analysis on control room habitability.

For the maximum concentration railroad accident, an instantaneous (puff) release of the entire contents of the tank car was assumed to occur at the closest point of approach to the site. For the onsite CO_2 accident, the distance to the control room intake was determined to be controlling. In these cases, only a part of the spilled material will immediately vaporize and form a cloud which could drift toward the control room intake. A flash coefficient (x) representing the fraction which immediately vaporized was determined for each material by relating the specific enthalpy (h) of the material before and after the spill, while taking into consideration the conditions under which each commodity was shipped. A 1 percent ambient dry bulb temperature of 87°F was chosen as the temperature occurring during the postulated toxic chemical releases to add some conservatism to the flash coefficient calculations. Equation 2.2.3-1 represents the algorithm used to calculate the flash coefficient. These are listed in Table 2.2.3-4. Thus,

$$h_{\text{before spill}} = xh_{\text{liquid vaporized}} + (1-x)h_{\text{liquid spilled}} \quad (2.2.3\text{-}1)$$

The concentration outside the plant control room was calculated as a function of elapsed time after the postulated event, using a three-dimensional Gaussian diffusion model consistent with the methods presented in Appendix B of Regulatory Guide 1.78[27]. A buildup inside the control room occurs since a total of 0.48 volume per hour (2,000 cfm) of outside air is drawn in through the normal air intake. The normal air intake is located at the rear of the control room toward the railroad, slightly above grade, at a distance of approximately 3,900 feet from the Chicago and Northwestern Railroad tracks (Figure 2.1.2-1). In order to retain the conservative nature of this analysis, the control room intake was assumed to be located at ground level.

In analyzing the chlorine release, the control room is automatically isolated with a reduced air exchange rate of 0.06 volume per hour 10 seconds after the concentration reaches the 5 ppm detection limit outside the control room. The reduced air exchange rate of 0.06 volume per hour as given in Regulatory Guide 1.78[27] was assumed in the evaluation of the effects of continued air exchange during the passage of the toxic vapor cloud over the control room. The analysis also included a 5 percentile accident meteorology Pasquill Stability Class F, established from onsite meteorological measurements, and a wake factor of 5.3 m^2 representing the minimum cross-sectional area of the railroad tank car. Both of these parameters are specified in Appendix B of Regulatory Guide 1.78[27]. The peak concentration inside the control room for the lowest wind speed under consideration (0.5 meter per second) is listed in Table 2.2.3-4.

Based on the analytical results presented in Tables 2.2.3-1 and 2.2.3-4, the design of the control room provides detection and automatic isolation of the intakes for chlorine (PSAR Sections 6.4 and 9.4.1). The toxicity limit of CO_2 is never exceeded, while anhydrous ammonia does not pose a habitability hazard due to its rapid vertical rise in response to its buoyant nature relative to air.

For the maximum concentration duration accident analysis, a meteorological condition of Pasquill Stability Class F with a 1 m/sec wind speed, as specified in Regulatory Guide 1.4, Revision 2[28], was applied. A constant-rate continuous leakage with 100 percent evaporation of the entire railroad tank car contents was assumed for a 24,000 second (6.67 hour) period. This was based on a duration noted for a chlorine tank car accident[29,30] and calculation of the release capacity required by the specifications for tank cars[31]. The calculated relief valve capacities generally allow the tank to completely empty in a few hours if the pressure in the tank were maintained at the pressure at which the relief valve is rated and tested. The flow rate is established by empirical relations given in the tank car specifications[31] which are based on the assumption that the entire surface area of the tank is maintained at 1,200°F. Under these conditions, sufficient relief capacity is provided to prevent the pressure from reaching the test pressure of the tank. If a fire at the tank were to develop as a result of the postulated accident, the flow rating would be developed slowly, even if the fire were to engulf the entire tank car. If a fire is not present, the normal tank pressure of approximately 0 to 30 percent of test pressure is still well below the relief valve start-to-discharge pressure of approximately 75 percent of the tank design pressure. Even if the relief valve or rupture disk is opened, the flow rate will decrease rapidly. Failure of the tank rupture disk or relief valves is not considered likely, since these components are designed to withstand an acceleration of 20 g[32]. Using these assumptions it can be seen that the concentration outside the control room could exceed the toxic limit for chlorine. However, the reduced air exchange of an isolated control room and the fresh air supply capable of being provided by the portable breathing apparatus available provides adequate operator protection.

2.2.3.1.4 Fires

Fires from accidents at the facilities or transportation routes previously discussed do not endanger the safe operation of the plant due to the separation distance. To ensure the safety of the plant, onsite fuel storage facilities are designed in accordance with the applicable fire codes (see Section 9.5.1).

2.2.3.1.5 Collisions with Service Water Pumphouse Intake Structure

In the extremely unlikely event that a ship or barge were to collide with and completely incapacitate one of the service water intakes, plant safety would not be jeopardized. The other 100 percent capacity (for both units) intake is separated from the postulated damaged intake and would satisfy plant safety requirements.

2.2.3.1.6 Liquid Spills

The service water intake structures are located in Lake Michigan, one approximately 3,300 ft offshore and the other approximately 4,300 ft offshore. The pumphouse/screenwell structure is located inland from the lake shoreline. Water is supplied from this facility to the service water, demineralized water, and cooling tower makeup systems. Service water is withdrawn from the bottom of Lake Michigan, thus minimizing the possibility of oil or other floating debris from entering the system. Potential sources of corrosive chemical spills, as discussed in Section 2.2.2, are remote from the site. Any release of corrosive chemicals will be sufficiently diluted by the lake such that concentrations in the service water will have no detrimental effect on plant systems.

2.2.3.1.7 Aircraft Impact

General Methodology

In order to evaluate the probability of an aircraft striking a critical structure of the plant, it is necessary to identify all flight operations in the vicinity, determine the operation frequency and historical crash rate for each type of aircraft, estimate the crash distribution relative to the locations of airport runways or airways, and factor in the size of both the critical structures and of the impact area which can be expected from the crash of the specific type of aircraft.

The probability may be expressed by the approximate general relationship

$$P = NARD \qquad (2.2.3\text{-}2)$$

where:

- P = probability of aircraft collision with the "target" per year
- N = number of operations per year (landings/take-offs or overflights)
- A = effective "target area" of the plant
- R = crash rate, specific to aircraft type and operation
- D = a density distribution function characterizing the crash location with respect to the runway or flight path

Each term is defined and evaluated for each applicable type of aircraft (e.g., general aviation, air carrier, military fighter) and type of operation (airport related or overflight). Using U.S. aviation statistics, the following steps are required:

1. Computing N: The number of aircraft operations currently performed and the number projected over the life span of the power plant are estimated for any airports, approaches, or airways identified as requiring analytical consideration.

2. Computing A: The effective "target" area presented by the Haven Nuclear Plant is a sum of three parts: the plan area, the shadow area, and the skidding area. The shadow area is a projection on the horizontal of the vertical face of a structure, using a typical angle of impact for a specific type of aircraft to determine the size of the "shadow." The skidding area is the product of the typical skidding distance and the length of the side of the plant exposed to the aircraft.

3. Computing R: U.S. crash data for each type of aircraft are analyzed to yield crash rates. General aviation accidents are treated as a whole.

4. Computing D: By analyzing the distribution of accident location with respect to the end of the runway in terms of polar coordinates (r, θ) for each aircraft type, a distribution function can be calculated for airport related accidents.

   Separate analyses are conducted for those accidents occurring within 5 miles of the airport and those beyond 5 miles from the airport.

   A similar analysis can be applied to in-flight accidents. A distribution function is calculated based on perpendicular distance from the crash location to the centerline of the air route.

Operations and Frequency (N)

The flight operations in the site vicinity are reviewed in Section 2.2.1. Most of the aircraft activity described in that section is well below the frequency of operation that the NRC has set as requiring analysis(3).

By inspection of Table 2.2.1-1, there are no airports with projected operations greater than 1,000 d^2 movements per year beyond 10 miles from the site, where d is the distance in miles from the site.

The average seaplane operation on Lake Michigan could be less than 0.2 mile from the plant without exceeding 500 d^2. This obviously will not happen with 25 miles of coast from which to choose.

Military pilot training flights in the vicinity are confined to the MINNOW Military Operations Area (MOA). Since the area is not a practice bombing range, and the MOA is a minimum of 8 miles from the plant, a detailed analysis of operations within the MOA is unwarranted.

The centerlines of the high and low altitude airways shown on Figure 2.2.1-7, as well as the direct route near V217, are a minimum of 11.0 miles from the plant. According to Section 3.5.1.6 of Regulatory Guide 1.70, Rev. 2, detailed analysis is not needed if the edge of the airway is more than 2 statute miles from the plant.

Operations at Sheboygan County Memorial Airport, which is 8.1 miles from the plant, currently exceed 500 d^2, or 33,000 operations, designated as the level where Regulatory Guide 1.70, Rev. 2, states that a detailed probability analysis is required.

Future operations are expected to increase as shown on Figure 2.2.1-5.

A detailed analysis of Bell's Airport, 2.7 miles away, is required because it is within 5 miles of the plant. The frequency and type of operations are discussed in Section 2.2.1.

Area of Impact (A)

The potential area of impact, or "target" area, in the Haven analysis is based upon the combined areas of all Category I structures.

The following structures contribute to the "target" area:

- Containment Structure
- Fuel Building
- Main Steam Valve Houses
- Auxiliary Building
- Safeguards Area
- Cable and Pipe Tunnels
- Service Water Pumphouse
- Control Building
- Diesel Generator Building and Fuel Oil Tanks (underground)

For simplicity as well as conservatism, all the area within the facade around the containment, auxiliary building, safeguards area, etc., is to be included in the plan area. The plant configuration is shown on Figure 2.2.3-1. The total plan area of these structures is shown in Table 2.2.3-5.

The critical structures are most exposed to general aviation approaching from the east, directly off the lake, when viewed in terms of potential shadow and skidding areas. The turbine building and cooling tower shield the critical structures from a significant portion of possible approaches from the west, and the critical structures are narrower in the east-west direction than in the north-south direction.

Skidding Distance

A representative skidding distance is defined or computed here for accidents during each of the aircraft operations possibly important to the Haven site. These are exclusively general aviation accidents.

The aircraft accident tapes[33] of the National Transportation Safety Board (NTSB) list skidding distance information for 3,508 fatal general aviation accidents during the period 1964-1975. Table 2.2.3-6 displays the distribution of skidding distances. It is noteworthy that the critical Haven structures begin only 70 to 185 ft from the top of the shore protection slope.

A plot of the cumulative fraction of accidents with stopping distances greater than or equal to a specific value, S_D, is shown on Figure 2.2.3-2. An exponential curve is fit to the data points in piecewise fashion. This function, $F(S_D)$, is

$$
\begin{aligned}
F(S_D) &= e^{-S_D/72} && \text{for } S_D \leq 75' \\
&0.56e^{-S_D/180} && \text{for } 75' < S_D \leq 375' \\
&0.25e^{-S_D/239} && \text{for } 375 < S_D \leq 925' \\
&0.045e^{-S_D/624} && \text{for } 925 < S_D \leq 3000'
\end{aligned}
\qquad (2.2.3\text{-}3)
$$

Integrating $F(S_D)$ between 0 and 3,000 yields a representative skidding distance of 126 ft.

Impact Angle

The NTSB tapes contain impact angles for 1,121 fatal general aviation accidents. The distribution of angles is shown in Table 2.2.3-7. The probability density function listed is the fractional number of occurrences divided by the 10 deg interval width. A "weighted" impact angle is computed by applying a weighting factor to the probability density distribution. The factor is the inverse of the tangent of the impact angle ($1/\tan\phi$) which measures the projection of the vertical aspect of a structure onto the horizontal surface. The integral of the product of the weighting factor and the probability density function yields the ratio of the length of the horizontal projection to the height of the structure. If an integration is performed piecewise using the data of Table 2.2.3-7 and using the central angle of the 10 deg interval as representative, the result is 1.91. The corresponding impact angle is

$$\phi = \tan^{-1}\left(\frac{1}{1.91}\right) = 28 \text{ degrees} \qquad (2.2.3\text{-}4)$$

Shadow Area and Skidding Area

The shadow areas associated with the above impact angles were computed graphically. The shadow areas are shown on Figure 2.2.3-1.

The skid area for general aviation was calculated assuming an approach from the east. The length of the side of the critical structures exposed to the aircraft is 941 ft. Added to this width is the width of half an aircraft wing span on each end of the plant. The addition recognizes the nonpoint nature of the missile hitting the "target." For general aviation, a 50 ft wing span was used (most general aviation aircraft are smaller than this)[34] to provide a total width of 991 ft.

The input data and the results of the target area calculation are contained in Table 2.2.3-5.

Accident Rates (R)

General aviation accident statistics for the period 1964-1975 indicate a total of 2,750 fatal accidents with airport data, i.e., airport related. Of these, 84 accidents occurred beyond 5 miles of an airport[33]. The total number of operations for this time period is estimated from several sources[35,36,37]. Table 2.2.3-8 summarizes the data.

The accident rates corresponding to these two cases are:

2.15×10^{-6} crashes/operation, all accidents with airport data;
6.56×10^{-8} crashes/operation, accidents with airport data beyond 5 miles.

Spatial Distribution Function (D)

The locations of accidents may be conveniently measured relative to the location of airports by using polar coordinates where r is the distance from the runway to the crash in miles, and θ is the angle between the airport runway centerline and the radial line to the crash location.

The density distribution D may be assumed to be the integral of a product of a function of r, f(r), and a function of θ, $g(\theta)$.

The function $D(r,\theta)$ was derived for general aviation accidents with airport data both within and beyond 5 miles of the airport. Table 2.2.3-9[33] gives the distribution of fatal general aviation accidents as a function of airport proximity (1964-1975). These data are plotted on Figure 2.2.3-3. An exponential fit to these points yielded the function $e^{-r/1.57}$. Now, f(r) is the derivative of 1 minus this function or

$$f(r) = 0.637e^{-r/1.57} \qquad (2.2.3\text{-}5)$$

In determining $g(\theta)$, 69 accidents were reviewed[38,39]. The data that were analyzed are shown in Table 2.2.3-10. The values are plotted on Figure 2.2.3-4. The best fit exponential is $e^{-\theta/49.6}$ so that the function $g(\theta)$ is

$$0.020e^{-\theta/49.6} \qquad (2.2.3\text{-}6)$$

Because θ has a maximum value of 180 deg, a constant factor is multiplied to $g(\theta)$ so that its integration between 0 deg and

180 deg equals 0.5. The function $D(r,\theta)$ for accidents within 5 miles of the airport becomes

$$D(r,\theta) = \frac{0.37}{r} e^{-r/1.57} e^{-\theta/49.6} \qquad (2.2.3\text{-}7)$$

For accidents beyond 5 miles it was assumed that there is a uniform distribution in θ. The function $f(r)$ was derived based on 51 accidents[38,39] with radii distributed as in Table 2.2.3-11. These data are plotted on Figure 2.2.3-5.

The best fit exponential has the form

$$e^{-(r-5)/4.56} \qquad (2.2.3\text{-}8)$$

and the function $D(r,\theta)$ is given by

$$\frac{0.034e^{-(r-5)/4.56}}{r} \qquad (2.2.3\text{-}9)$$

Probability of Impact (P)

It is assumed that Bell's Airport had 1,125 operations per year in 1977 and is expected to have the same in 2029 (N=1,125). All flights were general aviation and, therefore, the "target" area of the plant (A) is 0.02077 sq mi. The general aviation crash rate, R, equals 2.15×10^{-6} crashes per operation for general aviation considering all accidents with airport data. The density distribution, D, for general aviation within 5 miles of the airport is

$$D(r,\theta) = \frac{0.37}{r} e^{-r/1.57} e^{-\theta/49.6} \qquad (2.2.3\text{-}10)$$

or 0.00574 for Bell's Airport relative to the nearest target. The probability in either 1977 or 2029 would therefore be $P = 2.88 \times 10^{-7}$.

Sheboygan County Memorial Airport had 42,000 operations in 1977, all of which are considered general aviation (N=42,500). The "target" area (A) is again 0.02077 sq mi. Since the airport is over 5 miles away from the plant, the general aviation crash rate, R, equals only 6.56×10^{-8} crashes per operation. The density function, D, for general aviation beyond 5 miles from the airport is

$$D(r,\theta) = \frac{0.034}{r} e^{-(r-5)/4.56} \qquad (2.2.3\text{-}11)$$

or 0.00213 for Sheboygan relative to the nearest target. The probability of impact in 1977 was, therefore, $P = 1.23 \times 10^{-7}$.

In 2029, Sheboygan is expected to have 181,600 operations. If the crash rate and distribution characteristics are unchanged and if it is assumed that all operations are still considered general aviation, the probability will become $P = 5.27 \times 10^{-7}$.

The results of Table 2.2.3-12 should be regarded as highly conservative. Some of the conservative assumptions have been mentioned before, but it is worth enumerating some significant ones.

1. The number of transient operations at Bell's Airport was assumed to be 70 percent of the number it would have been if it were a public airport. This should be very conservative.

2. Haven Nuclear Plant structures designed against tornado missiles (see PSAR Table 3.5.2-1) have significant capacity to resist impactive loads caused by light aircraft.

3. The skidding distance of an aircraft, as reported by accident investigations, is often the total distance over which wreckage is spread. A large fraction of the momentum would be dissipated over an appreciably shorter distance.

4. The direction of approach to the Haven Nuclear Plant was chosen to maximize the target area. No weighting of the various possible directions was performed.

5. In the event of an accident, the pilot usually has partial control of the aircraft. The pilot could be expected to attempt to maneuver the aircraft to impact in an open space, where the chances of survival are better, rather than toward the massive buildings of a nuclear plant.

It is believed that the cumulative effect of these and other assumptions makes the results shown in Table 2.2.3-12 acceptably low.

2.2.3.1.8 Collapse of Onsite Structures

Structures important to safety, or whose failure would affect the safe shutdown of the plant, are designed to withstand the effects of natural phenomena as described in PSAR Section 3.1.2.2.

The possible collapse of the circulating water system cooling towers when subjected to tornado or seismic loading will not affect plant safety. The towers are located at a sufficient distance from the plant so that in the event of their collapse they will not strike any safety-related portion of the plant.

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TABLE 2.2.1-1

LARGEST AIRPORTS, 10-50 MILES FROM HAVEN

Airport and City	Approximate Distance (d)* from Haven[7,40]	Fiscal Yr 1977 Operations	Fiscal Yr 1987 Operations[41]	$\frac{1000}{d^2}$
Outagamie County Appleton, WI	48 mi	55,000	125,000	2,304,000
Austin-Straubel Green Bay, WI	48 mi	89,000	186,000	2,304,000
Manitowoc Municipal Manitowoc, WI	20 mi	22,000	47,000	400,000
Wittman Field Oshkosh, WI	42 mi	131,000	299,000	1,764,000

NOTE:
* d is the distance in miles from the airport to the Haven Nuclear Plant.

TABLE 2.2.1-2

FAA PROJECTIONS OF SHEBOYGAN
COUNTY MEMORIAL OPERATIONS[41]

Operations (000)	Actual FY1975	FY1977	FY1978	FY1979	FY1982	FY1987
Air Carrier	0	0	0	0	0	0
Air Taxi	7	8	9	10	13	21
Itinerant	24	27	30	33	41	58
Total	35	40	44	48	60	85
Instrument Approaches	728	855	943	1031	1306	1922

TABLE 2.2.1-3

SHEBOYGAN AIRPORT MASTER PLAN PROJECTED OPERATIONS(a)

Operations (000)	1973	1980	1985	1995
Single Engine Piston	31.3	38.8	47.0	59.0
Multi-Engine Piston	3.9	6.8	12.0	21.0
Turbo Prop	1.0	6.3	11.0	19.0
Jet	0.8	2.0	3.0	6.0
Other	0	1.5	1.5	3.0
Total	37.0	55.4	74.5	108.0

TABLE 2.2.2-2

FREQUENT SHIPMENTS OF HAZARDOUS CHEMICALS BY NEARBY INDUSTRIAL FACILITIES

Chemical	Shipment Type	Quantity	Frequency
Methanol	Lake Barge	30,000 barrels	7 to 9 shipments per year
Phenol	Truck	75-55 gallon drum	7 shipments per year
Natural Gas	Pipeline	4.0×10^5 ft^3 per hour	Continuous
Natural Gas	Pipeline	114.5×10^6 ft^3 per day	Continuous
Chlorine	Rail	65 tons	Greater than 30 shipments per year
Anhydrous Ammonia	Rail	33,500 gallons	Greater than 30 shipments per year

TABLE 2.2.3-1

CONTROL ROOM CHLORINE ANALYSIS*
MAXIMUM AND TOXIC CONCENTRATIONS VERSUS TIME
AS A FUNCTION OF WIND SPEED

	Wind Speed (meters/sec)**											
	0.3	0.5	0.7	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.5
Time to Reach 15 ppm (sec)***	350	230	180	150	130	120	110	100	90	90	NA	NA
Time to Reach 20 ppm (sec)***	370	250	200	170	150	130	130	NA	NA	NA	NA	NA
Time to Reach Maximum Concentration (sec)***	940	580	420	320	270	220	200	180	150	130	120	110
Maximum Concentration (ppm)****	112	67.3	48.1	37.5	30.7	26.0	22.5	19.9	17.8	16.1	14.7	13.5

NOTES:

*Based on rail shipment capacity of 65 tons

**Accident meteorological conditions of Pasquill Stability Class F were assumed and the wind speed was varied in order to maximize the control room concentrations (see Regulatory Guide 1.78, Appendix B). The peak concentration inside the control room occurs with a wind speed of 0.3 meter per second.

***Time refers to the time period after detection of control room normal intake (after ambient concentration reaches 5 ppm) until time stated. All times listed are to the nearest 10 second iteration.

****Flash coefficients (Table 2.2.3-4) were applied to the control room concentration evaluation (instantaneous release of entire tank contents). Control room concentration is based on a 0.48 volume per hour air exchange rate, followed by a reduced air exchange rate of 0.06 volume per hour 10 seconds after 5 ppm is reached outside the control room. No credit was allowed for chlorine removal by the emergency ventilation system.

TABLE 2.2.3-2

SITE HAZARD EVALUATION SUMMARY*

Potential Hazard	Distance to Site (mi)	Direction from Site	Basis for Conclusion That the Hazard Need Not Be Considered
1. Explosions	-	-	
a. Water Transportation			
Gasoline Ship 34,000 ton	0.8	E	A 1 psi peak reflected overpressure occurs approximately 800 feet from the ship.
b. Overland Transportation			
County Highway LS	0.53	W	Based on Reg. Guide 1.91, quantities for truckload and railroad shipments of TNT, the peak reflected overpressure of 1 psi would be approximately 1,700 feet and 2,100 feet away from the respective source.
Route 141	1.5	W	
Chicago & Northwestern Railroad	0.8	W	
c. Adjacent Industrial Facilities			There are no industrial sources of explosives within 5 miles of the site.

TABLE 2.2.3-2 (CONT'D)

Potential Hazard	Distance to Site (mi)	Direction from Site	Basis for Conclusion That the Hazard Need Not be Considered
2. Flammable Vapor Clouds (delayed ignition)			
a. Michigan Wisconsin Pipeline Company-one 10 inch and two 6 inch natural gas pipelines carrying 114.5 million cubic feet per day	4.8	W	An incident overpressure of 1 psi extends only 3,640 feet from a break.
b. Wisconsin Public Service Corporation-one 8 inch natural gas pipeline carrying 400,000 cubic feet per hour	3.7	SW	An incident overpressure of 1 psi extends only 930 feet from the break.
c. 9,000-gallon propane truck spill along county road	0.53	W	An incident overpressure of 1 psi extends only 380 feet from the truck for delayed ignition or 2,029 feet from the truck for a puff release and detonation.

TABLE 2.2.3-2 (CONT'D)

Potential Hazard	Distance to Site (mi)	Direction from Site	Basis for Conclusion That the Hazard Need Not Be Considered
d. 34,500-Gallon Propane Railroad Tank Car Spill	0.80	W	An incident overpressue of 1 psi extends 3,175 feet from the truck for a puff release and detonation.
3. Toxic Chemicals			
a. Chicago and Northwestern Railroad	4,200 feet	W	See Tables 2.2.3-1 and 2.2.3-4
b. US Highway 141 (next largest route is State Highway 42-4 miles from the site) 75 55-Gallon Phenol Drums	1.5	W	Phenol is not considered a hazard as it is normally shipped in dry form. With respect to quantity and distance, the Chicago and Northwestern source represents a more severe case.
4. Fires	-	-	There are no adjacent industrial or chemical plants.
5. Collisions with Intake Structure			
a. Ships or Barges	-	-	The service water system has redundant and separate intake structures.

TABLE 2.2.3-2 (CONT'D)

Potential Hazard	Distance to Site (mi)	Direction from Site	Basis for Conclusion That the Hazard Need Not Be Considered
6. Liquid Spills	-	-	The service water system has redundant and separate submerged intake structures. Spills would also be diluted in the lake.
7. Failure of Cooling Towers			The cooling towers are far enough from safety-related structures to prevent damage following tower collapse.
8. Aircraft Crash			
a. Bell's Airport	2.7	SSW	Table 2.2.3-3
b. Sheboygan County Memorial Airport	8.1	SW	Table 2.2.3-3

NOTE:

*Evaluation was performed using Regulatory Guide 1.78 as a basis.

TABLE 2.2.3-3

FLAMMABLE VAPOR CLOUD EXPLOSIONS

	Postulated Ignition Source	Equivalent Source (cfs)	Flammability Limits in Air (V %)	Extent of Flammable Cloud (m)	Blast TNT Equivalent (KT)	Extent of Incident Overpressure (1.0 psi Isopleth)
1.	9,000-gal propane spill on County Highway LS					
	Delayed ignition	13.4	2.8-7.0	65	0.000077	380 ft
	Puff release	-	2.8-7.0	-	0.0458	2,029 ft
2.	Michigan - Wisconsin pipeline break (delayed ignition)	1,320	5.3-14	695	0.065	3,640 ft
3.	Wisconsin Public Service pipeline break (delayed ignition)	111	5.3-14	155	0.0012	930 ft
4.	34,500 gal propane railroad tank car on Chicago railroad (puff release)	-	2.8-7.0	-	0.176	3,175 ft

TABLE 2.2.3-4

IMPACT OF ONSITE HAZARDOUS MATERIALS FREQUENTLY TRANSPORTED BY RAIL

Hazardous Material	Released Gaseous Quantity (g)	Toxicity Limit (ppm)	DOT Section No./ Classification	Flash Coefficient	Control Room Maximum Concentration* (ppm)	Maximum Duration Concentration Outside** (ppm)	Recommended Evacuation Radius*** (ft)
Anhydrous Ammonia	7.97×10^7	100	173.315/Non FE	0.2162	0****	0****	--
Chlorine *****	5.90×10^7	15	173.314/Non FG	0.2206	111	350	2,500
Carbon Dioxide	1.47×10^7	10,000	Not Applicable	0.5366	423	1,540	--

NOTES:

*Accident meteorological conditions of Pasquill Stability Class F were assumed and the wind speed was varied in order to maximize the control room concentrations. The peak concentration inside the control room occurs with a wind speed of 0.3 meter per second.

**Maximum duration accidents were evaluated by assuming that entire tank contents were released in 24,000 seconds. The steady state outside air concentration is listed in ppm. Pasquill Stability Class F and 1 meter per second wind speed were assumed.

***Recommended evacuation distance by the U.S. Bureau of Explosives

****Results from buoyant nature of anhydrous ammonia

*****Flash coefficients were applied to the maximum control room concentration evaluation only (instantaneous release of entire tank contents). Maximum control room concentration is based on a 0.48 volume per hour air exchange rate, followed by a reduced air exchange rate of 0.06 volume per hour, 10 seconds after 5 ppm is reached outside the control room. No credit was allowed for chlorine removal by the emergency ventilation system.

TABLE 2.2.3-5

TARGET AREA INFORMATION

Aircraft Type: (Operation)	General Aviation (all)
Plan Area (ft^2):	[illegible]73,000
Shadow Area (ft^2):	181,000
Frontal Exposure of Plant (ft):	991
Skidding Distance (ft):	126
Skidding Area (ft^2):	125,000
Total Target Area:	
ft^2 -	579,000
mi^2 -	0.02077

TABLE 2.2.3-6

DISTRIBUTION OF SKIDDING DISTANCES IN GENERAL AVIATION ACCIDENTS 1964 THROUGH 1975

Range of Distance (ft) S_e	Number of Occurrences	Range of Distance (ft) S_e	Number of Occurrences
0-50	2,129	1201-1300	4
51-100	391	1301-1400	2
101-150	262	1401-1500	4
151-200	175	1501-1600	1
201-250	136	1601-1700	0
251-300	109	1701-1800	0
301-350	58	1801-1900	1
351-400	40	1901-2000	2
401-450	40	2001-2100	2
451-500	33	2101-2200	1
501-550	10	2201-2300	1
551-600	32	2301-2400	0
601-650	9	2401-2500	1
651-700	14	2501-2600	0
701-750	8	2601-2700	0
751-800	8	2701-2800	1
801-850	2	2801-2900	0
851-900	10	2901-3000	1
901-950	6	-	
951-1000	5	-	
1001-1100	3	-	
1101-1200	7	5801-5900	1
		Total	3,508

TABLE 2.2.3-7

DISTRIBUTION OF IMPACT ANGLES IN GENERAL AVIATION ACCIDENTS 1964 THROUGH 1975

Range of Angles (degrees)	Number of Occurrences in 10 Degree Intervals	Probability Density Function	Weighting Factor
0-10	103	0.0092	11.430
11-20	51	0.0045	3.732
21-30	134	0.0120	2.145
31-40	46	0.0041	1.428
41-50	209	0.0186	1.000
51-60	185	0.0165	0.7002
61-70	51	0.0045	0.4663
71-80	96	0.0086	0.2679
81-90	246	0.0219	0.0875

TABLE 2.2.3-8

GENERAL AVIATION OPERATIONS, 1964 THROUGH 1975[35,36,37]

Calendar Year	Operations at Towered Airports (000)	Total Operations at Towered and Non-Towered Airports (000)
1964	23,020	63,945
1965	26,573	73,814
1966	33,445	92,903
1967	37,223	103,397
1968	41,567	115,464
1969	41,957	116,547
1970	41,384	114,956
1971	40,401	112,225
1972	38,172	115,400[37]
1973	41,363	114,897
1974	43,124	125,700[37]
1975	45,297	130,700[37]

NOTE:

References 36 and 37 indicate that nontowered general aviation operations constituted, conservatively, 64 percent of all operations for the period 1972-1977. This percentage was used to compute the total column for years with no indicated reference.

TABLE 2.2.3-9

GENERAL AVIATION ACCIDENTS VERSUS AIRPORT PROXIMITY
1964 THROUGH 1975

Proximity	Number of Fatal Accidents		
	Total	With Airport Data	Without Airport Data
In Traffic Pattern*	685	673	12
Within 1/4 mi	302	296	6
Within 1/2 mi	242	237	5
Within 3/4 mi	90	90	1
Within 1 mi	242	242	0
Within 2 mi	438	427	11
Within 3 mi	328	324	4
Within 4 mi	267	263	4
Within 5 mi	117	115	2
Total within 5 mi	2,711	2,666	45
Total beyond 5 mi	3,640	84	3,556
Total	6,351	2,750	3,601

NOTE:

*For purposes of analysis, those accidents in the "traffic pattern" were distributed among the other categories (as their precise location is unknown). This is accomplished as follows for accidents with airport data:

There are eight other categories and 673 = (84 x 8) + 1.
Therefore, after distribution the totals are:

Within 1/4 mi = 85 + 296 = 381
Within 1/2 mi = 84 + 237 = 321
Within 3/4 mi = 84 + 89 = 173
Within 1 mi = 84 + 242 = 326
Within 2 mi = 84 + 427 = 511
Within 3 mi = 84 + 324 = 408
Within 4 mi = 84 + 263 = 347
Within 5 mi = 84 + 115 = 199

TABLE 2.2.3-10

CUMULATIVE FREQUENCY DISTRIBUTION OF GENERAL AVIATION AIRPORT ACCIDENTS AND INCREASING ANGULAR DEVIATION FROM RUNWAY

Angle, θ, from Runway Center Line (Degrees)	Cumulative Fraction of Accidents with Angular Deviation $\geq \theta$
0	69/69 = 1.0
10	50/69 = 0.72
20	37/69 = 0.54
30	30/69 = 0.43
40	29/69 = 0.42
50	25/69 = 0.36
60	22/69 = 0.32
70	22/60 = 0.32
80	19/69 = 0.28
90	17/69 = 0.25

TABLE 2.2.3-11

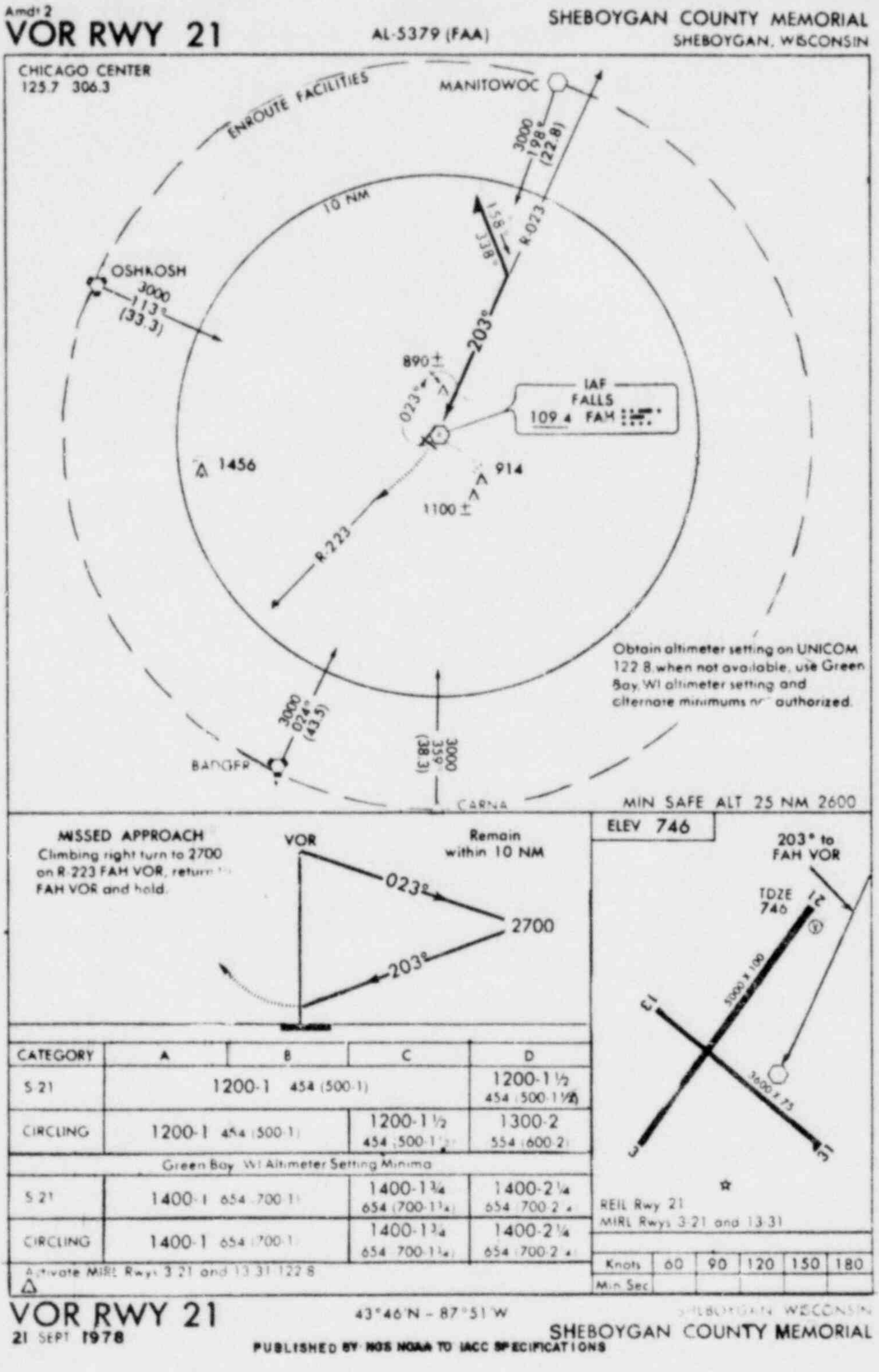
CUMULATIVE FREQUENCY DISTRIBUTION OF GENERAL AVIATION ACCIDENT OVER 5 MILES FROM AIRPORT

γ	Cumulative fraction $\geq \gamma$
5	51/51 = 1.0
6	47/51 = 0.92
7	38/51 = 0.75
8	28/51 = 0.55
9	22/51 = 0.43
10	20/51 = 0.39
11	16/51 = 0.31
12	14/51 = 0.27
13	11/51 = 0.22
14	7/51 = 0.14
15	6/51 = 0.12
20	3/51 = 0.06
25	2/51 = 0.04

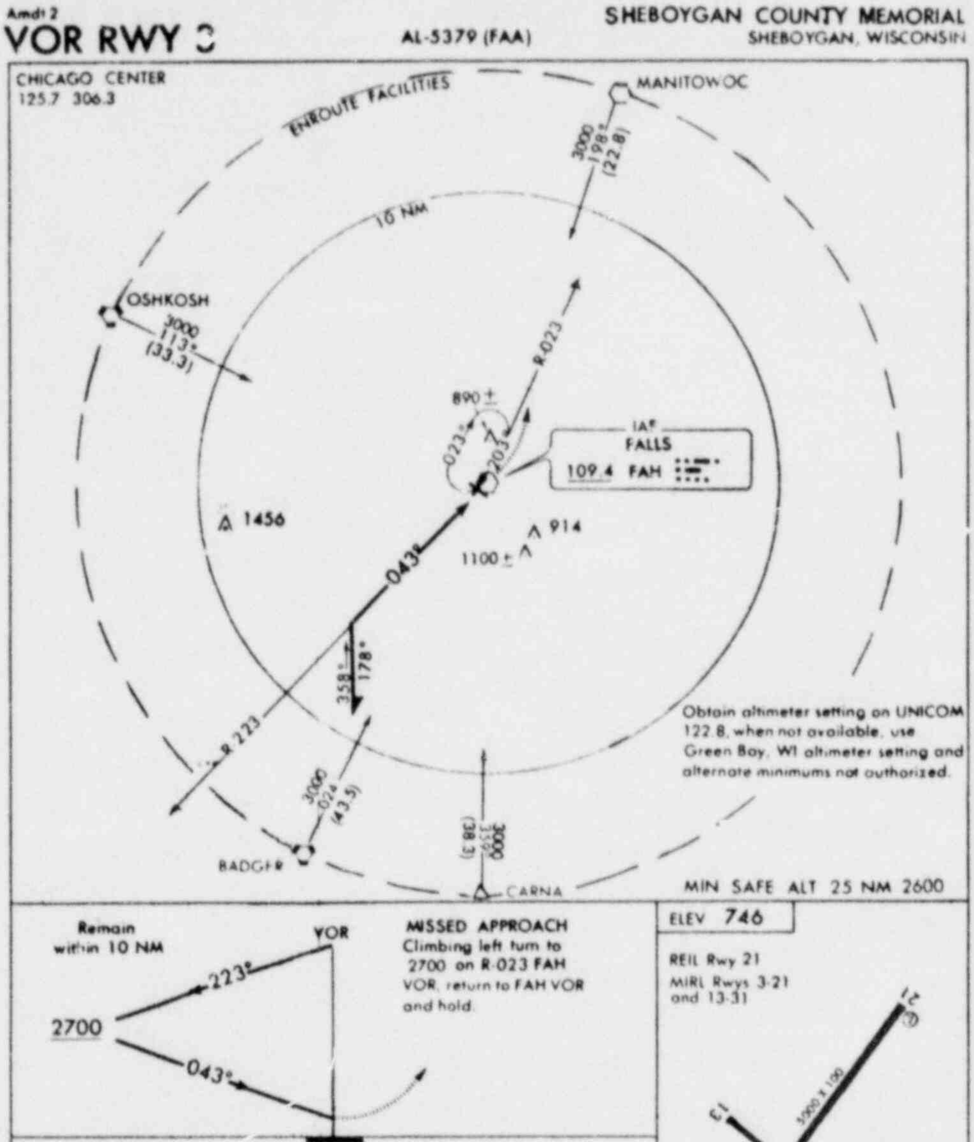
TABLE 2.2.3-12

PROBABILITY ESTIMATES

Airport	Year	Annual Operations	Probability (Collisions/Yr)
Bell's	1977	1,125	2.88×10^{-7}
Bell's	2029	1,125	2.88×10^{-7}
Sheboygan	1977	42,500	1.23×10^{-7}
Sheboygan	2029	181,600	5.27×10^{-7}



HAVEN NUCLEAR PLANT
FIGURE 2.2.1-5 (1 OF 3)
NOAA APPROACHES TO SHEBOYGAN AIRPORT
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT



CATEGORY	A	B	C	D
S-3	1480-1 734 (800-1)		1480-2 734 (800-2)	1480-2½ 734 (800-2½)
CIRCLING	1480-1 734 (800-1)		1480-2 734 (800-2)	1480-2½ 734 (800-2½)
Green Bay WI Altimeter Setting Minima				
S-3	1680-1¼ 934 (1000-1¼)		1680-2¼ 934 (1000-2¼)	1680-3 934 (1000-3)
CIRCLING	1680-1¼ 934 (1000-1¼)		1680-2¼ 934 (1000-2¼)	1680-3 934 (1000-3)

Activate MIRL Rwys 3-21 and 13-31 122.8

Knots	60	90	120	150	180
Min Sec					

VOR RWY 3
21 SEPT 1978
43°46'N - 87°51'W
SHEBOYGAN, WISCONSIN
SHEBOYGAN COUNTY MEMORIAL

PUBLISHED BY NOS NOAA TO IACC SPECIFICATIONS

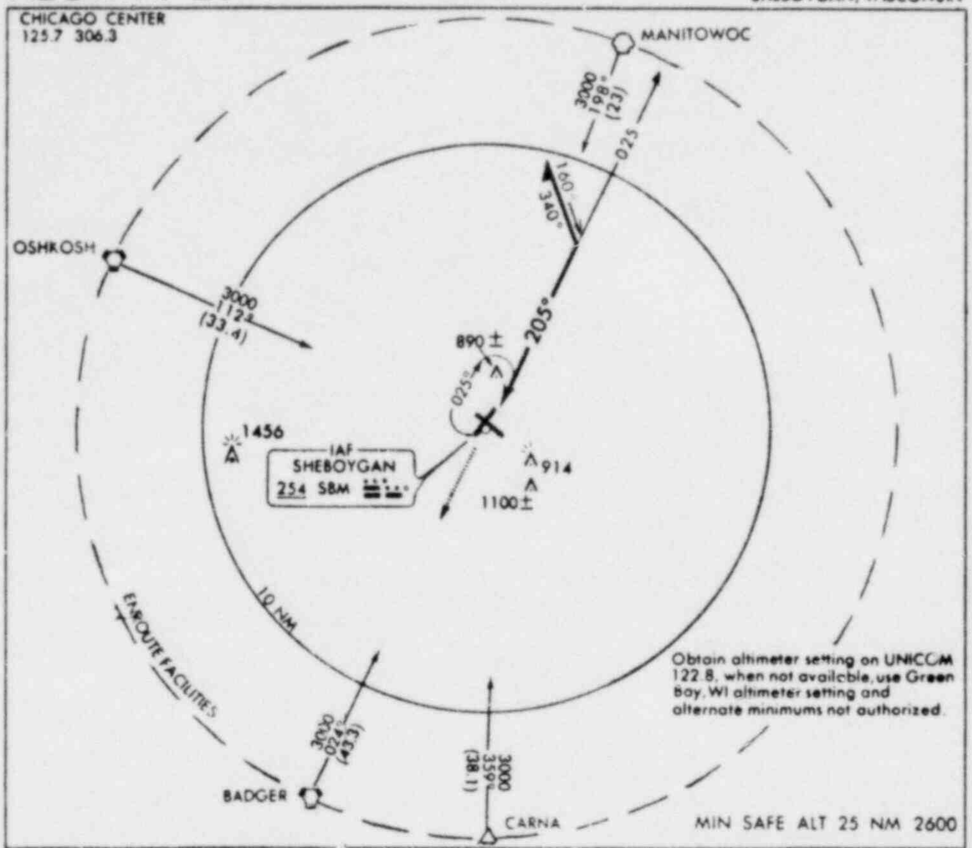
HAVEN NUCLEAR PLANT
FIGURE 2.2.1-5 (2 OF 3)
NOAA APPROACHES TO SHEBOYGAN AIRPORT
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

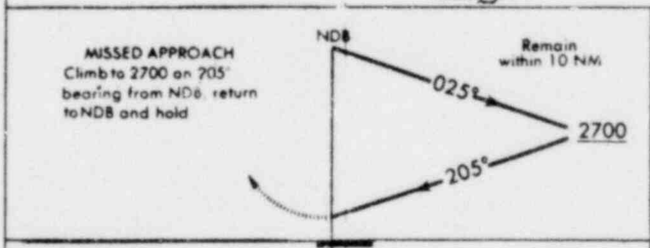
Amdt 3

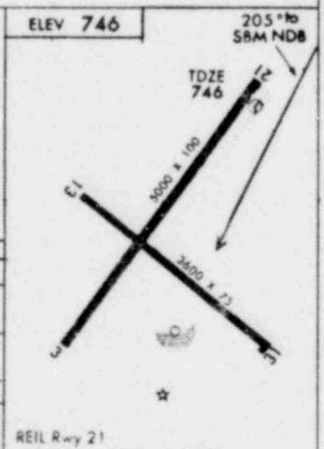
NDB RWY 21

AL-5379 (FAA)

SHEBOYGAN COUNTY MEMORIAL
SHEBOYGAN, WISCONSIN







CATEGORY	A	B	C	D
S-21	1240-1 494 (500-1)		1240-1¼ 494 (500-1¼)	1240-1¾ 494 (500-1¾)
CIRCLING	1240-1 494 (500-1)		1240-1½ 494 (500-1½)	1300-2 554 (600-2)
Green Bay, WI Altimeter Setting Minima				
S-21	1440-1 694 (700-1)		1440-2 694 (700-2)	1440-2½ 694 (700-2½)
CIRCLING	1440-1 694 (700-1)		1440-2 694 (700-2)	1440-2½ 694 (700-2½)

Activate MIRL Rwys 3-21 and 13-31 122.8

Knots	60	90	120	150	180
Min:Sec					

NDB RWY 21

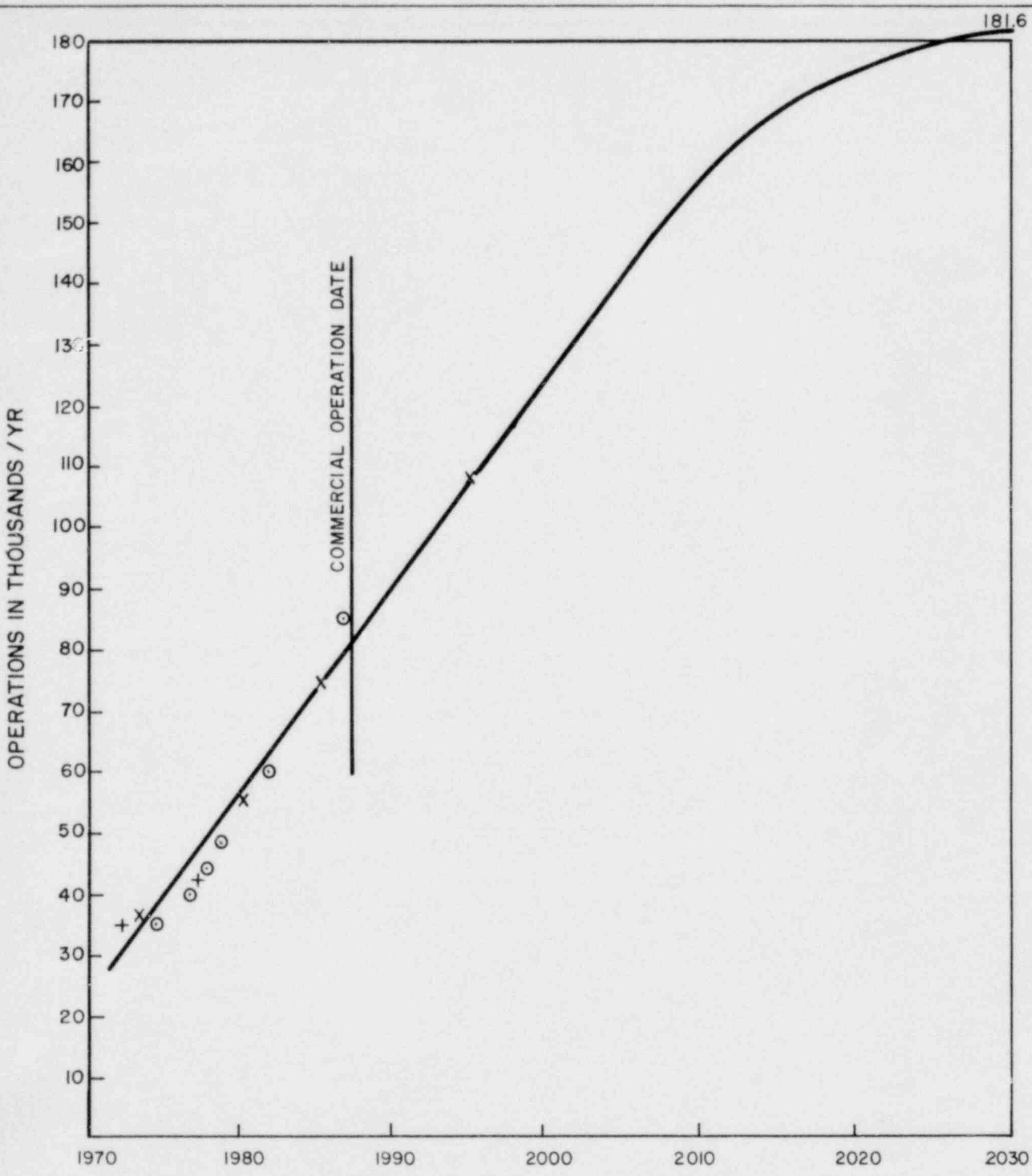
21 SEPT 1978

43°46'N-87°51'W

SHEBOYGAN, WISCONSIN
SHEBOYGAN COUNTY MEMORIAL

PUBLISHED BY NOS NOAA TO IACC SPECIFICATIONS

HAVEN NUCLEAR PLANT
FIGURE 2.2.1-5 (3 OF 3)
NOAA APPROACHES TO SHEBOYGAN AIRPORT
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

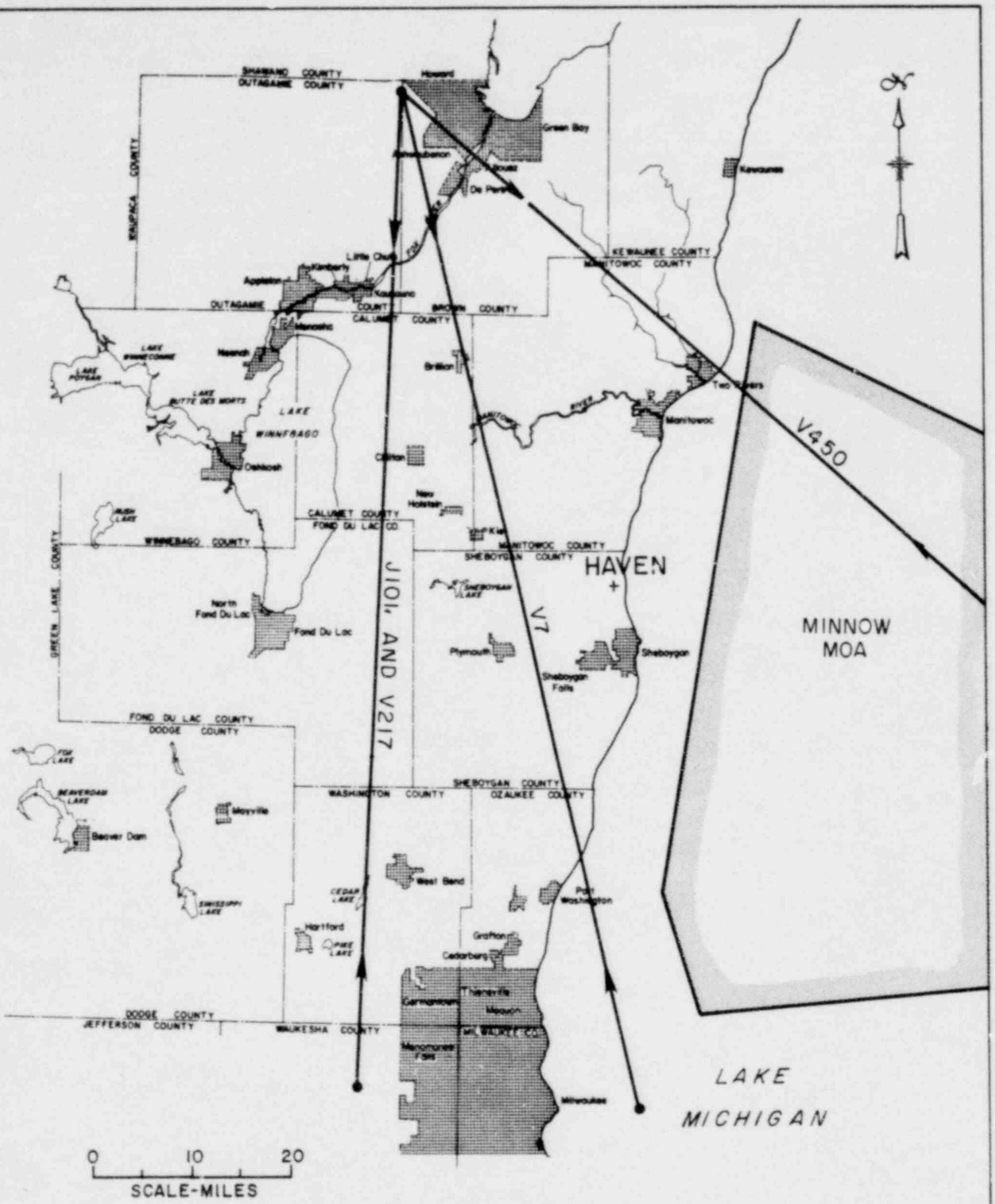


NOTE:
PRACTICAL ANNUAL CAPACITY = 181,600
(REF 4)

KEY

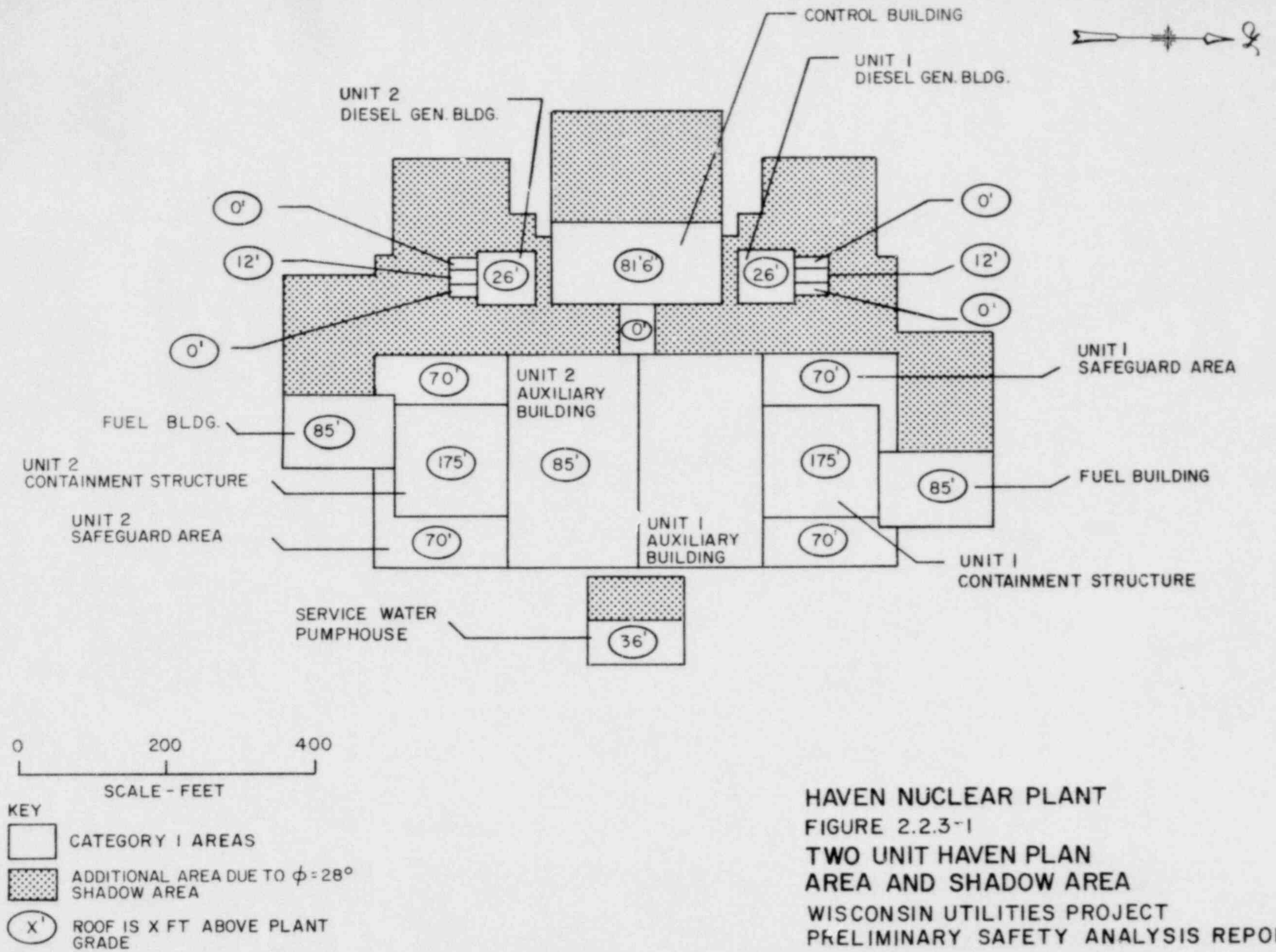
⊙ TOTAL OPERATIONS (REF 40)
X TOTAL OPERATIONS (REF 4)
+ TOTAL OPERATIONS (REF 6)

HAVEN NUCLEAR PLANT
FIGURE 2.2.1-6
SHEBOYGAN AIRPORT
PROJECTED OPERATIONS 1974-2029
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT



HAVEN NUCLEAR PLANT
FIGURE 2.2.1-7
NEAREST AIRWAYS AND MINNOW MOA
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

AMENDMENT 20

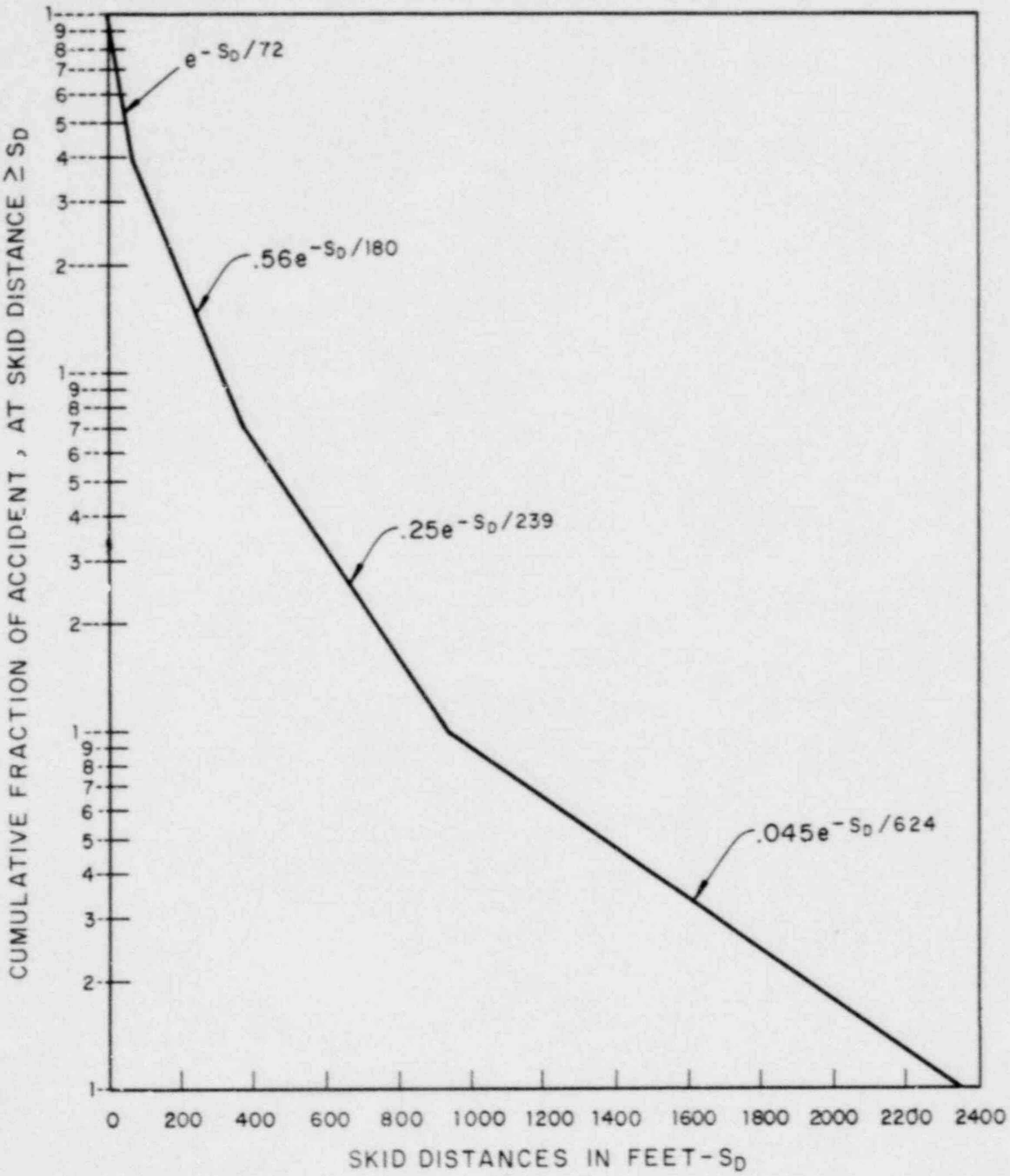


HAVEN NUCLEAR PLANT

FIGURE 2.2.3-1

TWO UNIT HAVEN PLAN
AREA AND SHADOW AREA

WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

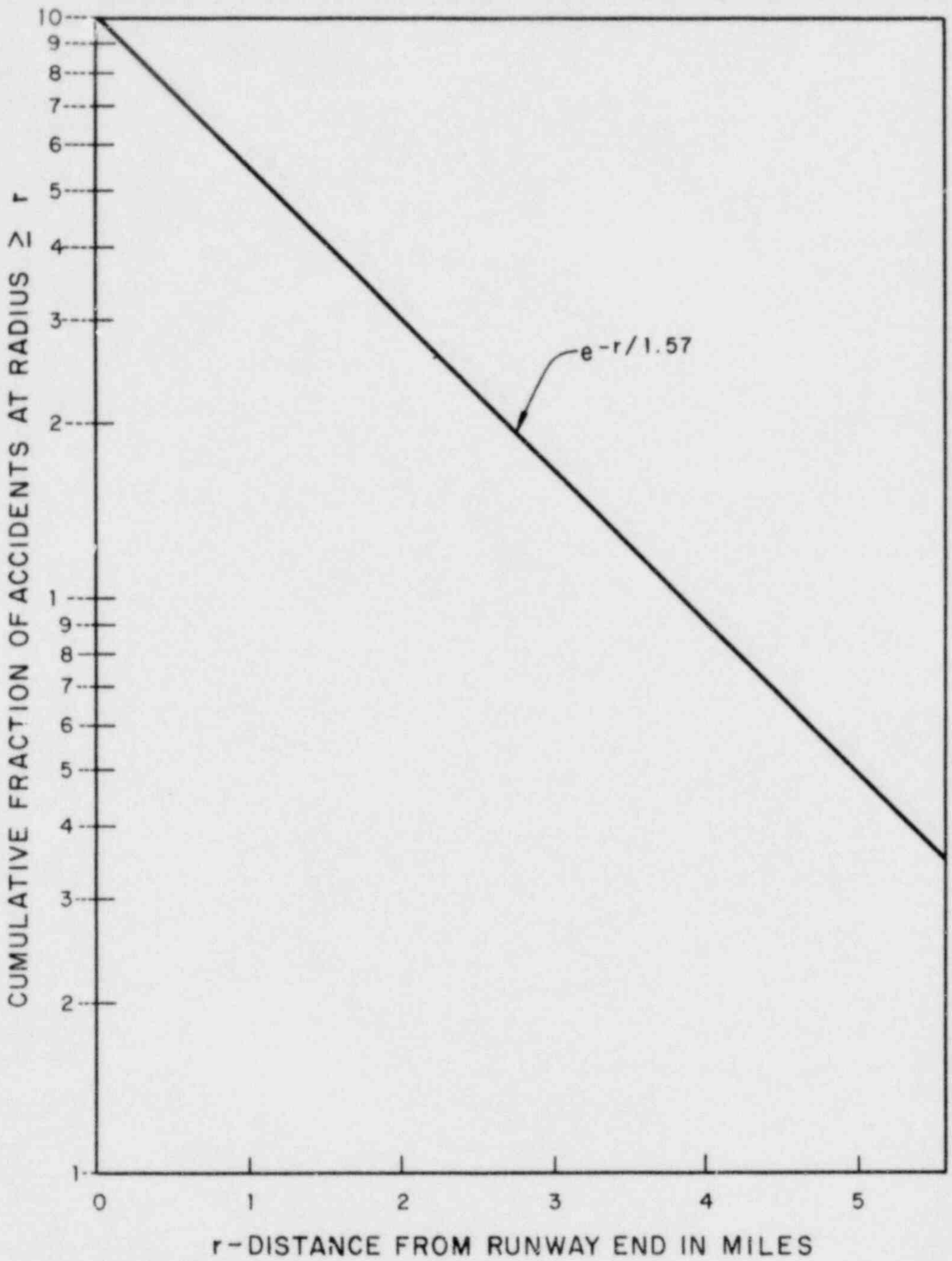


HAVEN NUCLEAR PLANT

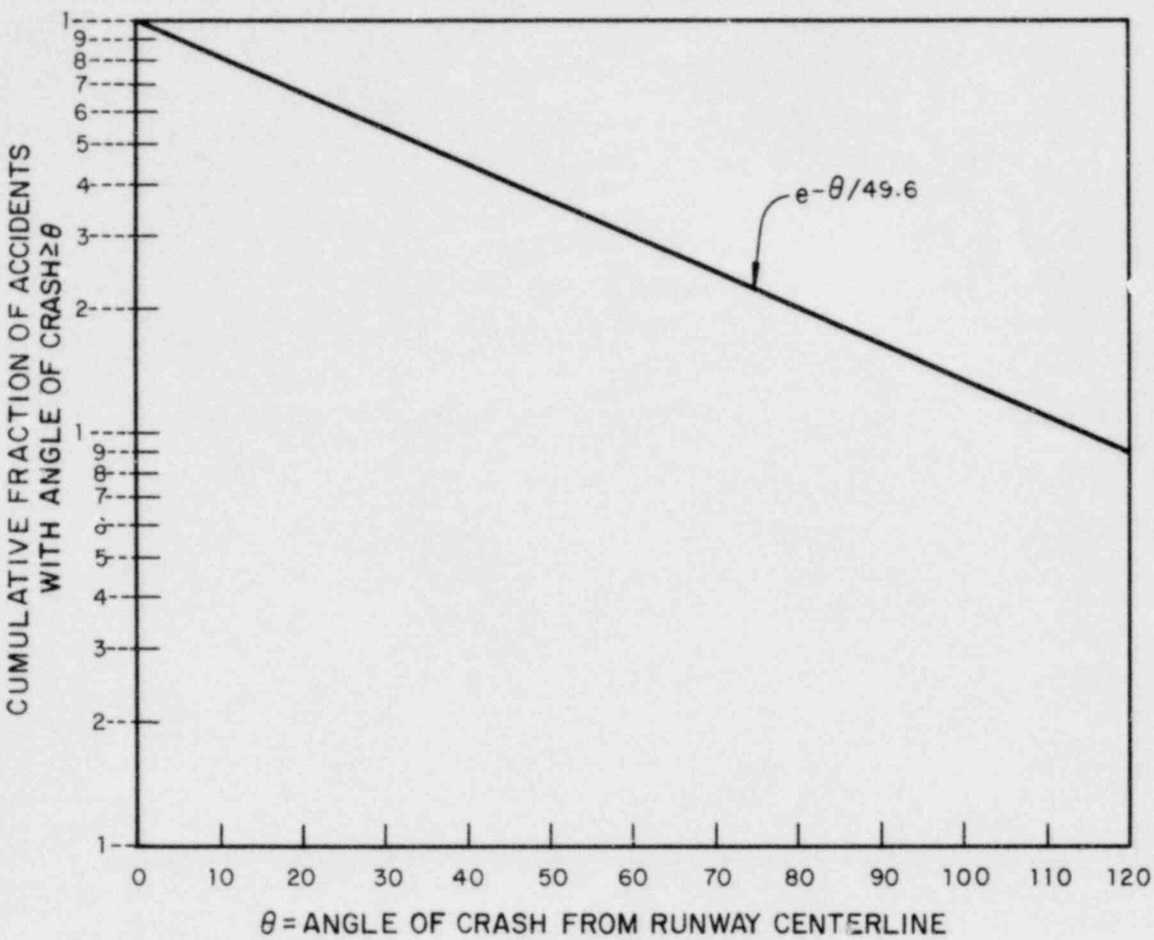
FIGURE 2.2.3-2

FREQUENCY CURVE OF
SKID DISTANCE FOR
GENERAL AVIATION ACCIDENTS

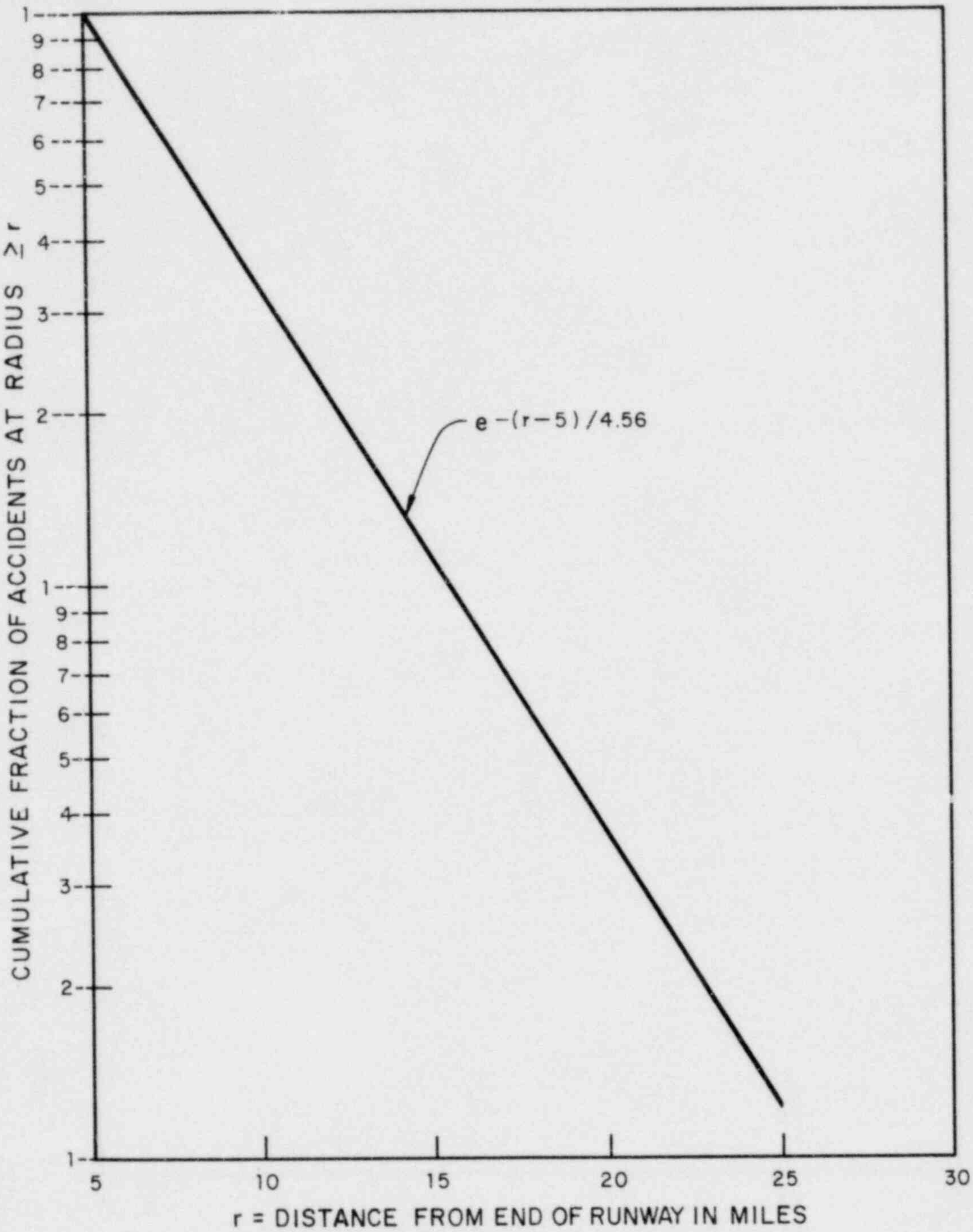
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT



HAVEN NUCLEAR PLANT
FIGURE 2.2.3-3
FREQUENCY CURVE OF
RADIAL LOCATION FOR
GENERAL AVIATION ACCIDENTS
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT



HAVEN NUCLEAR PLANT
FIGURE 2.2.3-4
FREQUENCY CURVE OF
ANGULAR LOCATION FOR
GENERAL AVIATION ACCIDENTS
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT



HAVEN NUCLEAR PLANT
FIGURE 2.2.3-5
FREQUENCY CURVE OF
RADIAL LOCATION FOR
GENERAL AVIATION ACCIDENTS
BEYOND 5 MILES
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

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GENERAL TABLE OF CONTENTS (CONT'D)

SECTION 2.4

HYDROLOGIC ENGINEERING

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HYDROLOGIC ENGINEERING

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amplified the initial conditions. The resulting reflected surge observed in Chicago, approximately 1 hour later, was from 3 to 8 feet.[32]

2.4.5.3 Surge and Seiche Sources

Seiches or free oscillations of the lake normally occur due to rapid decay of wind setup conditions. Because of the geometry of the lake with respect to the plant site, seiches are not considered to be controlling mechanisms with respect to flooding.

To compute the value of wind setup at the site, a one-dimensional computer model was used. Program input contains the basic physical characteristics of the lake. Average length, width, and depth were computed for a series of sections located along each selected wind path. The probable maximum wind speed and the wind stress coefficient are also input. This wind speed of 80 miles per hour is assumed to attain a steady-state over the entire length of the wind path.

Wind stress coefficients vary for different lakes. Given a fixed wind speed and the physical dimensions of the lake, it is the assumed wind stress coefficient which controls the predicted wind setup. The wind stress coefficient was determined by adjusting the coefficient until the computer model output matched the wind setup values produced by a historical storm.

The severe storm of November 16 through 17, 1955, was used to calibrate the model. Instantaneous lake level readings were recorded at Ludington, Michigan.[34] Wind speeds for the same period were recorded at Muskegon, Michigan.[35] These recording stations are located nearly due east across the lake from the Haven site. During the historical storm, winds of nearly 50 miles per hour produced a wind setup of 1.2 feet. The wind stress coefficient, which brought the model into agreement with recorded data, was 3.3×10^{-6}. This derived stress coefficient was assumed to be applicable for each wind path leading to the Haven site. This calibration is based on the assumption that the physical parameters of the lake are reasonably symmetric about the longitudinal axis.[36]

The program solves equations for the steady-state slope of the water surface while concurrently satisfying the conservation of volume equation. This program is based on the work of Hellstrom, Langhaar, and Keulegan, which is summarized in "Shore Protection, Planning, and Design," U.S. Army Coastal Engineering Research Center.[30] Several trials of wind direction were used to predict the critical path which would produce the maximum wind setup. Figure 2.4.5-1 presents the critical path as determined by this scheme.

Eighty mile per hour winds with the wind stress coefficient of 3.3 x 10^{-6} produced a setup of 2.5 ft. In addition to the wind setup value, barometric pressure will add to the wind setup; an additional 0.25 ft has been added to the wind setup value to allow for pressure changes across the lake. This figure is arrived at by computing the pressure differential which is associated with the maximum setup. Input includes a Coriolis parameter, air density, wind speed, and distance. The total value for the maximum storm surge is 2.75 ft. The value adopted for the study of wave runup is 3 ft.

2.4.5.4 Wave Action

Wave action has been assumed coincident with the maximum recorded monthly mean lake level (583.18 msl) and maximum surge (3 ft) as discussed in Section 2.4.5.3. The maximum wind of 80 miles per hour was assumed to be of unlimited duration over the maximum fetch to the site of 90 miles. A maximum significant deep water wave of 30 ft was calculated. A significant wave is defined as the average of the highest one-third of all waves occurring in a given period. The maximum probable wave is defined for this study as the average of the highest percentage of waves in a representative spectrum. The deep water wave corresponding to this condition is 50 ft. The periods for these waves would range from 11 to 16 seconds.

Table 2.4.5-1 presents expected frequencies of deep water waves offshore of the Haven site. Runup and shoaling are discussed in Section 2.4.5.6.

Littoral Drift

The Haven site overlooks Lake Michigan along a stretch of shoreline which is characterized by bluffs 45 to 60 ft high. Partially cobbled beaches, ranging in width from 5 to 35 ft, are found along this section[55]. Inspection of the bluffs reveals some slumping and erosion. The bluffs are roughly two-tiered, i.e., a moderate slope from the beach to a middle plateau region with a sharper rise from there toward the crest of the bluff. The bluffs have a moderate cover of grass, bushes, and small trees. Offshore of the site, the bottom material is composed of clay, silty clay, and sandy clay with interspersed rocks and boulders.

Little information regarding littoral drift movement is available for the reach from Sheboygan to Manitowoc. Two promontories (to the north, Rawley Point, which is located north of Two Rivers, and to the south, Sheboygan Point, which is located north of Sheboygan Harbor) shelter the region bounded between them from wave attack directly from the north and south. This precludes using sediment buildup around any structure in the lake (e.g., groin, breakwater) near or beyond Rawley and Sheboygan Points for an estimate of littoral drift. There are no structures suitable for this purpose sufficiently inside the bounded region. Aerial photographs obtained from the National Archives were used to investigate shoreline changes. The magnitude of the littoral was estimated based on a semi-empirical equation that appears in the Shore Protection Manual(31) and on meteorological weather data taken at the site.

Shoreline recession is discussed in Section 2.5.1.2.1. The recession rate estimated there agrees with an independent estimate made by the State of Wisconsin(55).

Meteorological data taken at the Haven site from June 1, 1973 to May 31, 1974 were used to predict the wave characteristics and the corresponding sediment transport. Wind speed and direction based on these data show a marked similarity to data gathered at General Mitchell Field in Milwaukee during this same period and also from January 1, 1955 to December 31, 1964(56). Analysis indicates that the prevailing deep-water wave heights range from 1.2 to 2.0 ft with a wave period of 3 seconds. The predominant littoral drift is from north to south with a net littoral transport rate of 24,000 cu yd/yr. The gross transport, which is the sum of the transports from the south to the north and from the north to the south, is approximately 79,000 cu yd/yr. A complementary study has been performed by the Chicago District of the Corps of Engineers at Hika Park, 5 miles north of the site(56). Daily visual observations of breaking wave heights and breaker angles for the period April 5 through September 6, 1974 were analyzed using methods described in the Shore Protection Manual. The observed breaker heights ranged from 1 to 3 ft. In the Corps analysis, the littoral drift rate estimated over part of the year was taken to be representative of the whole year. The prevailing drift was from north to south. A smaller north-to-south net transport obtained by the Corps of Engineers arose because winter waves, which are predominately from the north and which produce littoral drift to the south, were not included in their study. Consequently, the littoral drift rate based on the 1 year of meteorological data taken at the site was adopted.

2.4.5.5 Resonance

The Haven site should not experience any water level changes due to reflection or other harbor related fluctuations, as the site is located on a simple open lakeshore. Its location also precludes any appreciable rise due to disturbances along the main axis of the lake. The possibility of transverse resonance is present; however, the maximum instantaneous level at Ludington, Michigan (located almost directly across the lake) has never exceeded the recorded high water of 581.94 IGLD in the 20 years of record.

Free oscillations of the lake are usually the result of a decaying wind setup. Reinforcement by a change in wind direction or other external force is needed to create a rise higher than that of the initial condition. No records available show any values of instantaneous fluctuations which would reach significant proportions.

2.4.5.6 Runup

Wave runup was calculated using a bottom profile which consisted of a 3 to 1 slope of the shorefront revetment structure and the lake profile running perpendicular to shore located halfway between Units 1 and 2 of the Haven Nuclear Plant. Runup due to waves having various periods and breaking at different offshore locations along this profile was investigated using the methods outlined in the Shore Protection Manual[31].

The method is one of successive approximations involving the replacement of the actual composite slope with a hypothetical single slope running from the lake bottom, at the point where the incident wave breaks, up to the point of maximum runup on the structure. This procedure is repeated until convergence is attained. An assumption invoked is that the revetment has a smooth slope. This is a conservative assumption, because the structure would, normally, have a smaller runup due to its rough and permeable surface. In the unlikely event that glazed ice forms on the revetment structure, ice buildup in the nearshore area would force waves to break farther offshore, resulting in a smaller wave runup.

The runup value for waves impinging on a smooth impermeable slope was obtained using data derived in previous small-scale laboratory experiments. A correction factor for scale effects, as described in the Shore Protection Manual[31], was subsequently used in the analysis to obtain the runup value for the prototype structure.

A 3 to 1 riprap revetment structure along the shore will be provided to protect the beach from erosion. Figure 2.5.5-10 depicts the shorefront configuration with the revetment structure. On the basis of this profile, and the maximum lake level, the maximum runup is el 608 msl.

2.4.5.7 Protective Structures

The design requirement imposed on the plant with respect to lake flooding is that the plant grade elevation be above the extent of maximum wave runup. The design wave runup elevation of 608 ft msl leaves 2 ft of freeboard to the plant grade elevation of 610 ft msl. On sides other than the lake side, the site will be graded for protection from the inland PMF flooding. The ground floor of all safety-related structures will be at least 6 inches above finish grade to prevent flooding during the local PMF.

Shoreline stabilization will be necessary to halt the erosion which is presently occurring. A design wave height of approximately 12 ft will be used for the shoreline revetment design.

2.4.6 Probable Maximum Tsunami Flooding

An analysis of tsunami flooding is not considered applicable to inland lakes.

2.4.7 Ice Flooding

Ice formation is a common occurrence along all shoreline areas of Lake Michigan. However, the open lake freezes over completely only during the severest of winters. The winter of 1971-72 was near normal in accumulated freezing degree days. A freezing degree day is defined as a day with a temperature 1°F below freezing. Thus, a day with a mean temperature of 25 degrees would provide 7 freezing degree days. During 1971-72, the maximum ice coverage was reported as 40 percent[37]. This coverage is roughly equivalent to a 5-mile barrier extending lakeward from all shorelines. Normally, most shorelines are covered completely out to the 30 ft depth contour. Intermittent coverage occurs between the 30 ft and 100 ft contour[38].

The existing ice sheet may deteriorate due to thermal effects or be broken up by onshore/offshore winds and waves. Broken sheets of ice drift with the wind. With continuous onshore wave action, ice floe hummocks (i.e., small ice ridges) pile against the frozen beach surface. By this process, an ice foot forms.

Nearshore ice development in Lake Michigan was observed on the beaches adjacent to the Donald C. Cook Power Plant south of Benton Harbor, Michigan during 1969-1970 and 1970-1971. It was observed that the ice structure in the area consisted of an ice foot, a frozen lagoon of brash ice, an outer barrier of ice, a second frozen lagoon, a second outer barrier, and finally a transient field of floe ice. The outermost barrier was generally the largest of the lake ice barriers. It was estimated to be 25 ft high[39].

At the Haven site, however, since offshore winds prevail during winter, the ice foot formation is less severe than on the east coast of Lake Michigan. An ice reconnaissance was conducted at the Haven site during the early part of 1974. It was found that a pressure ice barrier 6 to 12 ft high was located approximately 30 to 150 ft offshore of the bluff. Soft ice or semi-solid ice intervened between the bluff and the ice barrier[58]. The first appearance of ice is usually reported in early December. Ice formation generally peaks in late January and early February and slowly diminishes toward spring. The ice foot formation will not affect the service water intakes.

Where there is no ice cover on the surface and substantial turbulence in the water body induced by wind and wave action, frazil ice can occur when the water is rapidly super-cooled and its temperature drops from above to below 32°F without freezing.

Under these super-cooled conditions, the frazil ice is in its active stage and is able to adhere to other materials. Therefore, whenever this super-cooled frazil ice-producing water is circulated to the depth of an intake structure, an ice buildup may occur that could eventually prevent passage of water into the intake. The frazil ice can also adhere to the underside of the leading edge of an ice cover to form anchor ice. Anchor ice formation is primarily associated with intensive turbulence induced by onshore breaking waves. Past observations of anchor ice at the Haven site are not available. The largest anchor ice formation observed at the beach near the Donald C. Cook Power Plant was found to be grounded on the bottom in a 12-foot water depth[39]. Since onshore winds at the Haven site are less severe than those on the east shore of Lake Michigan during winter, anchor ice at the Haven site is unlikely to occur to a 12 ft water depth.

Two submerged intake structures are provided for the service/makeup water systems. These intakes are located in sufficient water depth to preclude anchor ice from restricting the required flow. The intake design includes electrical bar racks used as a frazil ice preventive measure.

Section 9.2.5 provides a description of the design intake and intake locations.

Ice jam flooding of Sevenmile Creek has been evaluated. The PMF, which could be coincident with ice formation (November through March), is 11,000 cu ft per second, or less than one-half the PMF which could be derived from the all-season envelope. A backwater curve calculation was performed with a starting lake elevation of 595 ft msl to simulate a shoreline ice jam condition. The resulting profile was calculated for Sevenmile Creek and its tributaries and was found to be at a lower level than that indicated for the all-season probable maximum flood. Flood elevations computed at specific locations are listed in Table 2.4.7-1.

2.4.8 Cooling Water Canals and Reservoirs

No canals or reservoirs have been employed in design of the Haven Nuclear Plant other than the cooling tower basins which are located west of the plant. The normal water surface elevation in the basins is near the grade elevation of 630 ft msl at the cooling tower sites.

The cooling tower basins are below grade; the unlikely event of a cooling tower basin failure during a Safe Shutdown Earthquake

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The initial radioactivities in the boron recovery tank are assumed to be NUREG 0017 values adjusted to 1 percent failed fuel. Assumed radionuclide removal by plant process systems is consistent with NUREG 0017.

Concentrations at the nearest potable water intake are calculated in the following manner:

$$C_{pw} = \frac{C_{BRT} e^{-\lambda t}}{DF_{total}}$$

where:

C_{pw} = concentration in potable water (μCi/cc)

C_{BRT} = concentration in boron recovery tank (μCi/cc)

λ = radioactive decay constant

t = total travel time to potable water

DF_{total} = total dilution factor

Calculated radionuclide concentrations as a result of this postulated spill are presented in Table 2.4.13-6 and are lower than 10CFR20 Appendix B Table II concentrations for water.

2.4.13.4 Monitoring of Safeguard Requirements

The equipment required for monitoring the groundwater in case of any radioactive spill will be a portion of that used for the radiological environmental monitoring program. This program is described in Section 13.3.4.3 of the PSAR.

2.4.13.5 Design Basis for Subsurface Hydrostatic Loading

Safety-related structures are designed for water pressure and buoyancy based upon a maximum groundwater level at plant grade, El. 610 ft. Site groundwater conditions are discussed in Sections 2.4.13.1.2 and 2.5.4.6.

2.4.14 Technical Specifications and Emergency Operation Requirements

Safety-related equipment is protected from the maximum postulated flood water levels as described in Section 3.4. Technical specifications and emergency procedures for plant shutdown related to hydrological events are not required.

REFERENCES

1. U.S. Department of the Interior, Federal Water Pollution Control Administration. Lake Michigan Bathymetric Charts, Great Lakes Region. Great Lakes-Illinois River Basins Project, Chicago, Illinois.

2. Haven Site - Sheboygan County Aerial Survey, Chicago Aerial Survey 2140 Wolf Road, Des Plaines, Illinois.

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TABLE 2.4.2-2

PROBABLE MAXIMUM RAINFALL INTENSITY AND DURATION (WINTER)

Duration	Intensity (In.)
48 hrs	18.4
24 hr	15.06
12 hr	11.96
6 hr	9.43
5 hr	8.72
4 hr	8.02
3 hr	7.16
2.5 hr	6.60
2 hr	6.13
1.5 hr	5.47
1 hr	4.62
0.5 hr	2.83
15 min	2.18
10 min	1.81
5 min	1.27

TABLE 2.4.3-1

AVERAGE AND MAXIMUM PRECIPITATION

Location	Average Annual Precip, Inches	Maximum Annual Precip, Inches	Maximum 24-hr Rainfall, Inches
Kenosha	29.86	41.84	3.55
Racine	31.90	48.33	4.00
Milwaukee	27.62	41.86	5.28
Shorewood	31.64	42.46	---
Port Washington	27.96	38.39	---
Sheboygan	29.27	40.14	4.55
Manitowoc	28.39	46.43	6.39
Two Rivers	28.65	41.17	---
Kewaunee	26.53	34.99	4.92
Sturgeon Bay	27.20	39.65	4.57
Green Bay	26.56	38.03	3.68
Washington Island	28.11	37.25	---

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SECTION 2.5 (CONT'D)

LIST OF FIGURES

SECTION 2.5 (CONT'D)

LIST OF FIGURES

States (Ref. 9), both published by the U.S. Geological Survey. Thwaites' delineation of the faults is based almost completely on differences in elevations of various formations as recorded in wells, assuming elevation differences to be faults and extending these down to the Precambrian.

Since Thwaites' Buried Precambrian Map of Wisconsin was published in 1931 and updated in 1957, additional well data have become available. In light of the availability of these new data, additional studies were conducted for the purpose of more clearly defining the extent of the postulated faulting and also for establishing the existence of these faults.

These studies consisted of a literature search of published and unpublished data, interviews with geologists currently active in the area, geomorphic studies, and structure contouring of the top of the Maquoketa Group, the St. Peter sandstone, and the Trempealeau Group. The structure map of the Maquoketa is shown on Fig. 2.5.1-9D. Only a portion of the structure map of the St. Peter, pertinent to faulting within 50 miles of the site, is shown on Fig. 2.5.1-9E. A complete structure map of the St. Peter sandstone and the top of the Trempealeau Group for southeast Wisconsin are shown on Figs. 2.5.1-9F and 9G, respectively.

The methods of conducting these studies and the general conclusions derived are discussed below. Faults within the area of investigation are discussed individually in the following paragraphs.

The structure contour map of the top of the Maquoketa Group was constructed from the analysis of about 200 drilled wells. The structure contour maps of the top of the St. Peter sandstone and the Trempealeau Group were constructed from approximately 800 data points. These data consisted principally of well records from the files of the Wisconsin Geological and Natural History Survey (Wisconsin Survey), the Private and Public Water Supply Sections of the Wisconsin Department of Natural Resources, and the Illinois State Geological Survey (Illinois Survey). The Wisconsin Survey also provided unpublished outcrop data for Dane County, Wisconsin and the preliminary results of unpublished faulting investigations immediately east of Madison (Yahara Hills Area).

Several thousand well records were examined and evaluated. The data used in constructing the structure contour maps represent the most reliable information available for those records. In most cases, this information consists of the elevations of formation contacts determined by geologists of the two state surveys. In areas where such data are sparse, interpretations from well drillers' logs were used to complement the more detailed geologic logs.

Geomorphic studies consisted of an examination of the 7 1/2 and 15-minute topographic quadrangles, delineation of lineaments present on Earth Resources Technology Satellite (ERTS) imagery, and low-level aerial reconnaissance by helicopter.

Analysis of topography depicted on quadrangles did not reveal any clear cut instances of surface expression of fault traces. Along portions of the Janesville (6) and Madison (7) faults, fault 5, and the North Branch of fault 3, there appears to be some correspondence of drainage courses with the trend of the faults. There is no evidence to suggest development of any post-Pleistocene faulting features such as scarps or lateral offset of Pleistocene land forms. Certainly there was adequate time for pre-Pleistocene erosion to establish major drainage courses along the weaker rocks of fault zones. It is equally plausible to expect some portions of these drainage courses to have survived glacial erosion and/or deposition in modified and subdued form. These older modified patterns have been integrated into the post-Pleistocene drainage pattern.

ERTS Photographs E-1359-16091 and E-5511-15172 were studied at scales of 1:1,000,000 and 1:250,000. The 1:1,000,000 scale was found to have sharper detail and was, therefore, more useful for this study. The study identified a great many linears. Of these, only linears greater than 5 miles in length are plotted on Fig. 2.5.1-28 and described in Table 2.5.1-3. Minor morainic features and drumlin fields were not plotted.

Lineations interpreted from ERTS imagery show strong glacial overprints in the form of moraines, moraine (Lobe) margins, drumlin trains and similar, linear glacial features. In addition, the regular north-south/east-west subdivisions of land areas tend to mask natural lineations with similar trends. A large number of linears found in the study region could be related to glacial features. Other linears shown on Fig. 2.5.1-28, numbered 5, 8, 20, 21, 22, 23, 24, 25, 26, 35, 46, 56, 73, and 75 approximately parallel the strike of bedrock and may represent indistinct erosional cuestas. Linears 1, 2, 3, 6, 10, 11, 14, and 15 on the Door Peninsula do not follow the trend of glacial related linears or bedrock strike, but may reflect jointing or fracturing in the bedrock. There are lineations which correspond approximately to the trends of the Janesville (6) and Madison (7) faults. These are considered to reflect pre-Pleistocene erosional features as previously discussed. It is also possible that they may reflect surficial effects of localized groundwater anomalies caused by increased permeability along fault/jointing zones. No disturbance of Pleistocene glacial features was noted.

A study of regional geomorphic lineaments and their origin using LANDSAT (ERTS) imagery has been conducted by Saunders and Hicks and has identified eleven sets of lineaments throughout the continental United States (Ref. 203). They conclude that the major lineament set trending ESE originated during the early Precambrian in conjunction with a sea floor spreading event. Subsequent changes in crustal stresses were responsible for the development of the ten remaining lineament sets. The last stress change occurred during the Early Mesozoic.

The proposed origin of these lineament sets does not conflict with the geologic studies conducted for the Haven site and are in general agreement with the current theories of plate tectonics and presumed mantle convection patterns (Ref. 203).

Of the lineaments mapped by Saunders and Hicks, only the Lake Michigan lineament passes close to the site. Its location coincides with the west shore of Lake Michigan, north of Milwaukee, and apparently is related to the lake-shore bluff that developed as a result of shoreline recession. Lineaments such as the Green Bay and Racine lineaments are coincidental with smaller lineaments 23, 35, 94, and 96 shown on Fig. 2.5.1-28. Other lineaments mapped by Saunders and Hicks in the area of the site are not evident on Fig. 2.5.1-28.

Aerial reconnaissance of the Madison fault (7), the Janesville fault (6), the Waukesha fault (3), and fault 5 was flown, using a helicopter and an average flight height of 1,500 feet. No instances of disturbance of Pleistocene deposits along fault trends were noted. The location of the Waukesha Quarry fault (3A) was closely examined. It also had no surface expressions in the overlying soil materials. It is concluded from geomorphic evidence that movements on faults within the area must be a minimum of pre-Wisconsinan in age.

Where surface outcrops of faults could be located, radiometric dating of the gouge was attempted. The mineralogy of the sedimentary rocks of the area does not typically include radiometrically datable species and the lack of major tectonism provides no readily identifiable heating events. Gouges are typically granulated wall rock, either unaltered or modified by surficial or near surface weathering. Secondary mineralization, where present, typically consists of deposits left by downward percolating groundwater.

Two samples of gouge material were obtained from fault 3A for potential radiometric age dating. The locations and radiometric ages of the samples are shown in Table 2.5.1-2A. The mineralogical composition of the gouge samples is shown in Table 2.5.1-2B.

The contact between the Ordovician Maquoketa Group and the Silurian Niagaran dolomite was chosen for structure contouring because it is the youngest reliable horizon present over much of the area in the site vicinity. The contact (top) of the Maquoketa Group is conformable with the overlying Mayville Formation in Sheboygan County (Ref. 153). This contact should reflect any post-Ordovician deformation. Over 500 well logs were examined; however, relatively few wells penetrate the Maquoketa bedrock because it generally occurs more than 400 ft below ground surface. Clusters of deep wells do exist in many towns south and west of the site. Very little well data are available for correlation north of the site.

In the area contoured, the Niagaran dolomite occurs as a north-south trending belt about 35 miles wide. On the western border of the area the Silurian strata have been eroded and the Maquoketa is overlain by Pleistocene deposits. No data are available on the Silurian-Ordovician contact east of the site (beneath Lake Michigan).

Two anomalously low points at the top of the Maquoketa are located over 40 miles from the site in southern Ozaukee County. These low points trend northeast-southwest (Fig. 2.5.1-9D). The contours of the top of the underlying Galena limestone show a similar trend (Ref. 153).

The top of the St. Peter sandstone was chosen for contouring because it is the youngest reliable horizon present west of the Maquoketa study area. The contact (top) of the St. Peter with the overlying Platteville Formation is unconformable but a flat gently dipping surface would provide contrast for recognition of either faulting or erosional modification of the contoured surface. Because of its relatively shallow depth in the area contoured, a large number of wells penetrate the St. Peter and afford good control. The St. Peter/Platteville contact is continuous over the study area except in the northwestern corner where streams have eroded the contact from their valleys. Even in this region a sufficient extent of erosional remnants remains to provide good control.

The top of the Trempealeau Group (Jordan Formation) was contoured principally as a check on the results of the St. Peter contouring. In addition, its lower stratigraphic position afforded more continuous control in the northwestern portion of the study area. A portion of the structure contour map of the top of the St. Peter sandstone is shown on Fig. 2.5.1-9E. A complete structure map of the St. Peter in southeast Wisconsin is shown on Fig. 2.5.1-9F.

Appleton Fault (Fault 1)

The Appleton fault, as described by Thwaites (Ref. 116), is composed of two segments, each with a different trend. One portion trends southwest from Lake Michigan to southeastern Brown County. Another portion of the fault extends from this point essentially west to southwestern Waupaca County. However, recent work in the area by geologists at Lawrence University in Appleton indicates that there is no evidence for the fault (Ross, 1973, oral communication).

Thwaites (Refs. 116, 117, 118) indicates that faults occur in Precambrian and Paleozoic rocks in the Green Bay and Door Peninsula area. These faults include the Green Bay and Appleton faults, the postulated locations of which are shown on Fig. 2.5.1-9B. Little evidence for this interpretation exists in these publications. The 1957 publication is a map titled "Buried Precambrian of Wisconsin" and is a diagrammatic map of the state at a contour interval of 100 feet and a scale of 1:2,500,000. No text accompanies the map which is based on well data obtained from Thwaites' previous studies. Faults indicated in the 1940 and 1931 publications are also drawn on the Precambrian surface and all data were obtained from driller's records and well logs.

One other fault in the Green Bay-Door Peninsula area reported by Thwaites and Bertrand (Ref. 117) is based on records of two wells at Algoma drilled 200 feet apart. From these two data points, a fault, which is the eastern part of the Appleton fault, is mapped for a distance of 35 miles and extends from approximately 9 miles offshore in Lake Michigan, through Kewaunee County and into Brown County for 6 miles. The only information on the nature of the fault is that it strikes north of east and the southeast side is downthrown. The amount of displacement is not given for either fault.

Thwaites' postulated faults north of Two Rivers (Ref. 116) were discounted by Thwaites and Bertrand (Ref. 117). They state that the original conclusion was based on a driller's log of an old well in Two Rivers which does not check with newer wells nearby. They therefore concluded that no such faults exist in the vicinity of Two Rivers.

Thwaites and Bertrand (Ref. 117) also recognized that reef structures in the Silurian rocks of the Green Bay and Door Peninsula area are difficult to distinguish from faults. They stated the following:

No detailed gravity or magnetic studies have been made of the Janesville area of Rock County. Present regional gravity maps (Refs. 133, 41) and regional magnetic maps (Ref. 37) are too small scale to define specific bedrock configurations. Seismic profiles have not been conducted across Rock County to delineate subsurface information (Ostrom, 1974, personal communication).

Based on structure contours of the top of the St. Peter sandstone, the Janesville fault is shown to extend from 42°44'N, 88°40'W to beyond 42°42'N, 89°50'W. Thwaites (Ref. 117) extended the fault over a distance of 72 miles, an additional 14 miles west of the area contoured. The results of this study correspond closely to Thwaites' determination of the Janesville fault; thus it is reasonable to extend the fault over the entire 72 miles. The strike of the fault varies within about ±10 deg, but averages N86°E. The available well data are not sufficiently closely spaced to allow an accurate determination of dip; the dip direction is northerly and the trace of the fault plane across contours suggests a steep dip angle. Vertical displacement at the top of the St. Peter sandstone is about 100 feet, with the north side downthrown.

Definition of the Janesville fault is provided by approximately 10 wells. Extension of the fault eastward beyond 89°00'W is somewhat speculative since there are few wells in that area.

Supplemental to low-level aerial reconnaissance by helicoptor and examination of topographic quadrangles, an air photo study and field reconnaissance were made along the trend of the Janesville fault.

Aerial photographs (1 to 62,500 scale) were studied along the fault trend from 10 miles east to 20 miles west of Lake Koshkonong. No geomorphic evidence of the fault was found by analysis of the aerial photographs.

A field reconnaissance was made of the Janesville fault area for a distance of about 50 miles, extending eastward from Argyle to Milton. The reconnaissance concentrated on rock outcrops in road cuts and quarries throughout the study area. No exposures of faults were found.

Heyl (1975, oral communication), while working in the lead-zinc district of southwestern Wisconsin, checked the mines and quarries for an extension of the Janesville fault into this area, but found none. He did observe evidence of folding. Heyl also investigated the area of the Janesville fault as located by Thwaites, and found no surface expression of the fault.

Contacts with geologists knowledgeable of the geology of southern Wisconsin, regarding faulting in the area, revealed no new information on the extent or age of faulting.

The age of the Janesville fault is considered to be post-Devonian to pre-Cretaceous, based on regional considerations (Ostrom, 1975 personal communication) and the lack of geomorphic expression. There are no macro-seismic earthquakes associated with the fault.

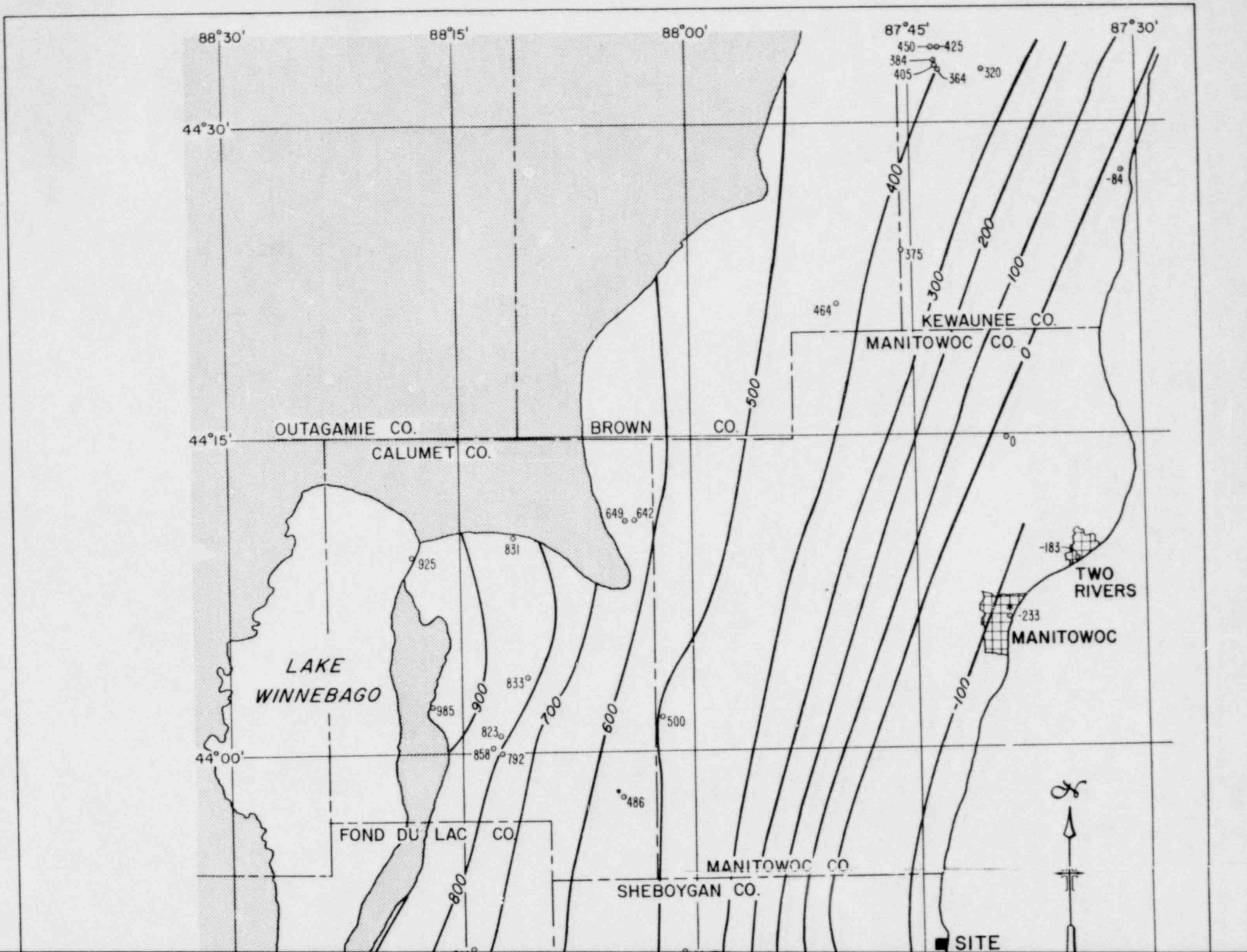
Madison Fault (Fault 7)

The Madison fault extends from 42°58.5'N, 89°04'W to 42°57'N, 89°52'W, a distance of about 41 miles. Thwaites (Ref. 117) showed a length of about 36 miles; the additional length suggested by structure contours of the top of the St. Peter sandstone is a westward extension of the previously mapped location. The strike of the fault along its eastern half averages east-west changing to N82°E along the western portion. Available well data for this fault are the best of any in this investigation. The dip of the Madison fault is essentially vertical, with occasional local variations that favor steep southerly dips. Maximum vertical displacement is approximately 40 feet, with the north side downthrown. Some data indicate as much as 100 feet of localized displacement.

About 25 wells, all of them logged by geologists, served to define the contours in the area of the Madison fault. A portion of this fault is in the Yahara Hills area currently under investigation by the Wisconsin Survey. The results of this study and the preliminary results of the Wisconsin Survey investigation agree closely.

A number of faults reported in Dane County do not appear equivalent to the Madison Fault as mapped by Thwaites. Several faults have been found or inferred as the result of recent geologic investigations by the Wisconsin Geological Survey in the Madison area. These include faults exposed in a roadcut west of the village of Mt. Vernon, and faults at the Yahara Hills golf course, east of Madison, which have been inferred from water well data. Anomalies in elevations of formation contacts in water wells and of formations in outcrops have suggested faults at various other locations in the Madison area.

According to Ostrom (oral communication, November 1974), there is little doubt as to the validity of the data that indicate the existence of these faults in the Madison area. However, the inferred faults are covered by overburden and available surface data are insufficient to establish their orientation or length. No gravity, magnetic or seismic surveys of Dane County exist other than the regional magnetic map (Ref. 37), and gravity maps (Refs. 133 and 41) which are too small scale to define faults.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CALUMET CO.
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SHEBOYGAN CO.
LAKE WINNEBAGO
TWO RIVERS
MANITOWOC
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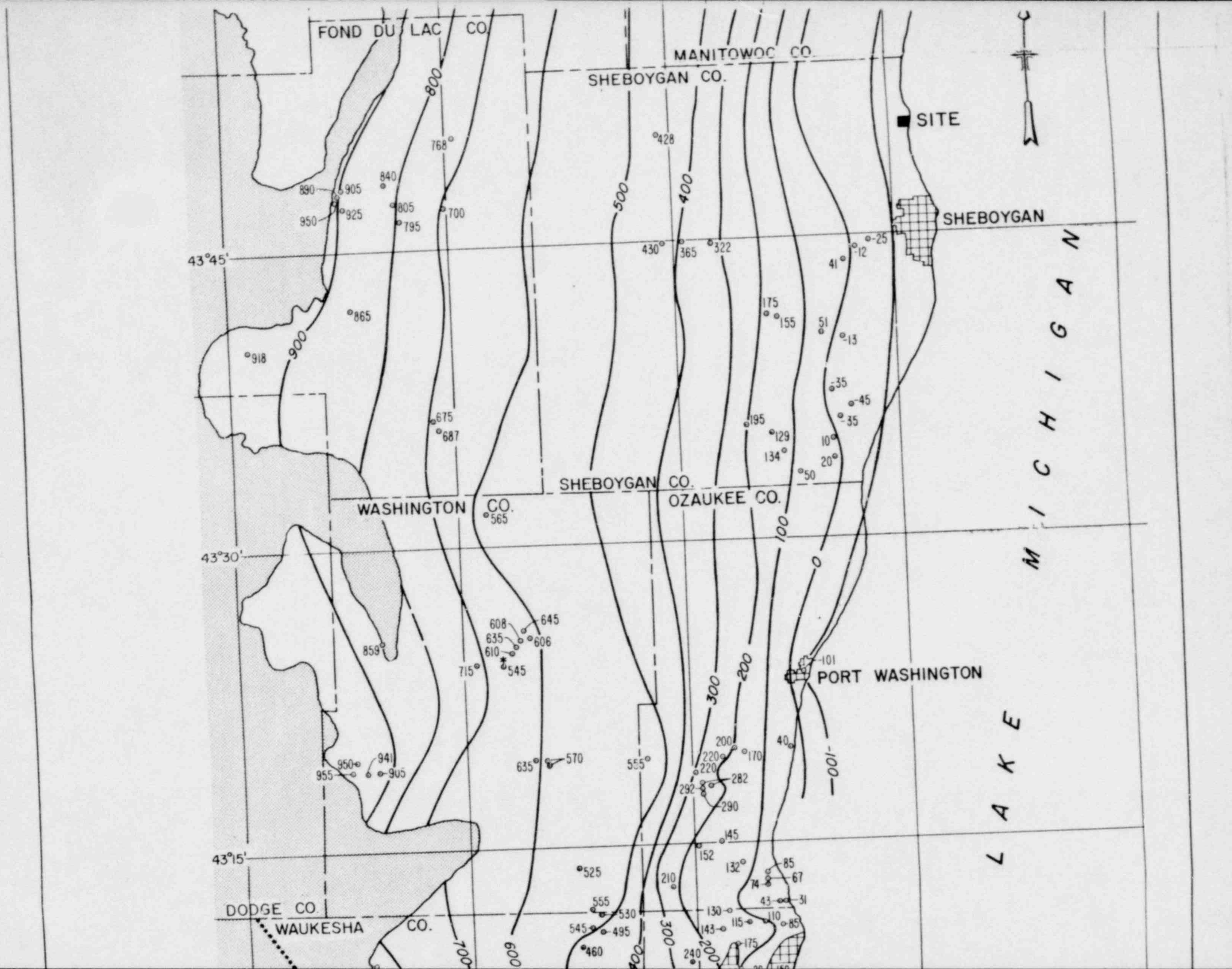
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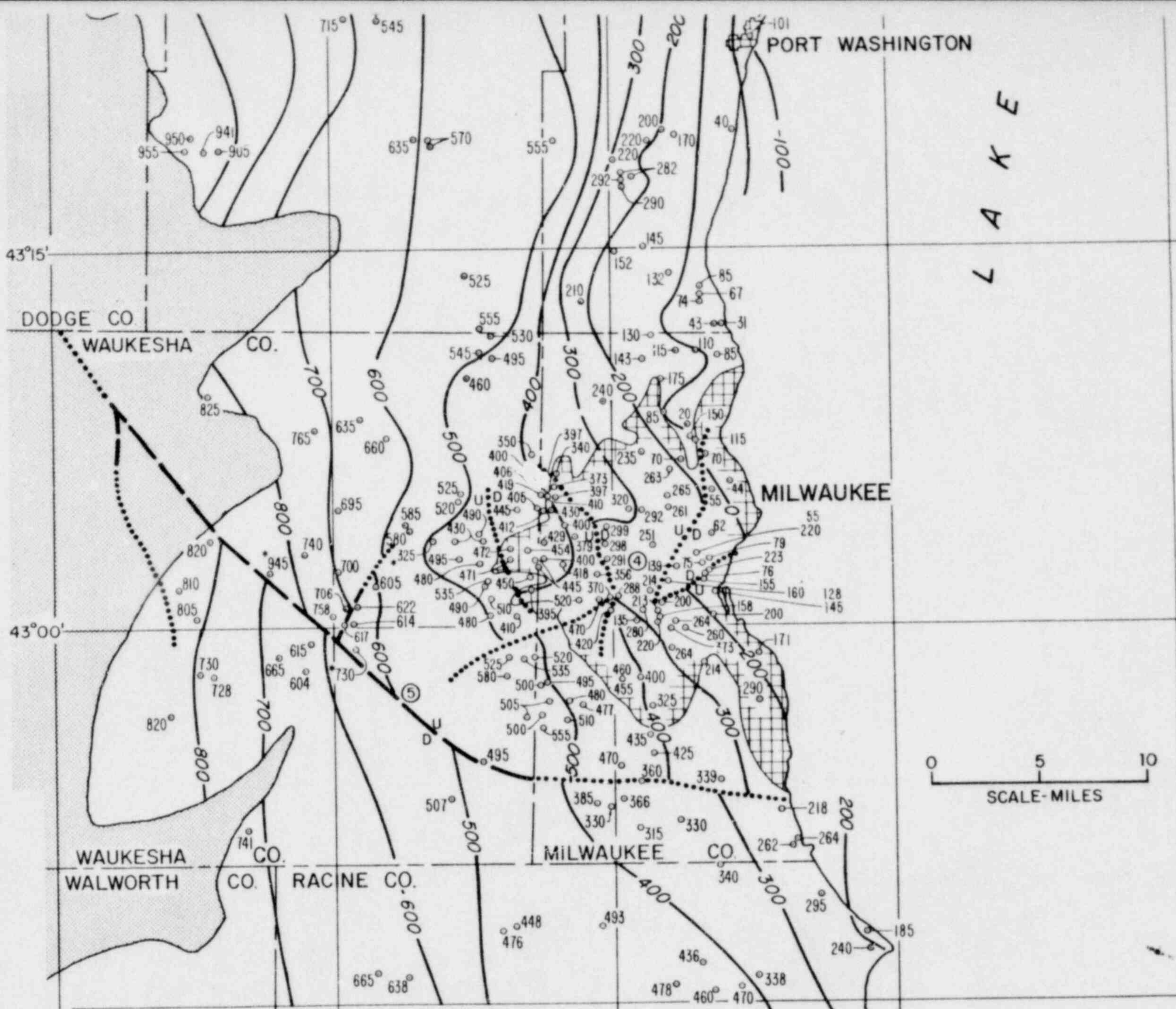


EXPLANATION

- ∘195 WELL LOCATION AND ELEVATION OF TOP OF MAQUOKETA
- —400— CONTOUR LINES — CONTOUR INTERVAL 100 FT.
- DASHED LINE DENOTES PROBABLE FAULT
- DOTTED LINE DENOTES POSSIBLE FAULT
- ⑤ NUMBERS REFER TO DETAILED FAULT DESCRIPTION IN TEXT

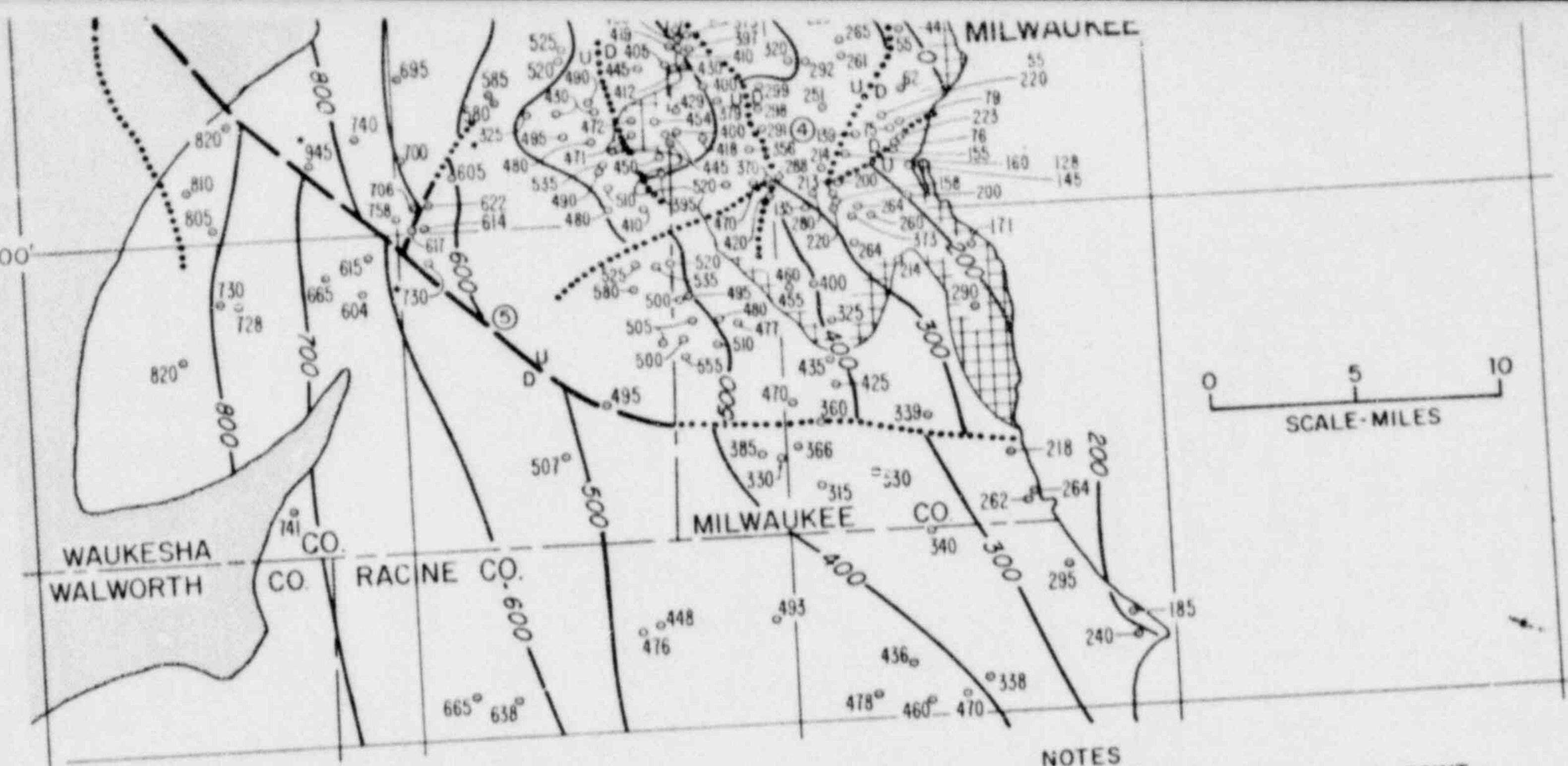
NOTES

*DENOTES ANOMALOUS DATA POINT NOT CONTOURED

OTHER ANOMALOUS DATA POINTS WITHIN MILWAUKEE CITY LIMITS ALSO NOT CONTOURED

DATUM-MEAN SEA LEVEL

HAVEN NUCLEAR PLANT
FIGURE 2.5.1-9D
STRUCTURE CONTOURS
TOP OF THE MAQUOKETA FORMAT
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REP
AMEND



EXPLANATION

195 WELL LOCATION AND ELEVATION OF TOP OF MAQUOKETA

400 CONTOUR LINES — CONTOUR INTERVAL 100 FT

DASHED LINE DENOTES PROBABLE FAULT
DOTTED LINE DENOTES POSSIBLE FAULT

⑤ NUMBERS REFER TO DETAILED FAULT DESCRIPTION IN TEXT

AREA IN WHICH THE MAQUOKETA IS ERODED

NOTES

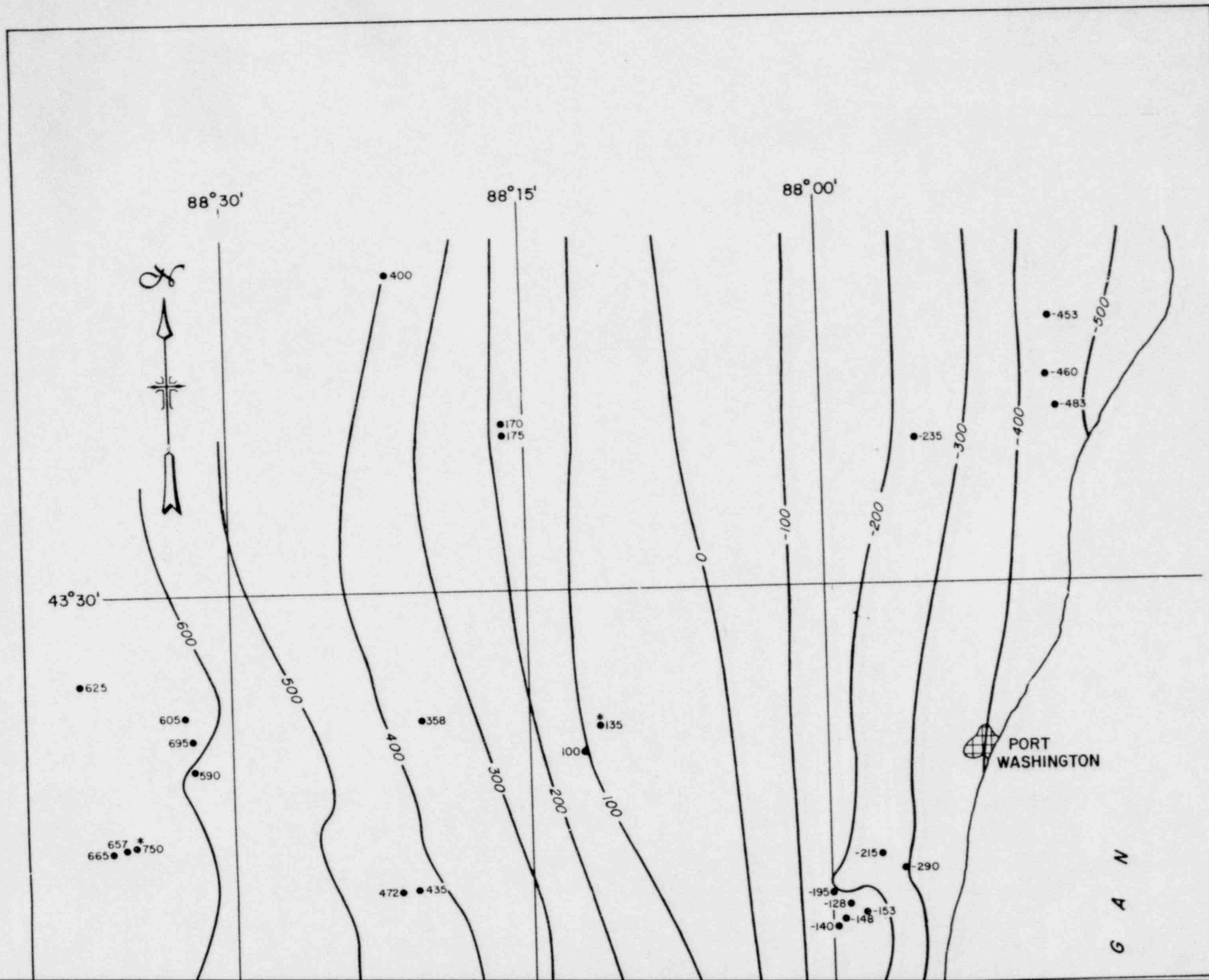
*DENOTES ANOMALOUS DATA POINT NOT CONTOURED

OTHER ANOMALOUS DATA POINTS WITHIN MILWAUKEE CITY LIMITS ALSO NOT CONTOURED

DATUM-MEAN SEA LEVEL

HAVEN NUCLEAR PLANT
FIGURE 2.5.1-9D
STRUTURE CONTOURS
TOP OF THE MAQUOKETA FORMATION
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

AMENDMENT 20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695
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657
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750
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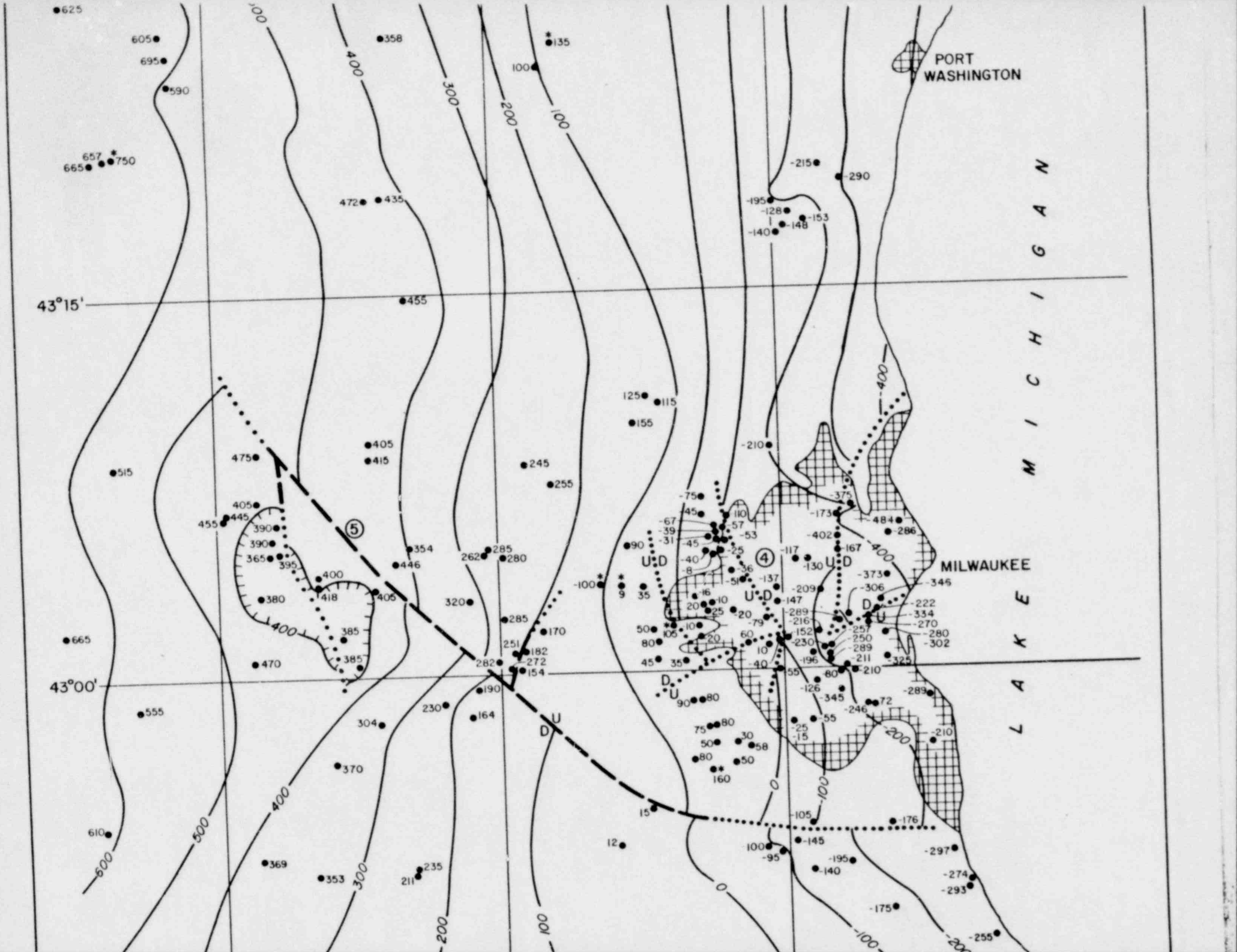
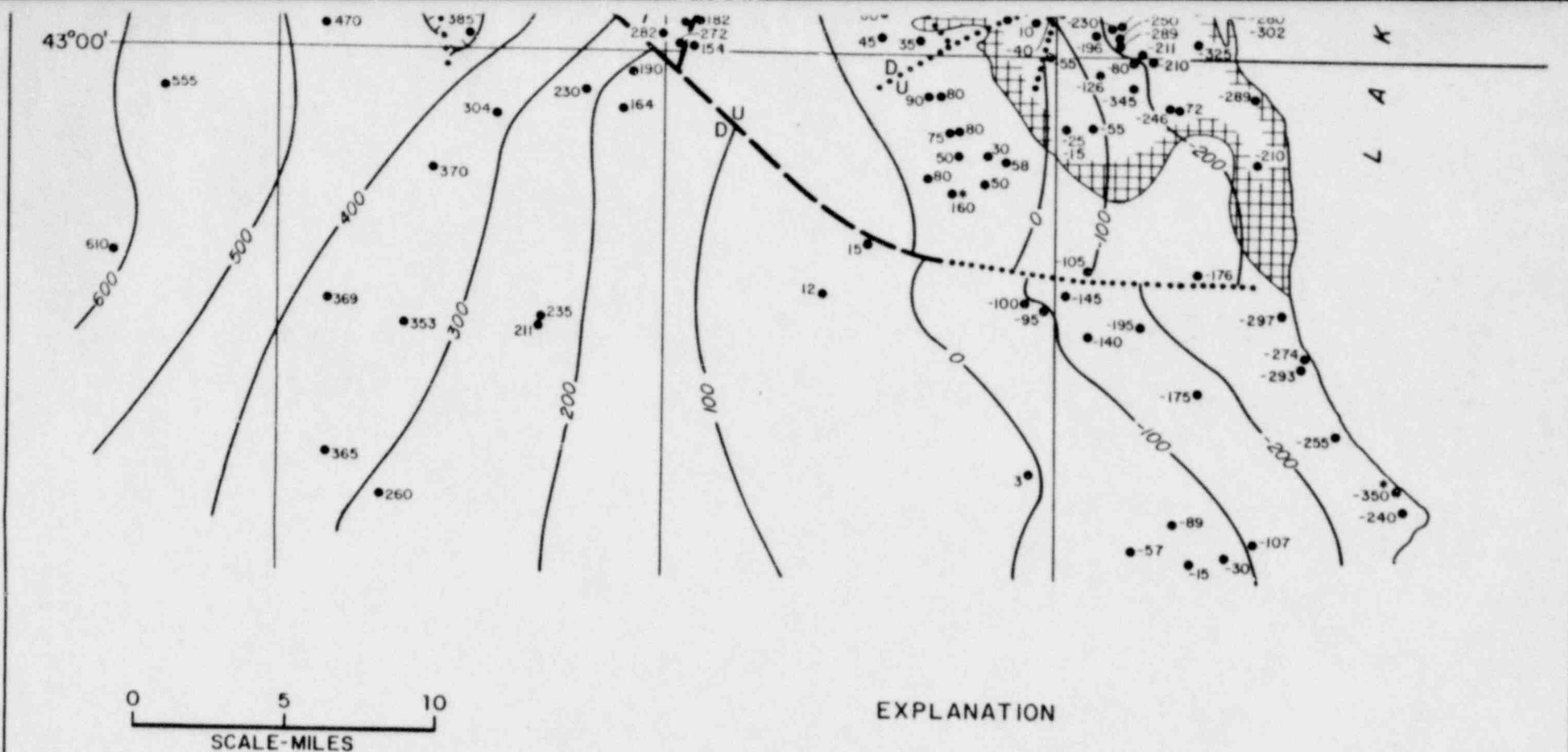
-148
-140


PORT WASHINGTON
MILWAUKEE
LAKE MICHIGAN
43°15'
43°00'



EXPLANATION

•245 WELL LOCATION AND ELEVATION OF TOP OF THE ST. PETER SANDSTONE

—200— CONTOUR LINES – CONTOUR INTERVAL 100 FT.

④ FAULTS - DASHED LINE WHERE PROBABLE FAULT; DOTTED LINE WHERE POSSIBLE FAULT OR FOLD. NUMBERS REFER TO DETAILED DESCRIPTION IN TEXT

CITY LIMITS

NOTE:

• DENOTES ANOMALOUS DATA POINT, NOT CONTOURED OTHER ANOMALOUS DATA POINTS WITHIN MILWAUKEE CITY LIMITS ALSO NOT CONTOURED

DATUM - MEAN SEA LEVEL

HAVEN NUCLEAR PLA
FIGURE 2.5.1-9E
STRUCTURE CONTOUR
THE ST. PETER SANDS
WISCONSIN UTILITIES PRO
PRELIMINARY SAFETY A

FAULTS - DASHED LINE WHERE PROBABLE FAULT; DOTTED LINE WHERE POSSIBLE FAULT OR FOLD. NUMBERS REFER TO DETAILED DESCRIPTION IN TEXT

CITY LIMITS

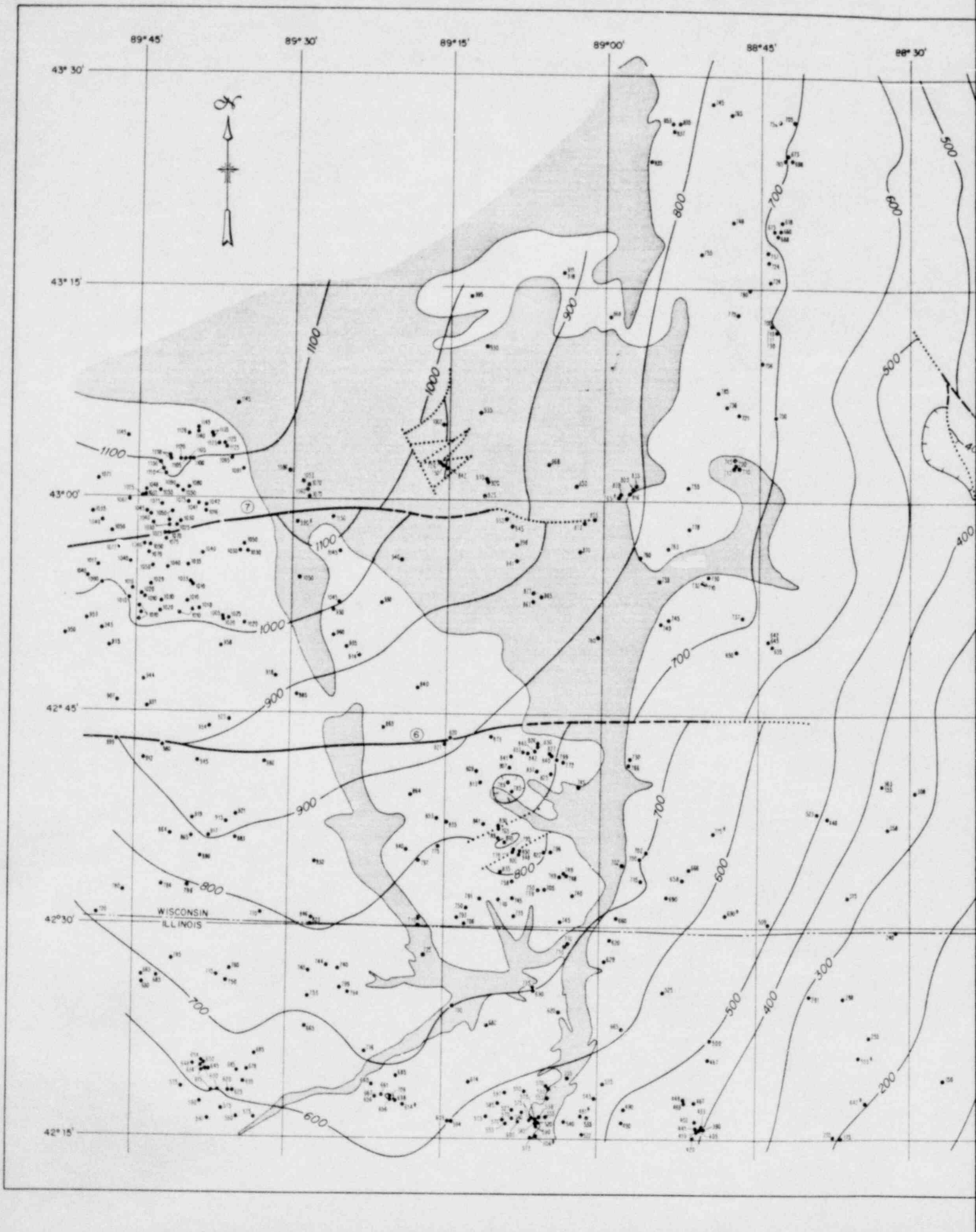
NOTE:

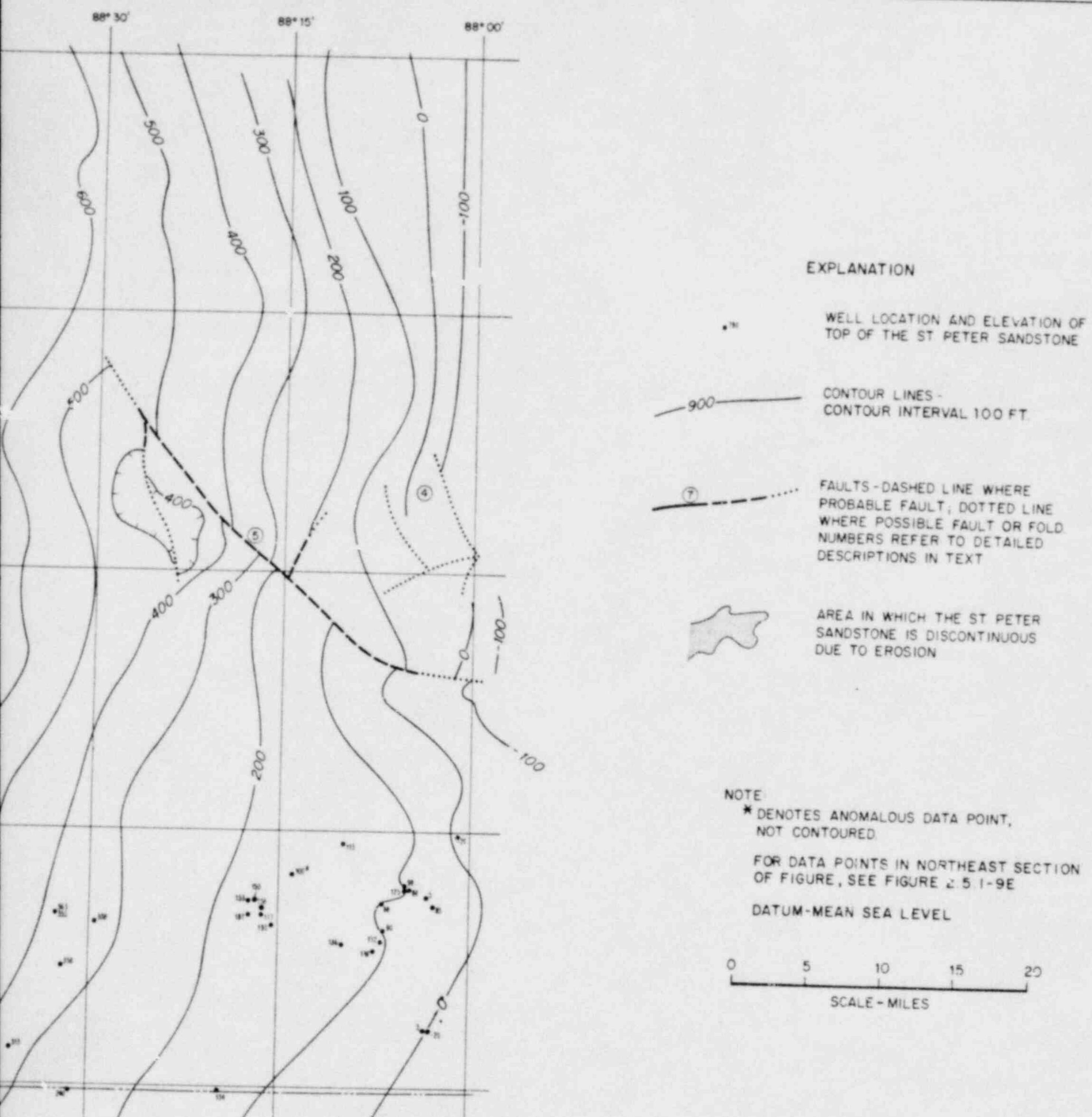
* DENOTES ANOMALOUS DATA POINT, NOT CONTOURED OTHER ANOMALOUS DATA POINTS WITHIN MILWAUKEE CITY LIMITS ALSO NOT CONTOURED

DATUM - MEAN SEA LEVEL

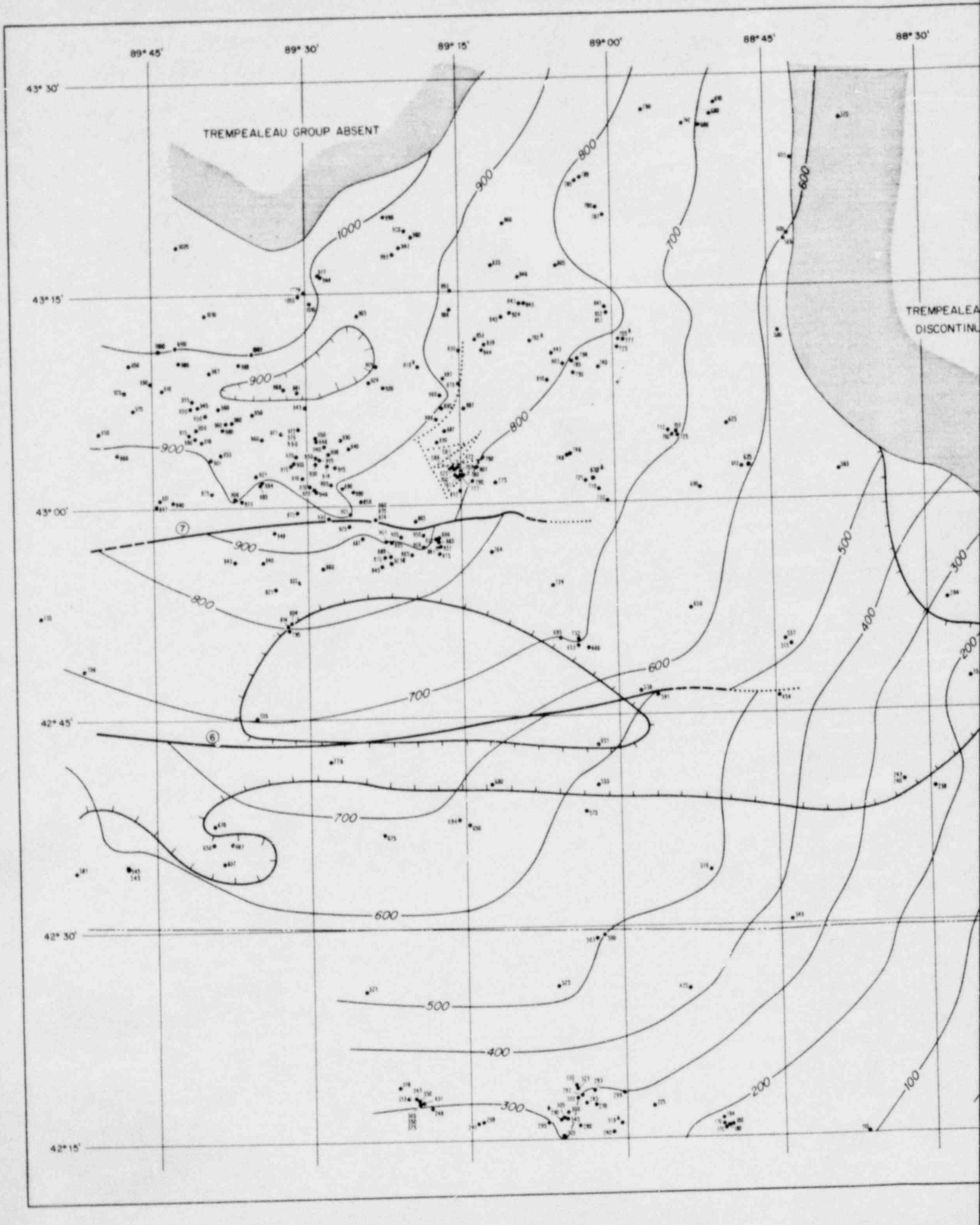
HAVEN NUCLEAR PLANT
FIGURE 2.5.1-9E
STRUCTURE CONTOURS - TOP OF THE ST. PETER SANDSTONE
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

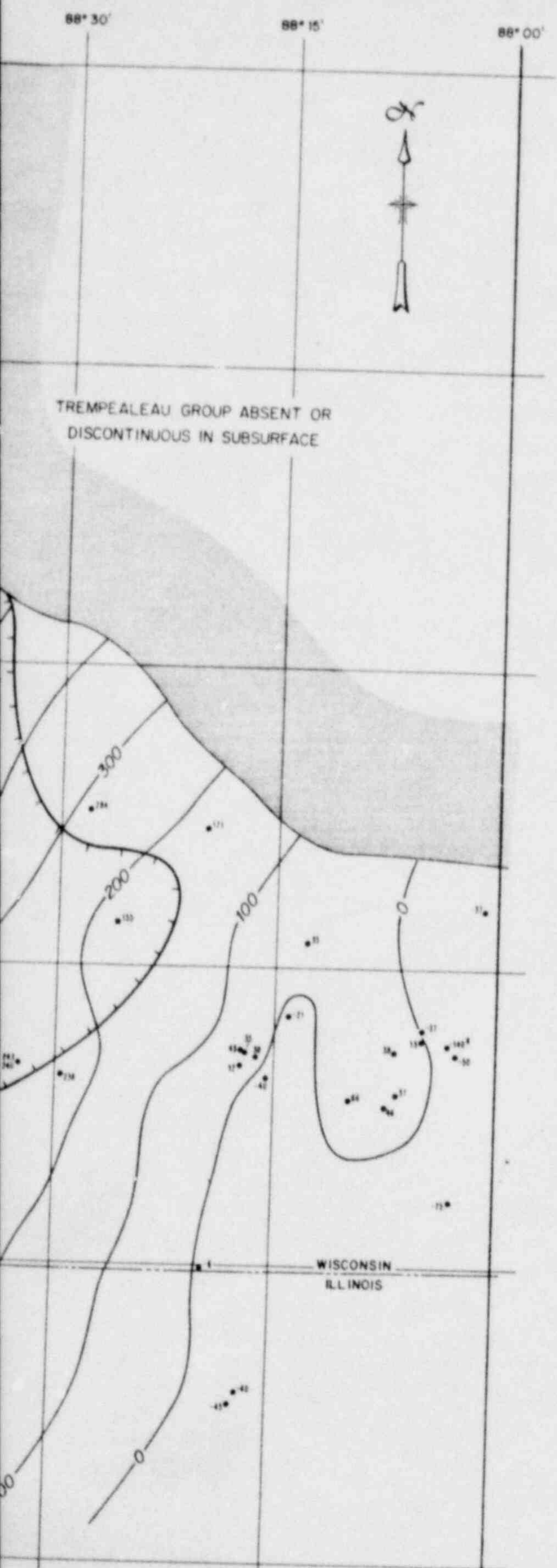
AMENDMENT 20


89° 45'
89° 30'
89° 15'
89° 00'
88° 45'
88° 30'
43° 30'
43° 15'
43° 00'
42° 45'
42°30'
42° 15'
WISCONSIN
ILLINOIS
1100
1000
900
800
700
600
500
400
300
200
7
6



HAVEN NUCLEAR PLANT
FIGURE 2.5.1-9F
STRUCTURE CONTOURS - TOP OF THE ST. PETER SANDSTONE
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT


89° 45'
89° 30'
89° 15'
89° 00'
88° 45'
88° 30'
43° 30'
43° 15'
43° 00'
42° 45'
42° 30'
42° 15'
TREMPEALEAU GROUP ABSENT
TREMPEALEA
DISCONTINU
1000
900
800
700
600
500
400
300
200
100
⑦
⑥



EXPLANATION

WELL LOCATION AND ELEVATION OF TOP OF THE TREMPEALEAU GROUP

900 CONTOUR LINES — CONTOUR INTERVAL 100 FT

FAULTS - DASHED LINE WHERE PROBABLE FAULT; DOTTED LINE WHERE POSSIBLE FAULT OR FOLD. NUMBERS REFER TO DETAILED DESCRIPTIONS IN TEXT

TREMPEALEAU GROUP CONFORMABLY (?) OVERLAIN BY PRAIRIE DU CHIEN GROUP

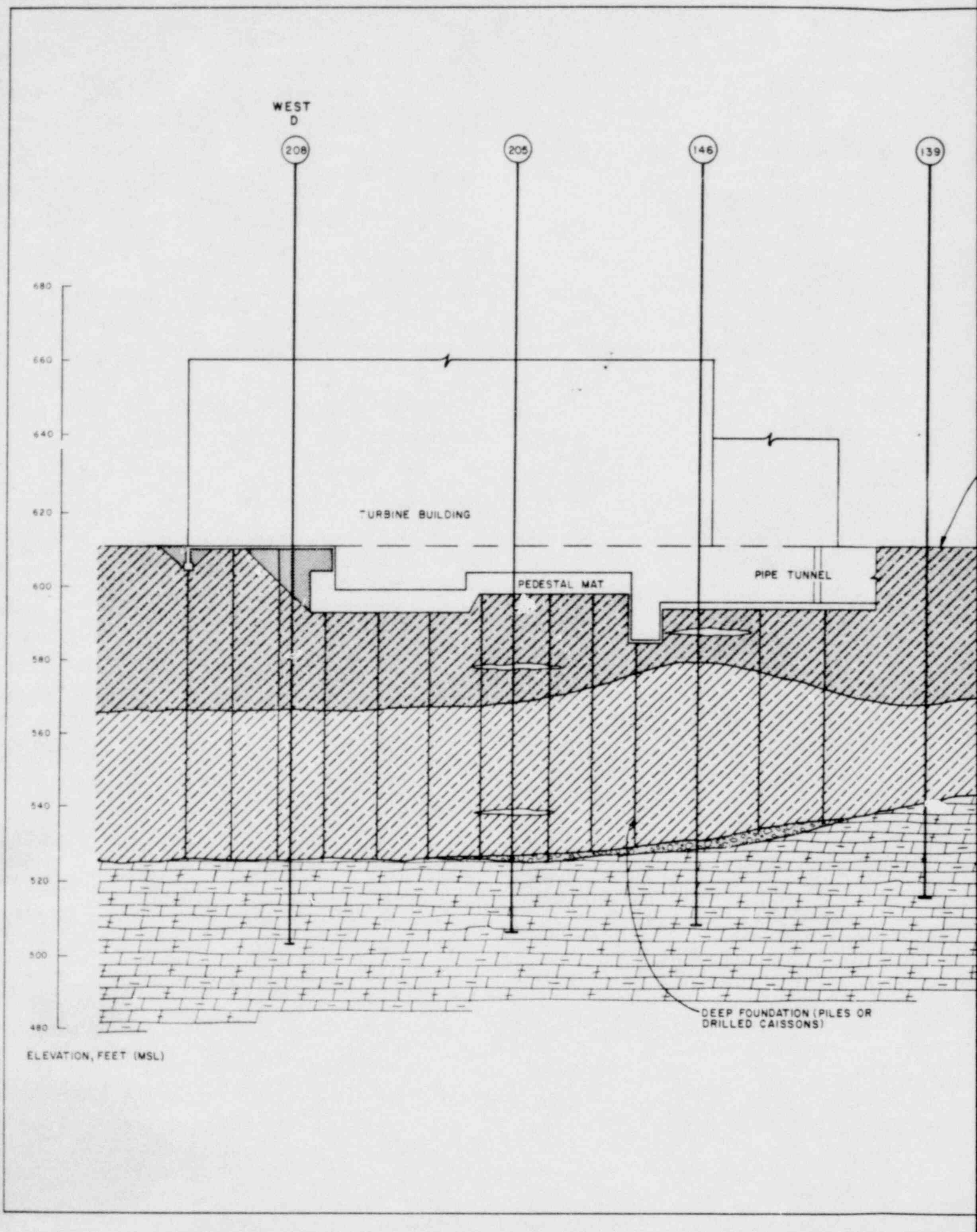
TREMPEALEAU GROUP UNCONFORMABLY OVERLAIN BY ANCELL GROUP

NOTE:
* DENOTES ANOMALOUS DATA POINT, NOT CONTOURED.

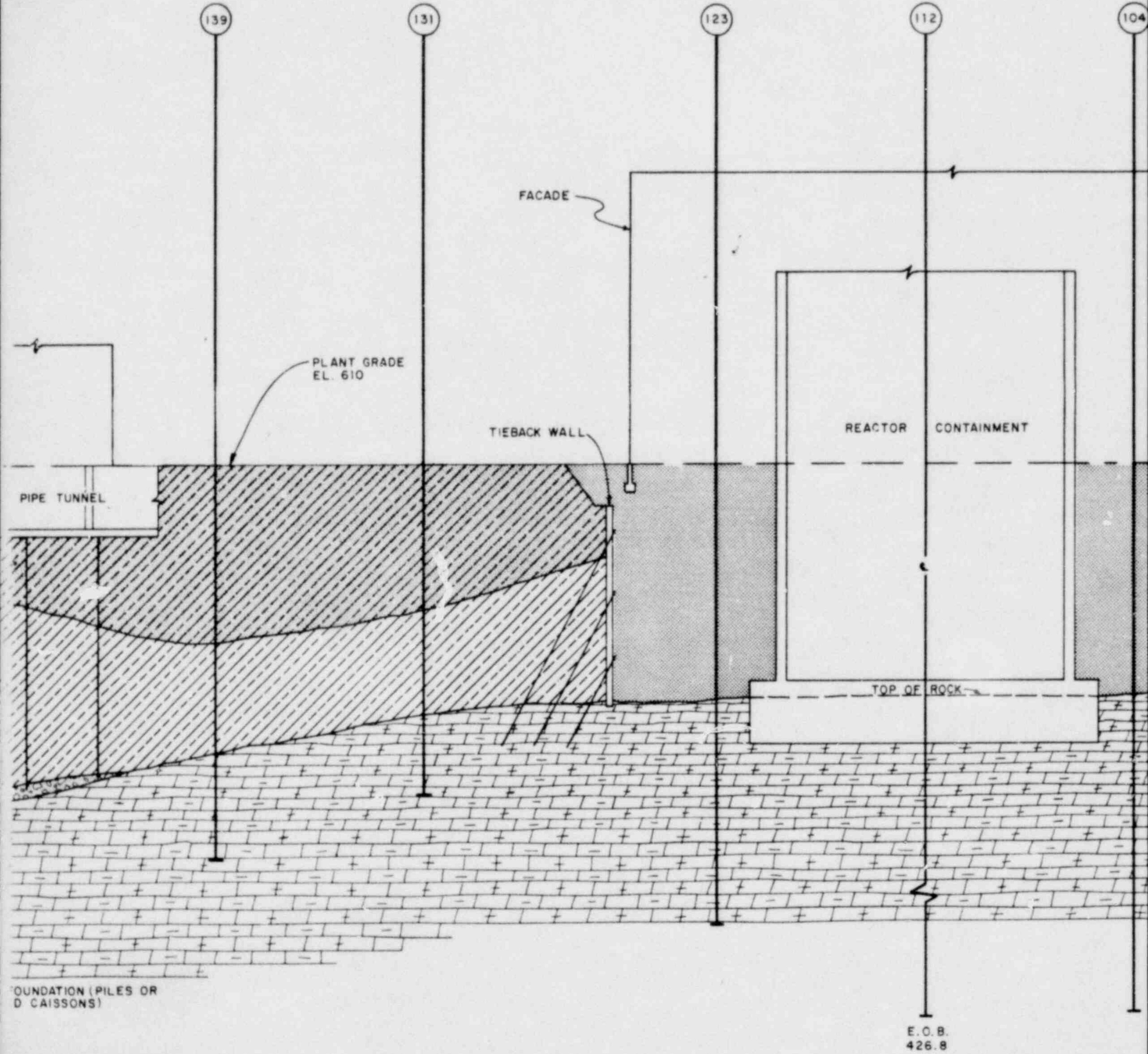
DATUM - MEAN SEA LEVEL

0 5 10 15 20
SCALE - MILES

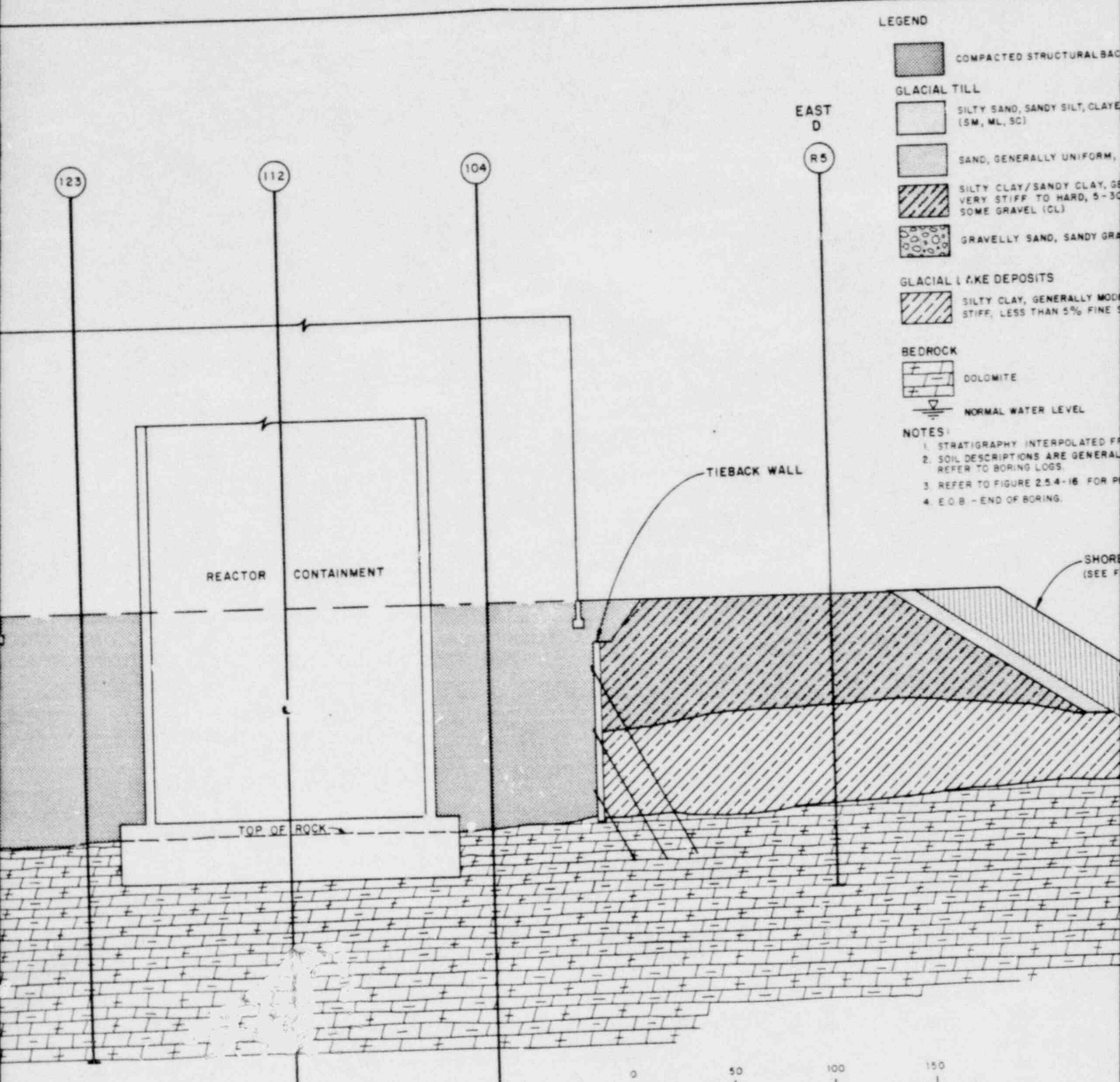
HAVEN NUCLEAR PLANT
FIGURE 2.5.1-9G
STRUCTURE CONTOURS - TOP OF THE TREMPEALEAU GROUP (JORDAN FORMATION)
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT



WEST
D
208
205
146
139
680
660
640
620
600
580
560
540
520
500
480
TURBINE BUILDING
PEDESTAL MAT
PIPE TUNNEL
DEEP FOUNDATION (PILES OR
DRILLED CAISSONS)
ELEVATION, FEET (MSL)



139
131
123
112
104
FACADE
PLANT GRADE
EL. 610
TIEBACK WALL
REACTOR CONTAINMENT
PIPE TUNNEL
TOP OF ROCK
OUNDATION (PILES OR
D CAISSONS)
E.O.B.
426.8



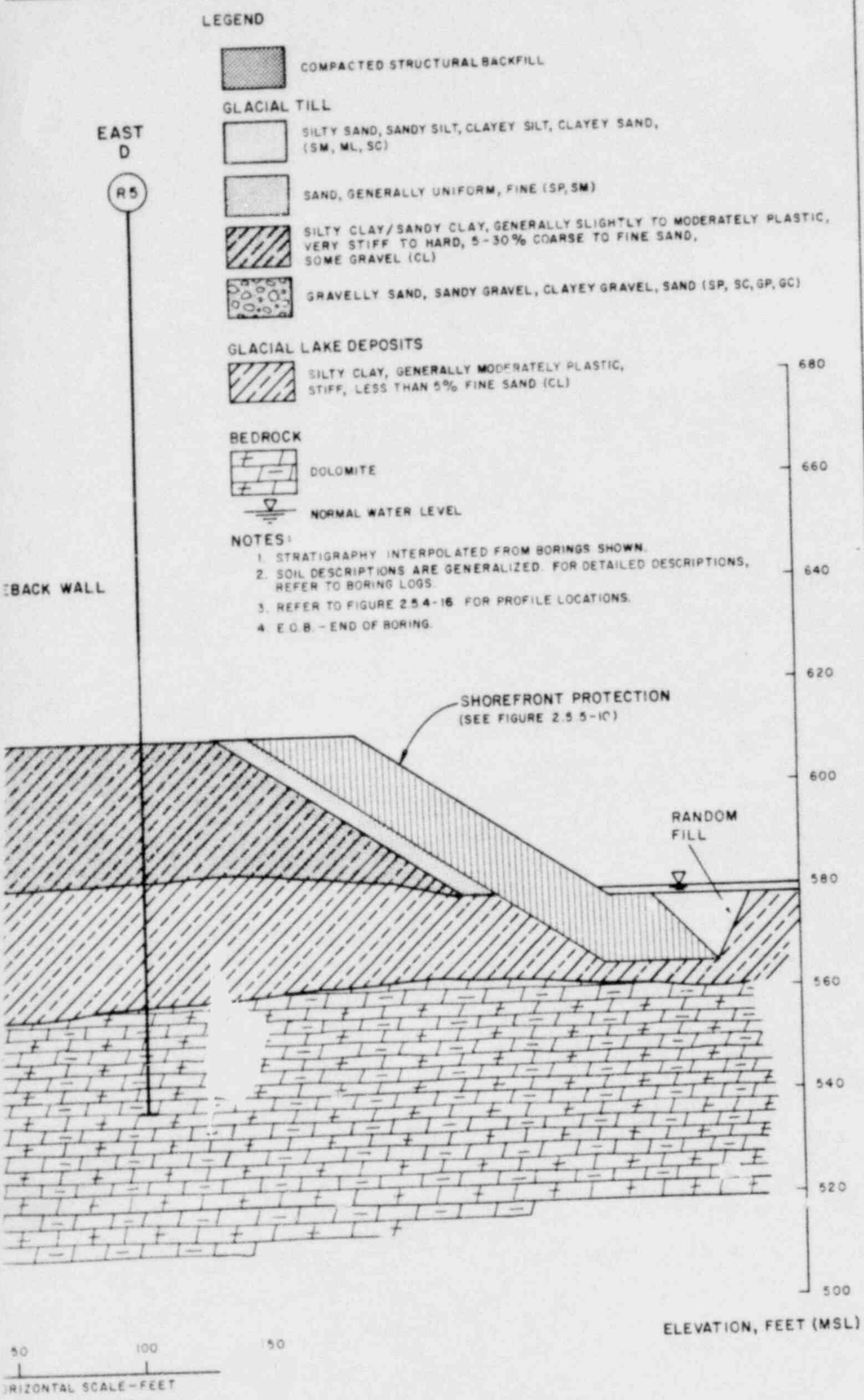
HAVEN N

FIGURE ?.5

SITE EXC

WISCONSIN

PRELIMINAR



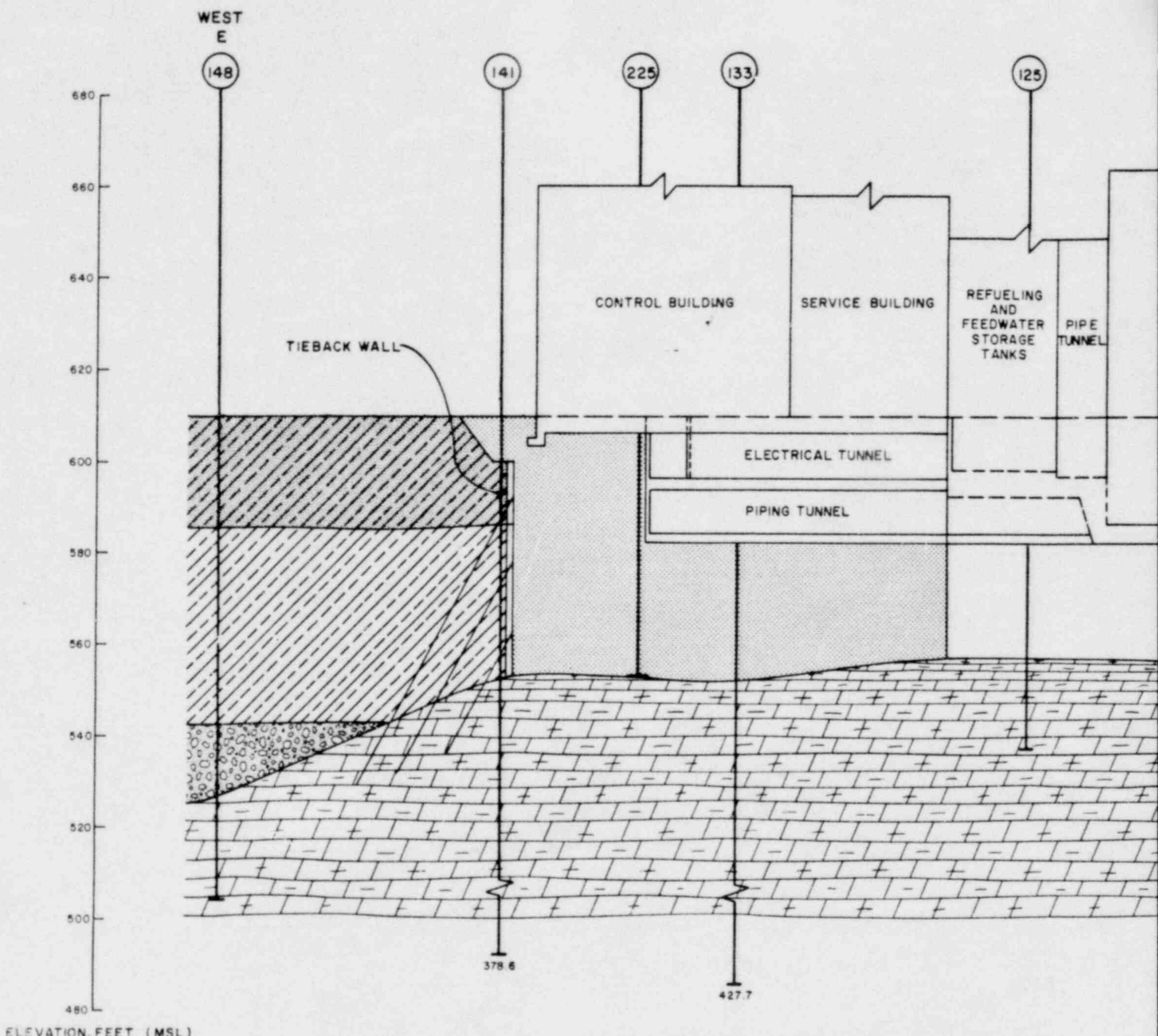
HAVEN NUCLEAR PLANT

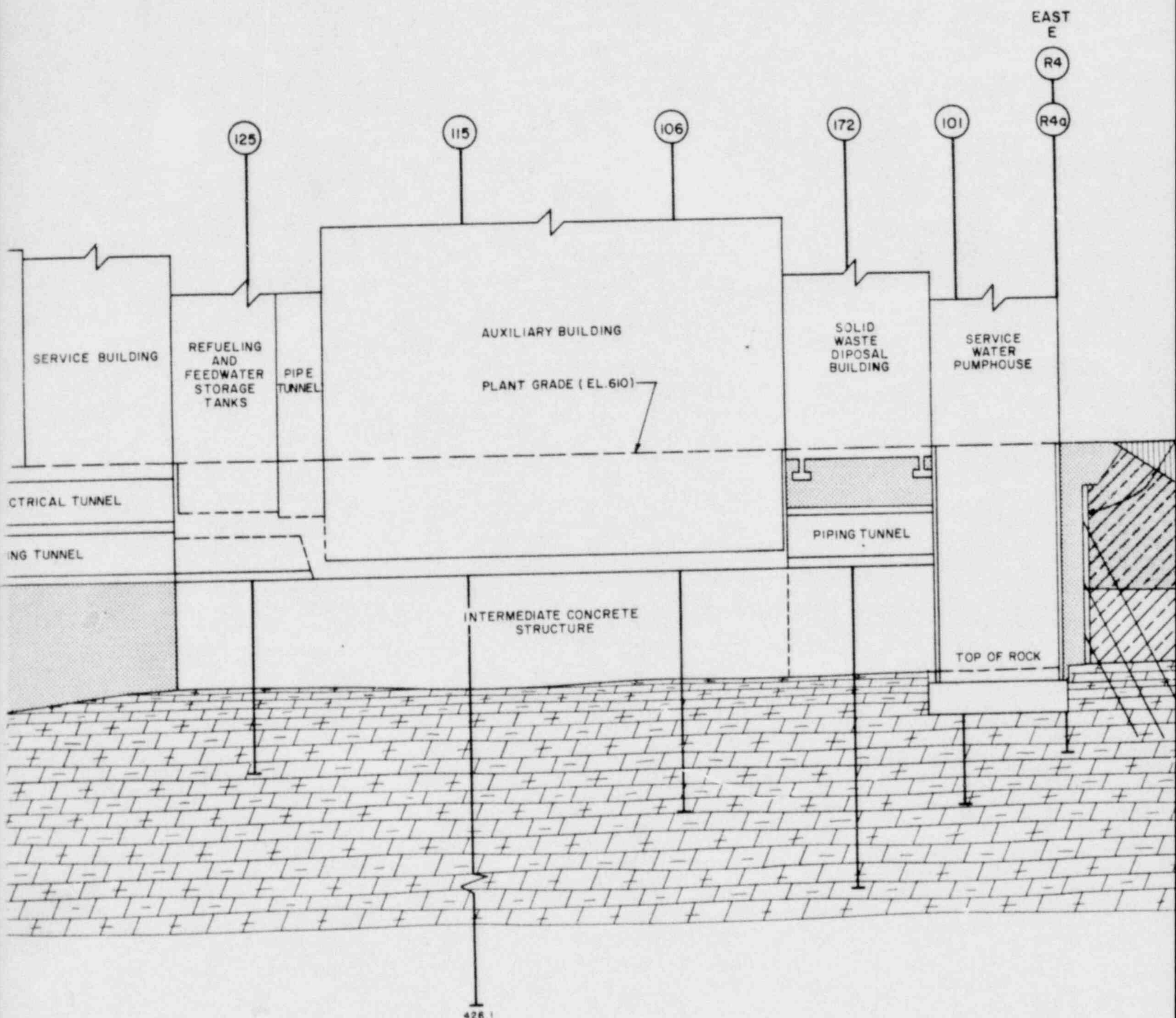
FIGURE 2.5.4-7

SITE EXCAVATION PROFILE D-D

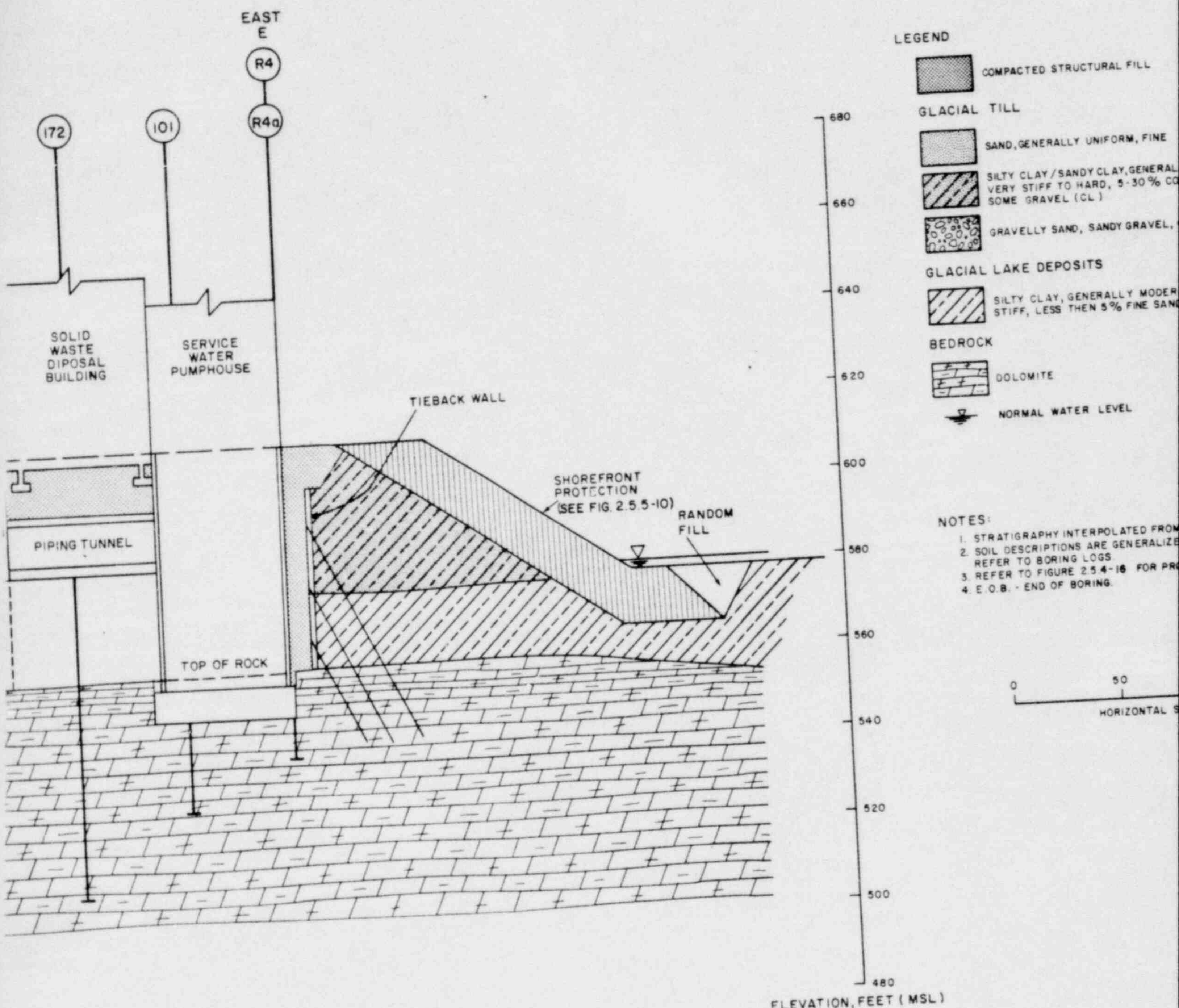
WISCONSIN UTILITIES PROJECT

PRELIMINARY SAFETY ANALYSIS REPORT

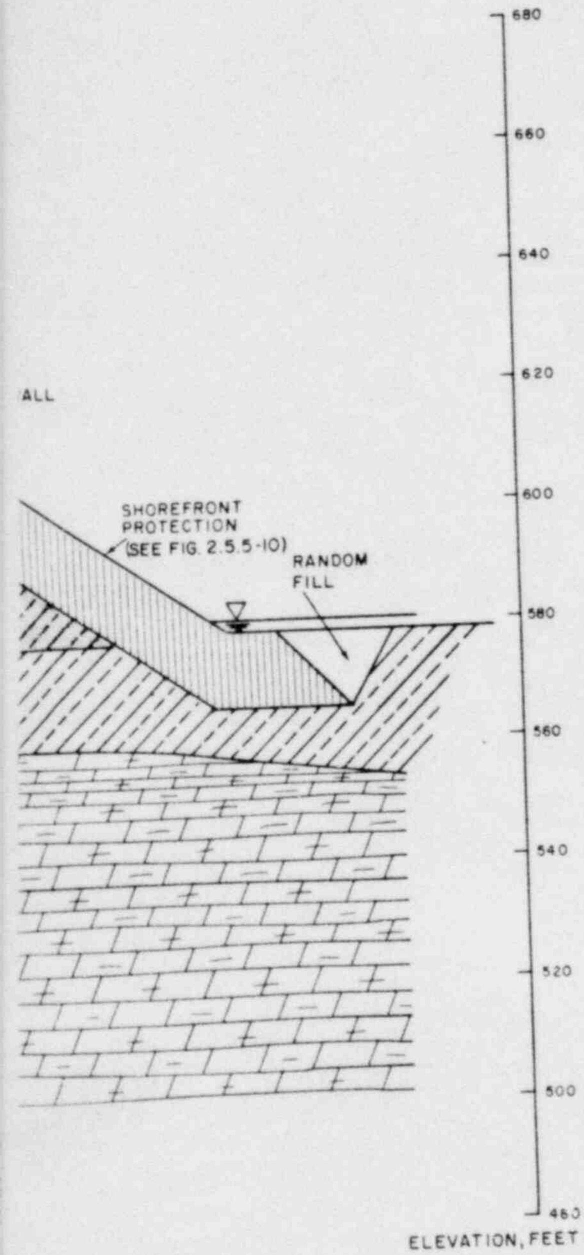

WEST
E
148
141
225
133
125
680
660
640
620
600
580
560
540
520
500
480
CONTROL BUILDING
SERVICE BUILDING
REFUELING AND FEEDWATER STORAGE TANKS
PIPE TUNNEL
TIEBACK WALL
ELECTRICAL TUNNEL
PIPING TUNNEL
378.6
427.7
ELEVATION, FEET (MSL)



EAST
E
R4
R4a
125
115
106
172
101
SERVICE BUILDING
REFUELING AND FEEDWATER STORAGE TANKS
PIPE TUNNEL
AUXILIARY BUILDING
PLANT GRADE (EL. 610)
SOLID WASTE DIPOSAL BUILDING
SERVICE WATER PUMPHOUSE
CTRICAL TUNNEL
ING TUNNEL
PIPING TUNNEL
INTERMEDIATE CONCRETE STRUCTURE
TOP OF ROCK
428.1



HAVEN NUC
FIGURE 2.5.4
SITE EXCAV
WISCONSIN UT
PRELIMINARY



LEGEND

COMPACTED STRUCTURAL FILL

GLACIAL TILL

SAND, GENERALLY UNIFORM, FINE

SILTY CLAY / SANDY CLAY, GENERALLY SLIGHTLY TO MODERATELY PLASTIC, VERY STIFF TO HARD, 5-30% COARSE TO FINE SAND, SOME GRAVEL (CL)

GRAVELLY SAND, SANDY GRAVEL, CLAYEY GRAVEL, SAND (SP, GP, GC)

GLACIAL LAKE DEPOSITS

SILTY CLAY, GENERALLY MODERATELY PLASTIC, STIFF, LESS THEN 5% FINE SAND (CL)

BEDROCK

DOLOMITE

NORMAL WATER LEVEL

NOTES:

1. STRATIGRAPHY INTERPOLATED FROM BORINGS SHOWN.
2. SOIL DESCRIPTIONS ARE GENERALIZED. FOR DETAILED DESCRIPTIONS, REFER TO BORING LOGS.
3. REFER TO FIGURE 2.5.4-16 FOR PROFILE LOCATIONS.
4. E.O.B. - END OF BORING.

0 50 100 150

HORIZONTAL SCALE - FEET

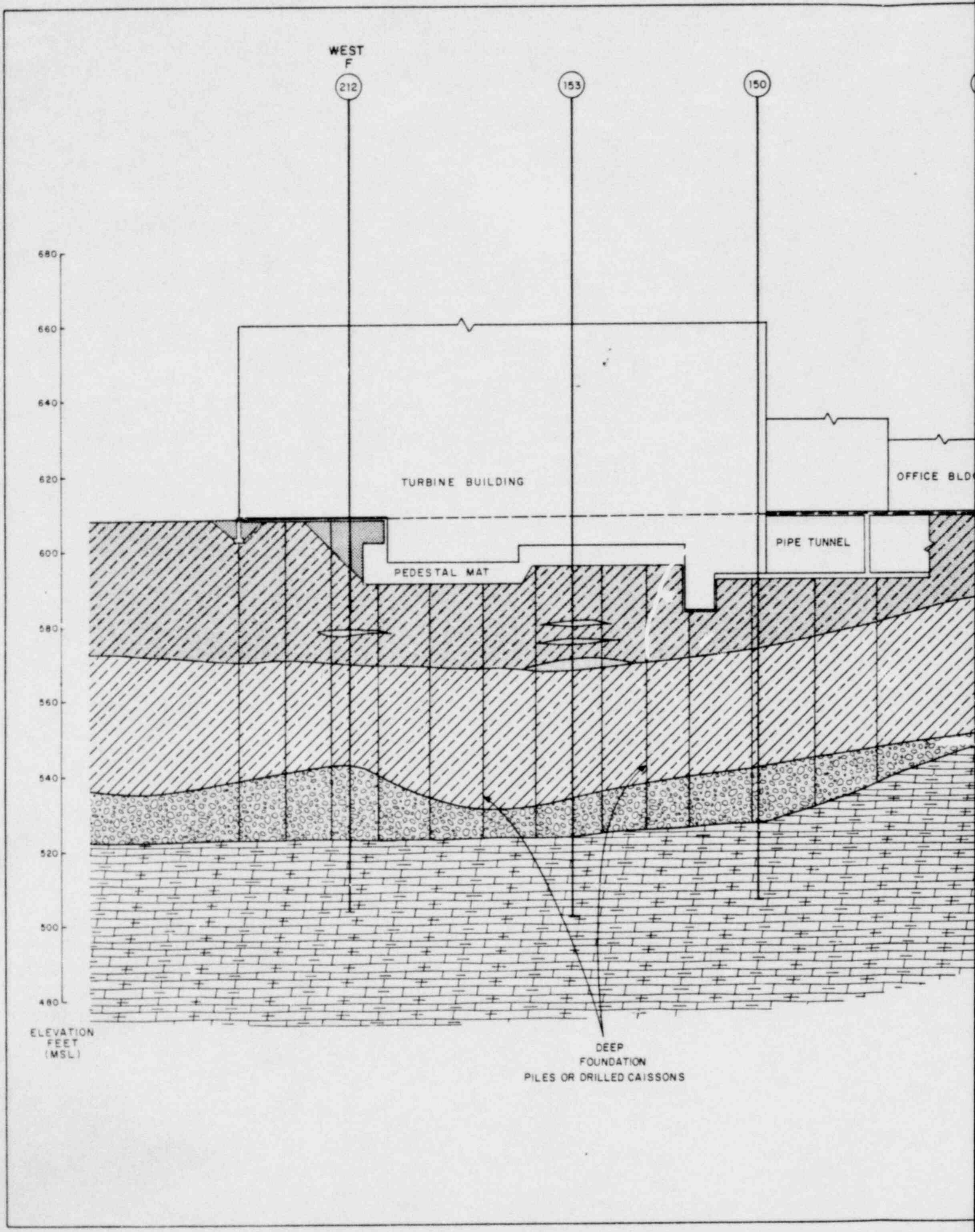
HAVEN NUCLEAR PLANT

FIGURE 2.5.4 - 8

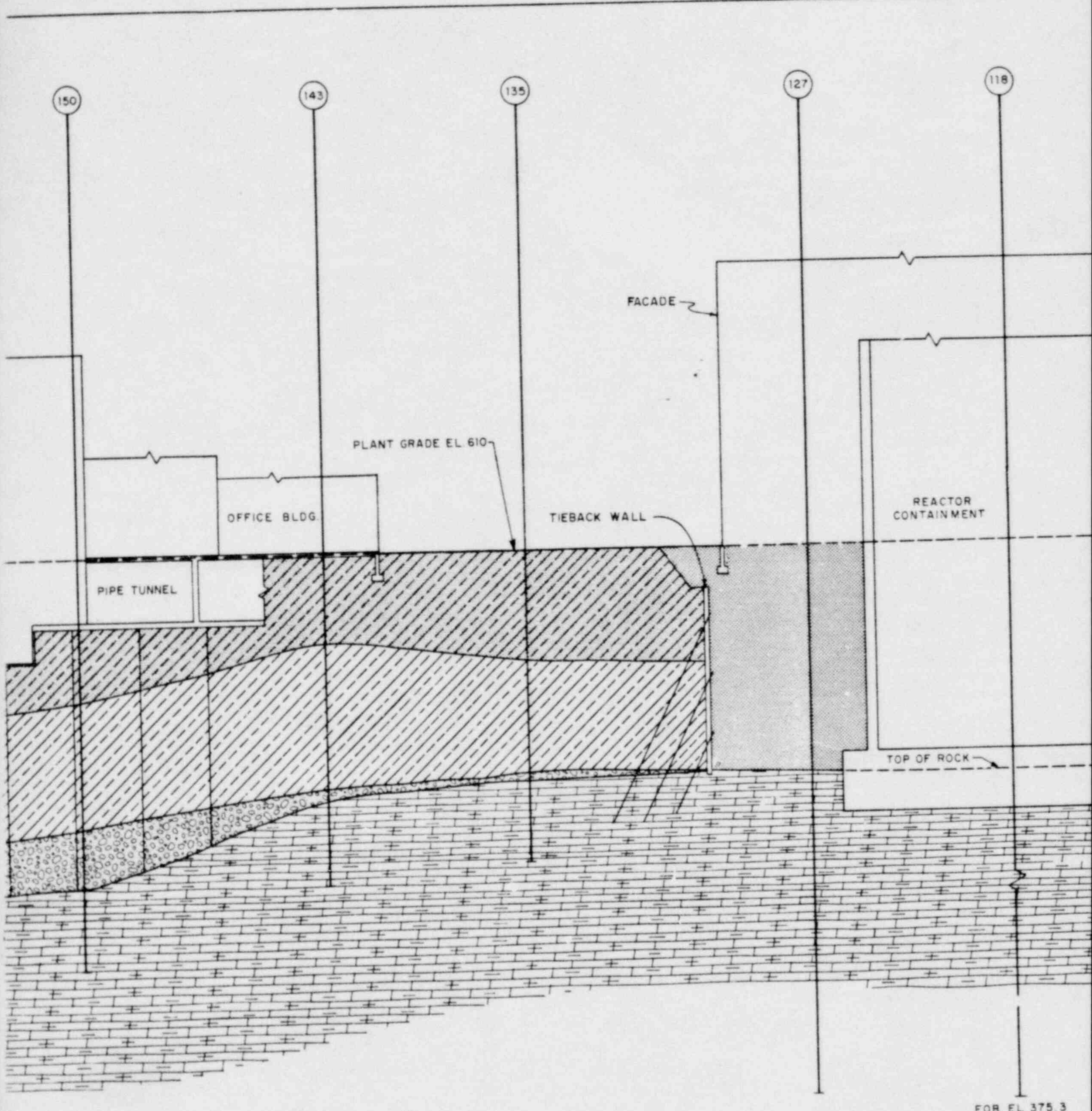
SITE EXCAVATION PROFILE E-E

WISCONSIN UTILITIES PROJECT

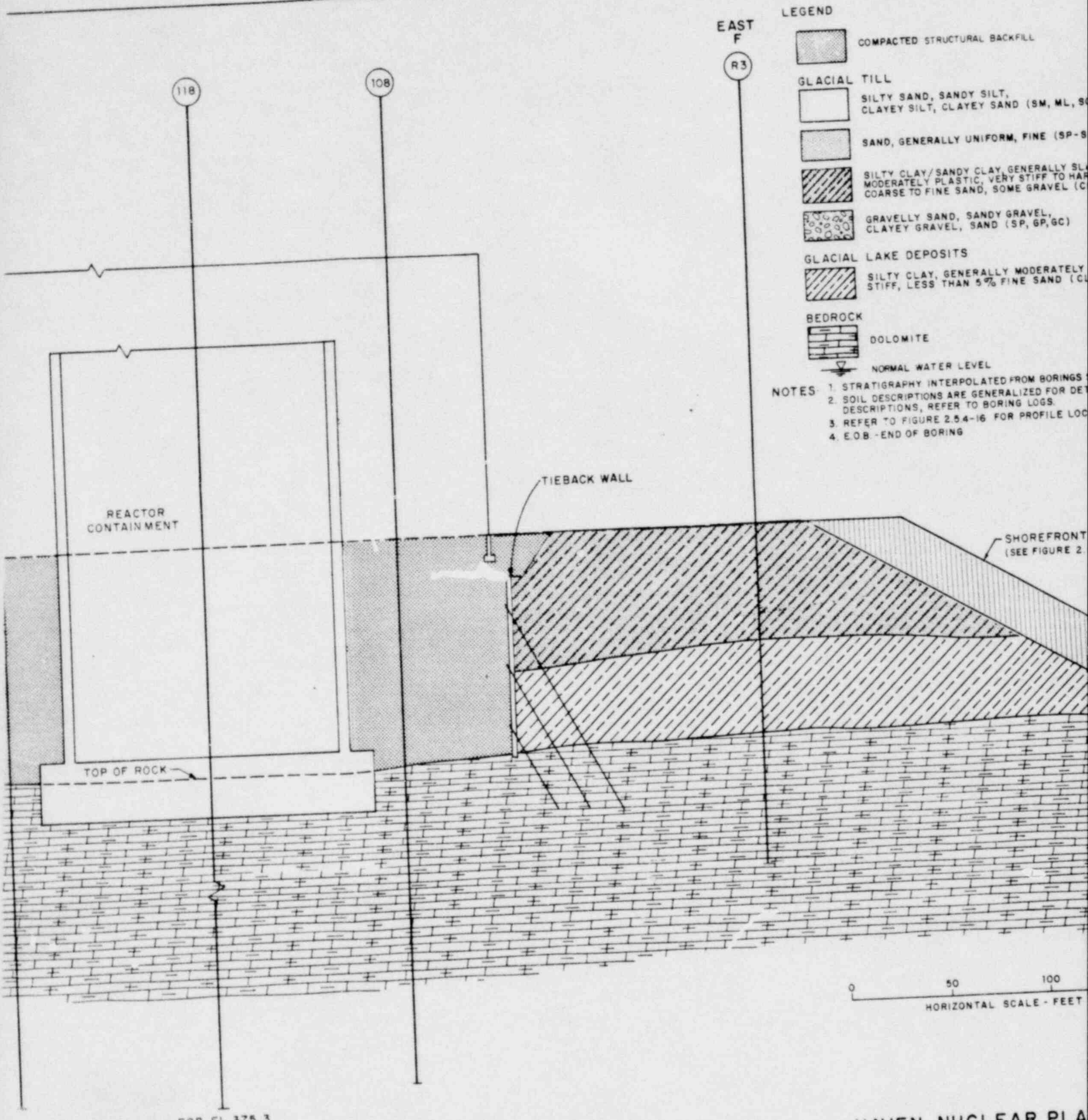
PRELIMINARY SAFETY ANALYSIS REPORT



WEST
F
212
153
150
680
660
640
620
600
580
560
540
520
500
480
ELEVATION
FEET
(MSL)
TURBINE BUILDING
OFFICE BLD
PIPE TUNNEL
PEDESTAL MAT
DEEP
FOUNDATION
PILES OR DRILLED CAISSONS


150
143
135
127
118
FACADE
PLANT GRADE EL. 610
OFFICE BLDG.
TIEBACK WALL
REACTOR CONTAINMENT
PIPE TUNNEL
TOP OF ROCK
EOB EL. 375.3

S



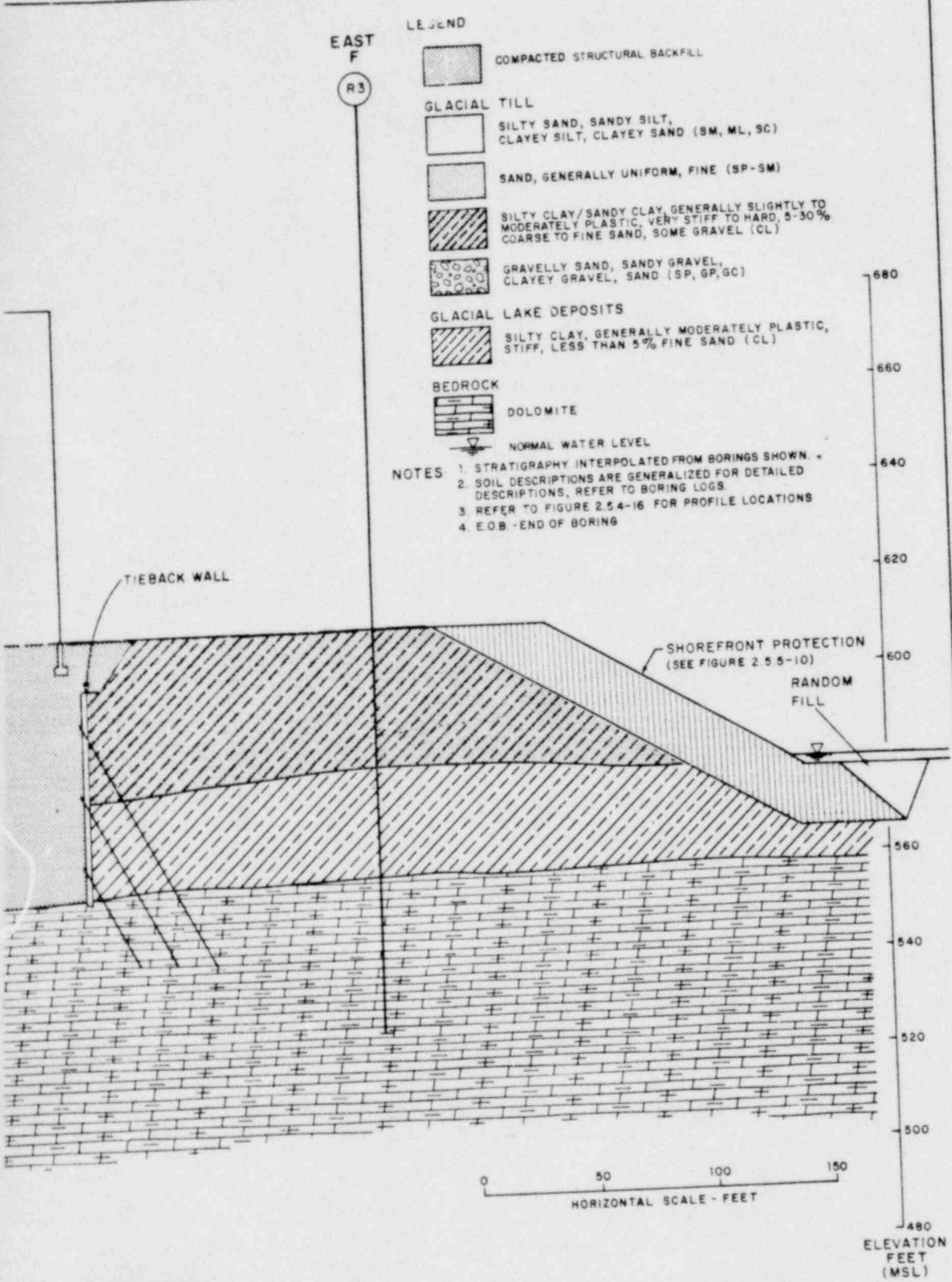
HAVEN NUCLEAR PLA

FIGURE 2.5.4-9

SITE EXCAVATION PR

WISCONSIN UTILITIES PROJ

PRELIMINARY SAFETY ANAL



HAVEN NUCLEAR PLANT

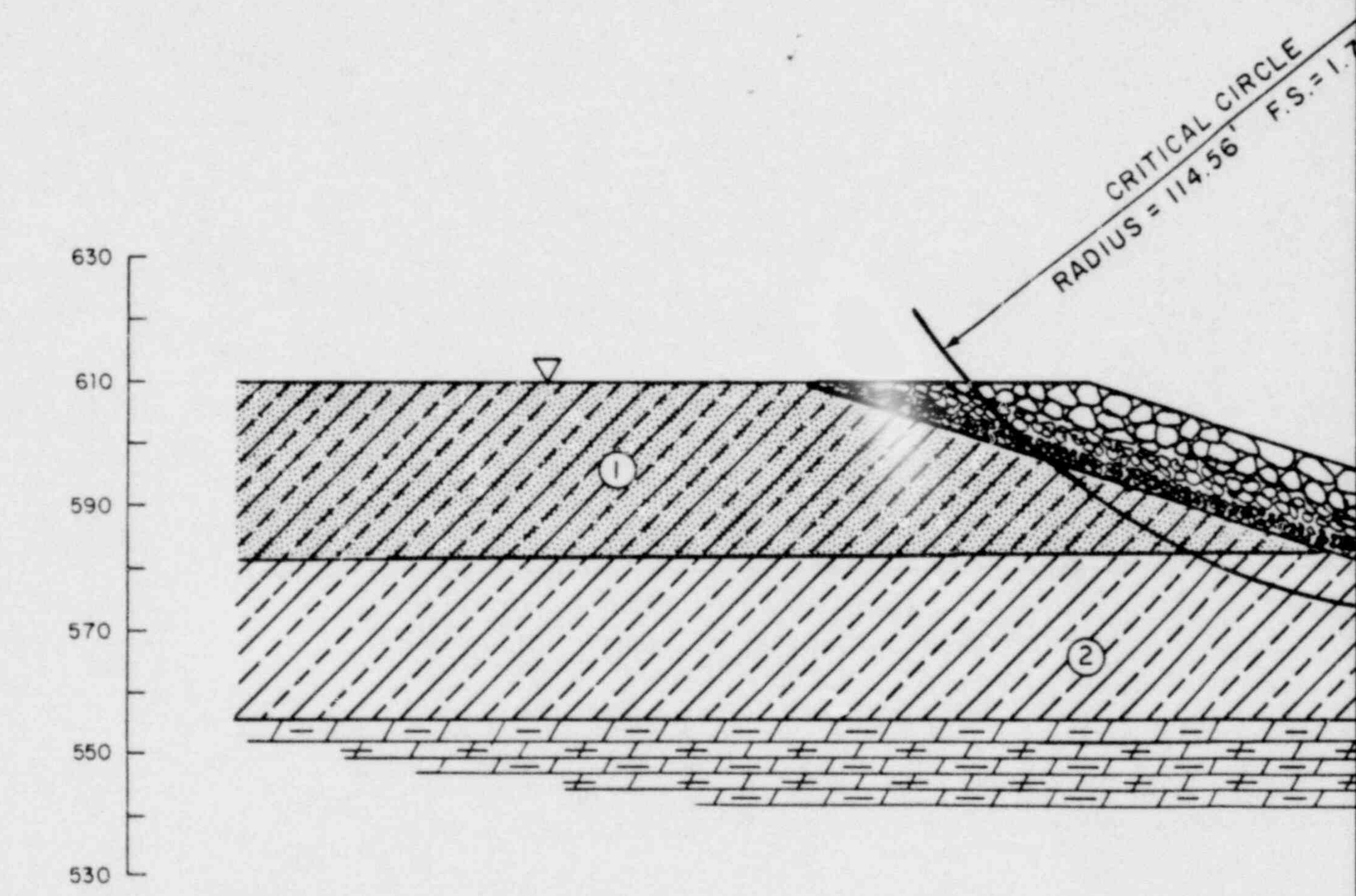
FIGURE 2.5.4-9

SITE EXCAVATION PROFILE F-F

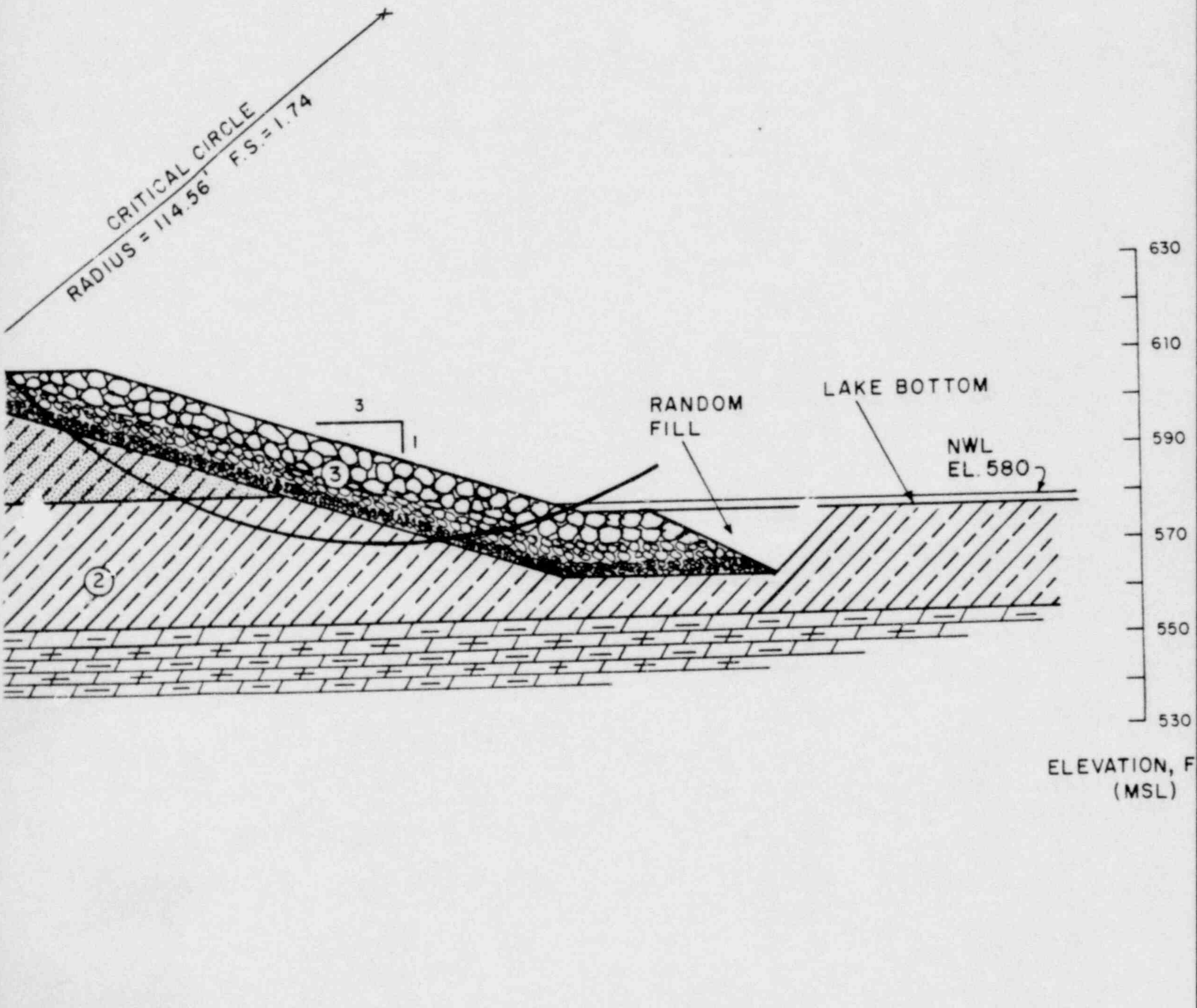
WISCONSIN UTILITIES PROJECT

PRELIMINARY SAFETY ANALYSIS REPORT

AMENDMENT 20



CRITICAL CIRCLE
RADIUS = 114.56'
630
610
590
570
550
530
ELEVATION, FEET
(MSL)



CRITICAL CIRCLE
RADIUS = 114.56'
F.S. = 1.74
3
1
3
2
RANDOM
FILL
LAKE BOTTOM
NWL
EL. 580
630
610
590
570
550
530
ELEVATION, F
(MSL)

LEGEND

GLACIAL TILL

SILTY CLAY, SANDY CLAY, GENERALLY SLIGHTLY TO MODERATELY PLASTIC, VERY STIFF TO HARD, 5-30% COARSE TO FINE SAND (CL)

GLACIAL LAKE DEPOSITS

SILTY CLAY, GENERALLY MODERATELY PLASTIC, STIFF, LESS THAN 5% FINE SAND (CL)

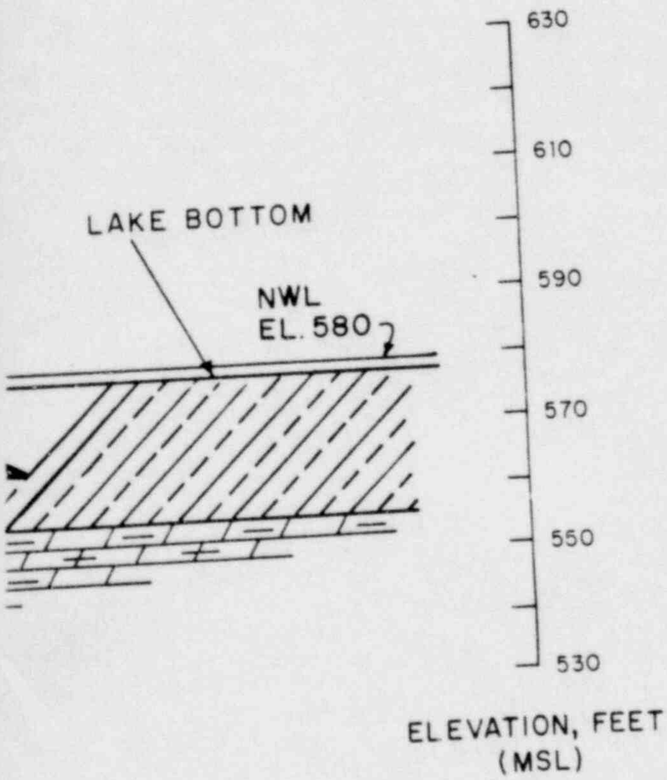
BEDROCK

DOLOMITE

SHORE PROTECTION

ROCK ARMOUR, BOULDERS AND COBBLES IN DISCRETE LAYERS (REFER TO FIGURE 2.5.5-10)

PHREATIC SURFACE



ENGINEERING SOIL PROPERTIES
LONG TERM DRAINED CONDITIONS

SOIL UNIT	TOTAL UNIT WEIGHT (pcf)	FRICTION ANGLE, $\bar{\Phi}$	COHESION $\bar{C}$ (psf)
1	136	28°	0
2	128	28°	0
3	150	38°	0

0 30 60
SCALE-FEET

HAVEN NUCLEAR PL

FIGURE 2.5.5-6

PERMANENT SHORELIN
GEOMETRY AND SOIL
LONG TERM DRAINED S

WISCONSIN UTILITIES PR
PRELIMINARY SAFETY AN

LEGEND

GLACIAL TILL

SILTY CLAY, SANDY CLAY, GENERALLY SLIGHTLY TO MODERATELY PLASTIC, VERY STIFF TO HARD, 5-30% COARSE TO FINE SAND (CL)

GLACIAL LAKE DEPOSITS

SILTY CLAY, GENERALLY MODERATELY PLASTIC, STIFF, LESS THAN 5% FINE SAND (CL)

BEDROCK

DOLOMITE

SHORE PROTECTION

ROCK ARMOUR, BOULDERS AND COBBLES IN DISCRETE LAYERS (REFER TO FIGURE 2.5.5-10)

∇ PHREATIC SURFACE

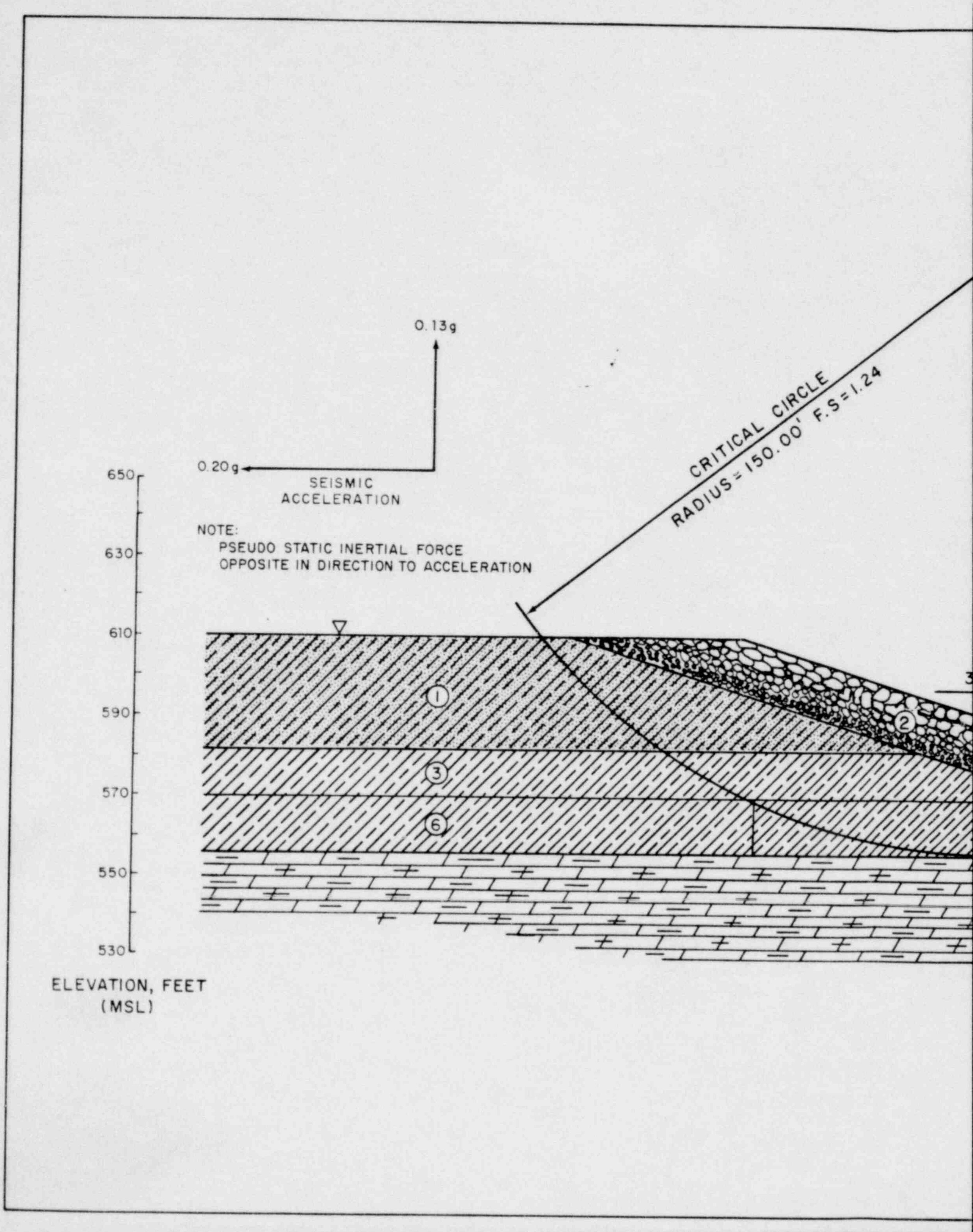
ENGINEERING SOIL PROPERTIES
LONG TERM DRAINED CONDITIONS

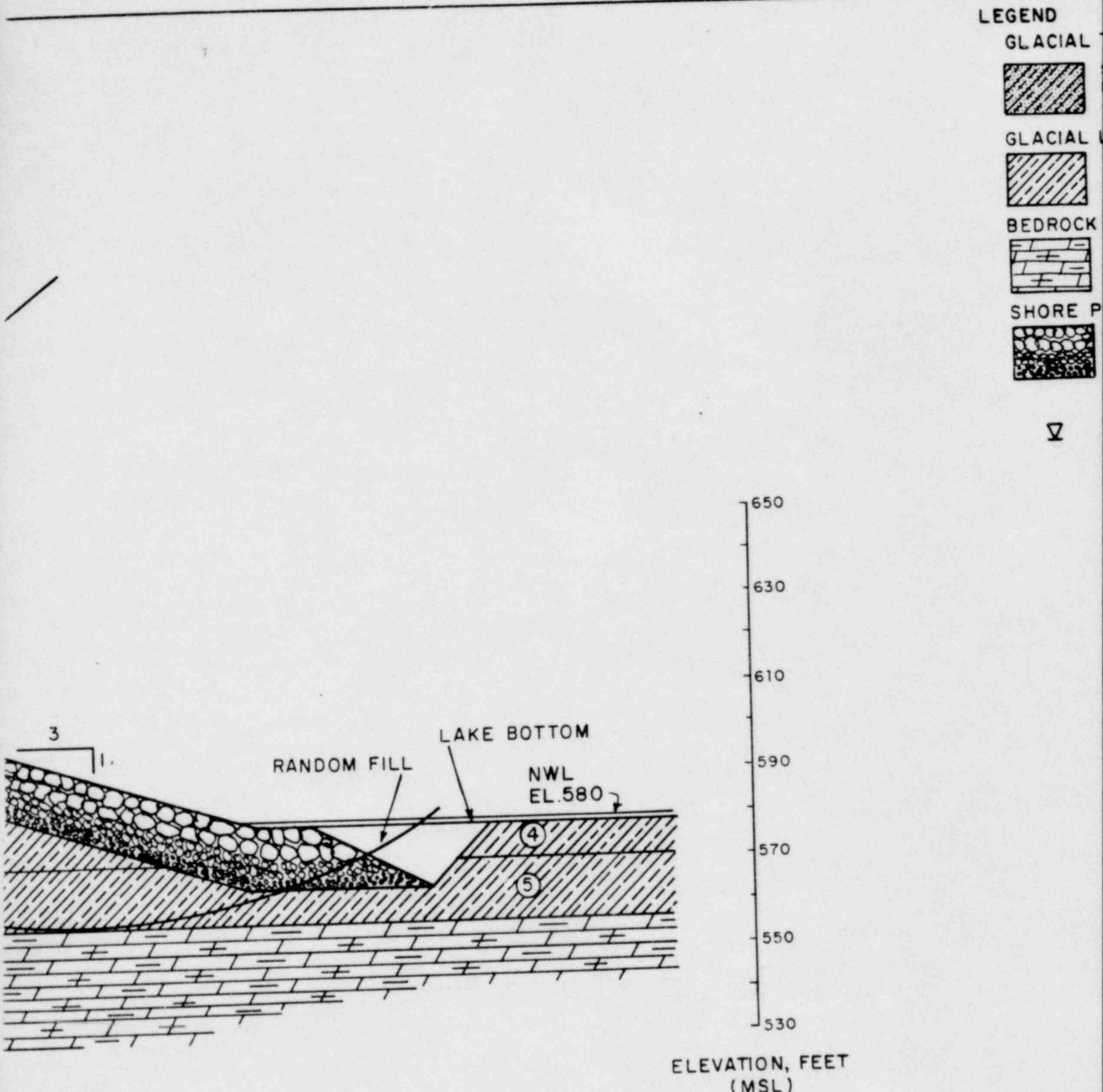
SOIL UNIT	TOTAL UNIT WEIGHT (pcf)	FRICTION ANGLE, $\bar{\phi}$	COHESION $\bar{C}$ (psf)
1	136	28°	0
2	128	28°	0
3	150	38°	0

0 30 60
SCALE-FEET

HAVEN NUCLEAR PLANT

FIGURE 2.5.5-6
PERMANENT SHORELINE SLOPE GEOMETRY AND SOIL PROPERTIES LONG TERM DRAINED STABILITY CASE
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT


0.13g
0.20g
SEISMIC
ACCELERATION
NOTE:
PSEUDO STATIC INERTIAL FORCE
OPPOSITE IN DIRECTION TO ACCELERATION
CRITICAL CIRCLE
RADIUS = 150.00' F.S = 1.24
650
630
610
590
570
550
530
ELEVATION, FEET
(MSL)
1
2
3
6



LEGEND
GLACIAL
GLACIAL
BEDROCK
SHORE P
3
1
RANDOM FILL
LAKE BOTTOM
NWL
EL.580
4
5
650
630
610
590
570
550
530
ELEVATION, FEET
(MSL)

LEGEND

GLACIAL TILL

SILTY CLAY, SANDY CLAY, GENERALLY SLIGHTLY TO MODERATELY PLASTIC, VERY STIFF TO HARD, 5-30 % COARSE TO FINE SAND (CL)

GLACIAL LAKE DEPOSITS

SILTY CLAY, GENERALLY MODERATELY PLASTIC, STIFF, LESS THAN 5% FINE SAND (CL)

BEDROCK

DOLOMITE

SHORE PROTECTION

ROCK ARMOUR, BOULDERS AND COBBLES IN DISCRETE LAYERS (REFER TO FIGURE 2.5.5-10)

∇ PHREATIC SURFACE

ENGINEERING SOIL PROPERTIES
SEISMIC CONDITIONS

SOIL UNIT	TOTAL UNIT WEIGHT (pcf)	FRICTION ANGLE, $\bar{\phi}$	UNDRAINED SHEAR STRENGTH (psf)
1	136	0°	2600
2	150	38°	0
3	128	0°	2400
4	128	0°	330
5	128	0°	1150
6	128	0°	2900

0 30 60 90

SCALE-FEET

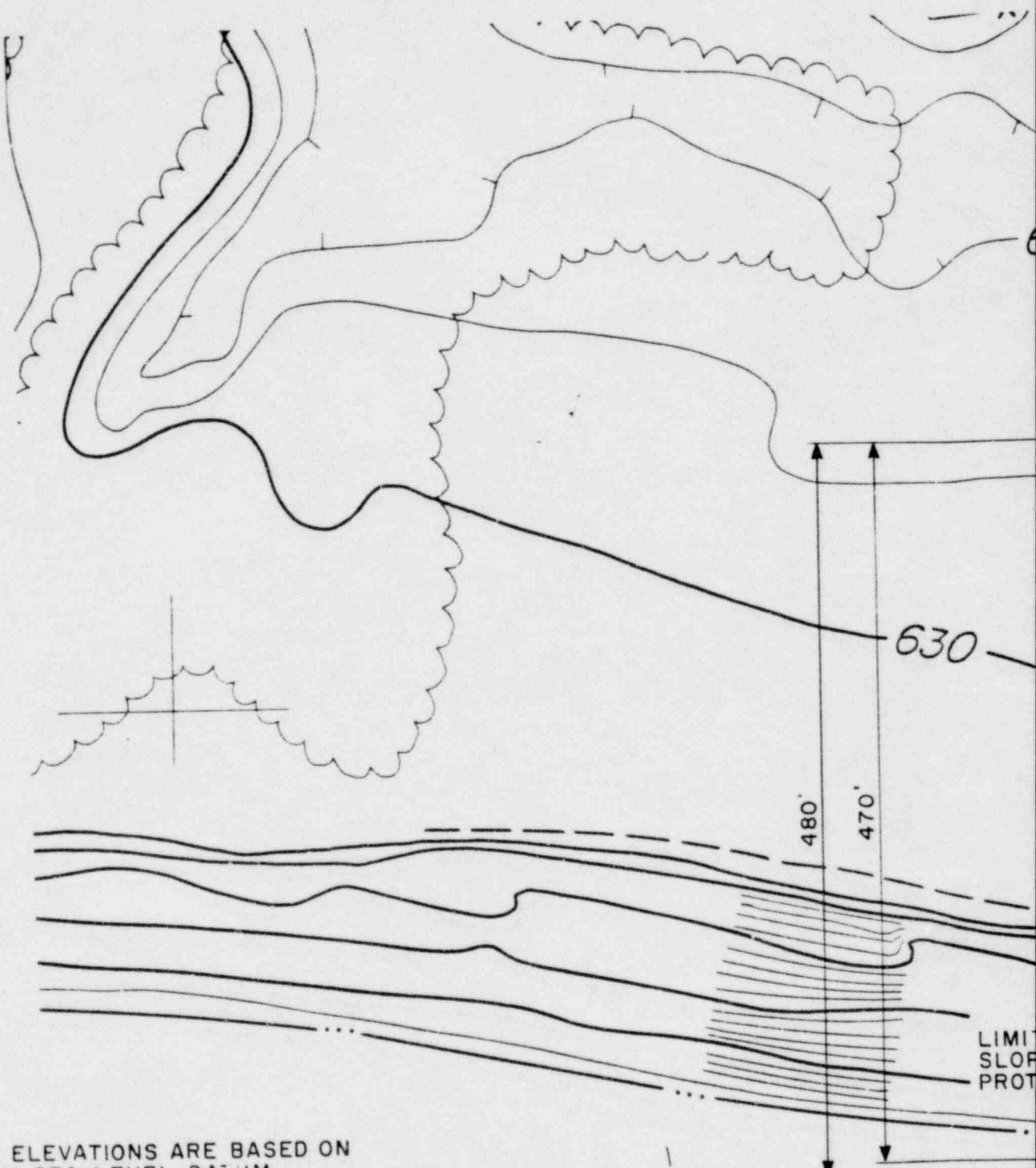
HAVEN NUCLEAR PLANT

FIGURE 2.5.5-8

PERMANENT SHORELINE SLOPE GEOMETRY AND SOIL PROPERTIES SEISMIC LOADING CASE

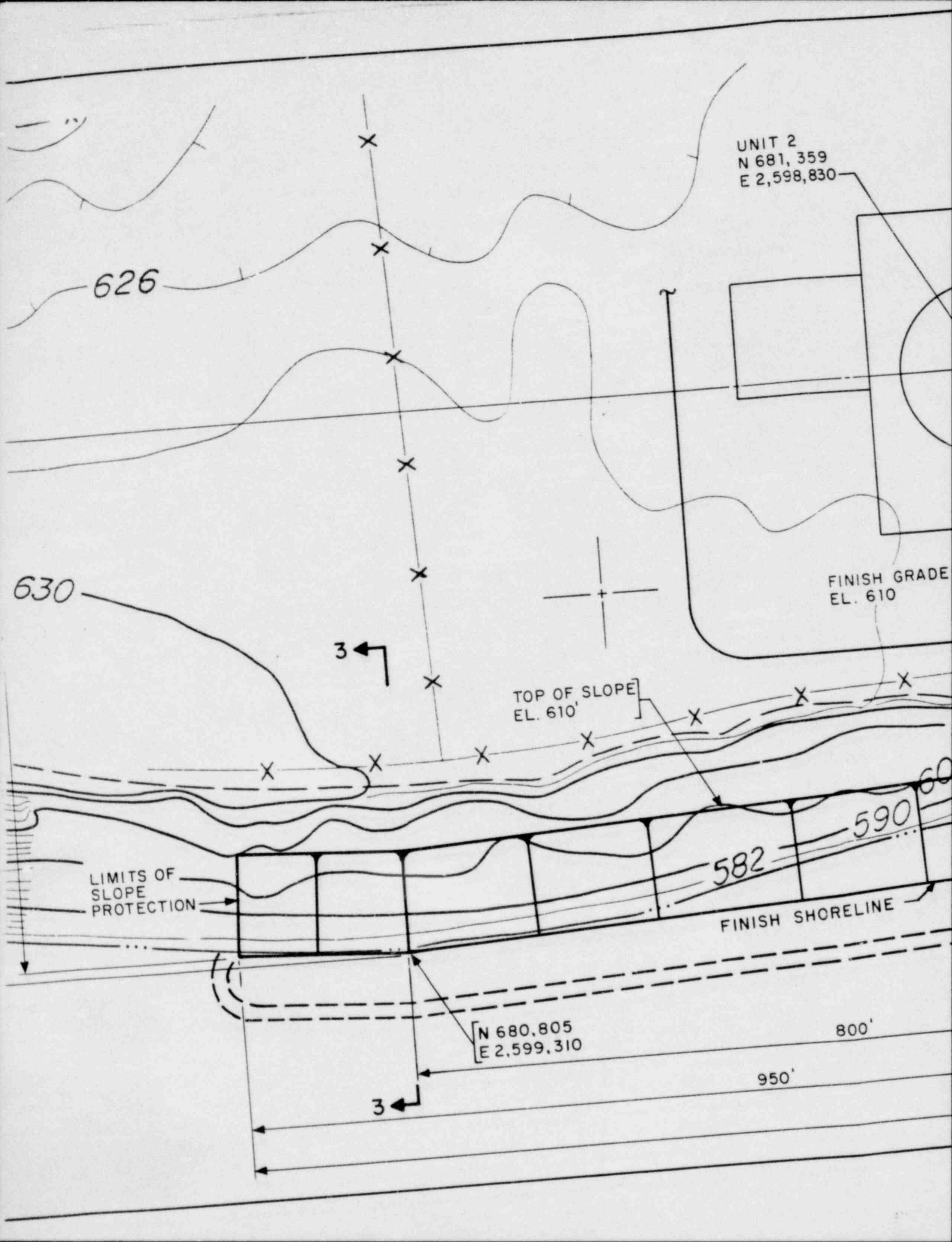
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

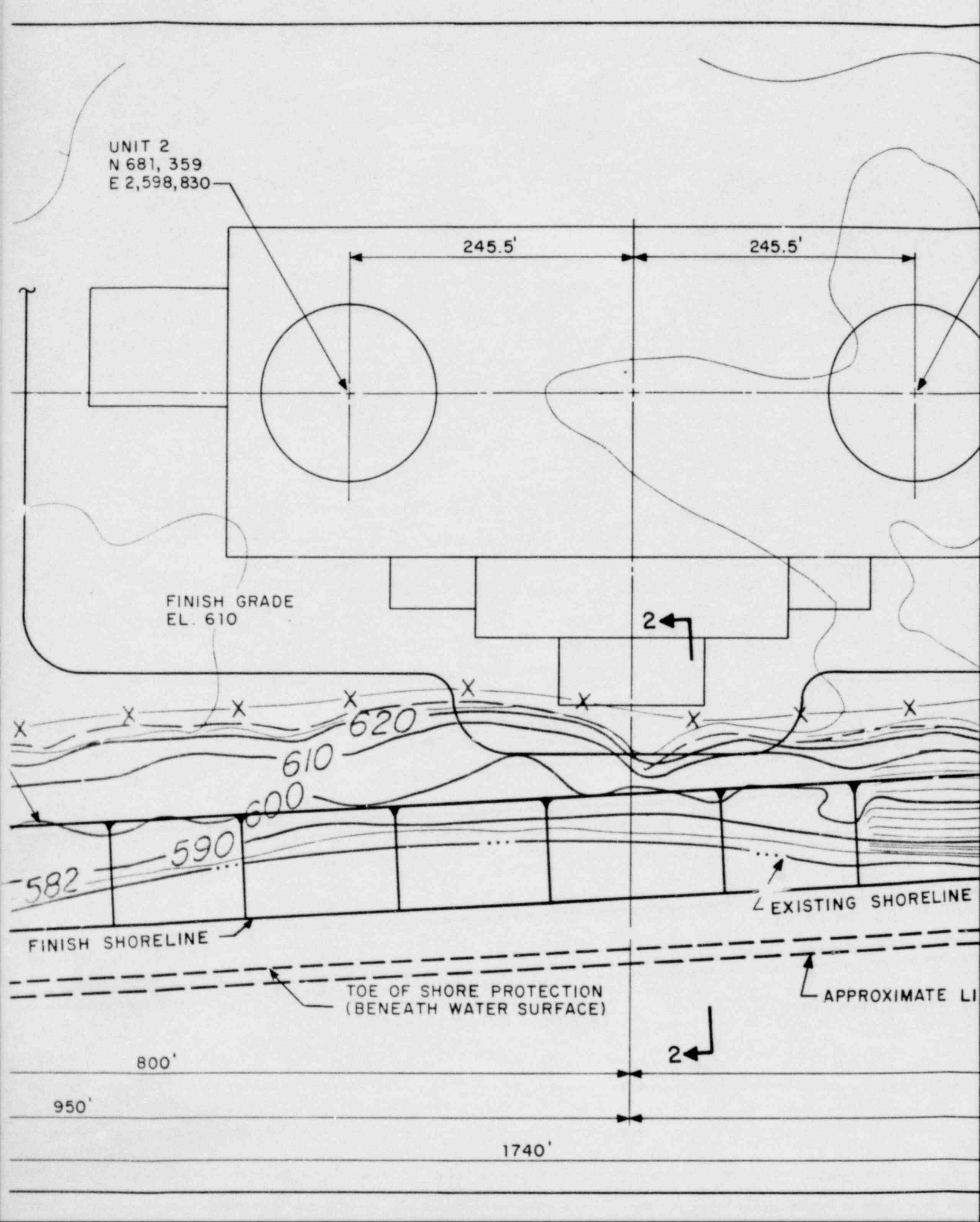
AMENDMENT 20



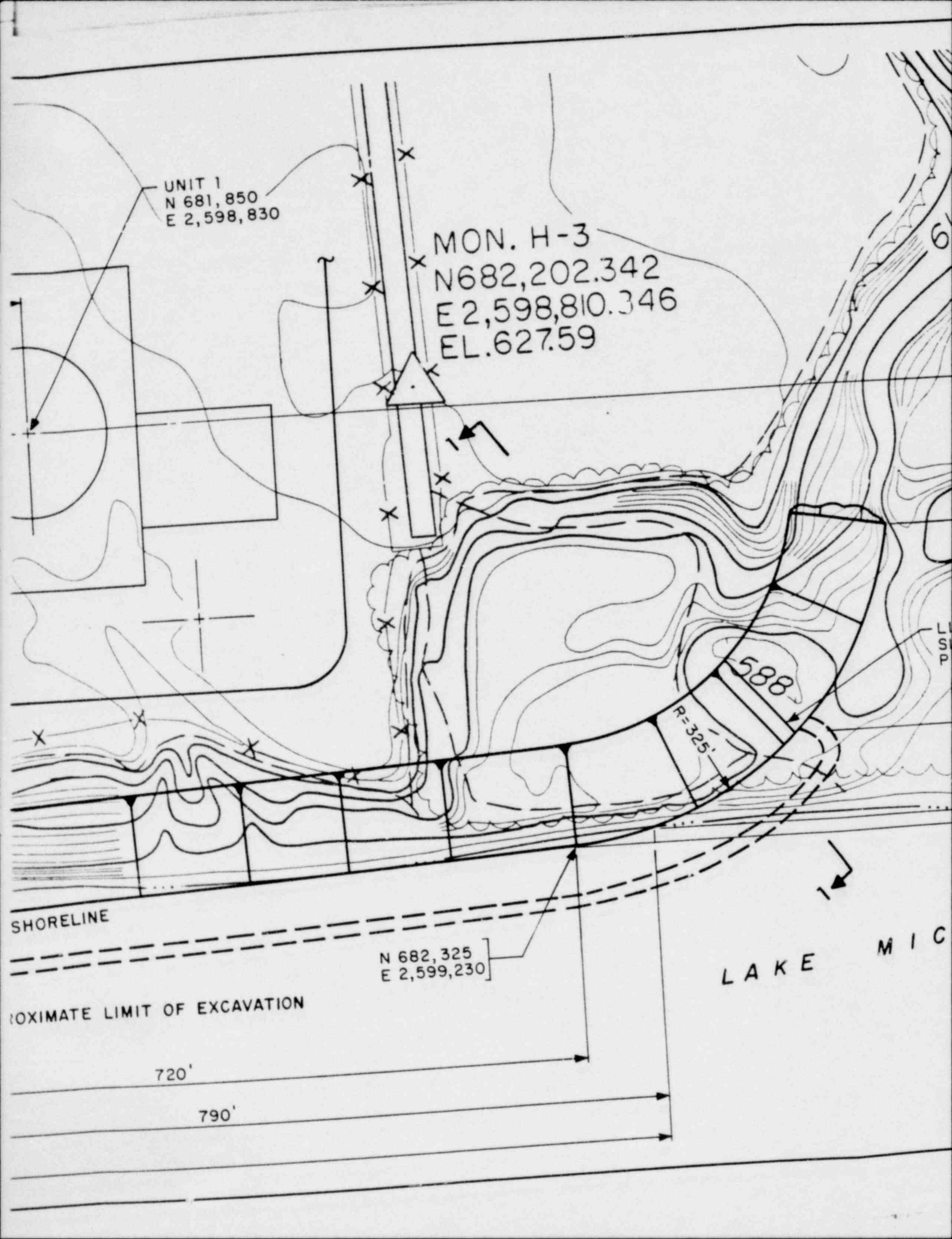
NOTE:

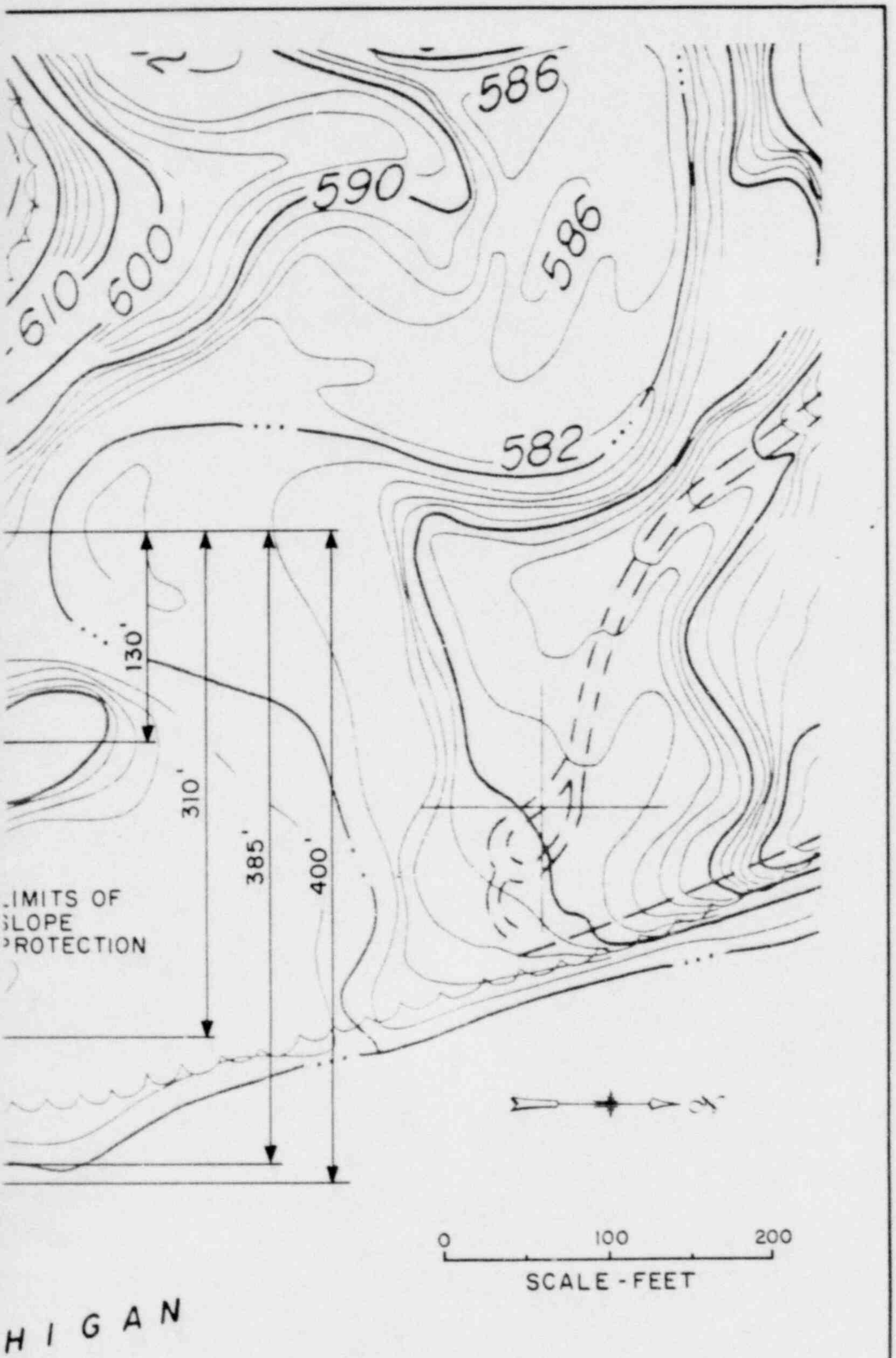
1. ALL ELEVATIONS ARE BASED ON MEAN SEA LEVEL DATUM.
2. COORDINATES ARE BASED ON WISCONSIN STATE COORDINATE SYSTEM SOUTH ZONE.
3. TOPOGRAPHY BASED ON AERIAL SURVEY BY CHICAGO AERIAL SURVEY.
4. FINISH SHORELINE IS BASED ON NORMAL WATER LEVEL (NWL) FOR LAKE MICHIGAN, WHICH IS EL. 580 FT. MSL.


UNIT 2
N 681, 359
E 2,598,830
626
630
FINISH GRADE
EL. 610
3
TOP OF SLOPE
EL. 610'
590
582
LIMITS OF
SLOPE
PROTECTION
FINISH SHORELINE
N 680,805
E 2,599,310
800'
950'
3



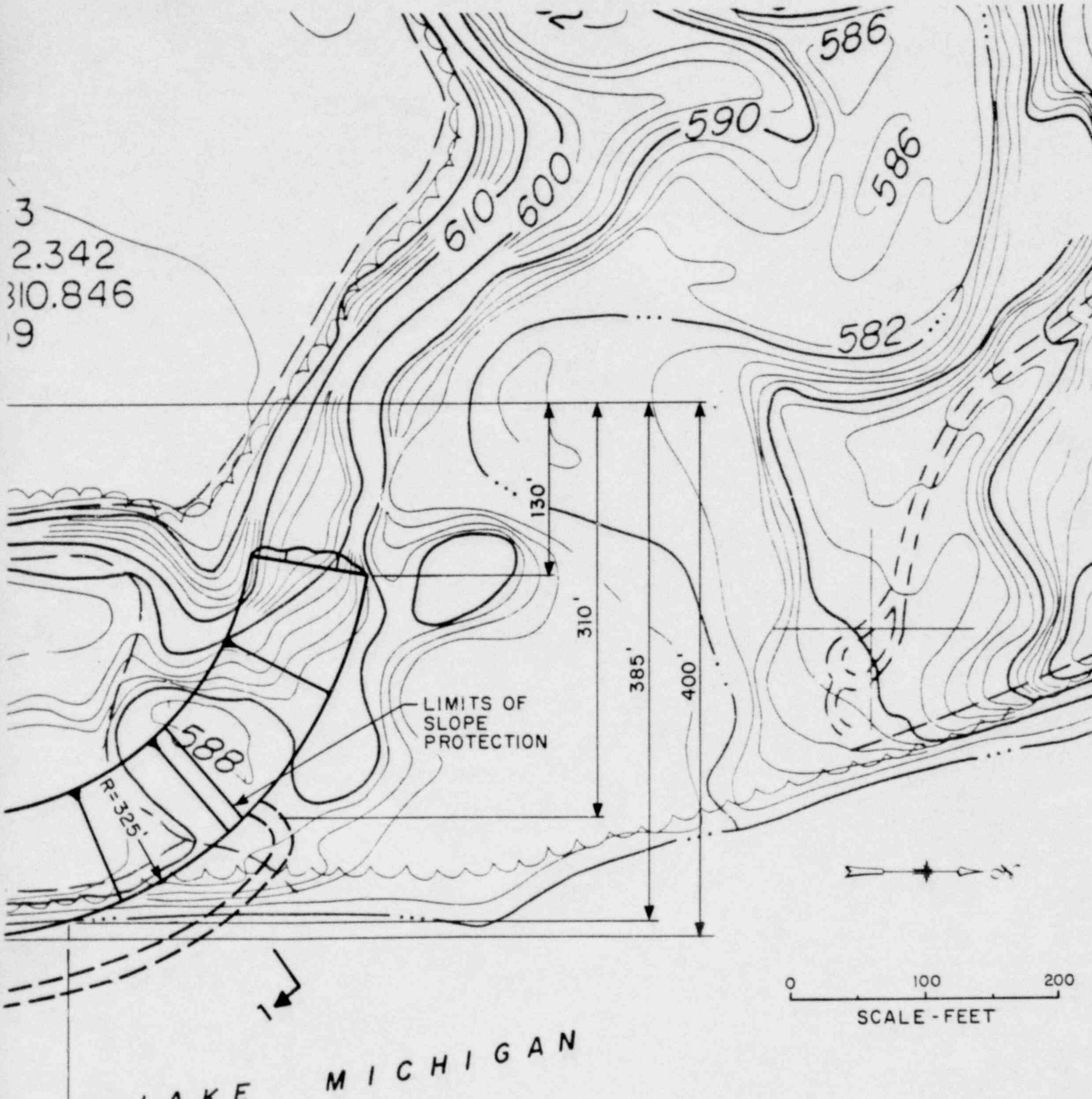
UNIT 2
N 681, 359
E 2,598,830
245.5'
245.5'
FINISH GRADE
EL. 610
2
620
610
600
590
582
EXISTING SHORELINE
FINISH SHORELINE
TOE OF SHORE PROTECTION
(BENEATH WATER SURFACE)
APPROXIMATE LI
2
800'
950'
1740'


UNIT 1
N 681,850
E 2,598,830
MON. H-3
N682,202.342
E2,598,810.346
EL.627.59
588
R=325'
SHORELINE
N 682,325
E 2,599,230
LAKE MIC
ROXIMATE LIMIT OF EXCAVATION
720'
790'



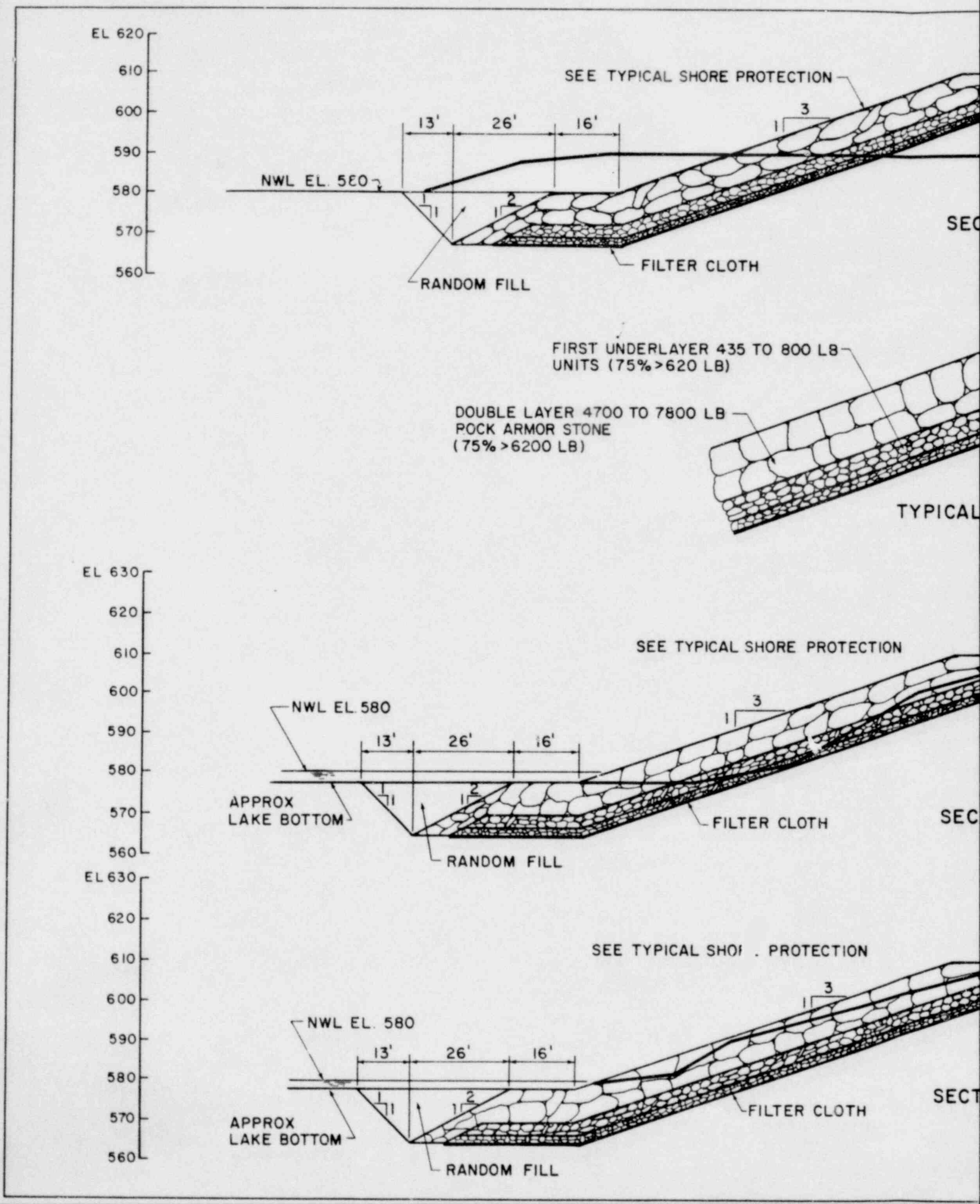
HAVEN NUCLEAR PLANT
FIGURE 2.5.5-9
SHORELINE MODIFICATIONS
HAVEN SITE
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

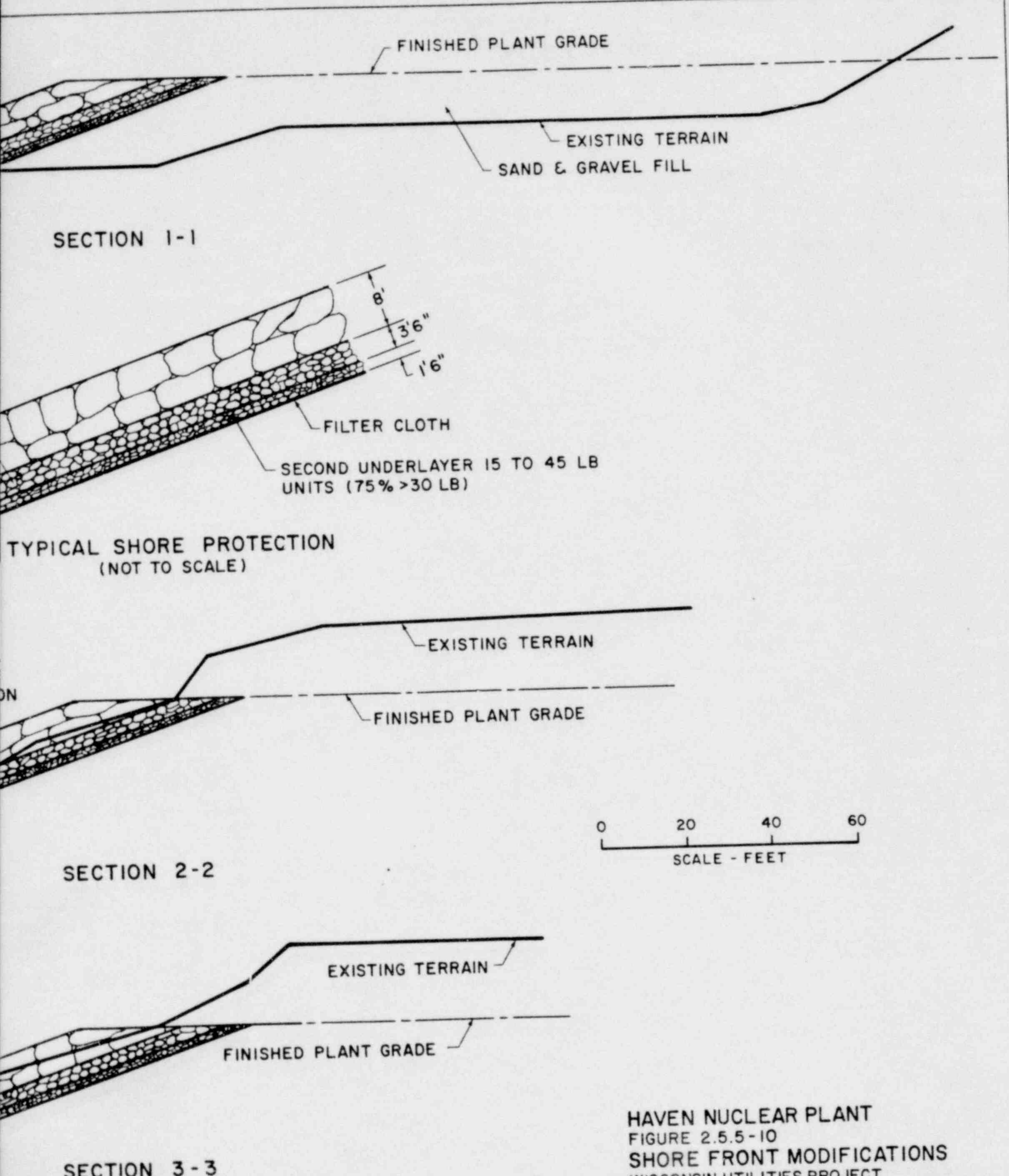
AMENDMENT 20



HAVEN NUCLEAR PLANT
FIGURE 2.5.5-9
SHORELINE MODIFICATIONS
HAVEN SITE
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

AMENDMENT


EL 620
610
600
590
580
570
560
SEE TYPICAL SHORE PROTECTION
13'
26'
16'
NWL EL. 580
3
1
2
FILTER CLOTH
RANDOM FILL
SEC
FIRST UNDERLAYER 435 TO 800 LB UNITS (75% >620 LB)
DOUBLE LAYER 4700 TO 7800 LB ROCK ARMOR STONE (75% >6200 LB)
TYPICAL
EL 630
620
610
600
590
580
570
560
SEE TYPICAL SHORE PROTECTION
NWL EL. 580
13'
26'
16'
APPROX LAKE BOTTOM
FILTER CLOTH
RANDOM FILL
SEC
EL 630
620
610
600
590
580
570
560
SEE TYPICAL SHORE PROTECTION
NWL EL. 580
13'
26'
16'
APPROX LAKE BOTTOM
FILTER CLOTH
RANDOM FILL
SECT



HAVEN NUCLEAR PLANT
FIGURE 2.5.5-10
SHORE FRONT MODIFICATIONS
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

AMENDMENT 20

HAVEN SITE ADDENDUM

LIST OF EFFECTIVE PAGES

CHAPTER 9

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9.2-3	16
9.2-4 thru 6A	18
9.2-7 thru 12	16
9.3-1	17
9.4-1 thru 3	20
9.5-1	18
T9.2.1-1	18
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CHAPTER 9

AUXILIARY SYSTEMS

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9.4.1 Control Building Air Conditioning, Heating, and Emergency Ventilation

9.4.1.1 Design Basis

In addition to the requirements of PSAR Section 9.4.1.1, the Haven site requires redundant QA and Seismic Category I chlorine detectors. These detectors are provided in the normal fresh air intake of the control room ventilation system to detect the ingress of chlorine. The detectors are shown on Figure 9.4.1-1.

9.4.1.2 System Description

In the event chlorine is detected in the normal fresh air intake at a concentration greater than or equal to 5 ppm, automatic isolation of the air supply and initiation of the emergency filtration system in the recirculation mode occurs within 10 seconds after detection. A discussion of the consequences of a chlorine release near the site is provided in Section 2.2.3.1.3.

9.4.1.3 Safety Evaluation

Chlorine detectors in the normal fresh air intake of the control room ventilation system will detect and alarm the presence of chlorine in excess of 5 ppm. Isolation of the outside air supply and initiation of the emergency filtration system in the recirculation mode occurs automatically. Even without credit for chlorine removal via the emergency filtration system, the above actions provide adequate time for operators to don the self-contained portable breathing apparatus located in the control room. A discussion of the chlorine releases analyzed for the site is provided in Section 2.2.3.1.3.

9.4.1.5 Instrument Applications

Under conditions of high ambient chlorine levels in the outside air, the chlorine detectors located in the control room normal fresh air intake initiate an alarm, isolate the normal ventilation air inlet, and place the emergency filtration systems in the recirculation mode of operation. In this operating mode, recirculated air passes through a filter train before entering the air conditioning units of the control, instrument rack, mechanical, and computer rooms.

Chlorine alarms are provided in the control room.

9.4.9 Service Water Pumphouse Ventilation

9.4.9.1 General

The Haven service water pumphouse ventilation system fulfills all of the safety requirements of the system described in the PSAR. However, the use of Lake Michigan as the ultimate heat sink rather than the spray ponds described in 9.2.5 of the PSAR, requires certain modifications. Therefore, the complete service water pumphouse ventilation system and requirements for the Haven site are described herein, and replace the description provided in 9.4.9 of the PSAR.

9.4.9.2 Design Bases

The service water pumphouse ventilation system except for unit heaters is a safety-related system and Seismic Category I and is designed to maintain a controlled environment for personnel and equipment.

The summer design temperature within the service water pumphouse is a maximum of 103°F when the outside air temperature is 92°F, based on ASHRAE design temperature for 1 percent occurrence. The winter design temperature is a minimum of 60°F, coincident with an outside temperature of -22°F and shutdown of the unit.

9.4.9.3 System Description

The service water pumphouse ventilation system is shown on Figure 9.4.9-1.

Each half of the service water pumphouse is provided with a ventilation system consisting of two supply fans, two outside air supply dampers, two exhaust air dampers and associated ductwork. In each half of the pumphouse, one of the fans and associated equipment are powered from a Unit 1 power source while the other fan and associated equipment are powered from a Unit 2 power source. The power sources for both Unit 1 and 2 supply fans located in the same half of the pumphouse are of the same train designation. The service water pumps located in each half of the pumphouse are arranged similarly (Section 9.2.1).

The heating system for the service water pumphouse consists of two electric unit heaters in each half of the pumphouse that are individually controlled by room type temperature controllers.

9.4.9.4 Safety Evaluation

The service water pumphouse ventilation system maintains an ambient temperature suitable for personnel and equipment. The temperature in the pumphouses is maintained between 103°F, maximum and 60°F minimum to ensure the capability of post-accident operation of the required number of service water pumps under all conditions.

Emergency power is supplied to each ventilation system supply fan and respective controls by the emergency bus supplying the service water pumps in the respective pumphouse.

The ventilation system for the service water pumphouse is Safety Class 3, QA Category I and Seismic Category I.

9.4.9.5 Test and Inspection Requirements

The service water pumphouse ventilation system is inspected after installation to ensure that equipment has been properly installed. Following installation, the system is tested and air flow balanced.

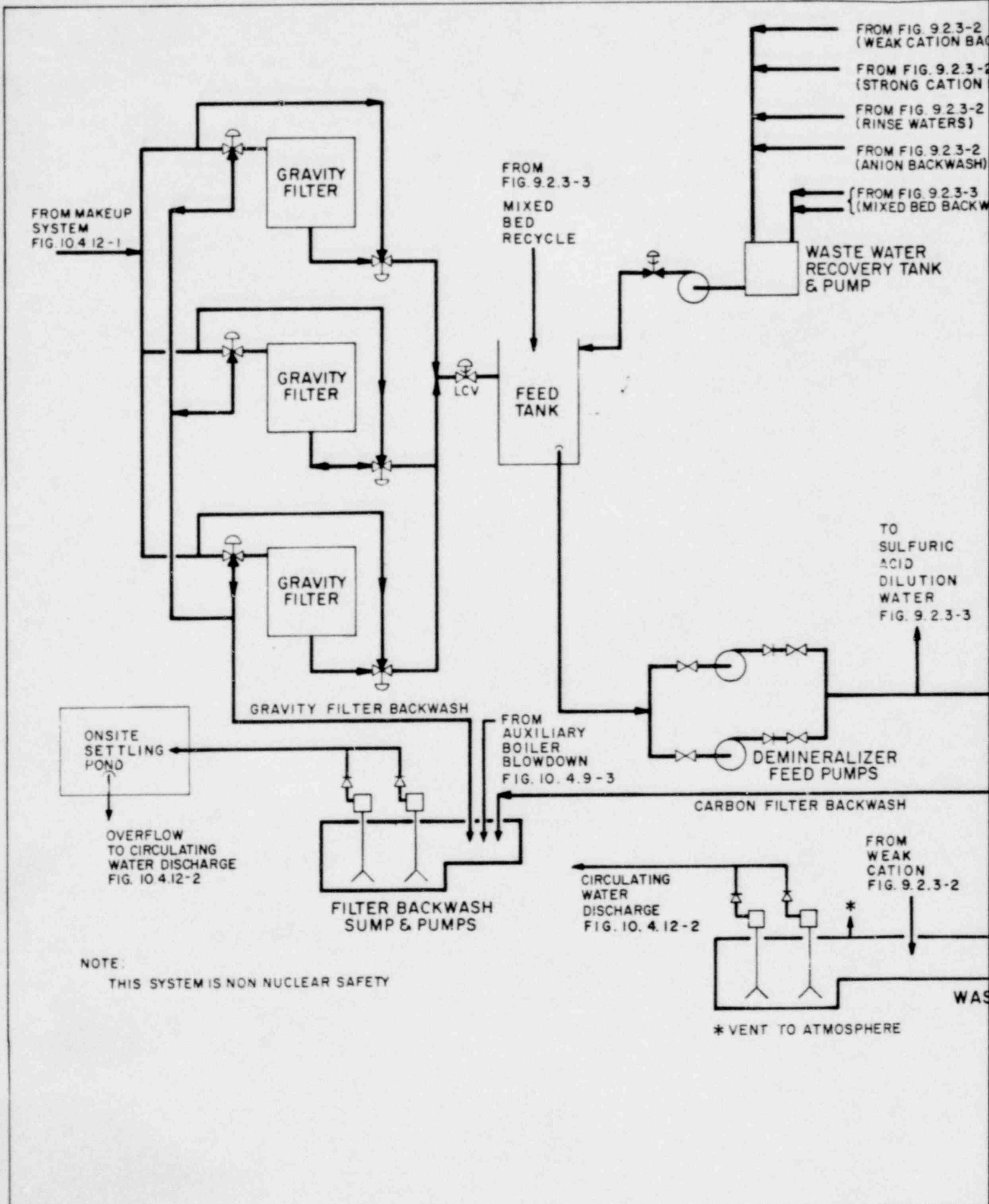
The service water pumphouse ventilation system is normally in continuous operation. Routine surveillance and preventive maintenance are performed and eliminate the need for periodic testing.

9.4.9.6 Instrumentation Applications

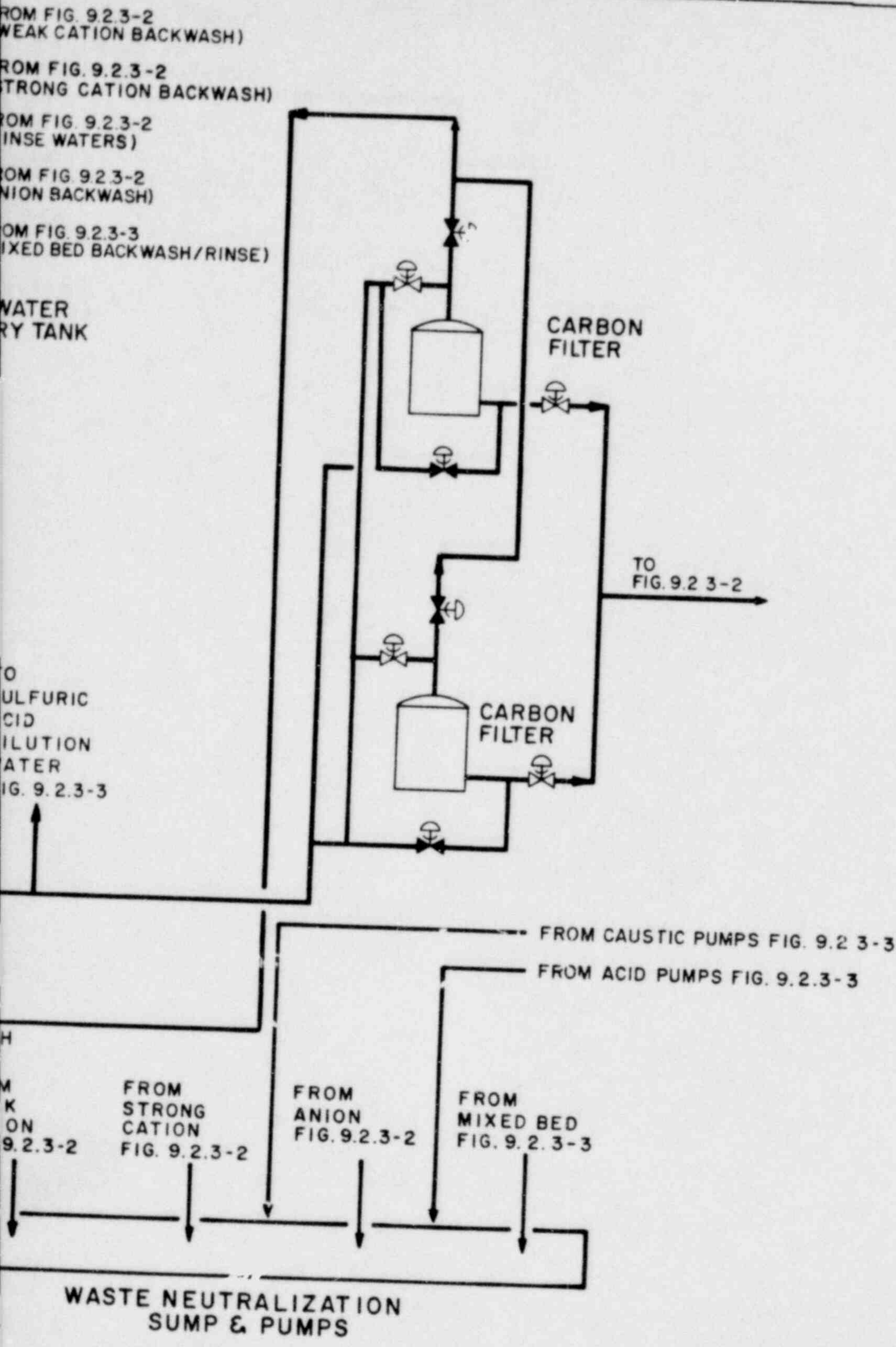
A room temperature controller starts the Unit No. 1 supply fan when the temperature rises to 75°F and stops the fan when the temperature falls to 65°F.

An additional temperature controller starts the Unit No. 2 supply fan when the temperature rises to 90°F and stops the fan when the temperature falls to 80°F.

The electric unit heaters are individually controlled by room-type temperature controllers. If the service water pumphouse ventilation system fails, a room temperature sensor detects high or low service water pumphouse ambient temperature and annunciates in the control room.



NOTE:
THIS SYSTEM IS NON NUCLEAR SAFETY



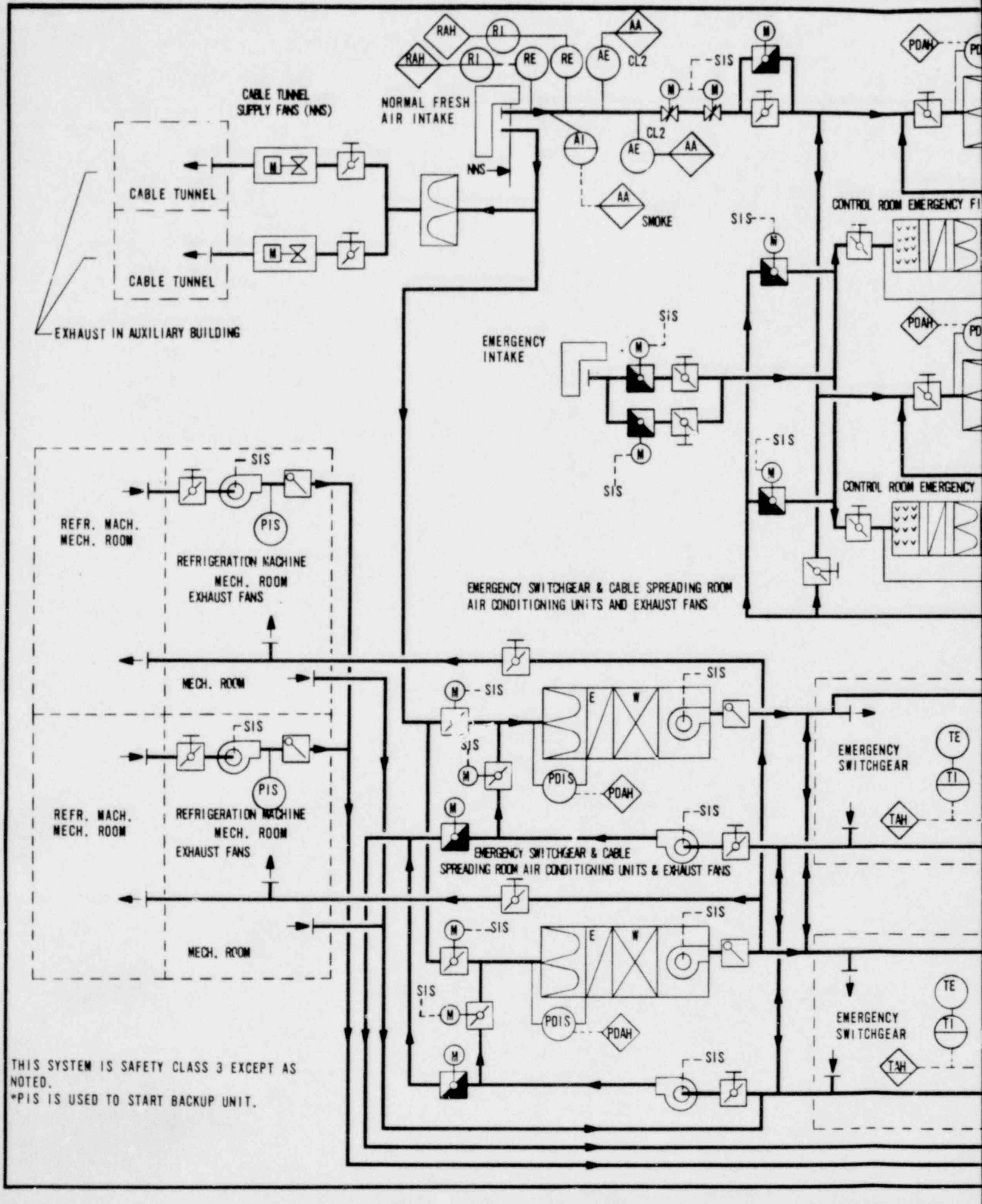
HAVEN NUCLEAR PLANT

FIGURE 9.2.3-1

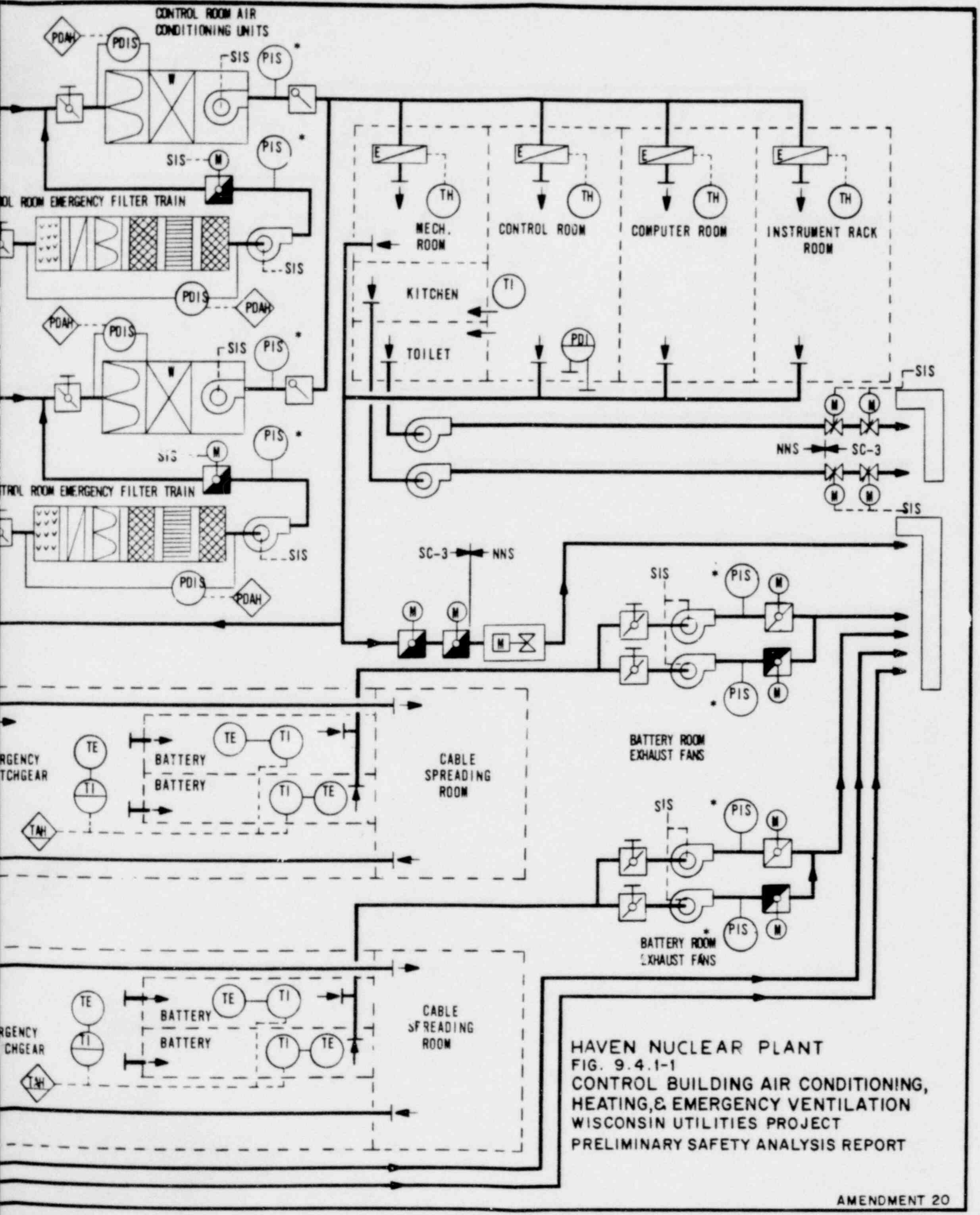
DEMINERALIZED WATER MAKEUP SYSTEM

WISCONSIN UTILITIES PROJECT

PRELIMINARY SAFETY ANALYSIS REPORT



THIS SYSTEM IS SAFETY CLASS 3 EXCEPT AS NOTED.
*PIS IS USED TO START BACKUP UNIT.



HAVEN NUCLEAR PLANT
FIG. 9.4.1-1
CONTROL BUILDING AIR CONDITIONING, HEATING, & EMERGENCY VENTILATION
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onshore discharge structure. Butterfly valves (Figure 9.2.1-1) are provided to recirculate warm water within the screenwell during cold weather operation. Steam generator blowdown (Section 10.4.8) is also discharged to the blowdown system along with wastes from the sewage treatment, the makeup water treatment plant (Figure 9.2.3-1), and turbine building drains (Figure 9.3.3-4).

Screenwash water from the travelling water screens is intermittently discharged to the blowdown system after trash removal as shown on Figure 9.2.1-1.

Radioactive liquid wastes are treated in the liquid radioactive waste system (Section 11.2). Depending on the results of radiochemical analysis and water inventory, distillate from the waste test tanks is either released to the blowdown system for dilution, or is recycled within the plant.

The condensate system (Section 10.4.7) may be drained to the blowdown system if necessary for maintenance of water inventory requirements.

Figure 10.4.12-3 provides the average expected flow rates and water use for both units during power operation.

10.4.12.4 Safety Evaluation

A failure of these systems will not affect the integrity of any safety-related equipment. Monitoring of the effluent from the radioactive liquid waste system to the blowdown system is described in Section 11.6 of the PSAR.

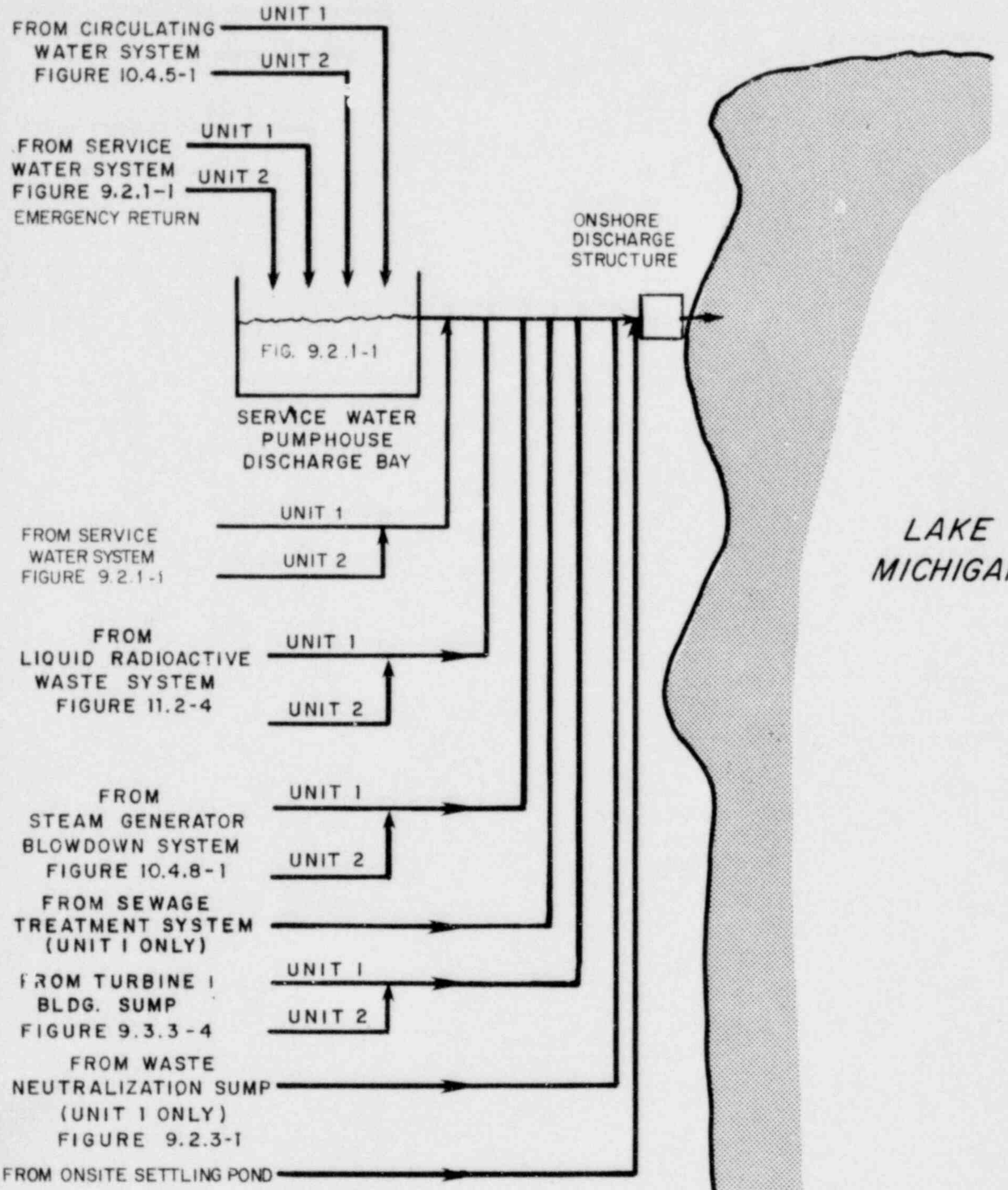
10.4.12.5 Test and Inspection Requirements

System components may be functionally tested during start-up and are in continual operation thereafter.

10.4.12.6 Instrumentation Applications

Instrumentation is provided for the makeup and blowdown system to alert the operator in the event of component malfunction.

Makeup water pumps are provided with local discharge pressure gages. A discharge pressure switch actuates an alarm in the control room on low discharge pressure. Pump-status indication lights are provided in the control room. The pump motors are equipped with motor overload trips.



NOTE:

THIS SYSTEM IS NON-NUCLEAR SAFETY (NNS).

THE SERVICE WATER PUMPHOUSE DISCHARGE BAY IS SEISMIC CATEGORY I

HAVEN NUCLEAR PLANT
FIGURE 10.4.12-2
BLOWDOWN SYSTEM
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

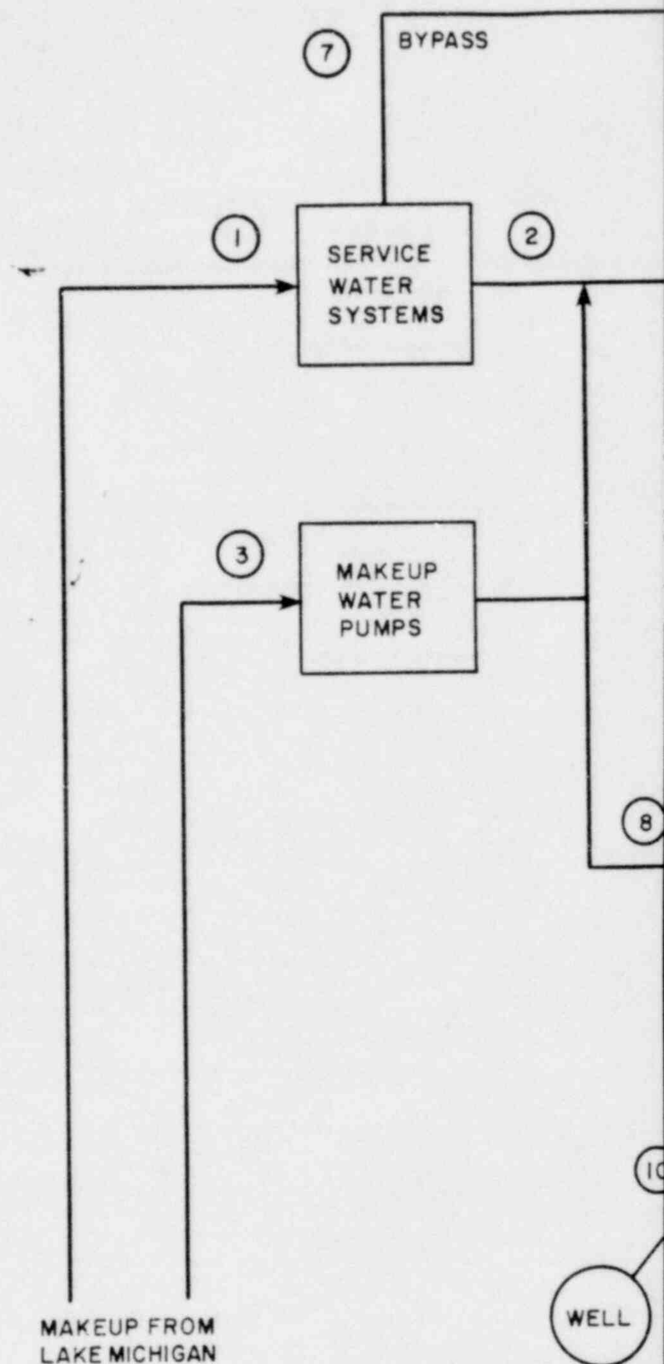
ITEM	FLOW RATE (Two Units) GPM AVERAGE
1. SERVICE WATER	22,200
2. MAKEUP FROM SERVICE WATER	22,200
3. MAKEUP WATER	11,580
4. COMBINED COOLING TOWER MAKEUP	33,600
5. COOLING TOWER BLOWDOWN	15,400
6. EVAPORATION AND DRIFT LOSSES	18,200
7. SERVICE WATER BYPASS	0
8. DEMINERALIZED WATER MAKEUP	180
9. DEMINERALIZED WATER	66
10. WATER FROM WELL	5(1)
11. WELL WATER	3(1)
12. POTABLE WATER USAGE	2(1)
13. DEMINERALIZER REGENERATION WASTE & SETTLING POND OVERFLOW	14(1)
14. EVAPORATION AND MISC. LOSSES	3(1)
15. RADIOACTIVE WASTE	6(1)
16. STEAM GENERATOR BLOWDOWN	148
17. FLOOR AND EQUIPMENT DRAINAGE AND SAMPLE WASTE	12(1)
18. SANITARY WASTE	2(1)
19. TOTAL DISCHARGE	15,582(2)
TOTAL WITHDRAWAL FROM LAKE AND WELL	33,785(3)

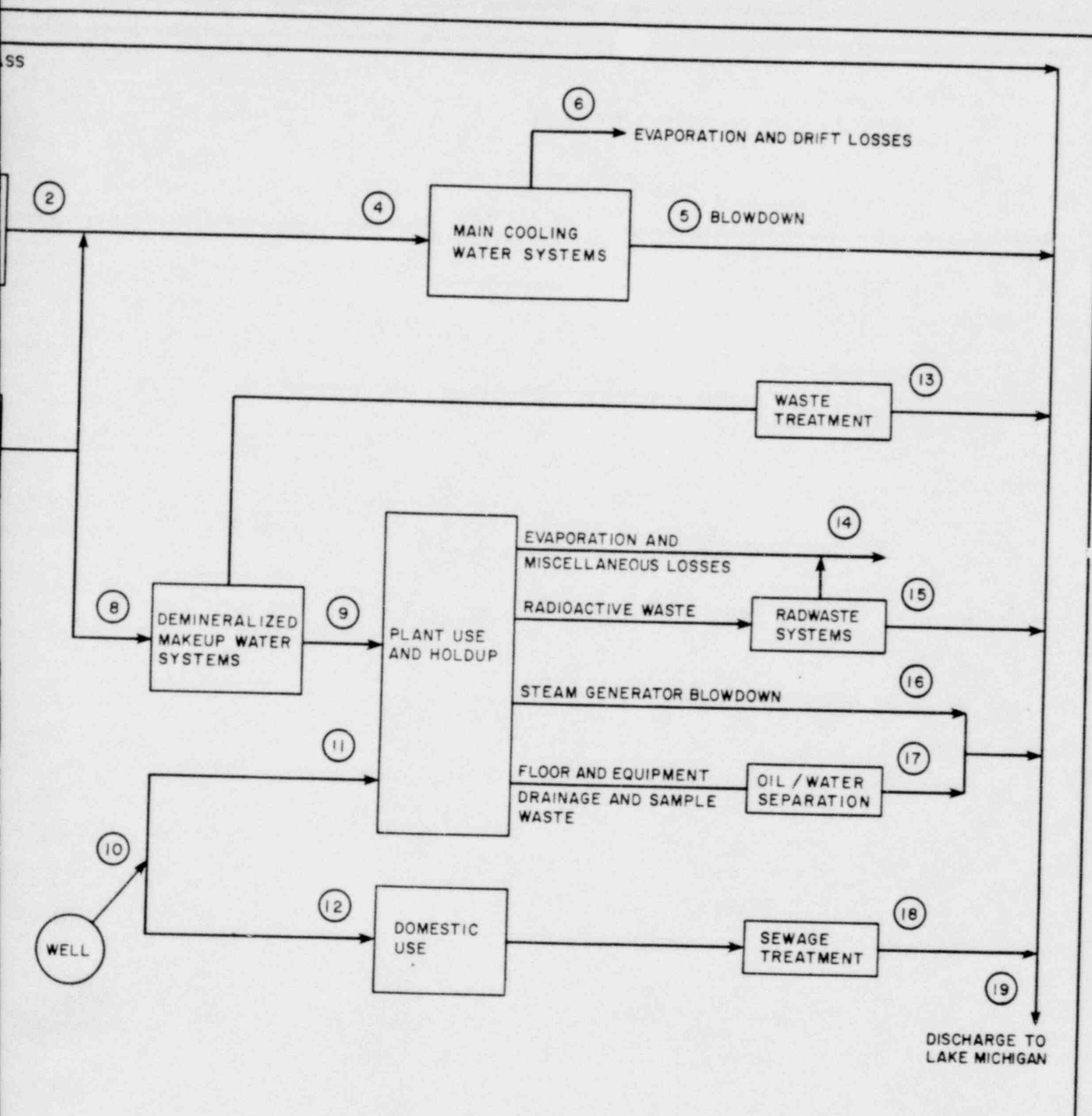
NOTES:

(1) INTERMITTENT FLOW EXPRESSED AS CONTINUOUS FLOW.

(2) DISCHARGE IS THE SUM OF STREAMS 5,13,15,16,17 & 18.

(3) TOTAL WATER USE IS THE SUM OF STREAMS 1,3 & 10.





HAVEN NUCLEAR PLANT
FIGURE 10.4.12 - 3
WATER USE DIAGRAM
WISCONSIN UTILITIES PROJECT
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TABLE 15.4.1-4

PURGE CONTRIBUTION TO LOCA DOSE

Type of Dose	Incremental Site Specific Dose[1] (rem)
Exclusion Area (2 hr)	
Thyroid	18.8
Whole Body	Negligible

NOTE:

[1] Calculated site specific doses are based on 12 months of onsite meteorological data.

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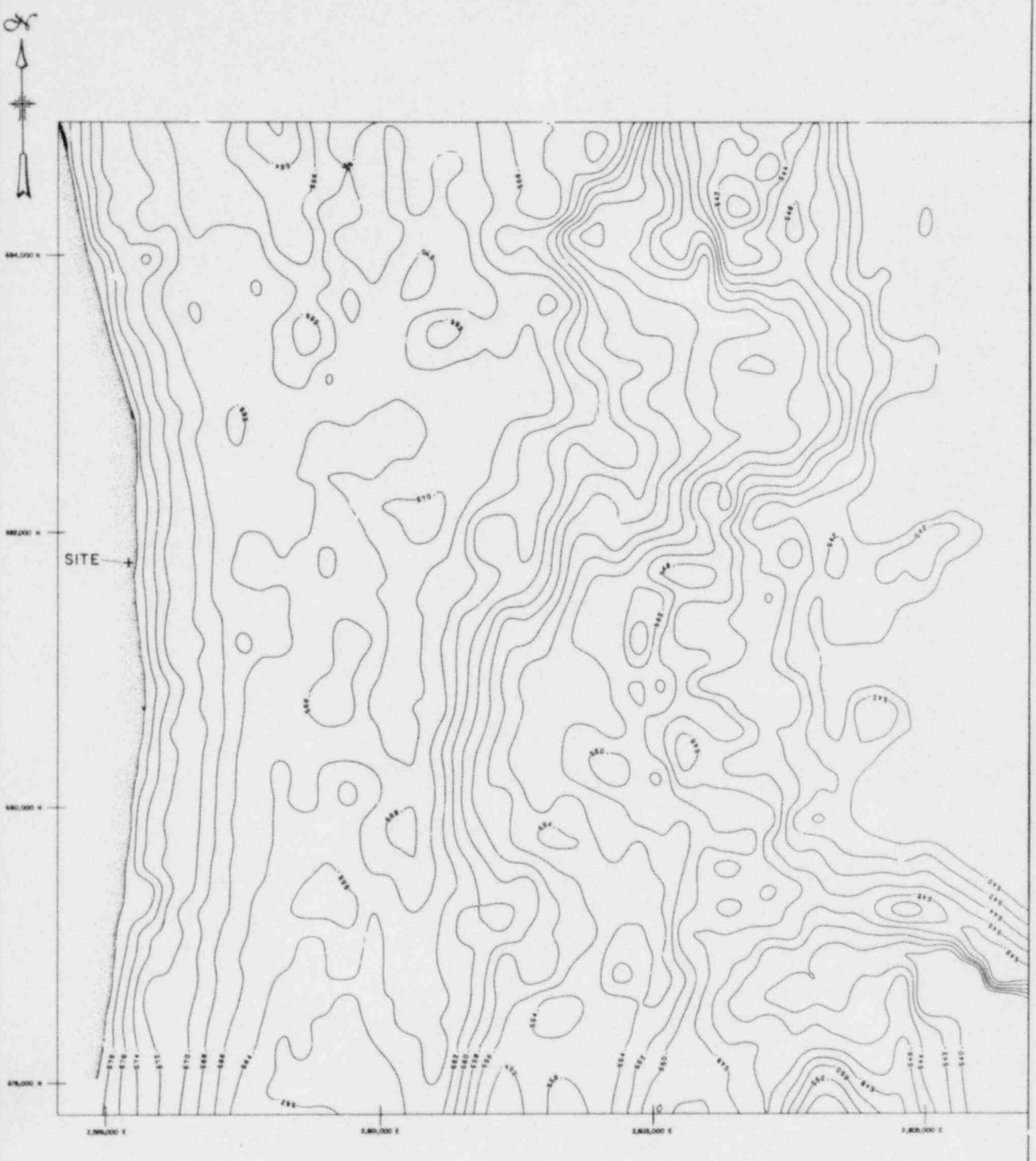
APPENDIX 2D

BATHYMETRY SURVEY - HAVEN SITE - 1978

A bathymetric survey was conducted offshore of the Haven site on May 3, 1978 by NALCO Environmental Sciences. Twenty-one parallel transects oriented roughly perpendicular to the shore were run by a boat equipped with a Raytheon DE-719B continuous recording fathometer. In addition to these transects with their uniform spacing of 100 m, four tie lines running parallel to the shoreline were also surveyed. The boat was positioned on the transects by a transit team on shore. The bottom was surveyed offshore to approximately the 40 ft contour and as near to shore as the boat draft permitted (usually to a 5 ft depth). Horizontal control was established with a Motorola Mini-Ranger Navigation System. A correlation between depth and location was made using an on-board digital clock. Horizontal coordinates and time were printed together on a printer at 1 second intervals. A time mark on the fathometer chart paper at 30 second intervals allowed for an accurate depth-location correlation.

The lake water level during the time of the survey was 579.59 ft mean sea level (msl) or 578.35 ft International Great Lakes Datum (IGLD). The fathometer readings were adjusted so that the bottom elevation (msl), rather than the water depth on the day of the survey, provided the basis for the bathymetry map. Figure 2D-1 depicts the smoothed bottom contours at 2 ft intervals. It is derived from a more detailed map on which the bottom elevation values along the transects were marked and printed. Given the lake level for a particular day of interest, the water depth itself at a surveyed point can be directly computed by referring to these results. The approximate position of the shoreline was drawn in accordance with the location of 30 onshore transect markers (stakes) which were surveyed in to the waterline in early November 1977. On Figure 2D-1, those contours shoreward of the 574 ft contour are interpolated, because data points are, for the most part, missing in this region. The horizontal coordinate system and the vertical datum employed are the same as for the December 1973 bottom profiling survey.

A comparison of respective offshore profiles for 1973 and 1978 indicates erosion close to shore, deposition farther offshore, and some erosion again lakeward from there. The elevation changes do not exceed 3 ft at any point. Such variations cannot be solely interpreted as part of a long-term trend because of other mechanisms which may account for the difference. Seasonal influences favor such a profile change between December and May, i.e., offshore sediment transport dominating during the winter season and onshore transport restoring the profile during summer. In addition, instrumentation error and the accuracy of horizontal positioning in the two surveys may have contributed to the observed differences. The bathymetry results for 1973 and 1978 do show that the overall contour pattern has not markedly changed over this period.



NOTE:
ELEVATIONS IN FEET RELATIVE TO USGS MEAN SEA LEVEL (1929)

HAVEN NUCLEAR PLANT
FIGURE 2D-1
BATHYMETRY SURVEY - MAY 3, 1978
WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

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QUESTION 312.6 (2.2)

It is stated that the frequency and size of the shipments of toxic chemicals on the Chicago and Northwestern Railroad, 4,200 feet from the control room air intakes, will be requested from the railroad. Discuss the status of your request and, if such information has not been obtained, postulate an accident involving the toxic chemicals listed in Regulatory Guide 1.78 and demonstrate that the control room operators are adequately protected. Show calculations.

RESPONSE:

Sections 2.2.3.1.3 and 9.4.1 of the Site Addendum have been updated to reflect the Chicago and Northwestern Railroad hazardous chemical information. Calculation techniques are also provided in Section 2.2.3.1.3 of the Site Addendum.

QUESTION 312.8 (2.2)

Evaluate the potential hazards to the plant associated with all types of civilian and military airspace operations which are taking place or are expected to take place during the operating lifetime of the plant.

RESPONSE:

The response to this question is provided in Section 2.2.

QUESTION 360.7 (App 2M)

Provide a gravity map and interpretation of the gravity data for Lake Michigan.

RESPONSE:

The response to this question will be provided in a future amendment.

QUESTION 360.8 (App 2M)

Modify the following figures in Appendix 2M to reflect the following:

(1) 2M-3 Include the fault which exists 5 miles southeast of the Haven Site;

(2) 2M-6 Include fault F on geologic cross Section BB;

(3) 2M-7 Include the fault which exists 5 miles southeast of the Haven Site on geologic cross Section CC;

(4) 2M-8 Include faults L, M, and N on geologic cross Section DD;

(5) 2M-10 Include the location of faults C through N;

(6) 2M-12 Label the geologic contacts and longitude lines on the profiles; and

(7) 2M-13 Label the geologic contacts and longitude lines on the profiles. Label the fault and identify the reflection line on the figure.

RESPONSE:

The response to this question will be provided in a future amendment.

QUESTION 360.9 (App 2M)

Provide a figure which shows both the faults on seismic profiles and the regional faults shown in Figure 2.5.1-9B of the PSAR. Discuss the possible continuation of the faults under Lake Michigan into Wisconsin and Michigan.

RESPONSE:

The response to this question will be provided in a future amendment.

QUESTION 360.10 (App 2M)

Discuss the ages of the rock units offset by the faults seen on the seismic reflection records. Discuss the age of the oldest rock units penetrated by the shallow versus the deep reflection records.

RESPONSE:

The response to this question will be provided in a future amendment.

QUESTION 360.11 (App 2M)

Provide full size copies of:

(1) University of Wisconsin shallow reflection lines 12 through 17;

(2) Grant Geophysical deep reflection lines D.O. 17, 18, 19, 23, 25, and 30;

(3) Illinois Geological Survey high resolution seismic lines; and

(4) Weston Geophysical Company's reflection record which shows the fault which exists 5 miles southeast of the Haven Site.

RESPONSE:

Full size copies of this information were provided to the NRC by letter to Mr. Harold R. Denton, Director, Office of Nuclear Reactor Regulation, dated December 8, 1978.

QUESTION 360.12 (App 2M)

Provide further discussion of the arguments for connecting faults G, H and C. Are there any geologic structures on the shores of Lake Michigan with a similar northeast trend? Provide a regional geological analysis to support the assumption that all the faults in Lake Michigan strike the same direction.

RESPONSE:

The response to this question will be provided in a future amendment.

QUESTION 360.13 (App 2M)

Provide a full scale bathymetric chart of Lake Michigan.

RESPONSE:

A full size copy of this information was provided to the NRC by letter to Mr. Harold R. Denton, Director, Office of Nuclear Reactor Regulation, dated December 8, 1978.

QUESTION 360.14 (App 2M)

Show on the cross sections where the breccia related to possible salt collapse occurs. Discuss in detail the relationship of the apparent zone of salt collapse and the irregular bottom north of 44°10'N, which is assumed to be due to differential erosion of breccias caused by salt collapse.

RESPONSE:

The response to this question will be provided in a future amendment.

QUESTION 360.15 (App 2M)

What is the basis for correlation of Or (Richmond Group-Michigan) with Om (Maquoketa Group-Wisconsin)?

RESPONSE:

The Michigan Geological Survey lists the Richmond Group (Or) as Cincinnatian and the Wisconsin Geological Survey lists the Maquoketa Group (Om) as Cincinnatian. The shale and dolomite of the Maquoketa contain upper Ordovician (Cincinnatian) fauna and is essentially Richmond age[1]. Therefore, the Richmond Group (Michigan) and the Maquoketa Group (Wisconsin) are time equivalents and correlatable.

Reference:

(1) Prouty, C.E. Lower Paleozoic and Pleistocentic Stratigraphy across Central Wisconsin. Annual Field Excursion, Michigan Basin Geological Society, May 1960.

QUESTION 360.16 (App 2M)

If a Pleistocene river channel is responsible for the fault-like conditions observed on lines 13, 14 and 15 and D.O. 25, why isn't the channel apparent on lines 12 and 16?

RESPONSE:

The response to this question will be provided in a future amendment.

QUESTION 360.17 (App 2M)

Provide an estimate of the seismic detection magnitude threshold for Lake Michigan given the current seismic monitoring around the Lake. In this regard, it should also be noted that the microearthquakes recorded at the Milwaukee station could have originated in northeastern Lake Michigan.

RESPONSE:

The magnitude of an earthquake occurring in eastern North America is determined from the following formulas developed by Nuttli[1]:

$$m_b = 3.75 + 0.90\ (\log\Delta) + \log A/T \quad 0.5° \le \Delta \le 4°$$

$$m_b = 3.30 + 1.66\ (\log\Delta) + \log A/T \quad 4° \le \Delta \le 30°$$

where:

- Δ is the distance from earthquake to seismograph station in degrees,
- A is zero to peak ground motion in microns, and
- T is the period of the wave.

These formulas can be applied to various seismographic stations operating in the central United States and Canada to determine the seismic detection magnitude threshold for Lake Michigan.

Figure Q360.17-1 shows the distribution of seismographic stations located in the central United States and Canada that will detect earthquake activity in Lake Michigan. Assuming that a minimum zero to peak amplitude of 2 mm on the seismogram enables distinction to be made between the earthquake signal and background noise, and measuring the peak amplitude at a 1 second period, the equations for magnitude computation become:

$$m_b = 3.75 + 0.90\ (\log\Delta) + \log\left(\frac{2\times10^3}{M}\right) \quad 0.5° \le \Delta \le 4°$$

$$m_b = 3.30 + 1.66\ (\log\Delta) + \log\left(\frac{2\times10^3}{M}\right) \quad 4° \le \Delta \le 30°$$

where M is the magnification of short period instruments at various stations. Table Q360.17-1 lists the magnifications of the short period instruments at the seismographic stations shown on Figure Q360.17-1 at a period of 1 second. It also lists the distances from the seismographic station up to which earthquakes of various magnitudes would be recorded as determined from the above equations. These distances are plotted on Figure Q360.17-1 for magnitude 3.0, and for magnitude 2.0 where the calculated distance is within the range of accuracy of the equations. This figure shows that earthquakes with magnitude ≥ 3.0 would be recorded by most of the stations in the central United States, ensuring epicentral determination based on instrumental records. For example, earthquakes with magnitude ≥ 3.0 in central and southern Lake Michigan would be detected by Bloomington, the Vincennes array, and probably by Minneapolis, Kalamazoo, and the Anna, Ohio array near Sidney, Ohio. Earthquakes with magnitude ≥ 3.0 in northern Lake Michigan would be recorded by Thunder Bay, the Vincennes array, and probably by Minneapolis. A network of short period instruments is being installed near Houghton, Michigan which will further improve the detection capability for northern Lake Michigan. Two seismographic stations at Chicago and Dubuque are also favorably situated for detecting earthquakes in southern and central Lake Michigan, but since the instruments at these stations are not calibrated, detection distances for magnitudes 2.0 and 3.0 cannot be determined.

An earthquake of magnitude 3.7 in northern Illinois on September 15, 1972 was located instrumentally. An earthquake of magnitude 2.9 near Chicago on November 18, 1977 was detected by the Minneapolis station and the micro-earthquake network array established near Vincennes, Indiana. The onset of arrival times on this array was used to determine the location of this earthquake. This array is capable of locating earthquakes in Lake Michigan with magnitude ≥ 2.5.

It can be concluded that earthquakes of magnitude ≥ 3.0 in Lake Michigan would be detected by a sufficient number of stations to ensure epicentral determination. Additionally, the high gain micro-earthquake array located near Vincennes is capable of detecting earthquakes of magnitude ≥ 2.5 in Lake Michigan.

REFERENCE:

1. Nuttli, O.W. Seismic Wave Attenuation and Magnitude Relations for Eastern North America. Journal of Geophysical Research, Vol. 78, 1973, p 876-885.

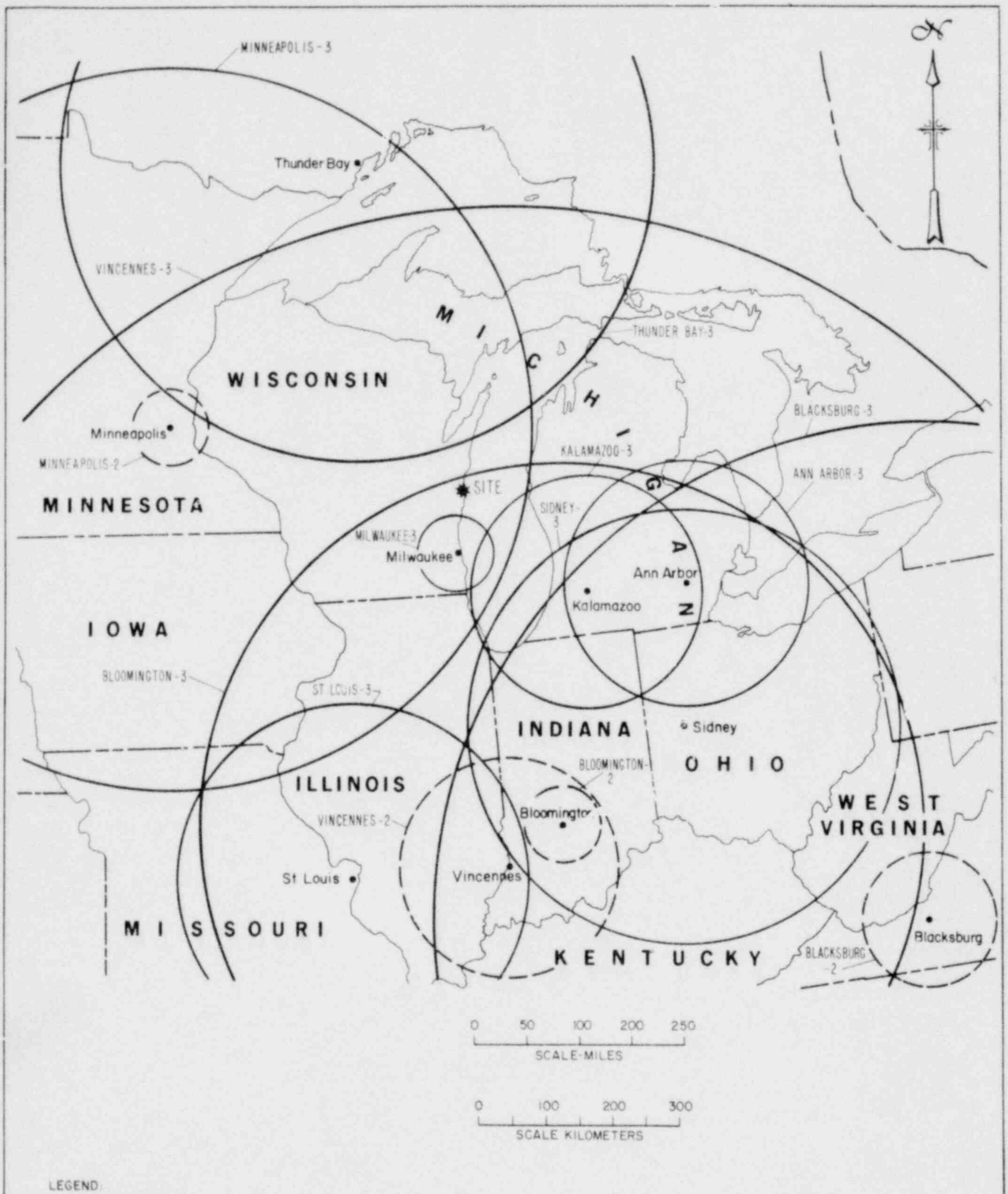
TABLE Q360.17-1

EARTHQUAKE MAGNITUDE DETECTION CAPABILITY OF SHORT PERIOD INSTRUMENTS AT VARIOUS SEISMOGRAPHIC STATIONS

Seismograph Station Location	Magnification of Short Period Instruments	Distance from Seismographic Station up to which Earthquakes of Various Magnitudes Are Recorded (km)		
		2.0	3.0	4.0
Ann Arbor	18,000	*	185	1050
Blacksburg	100,000	100	750	3000
Bloomington	60,000	55	550	2200
Kalamazoo	17,000	*	175	1050
Milwaukee	5,900	*	55	550
Minneapolis	60,000	55	550	2200
St. Louis	25,000	*	275	1300
Sidney	30,000	*	335	1450
Thunder Bay	42,500	*	450	1800
Vincennes	160,000	165	985	*

NOTE:

*Indicates calculated distances not within range of accuracy of equations



HAVEN NUCLEAR PLANT

FIGURE Q 360.17-1

DETECTION CAPABILITIES OF SEISMOGRAPHIC STATIONS IN THE CENTRAL UNITED STATES

WISCONSIN UTILITIES PROJECT
PRELIMINARY SAFETY ANALYSIS REPORT

QUESTION 360.18 (App 2M)

Discuss in detail the following as possible sources of faulting in Lake Michigan:

(1) Reactivation of Precambrian faults (consider any faults inferred from the aeromagnetic or gravity studies and their relationships to the faults found on the seismic reflection records);

(2) Solution of the salt formations and associated collapse of the overlying formations;

(3) Crustal rebound following Pleistocene glaciation; and

(4) Channel fill which appears as faulting on the seismic reflection records.

RESPONSE:

The response to this question will be provided in a future amendment.

QUESTION 361.10 (2.5)

Provide the following information with regard to Figures 2.5.1-9E Structure Contour Top of the St. Peter and 2.5.1-9D Structure Contours Top of the Maquoeta Formation:

a) Modify Figures 2.5.1-9D and 9E to include the borehole locations and depth to top of the respective formation.

b) Extend Figure 2.5.1-9D to the south to include the Milwaukee area.

c) On page 2.5-25, the PSAR states that "a portion of the structural contour map of the top of the St. Peter Sandstone is shown on Figure 2.5.1-9E." Provide the complete structural contour map of the top of the St. Peter Sandstone.

d) Provide the structural contouring on top of the Trempeleau Group. Include on this the borehole locations and depth to the contact with the top of the Trempeleau Group.

RESPONSE:

The response to this question is provided on Figures 2.5.1-9D, 9E, 9F, and 9G and Section 2.5.1.1.3 of this Site Addendum.