SECTION 2 SITE AND ENVIRONS

TABLE OF CONTENTS

Section Page

Section Page

2.1 Introduction

The Monticello site was thoroughly investigated as a site for a nuclear power plant and found to be suitable as evidenced by issuance of a construction permit (Docket No. 50-263) on June 19, 1967.

Section 2 contains information on the site and environs of the Monticello Nuclear Generating Station.

2.2 Site Description

2.2.1 Location

The plant is located within the city limits of Monticello, Minnesota (1990 population 4,941), on the right bank of the Mississippi River in Section 33, T-122N, R-25W, in Wright County, Minnesota, at 45° 20' N latitude and 93° 50′ W longitude. The reactor center line is located at approximately 850,810 feet North and 2,036,920 feet East as determined on the Minnesota State Grid, South Zone.

The plant site consists of approximately 2150 acres of land owned in fee by Northern States Power Company, a wholly owned operating subsidiary of Xcel Energy Corporation (Xcel Energy). Part of this property is on the left bank of the river in Sherburne County and part is on the right bank in Wright County. Drawing ND-95208, Section 15, shows the plant site boundaries. This figure also shows an outline of the minimum fenced area which defines the restricted area boundary or site boundary for gaseous releases in accordance with10CFR20 and Appendix I to 10CFR50. Due to the prevailing wind pattern, the direction of maximum integrated dosage for normal effluent releases is SSE. The southern property line generally follows the northern boundary of the right-of-way for the Burlington Northern Railway. The exclusion zone has been arbitrarily selected to occupy the same fenced area. This more than satisfies the 10CFR100 (as augmented by 10CFR50.67) definition of an exclusion zone. Access to the exclusion zone is restricted by a perimeter fence with No Trespassing signs posted at intervals along the fence. Access to the exclusion zone by water is not restricted by a fence; however, No Trespassing signs are placed at intervals along the shoreline of the river.

The nearest site boundary is approximately 1630 feet S 30 degrees W of the reactor center line. The distance to the nearest residence is about 0.6 mile to the southwest, and the nearest large city, St. Cloud, is 22 miles upstream from the plant site. The northwestern suburbs of Minneapolis are about 30 miles southeast from the site.

2.2.2 Topography

The topography of the Monticello site is characterized by relatively level bluffs which rise sharply above the river. Three distinct bluffs exist at the plant site at elevations 920, 930, and 940 feet above mean sea level (ft msl). Normal river is 905 ft msl, and the maximum reported flood is at 916 ft msl.

Bluffs located about 1 mile north and south of the site rise to 950 ft msl. Beyond 1 mile north, the terrain is relatively level with numerous lakes and wooded areas. To the south, west, and east, the terrain is hilly and dotted with numerous small lakes.

2.2.3 Access

Highway access is available to Wright County Road 75 which is about 3000 feet southeast of the reactor building. Interstate 94 runs northwest from Minneapolis about 3700 feet southwest of the site. Drawing ND-95208, Section 15, shows the location of these highways.

Railroad access is available from the Burlington Northern track which is about 2300 feet southwest. The site is served by a spur from this line.

The reach of the Mississippi River near the site is not suitable for navigation because its gradient is very steep and numerous shoals exist due to the current.

2.2.4 Land Use

The land surrounding the site is predominantly rural. There are a few small villages and many lakes within a 15-mile radius of the site. The terrain is heavily wooded along the river, while the bluffs away from the river are cultivated and used for dairy farming. Crops raised in the area include soybeans, corn, oats, hay, and potatoes.

2.2.5 Population Distribution

The area in which the Monticello Plant is located is principally rural in character and the land is used primarily for farming. The main residential and business district of Monticello is about 3 miles southeast of the plant. Other nearby communities include: Becker (2010 population of 4,538) about 4 miles northwest; Big Lake (2010 population of 10,060) about 5 miles east; Maple Lake (2010 population of 2,059) about 10 miles southwest; and Buffalo (2010 population of 15,453) about 10 miles south. The closest large cities are St. Cloud (2010 population of 65,842) about 20 miles northwest and Minneapolis (2010 population of 382,578) and St. Paul (2010 population of 285,068) about 30 miles southeast of the plant. 01441967

The resident population within the 10 mile Emergency Planning Zone (EPZ) (2010 estimate) is approximately 68,635. Similarly, within a 50-mile radius of the plant (approx. 7,850 square miles) the population in 1990 is estimated to be 2,273,213, of which about 90% reside in the Minneapolis-St. Paul metropolitan area. The projected population within the 50-mile radius in the year 2000 is approximately 2.25 million.

In Wright County and in Sherburne County, immediately across the Mississippi River to the Northeast, about 80% of the land is used for farming. It is expected that these two counties will remain largely agricultural.

Table 2.2-1 shows the 2010 population. 01441967

The low population zone radius for the Monticello facility has arbitrarily been selected as one mile. Due to the sparse population of the area there will be no difficulty in taking appropriate protective action in the event of a serious accident. Based on the 10CFR100 (as augmented by 10CFR50.67) definition of a low population zone radius and the radiological effects presented in Section 14, the selection of a one-mile radius is more than adequate.

In November 2012 an updated Monticello Evacuation Time Estimate was completed. This study was based on the most recent (2010) census estimates and considered factors such as transient and seasonal population changes, special facilities, and changes in the area transportation (roadway) network. 01441967

2.2.6 Conclusions

The population distribution around the site is quite low. Good isolation from population centers is evident. Land use is devoted to agriculture. Therefore, from the population distribution and land usage viewpoint, the site is suitable for the facility as designed. The analyses of design basis accidents in Section 14 verify that maximum expected doses at or beyond the exclusion area boundary are well below the reference doses given in 10CFR50.67

Table 2.2-1 Estimated 2010 Resident Population Distribution Around the Monticello Nuclear Generating Plant

Radius (MILES)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0-1	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	22
1-2	4	0	0	0	205	63	919	319	0	143	0	122	61	98	0	0	1,934
2-3	0	2	11	135	110	455	1,417	89	0	220	0	94	22	1	0	0	2,556
3-4	533	4	313	1,356	272	358	2,189	1,174	130	0	322	84	164	32	29	44	7,004
4-5	568	244	304	2,970	1,718	827	2,328	687	263	124	115	29	11	232	39	1,044	11,503
5-6	476	78	256	1,112	3,088	1,341	2,571	81	46	73	161	57	59	175	32	1,847	11,453
6-7	144	319	419	527	179	407	349	112	139	101	123	40	299	104	4	464	3,730
7-8	125	546	603	683	640	492	103	46	327	141	100	176	167	203	275	719	5,346
8-9	141	304	276	932	292	869	103	70	1,361	237	365	147	273	135	65	171	5,741
9-10	179	391	350	537	1,014	526	164	64	2,701	248	178	94	184	181	130	71	7,012
10-11*	404	138	519	208	652	325	1,260	150	3,281	104	2,238	345	154	1,993	196	367	12,334
TOTAL	2,574	2,026	3,051	8,460	8,170	5,663	11,403	2,792	8,270	1,391	3,602	1,188	1,394	3,154	770	4,727	68,635

*Note this population is the remainder of the 10-Mile EPZ due to geopolitical boundaries which extend into the 10-11 mile range.

01441967

2.3 Meteorology

2.3.1 General

Travelers Research Corporation analyzed the meteorology of the plant site. Initial design criteria related to meteorology were based on data taken at St. Cloud and Minneapolis. Since the original Facility Description and Safety Analysis Report was written, a meteorological program was established to provide actual on-site meteorological data. The data obtained from this program are summarized in USAR Tables 2.3-5 through 2.3-20 These data confirm the adequacy of the initial design criteria used in the plant design. 01081199

The general climatic regime of the site is that of a marked continental type characterized by wide variations in temperature, scanty winter precipitation, normally ample summer rainfall, and a general tendency to extremes in all climatic features. Of special interest are the extremes in annual snowfall, which may be as little as six inches or as much as 88 inches; a temperature range of 145°F for the period of record; occasional severe thunderstorms with heavy rainfall and high winds; and the possibility of an occasional tornado or ice storm. These and other pertinent meteorological data are presented in the following sections.

2.3.2 Temperature

Average and extreme monthly air temperatures for the Monticello site are not available, but 54 years of data for St. Cloud and Minneapolis - St. Paul have been adjusted to give representative average values for the site area. The site is approximately 13 miles closer to St. Cloud than to Minneapolis. A summary of monthly air temperatures from January to December is given in Table 2.3-1.

2.3.3 Precipitation

Precipitation in the Monticello area is typical for the marked continental climate, with scanty winter precipitation and normally ample summer rainfall. The months of May through September have the greatest amounts of precipitation; average fall of rain during this period is 17-18 inches, or more than 70% of the annual rainfall. Thunderstorms are the principal source of rain during May through September and the Monticello area normally experiences 36 of these annually. The heaviest rainfall also occurs during a particularly severe thunderstorm. A summary of precipitation statistics is shown in Table 2.3-2 (based on St. Cloud and Minneapolis - St. Paul averages). Average monthly snowfall statistics are given in Table 2.3-3.

Intense rainfall is produced by an occasional severe thunderstorm. The return period of extreme short interval rainfall is a useful guide. The nearest location for which return period data are available and which should be reasonably representative for the Monticello area is Minneapolis. This data is shown in Figure 2.3-1.

Snow load data available from a Housing and Home Finance Agency (HHFA) study conducted in 1952 (Reference 18) are given in Table 2.3-4.

Data relating to freezing rain and resultant formation of glaze ice on highways and utility lines are available from the following studies:

American Telephone and Telegraph Company, 1917-18 to 1924-25 (Reference 19)
Edison Electric Institute, 1926-27 to 1937-38 (Reference 20)
Association of American Railroads, 1928-29 to 1936-37 (Reference 21)
Quartermaster Research and Engineering Command, U.S. Army, 1959 (Reference 22)

The U.S. Weather Bureau also maintains annual summaries. The following is a fairly accurate description of the glaze-ice climatology of middle Minnesota.

Time of occurrence - October through April
Average frequency without regard to ice thickness, 1-2 storms per year
Duration of ice on utility lines - 36 hours (mean) to 83 hours (maximum of record)

Return periods for freezing rain storms producing ice of various thickness are:

0.25 inch - Once every 2 years
0.50 inch - Once every 2 years
0.75 inch - Once every 3 years

2.3.4 Winds and Wind Loading

The preoperational meteorological data program is described in Sections 2.3.4 and 2.3.5 of the FSAR. The Monticello plant is currently provided with a 100-meter meteorological tower. Wind speed, direction, and temperature difference instrumentation is located at approximately ten meters and at the elevation of the plant effluent point (43 meters and 100 meters). In addition, temperature and rainfall instruments are provided. Meteorological data is used to compute dispersion (X/Q) and deposition (D/Q) factors for use in the dose assessment of airborne releases. Wind speed, direction, and atmosphere stability class are averaged over the release period and serve as inputs to a dispersion model. Stability class is determined using temperature difference measurements between the ten meter elevation and the elevation of the release.

Wind frequency distributions for the 10 and 100 meter tower elevations for the period January 1, 1980 through December 31, 1980 are presented in Tables 2.3-5 through 2.3-20. The distributions are for Stability A through G, as defined in Table 1 of the proposed revision 1 to Regulatory Guide 1.23 issued September 1980 (Reference 39). Annual average dispersion factor (X/Q) and deposition per unit area (D/Q) were computed for this period and are presented in Tables 2.3-22 through 2.3-27. NRC computer code XOQDOQ was used for these calculations (Reference 14). This historical data may be useful in estimating off-site doses due to routine releases of airborne radioactive effluents from the reactor building vent and plant stack.

Wind frequency distributions for the 10, 43 and 100 meter tower elevations for the period of January 1, 1998 through December 31, 2002 were prepared for use in calculating atmospheric dispersion coefficients for design basis radiological consequences analysis using Alternative Source Term Methodology (reference USAR Section 14.7). These distributions appy only to the accident analyses. 01081199

2.3.4.1 Tornadoes and Severe Thunderstorms

Severe storms such as tornadoes are not numerous, but they do occur occasionally. The latitude of the Monticello site places it at the northern edge of the region of maximum tornado frequency in the United States, but only a few tornadoes have occurred in this vicinity. Eight tornadoes have been reported in Wright County during the period 1916-1967, two of which subsequently moved across the Mississippi River into Sherburne County.

A 1-degree square[1], lying between 45 and 46 degrees north, and between 93 and 94 degrees west, encompasses the Monticello site. There have been approximately eight tornado occurrences reported in this 1-degree square in the 14-year test period, 1953-1966. The ratio of eight tornadoes in 14 years gives a mean annual tornado frequency of 0.6. This frequency is confirmed by the Mean Annual Tornado Frequency figures published by the U.S. Department of Commerce, Weather Bureau (Reference 31).

Using the methods described by H. C. S. Thom (Reference 2), with a mean annual tornado frequency of 0.6, the probability of a tornado striking a given point in the outlined 1-degree square, which encompasses the Monticello site, can be calculated to be $5x10^{-4}$ per year, or one tornado every 2000 years. The effects of the tornado phenomenon including possible effects of missiles and water loss effects in the fuel pool are discussed in Reference 3 of this section.

Subsequently, it was determined the drywell head could become a missile hazard for the spent fuel pool, however, since the probability is less than 10^{-7}, it is not a credible missile.

The average number of thunderstorms for Minneapolis and St. Cloud is 36 with more than half of these occurring in June, July, and August. Therefore, it is expected that the Monticello site may experience an average of 36 thunder-storms annually. The fastest wind recorded for 54 years of record for each month at Minneapolis is given in Table 2.3-21.

2.3.4.2 Conclusions

The meteorology of the site area is basically that of a marked continental area with relatively favorable atmospheric dilution conditions prevailing. Diffusion climatology comparisons with other locations indicate that the site is typical of the North Central United States. Frequency of inversion is expected to be 30-40% of the year.

1. In this area, a 1-degree square is approximately 3,354 square miles.

The site is located in an area occasionally traversed by storms and tornadoes. Maximum reported wind speed associated with passage of storm is 92 mph.

2.3.5 Plant Design Based on Meteorology

The station is designed with an off-gas stack to be used for continuous dispersal of gases to the atmosphere. Based on meteorological data at the site, plant operational characteristics, and stack design, the off-site doses arising from routine plant operation will satisfy the guidelines of Appendix I to 10CFR50.

A listing of other relevant reference material is given in References 4 through 9.

Class I and Class II Station structures are designed to withstand the effects of 100 mph winds at 30-feet above ground with a gust factor of 1.1. Structures and systems which are necessary for a safe shutdown of the reactor and maintaining a shutdown condition are designed to withstand tornado wind loadings of 300 mph.

Bibliography: Rainfall Intensity - Duration - Frequency Curves, Tech. Paper No. 25, U.S. Weather Bureau (1955) (Reference 23).

Climatological Data with Comparative Data, Minneapolis - St. Paul, Minnesota, 1953-1956 - U.S. Weather Bureau (2 publications) (Reference 24).

Climatological Data with Comparative Data, St. Cloud, Minnesota 1953-1965 - U.S. Weather Bureau (2 publications) (Reference 25).

Climatography of the United States, No. 86-17, Minnesota, U.S. Weather Bureau (Reference 26).

Local Climatological Data with Comparative Data, 1965 - U.S. Weather Bureau (Reference 27).

“Snow Load Studies”, Housing Research Paper 19, Housing and Home Finance Agency, 1952 (Reference 28).

“Glaze, Its Meteorology and Climatology, Geographical Distribution and Economic Effects,” Quartermaster Research and Engineering Center, 1959 (Reference 29).

Climatography of the United States No. 60-21, Minnesota - U.S. Weather Bureau (Reference 30).

Table 2.3-1 Monthly Air Temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	21	24	38	55	68	77	83	80	72	59	40	26
Minimum	3	6	20	35	46	56	61	59	50	39	24	10
Mean	12	15	29	45	57	66	72	70	61	49	32	18
Extreme Maximum	59	61	82	91	105	103	107	104	105	90	75	63
Extreme Minimum	-38	-34	-30	4	20	33	42	38	22	8	-18	-29

Table 2.3-2 Summary of Precipitation Statistics

Month	Days with 0.01 inch or more	Mean (inches)	Extreme Monthly Min. (inches)	Extreme Monthly Max. (inches)	*Max. in 24 hours (inches)	Days with Thunder-storms
Dec	9	0.77	T	2.48	1.05	0
Jan	8	0.78	0.02	2.82	1.90	0
Feb	7	0.80	0.01	3.10	1.83	0
Winter	24	2.35	-	-	-	0
March	10	1.32	0.11	3.95	2.00	1
April	9	1.94	0.32	5.72	3.15	2
May	12	3.11	0.20	10.00	5.00	5
Spring	31	6.37	-	-	-	8
June	13	4.06	0.87	9.78	3.35	8
July	10	2.86	0.31	12.34	4.80	7
Aug	10	2.83	0.31	8.99	4.62	6
Summer	33	9.75	-	-	-	21
Sept	9	2.92	0.24	9.24	3.65	4
Oct	8	1.65	.01	7.18	3.24	2
Nov	8	1.40	.01	4.66	1.44	1
Fall	25	5.97	T	-	-	7
Annual	113	24.44				

* St. Cloud 1894-1965
T = TRACE

I/cah

Table 2.3-3 Average Monthly Snowfall (inches)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Minneapolis St. Paul	6.3	8.0	11.5	2.7	0.2	0.0	0.0	0.0	0.1	0.3	6.1	7.0	42.2
St. Cloud	6.5	7.7	11.5	2.8	0.1	0.0	0.0	0.0	0.1	0.4	6.3	7.0	42.4

Maximum in 24 hours: Minneapolis 16.2 inches
St. Cloud 12.2 inches

Table 2.3-4 Snow Load Data

Location	Wt. of Seasonal Snowpack Equalled or Exceeded 1 Yr in 10	Wt. of Max Snowpack of Record	Wt. of Estimated Max. Accumulation on Grd plus Wt. of Max. Possible Storm
Minneapolis	30 lb/ft^2	40 lb/ft^2	50 lb/ft^2
St. Cloud	30 lb/ft^2	40 lb/ft^2	50 lb/ft^2

Table 2.3-5 Wind Frequency Distributions at 10 Meter Level, Stability Class A (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	3	20	34	15	4	0	76
NNE	4	11	11	2	0	0	28
NE	5	17	23	1	0	0	46
ENE	9	25	13	0	0	0	47
E	4	18	12	3	1	0	38
ESE	4	24	32	7	1	0	68
SE	4	22	43	24	0	0	93
SSE	3	13	47	32	7	0	102
S	2	18	39	36	26	0	121
SSW	3	25	60	26	3	0	117
SW	2	21	43	10	0	0	76
WSW	5	27	34	18	1	0	85
W	3	25	12	15	4	0	59
WNW	5	21	34	22	5	0	87
NW	4	20	51	27	7	0	109
NNW	2	10	37	30	5	0	84
VAR	0	0	0	0	0	0	0

Total Hours this Class	1242
Hours of Calm this Class	6
Percent of all Data this Class	15.14

Table 2.3-6 Wind Frequency Distributions at 10 Meter Level, Stability Class B (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	1	7	11	3	0	0	22
NNE	0	6	4	0	1	0	11
NE	1	4	5	1	0	0	11
ENE	0	5	0	0	0	0	5
E	0	4	0	0	0	0	4
ESE	0	4	4	1	1	0	10
SE	0	4	2	1	1	0	8
SSE	1	5	3	3	2	0	14
S	3	5	3	3	0	0	14
SSW	2	2	7	2	0	0	13
SW	4	2	4	0	0	0	10
WSW	1	5	5	1	0	0	12
W	0	1	4	2	0	0	7
WNW	1	7	8	2	1	0	19
NW	1	7	9	6	3	0	26
NNW	1	8	8	4	1	0	22
VAR	0	0	0	0	0	0	0

Total Hours this Class	208
Hours of Calm this Class	0
Percent of all Data this Class	2.54

Table 2.3-7 Wind Frequency Distributions at 10 Meter Level, Stability Class C (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	4	14	15	5	2	0	40
NNE	1	7	11	1	0	0	20
NE	2	7	5	1	0	0	15
ENE	0	11	0	0	0	0	11
E	1	5	1	0	0	0	7
ESE	2	6	6	1	1	0	16
SE	0	5	8	2	2	0	17
SSE	0	7	6	7	0	0	20
S	1	5	9	4	1	1	21
SSW	0	6	4	1	0	1	12
SW	2	8	11	4	0	0	25
WSW	0	8	6	0	1	0	15
W	0	7	3	3	2	0	15
WNW	2	4	14	7	1	0	28
NW	2	1	12	2	1	0	18
NNW	0	8	16	8	0	0	32
VAR	0	0	0	0	0	0	0

Total Hours this Class	313
Hours of Calm this Class	1
Percent of all Data this Class	3.82

Table 2.3-8 Wind Frequency Distributions at 10 Meter Level, Stability Class D (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	37	83	118	62	10	0	310
NNE	19	56	55	18	3	0	151
NE	26	56	61	12	0	0	155
ENE	24	71	28	1	0	0	124
E	12	58	47	9	0	0	126
ESE	13	75	79	34	0	0	201
SE	11	63	123	40	6	0	243
SSE	13	35	80	14	1	0	143
S	11	34	53	26	6	0	130
SSW	8	31	36	8	4	1	88
SW	5	23	27	3	2	0	60
WSW	9	18	24	4	3	0	58
W	7	28	20	15	3	0	78
WNW	5	40	72	29	20	3	169
NW	17	37	95	55	25	1	230
NNW	26	69	170	108	14	0	387
VAR	0	0	0	0	0	0	0

Total Hours this Class	2753
Hours of Calm this Class	100
Percent of all Data this Class	33.56

Table 2.3-9 Wind Frequency Distributions at 10 Meter Level, Stability Class E (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	28	96	48	7	0	0	179
NNE	15	39	17	2	0	0	73
NE	19	50	21	3	0	0	93
ENE	17	30	13	1	0	0	61
E	14	35	19	1	0	0	69
ESE	13	61	45	2	0	0	121
SE	12	70	49	3	0	0	134
SSE	9	50	38	15	1	0	113
S	10	32	33	28	2	0	105
SSW	13	35	41	22	1	0	112
SW	15	21	18	5	0	0	59
WSW	15	28	14	11	0	0	68
W	18	43	30	2	0	0	93
WNW	9	101	98	22	0	0	230
NW	11	54	87	36	2	0	190
NNW	20	87	113	33	4	0	257
VAR	0	0	0	0	0	0	0

Total Hours this Class	2008
Hours of Calm this Class	51
Percent of all Data this Class	24.48

Table 2.3-10 Wind Frequency Distributions at 10 Meter Level, Stability Class F (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	29	35	2	0	0	0	66
NNE	8	14	2	0	0	0	24
NE	18	14	2	0	0	0	34
ENE	14	9	0	0	0	0	23
E	12	26	0	0	0	0	38
ESE	14	46	6	0	0	0	66
SE	9	40	6	5	0	0	60
SSE	15	36	9	2	2	1	65
S	9	29	19	0	0	0	57
SSW	14	33	8	2	0	0	57
SW	20	25	6	0	0	0	51
WSW	18	39	3	1	0	0	61
W	18	37	7	0	0	0	62
WNW	15	31	0	0	0	0	46
NW	17	29	10	0	0	0	56
NNW	14	69	11	0	0	0	94
VAR	0	0	0	0	0	0	0

Total Hours this Class	871
Hours of Calm this Class	11
Percent of all Data this Class	10.62

Table 2.3-11 Wind Frequency Distributions at 10 Meter Level, Stability Class G (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	43	23	1	0	0	0	67
NNE	16	7	1	0	0	0	24
NE	17	12	0	0	0	0	29
ENE	15	1	0	0	0	0	16
E	15	5	0	0	0	0	20
ESE	17	10	0	0	0	0	27
SE	18	14	0	0	0	0	32
SSE	35	30	0	0	0	0	65
S	33	44	6	0	0	0	83
SSW	49	35	3	0	0	0	87
SW	35	14	0	0	0	0	49
WSW	38	28	0	0	0	0	66
W	33	22	0	0	0	0	55
WNW	32	11	0	0	0	0	43
NW	26	19	0	0	0	0	45
NNW	41	30	0	0	0	0	71
VAR	0	0	0	0	0	0	0

Total Hours this Class	808
Hours of Calm this Class	29
Percent of all Data this Class	9.85

Table 2.3-12 Wind Frequency Distributions at 10 Meter Level, All Classes Combined (Hours at Each Wind Speed and Direction)

(Page 1 of 2)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	145	278	229	92	16	0	760
NNE	63	140	101	23	4	0	331
NE	88	160	117	18	0	0	383
ENE	79	152	54	2	0	0	287
E	58	151	79	13	1	0	302
ESE	63	226	172	45	3	0	509
SE	54	218	231	75	9	0	587
SSE	76	176	183	73	13	1	522
S	69	167	162	97	35	1	531
SSW	89	167	159	61	8	2	486
SW	83	114	109	22	2	0	330
WSW	86	153	86	35	5	0	365
W	79	163	76	37	14	0	369
WNW	69	215	226	82	27	3	622
NW	78	167	264	126	38	1	674
NNW	104	281	355	183	24	0	947
VAR	0	0	0	0	0	0	0

Data Recovery Summary for Period

Total Hours	8784
Hours of Calm	198
Hours of Bad Data	581
Percent Data Recovery	93.39

I/cah

Table 2.3-12 Wind Frequency Distributions at 10 Meter Level, All Classes Combined (Hours at Each Wind Speed and Direction)

(Page 2 of 2)

Percent Acceptable Observations in Each Stability Class

Class A	15.14
Class B	2.54
Class C	3.82
Class D	33.56
Class E	24.48
Class F	10.62
Class G	9.85

Average Wind Speed for Each Wind Category

1 to 3 MPH	2.4
4 to 7 MPH	5.5
8 to 12 MPH	9.7
13 to 18 MPH	14.7
19 to 24 MPH	20.5
Above 24 MPH	25.8

Table 2.3-13 Wind Frequency Distributions at 100 Meter Level, Stability Class A (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	1	3	9	7	6	7	33
NNE	2	3	0	0	0	0	5
NE	0	1	0	1	0	0	2
ENE	0	2	2	0	0	0	4
E	0	0	0	1	0	0	1
ESE	0	6	7	16	3	2	34
SE	0	7	8	24	13	4	56
SSE	0	1	10	32	21	1	65
S	0	3	10	28	18	7	66
SSW	0	3	16	23	16	8	66
SW	1	6	9	16	6	2	40
WSW	0	1	9	24	18	0	52
W	0	3	8	8	17	3	39
WNW	1	1	4	2	7	4	19
NW	1	2	4	11	7	1	26
NNW	0	1	5	17	9	1	33
VAR	0	0	0	0	0	0	0

Total Hours this Class	656
Hours of Calm this Class	115
Percent of all Data this Class	7.98

Table 2.3-14 Wind Frequency Distributions at 100 Meter Level, Stability Class B (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	4	15	16	4	0	39
NNE	0	4	5	10	0	0	19
NE	0	3	10	3	0	0	16
ENE	1	3	6	1	0	0	11
E	0	2	3	0	0	0	5
ESE	0	3	7	2	2	1	15
SE	0	2	8	3	3	0	16
SSE	0	1	14	9	2	1	27
S	0	5	8	5	4	1	23
SSW	1	2	14	9	7	1	34
SW	1	4	14	5	2	0	26
WSW	0	4	6	5	5	0	20
W	0	5	6	4	4	3	22
WNW	0	2	4	2	1	5	14
NW	0	3	7	8	11	1	30
NNW	0	4	11	8	9	0	32
VAR	0	0	0	0	0	0	0

Total Hours this Class	349
Hours of Calm this Class	0
Percent of all Data this Class	4.25

Table 2.3-15 Wind Frequency Distributions at 100 Meter Level, Stability Class C (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	3	16	15	2	1	37
NNE	0	5	13	2	0	0	20
NE	0	2	2	4	0	0	8
ENE	0	4	11	0	0	0	15
E	0	3	9	2	1	0	15
ESE	0	8	6	5	0	0	19
SE	0	4	1	3	2	0	10
SSE	1	1	9	5	3	0	19
S	0	3	7	1	2	2	15
SSW	0	6	13	7	4	1	31
SW	0	4	4	6	1	1	16
WSW	0	4	7	7	0	0	18
W	0	4	4	5	3	1	17
WNW	2	3	11	7	5	7	35
NW	1	3	12	21	4	4	45
NNW	3	11	10	10	4	3	41
VAR	0	0	0	0	0	0	0

Total Hours this Class	361
Hours of Calm this Class	0
Percent of all Data this Class	4.39

Table 2.3-16 Wind Frequency Distributions at 100 Meter Level, Stability Class D (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	17	46	84	120	101	49	417
NNE	15	38	45	67	19	3	187
NE	10	21	36	37	18	6	128
ENE	6	36	60	34	4	1	141
E	10	45	51	25	12	5	148
ESE	12	39	59	56	44	15	225
SE	9	27	51	130	69	20	306
SSE	4	30	51	76	26	14	201
S	7	15	50	60	18	11	161
SSW	11	25	40	39	32	7	154
SW	6	22	25	28	16	8	105
WSW	6	17	17	33	9	7	89
W	5	27	15	22	18	15	102
WNW	13	26	47	61	48	41	236
NW	8	23	52	100	95	63	341
NNW	10	45	90	151	120	82	498
VAR	0	0	0	0	0	0	0

Total Hours this Class	3504
Hours of Calm this Class	65
Percent of all Data this Class	42.64

Table 2.3-17 Wind Frequency Distributions at 100 Meter Level, Stability Class E (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	2	16	36	80	54	12	200
NNE	1	12	20	51	17	1	102
NE	2	12	20	29	12	3	78
ENE	0	12	42	19	7	1	81
E	5	7	35	30	7	0	84
ESE	4	10	21	39	20	3	97
SE	0	8	25	61	32	4	130
SSE	2	9	27	76	40	5	159
S	2	14	30	36	36	18	136
SSW	1	4	23	43	52	20	143
SW	2	8	10	20	53	7	100
WSW	3	18	17	20	22	2	82
W	2	13	21	29	18	3	86
WNW	2	6	31	66	55	4	164
NW	2	14	29	75	50	2	172
NNW	3	15	31	68	67	11	195
VAR	0	0	0	0	0	0	0

Total Hours this Class	2032
Hours of Calm this Class	23
Percent of all Data this Class	24.73

Table 2.3-18 Wind Frequency Distributions at 100 Meter Level, Stability Class F (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	3	9	14	27	18	2	73
NNE	0	5	17	16	13	0	51
NE	1	6	22	13	7	1	50
ENE	0	6	21	14	0	0	41
E	2	6	13	18	3	0	42
ESE	0	6	9	18	7	1	41
SE	2	8	12	22	18	0	62
SSE	2	5	13	30	21	3	74
S	2	8	8	30	12	7	67
SSW	0	2	9	21	33	2	67
SW	1	2	8	42	30	0	83
WSW	2	8	10	19	23	5	67
W	1	6	17	14	10	1	49
WNW	3	8	17	37	11	1	77
NW	4	10	22	33	5	0	74
NNW	5	14	22	37	4	0	82
VAR	0	0	0	0	0	0	0

Total Hours this Class	1000
Hours of Calm this Class	0
Percent of all Data this Class	12.17

Table 2.3-19 Wind Frequency Distributions at 100 Meter Level, Stability Class G (Hours at Each Wind Speed and Direction)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	7	8	5	2	0	22
NNE	0	2	14	7	2	0	25
NE	1	3	7	6	2	0	19
ENE	1	3	9	1	0	0	14
E	0	2	5	6	0	0	13
ESE	0	3	3	5	0	0	11
SE	0	0	8	8	3	0	19
SSE	3	5	2	5	2	0	17
S	0	2	3	2	0	0	7
SSW	0	2	5	11	1	0	19
SW	0	8	13	7	7	0	35
WSW	3	4	11	3	4	1	26
W	0	3	13	6	2	0	24
WNW	0	3	11	5	4	0	23
NW	2	6	8	9	0	0	25
NNW	1	5	5	2	2	2	17
VAR	0	0	0	0	0	0	0

Total Hours this Class	316
Hours of Calm this Class	0
Percent of all Data this Class	3.85

Table 2.3-20 Wind Frequency Distributions at 100 Meter Level, All Classes Combined (Hours at Each Wind Speed and Direction)

(Page 1 of 2)

Wind Speed (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	23	88	182	270	187	71	821
NNE	18	69	114	153	51	4	409
NE	14	48	97	93	39	10	301
ENE	8	66	151	69	11	2	307
E	17	65	116	82	23	5	308
ESE	16	75	112	141	76	22	442
SE	11	56	113	251	140	28	599
SSE	12	52	126	233	115	24	562
S	11	50	116	162	90	46	475
SSW	13	44	120	153	145	39	514
SW	11	54	83	124	115	18	405
WSW	14	56	77	111	81	15	354
W	8	61	84	88	72	26	339
WNW	21	49	125	180	131	62	568
NW	18	61	134	257	172	71	713
NNW	22	95	174	293	215	99	898
VAR	0	0	0	0	0	0	0

Data Recovery Summary for Period

Total Hours	8784
Hours of Calm	203
Hours of Bad Data	566
Percent Data Recovery	93.56

I/cah

Table 2.3-20 Wind Frequency Distributions at 100 Meter Level, All Classes Combined (Hours at Each Wind Speed and Direction)

(Page 2 of 2)

Percent Acceptable Observations in Each Stability Class

Class A	7.98
Class B	4.25
Class C	4.39
Class D	42.64
Class E	24.73
Class F	12.17
Class G	3.85

Average Wind Speed for Each Wind Category

1 to 3 MPH	2.6
4 to 7 MPH	5.7
8 to 12 MPH	10.2
13 to 18 MPH	15.5
19 to 24 MPH	21.1
Above 24 MPH	28.2

Table 2.3-21 Maximum Wind Velocity

Month	Speed, MPH	Direction	Year
Jan	47	NW	1928
Feb	52	NW	1952
March	56	SW	1920
April	58	N	1912
May	61	NW	1964
June	63	NW	1939
July	92*	W	1951
August	57	NW	1922
September	50	NW	1921
October	73	S	1949
November	60	SW	1959
December	52	W	1946

* Associated with the July 20, 1951 tornado

I/cah

Table 2.3-22 Annual Average Dispersion Factor (X/Q) - Reactor Building Vent Releases

Reactor Building Vent
No Decay, Undepleted
Corrected for Open Terrain Recirculation

Annual Average CHI/Q (Sec/Meter Cubed) — Distance in Miles

Sector	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	6.345E-06	2.532E-06	1.812E-06	1.206E-06	7.098E-07	4.539E-07	3.211E-07	2.736E-07	2.433E-07	2.106E-07	1.864E-07
SSW	2.742E-06	1.163E-06	8.628E-07	5.724E-07	3.233E-07	2.500E-07	2.108E-07	1.543E-07	1.192E-07	1.011E-07	8.773E-08
SW	2.985E-06	1.246E-06	9.472E-07	6.498E-07	3.851E-07	3.108E-07	2.672E-07	2.090E-07	1.704E-07	1.497E-07	1.320E-07
WSW	1.949E-06	8.250E-07	6.662E-07	4.821E-07	3.037E-07	2.462E-07	2.106E-07	1.548E-07	1.198E-07	1.071E-07	9.643E-08
W	2.393E-06	9.695E-07	7.325E-07	5.018E-07	3.014E-07	2.422E-07	2.084E-07	1.631E-07	1.329E-07	1.061E-07	8.733E-08
WNW	4.552E-06	1.768E-06	1.247E-06	8.060E-07	4.532E-07	3.477E-07	2.900E-07	2.393E-07	2.020E-07	1.594E-07	1.300E-07
NW	5.502E-06	2.094E-06	1.399E-06	8.565E-07	4.435E-07	2.855E-07	2.046E-07	1.688E-07	1.459E-07	1.235E-07	1.071E-07
NNW	4.704E-06	1.698E-06	1.112E-06	6.930E-07	3.859E-07	2.493E-07	1.796E-07	1.386E-07	1.121E-07	9.375E-08	8.041E-08
N	5.225E-06	1.822E-06	1.133E-06	6.806E-07	3.661E-07	2.315E-07	1.643E-07	1.347E-07	1.163E-07	9.604E-08	8.136E-08
NNE	4.357E-06	1.489E-06	9.479E-07	5.946E-07	3.437E-07	2.255E-07	1.642E-07	1.275E-07	1.035E-07	8.665E-07	7.431E-08
NE	2.523E-06	9.147E-07	5.967E-07	3.771E-07	2.148E-07	1.592E-07	1.290E-07	1.011E-07	8.234E-08	6.909E-08	5.929E-08
ENE	3.074E-06	1.035E-06	6.587E-07	4.245E-07	2.560E-07	1.829E-07	1.424E-07	1.119E-07	9.141E-08	7.688E-08	6.611E-08
E	3.142E-06	1.104E-06	7.441E-07	4.922E-07	2.963E-07	1.999E-07	1.471E-07	1.146E-07	9.290E-08	7.763E-08	6.638E-08
ESE	5.744E-06	2.195E-06	1.425E-06	8.550E-07	4.320E-07	2.693E-07	1.880E-07	1.411E-07	1.112E-07	9.091E-08	7.636E-08
SE	6.575E-06	2.438E-06	1.529E-06	8.966E-07	4.458E-07	2.949E-07	2.192E-07	1.638E-07	1.287E-07	1.049E-07	8.790E-08
SSE	9.467E-06	3.635E-06	2.343E-06	1.395E-06	7.007E-07	4.363E-07	3.045E-07	2.284E-07	1.801E-07	1.473E-07	1.239E-07

Annual Average CHI/Q (Sec/Meter Cubed) — Distance in Miles

Sector	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	1.584E-07	8.944E-08	6.152E-08	3.795E-08	2.685E-08	2.049E-08	1.641E-08	1.359E-08	1.155E-08	9.997E-09	8.787E-09
SSW	7.398E-08	4.073E-08	2.760E-08	1.673E-08	1.170E-08	8.858E-09	7.051E-09	5.812E-09	4.916E-09	4.241E-09	3.715E-09
SW	1.104E-07	5.913E-08	3.946E-08	2.349E-08	1.626E-08	1.223E-08	9.682E-09	7.949E-09	6.701E-09	5.765E-09	5.040E-09
WSW	8.102E-08	4.410E-08	2.971E-08	1.787E-08	1.244E-08	9.379E-09	7.442E-09	6.118E-09	5.163E-09	4.445E-09	3.888E-09
W	7.362E-08	4.039E-08	2.729E-08	1.647E-08	1.150E-08	8.698E-09	6.922E-09	5.706E-09	4.827E-09	4.165E-09	3.650E-09
WNW	1.087E-07	5.814E-08	3.870E-08	2.297E-08	1.588E-08	1.194E-08	9.459E-09	7.772E-09	6.557E-09	5.645E-09	4.939E-09
NW	9.039E-07	4.975E-08	3.367E-08	2.037E-08	1.424E-08	1.079E-08	8.595E-09	7.093E-09	6.006E-09	5.187E-09	4.550E-09
NNW	6.954E-08	4.177E-08	2.987E-08	1.936E-08	1.413E-08	1.103E-08	8.994E-09	7.559E-08	6.498E-09	5.684E-09	5.041E-09
N	7.033E-08	4.216E-08	3.010E-08	1.946E-08	1.419E-08	1.108E-08	9.028E-09	7.587E-09	6.523E-09	5.706E-09	5.061E-09
NNE	6.492E-08	4.041E-08	2.954E-08	1.967E-08	1.461E-08	1.155E-08	9.510E-09	8.057E-09	6.972E-09	6.134E-09	5.467E-09
NE	5.180E-08	3.212E-08	2.336E-08	1.544E-08	1.141E-08	8.987E-09	7.377E-09	6.234E-09	5.384E-09	4.728E-09	4.207E-09
ENE	5.786E-08	3.612E-08	2.639E-08	1.753E-08	1.298E-08	1.024E-08	8.412E-09	7.113E-09	6.146E-09	5.398E-09	4.805E-09
E	5.781E-08	3.546E-08	2.563E-08	1.681E-08	1.236E-08	9.700E-09	7.940E-09	6.694E-09	5.770E-09	5.058E-09	4.495E-09
ESE	6.554E-08	3.835E-08	2.701E-08	1.722E-08	1.248E-08	9.695E-09	7.881E-09	6.611E-09	5.675E-09	4.959E-09	4.394E-09
SE	7.530E-08	4.381E-08	3.074E-08	1.947E-08	1.401E-08	1.082E-08	8.747E-09	7.302E-09	6.241E-09	5.432E-09	4.797E-09
SSE	1.065E-07	6.296E-08	4.487E-08	2.923E-08	2.100E-08	1.621E-08	1.317E-08	1.105E-08	9.685E-09	8.630E-09	7.607E-09

I/cah

Table 2.3-23 Annual Average Dispersion Factor (X/Q) - Plant Stack Releases

Offgas Stack
No Decay, Undepleted
Corrected for Open Terrain Recirculation

Annual Average CHI/Q (Sec/Meter Cubed) — Distance in Miles

Sector	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	2.115E-07	4.610E-07	2.388E-07	1.593E-07	1.288E-07	9.864E-08	7.790E-08	6.894E-08	6.157E-08	5.380E-08	4.765E-08
SSW	2.837E-07	7.831E-07	3.300E-07	1.700E-07	1.106E-07	9.136E-08	7.844E-08	6.159E-08	5.017E-08	4.336E-08	3.810E-08
SW	1.845E-08	3.655E-08	3.938E-08	3.921E-08	3.866E-08	4.136E-08	4.103E-08	3.536E-08	3.093E-08	2.878E-08	2.690E-08
WSW	2.433E-08	4.174E-08	4.948E-08	4.936E-08	4.708E-08	4.665E-08	4.328E-08	3.408E-08	2.772E-08	2.516E-08	2.304E-08
W	5.617E-09	2.206E-08	3.707E-08	4.484E-08	5.007E-08	5.511E-08	5.516E-08	4.752E-08	4.142E-08	3.487E-08	2.990E-08
WNW	1.006E-07	6.505E-08	6.450E-08	6.468E-08	6.394E-08	6.555E-08	6.264E-08	5.602E-08	5.023E-08	4.155E-08	3.514E-08
NW	1.418E-07	6.927E-08	5.869E-08	5.975E-08	5.870E-08	5.118E-08	4.319E-08	3.917E-08	3.548E-08	3.103E-08	2.750E-08
NNW	1.477E-07	8.592E-08	6.979E-08	6.209E-08	5.752E-08	4.724E-08	3.884E-08	3.244E-08	2.757E-08	2.381E-08	2.085E-08
N	1.476E-07	8.231E-08	6.138E-08	5.204E-08	4.793E-08	3.936E-08	3.252E-08	2.897E-08	2.597E-08	2.233E-08	1.949E-08
NNE	1.582E-07	1.080E-07	8.621E-08	6.771E-08	5.532E-08	4.327E-08	3.479E-08	2.873E-08	2.427E-08	2.089E-08	1.825E-08
NE	2.384E-07	4.483E-07	1.951E-07	9.784E-08	5.879E-08	4.452E-08	3.628E-08	2.946E-08	2.468E-08	2.114E-08	1.844E-08
ENE	1.202E-07	7.218E-08	5.321E-08	3.986E-08	3.219E-08	2.775E-08	2.422E-08	2.069E-08	1.795E-08	1.577E-08	1.402E-08
E	9.542E-08	6.545E-08	5.063E-08	3.953E-08	3.280E-08	2.701E-08	2.253E-08	1.910E-08	1.645E-08	1.437E-08	1.271E-08
ESE	1.608E-07	4.092E-07	1.913E-07	1.103E-07	7.750E-08	5.977E-08	4.803E-08	3.978E-08	3.375E-08	2.917E-08	2.560E-08
SE	1.908E-07	4.410E-07	2.167E-07	1.285E-07	8.914E-08	7.234E-08	6.044E-08	4.895E-08	4.075E-08	3.467E-08	3.003E-08
SSE	8.598E-08	9.415E-08	1.104E-07	1.062E-07	9.305E-08	7.625E-08	6.228E-08	5.167E-08	4.366E-08	3.751E-08	3.271E-08

Annual Average CHI/Q (Sec/Meter Cubed) — Distance in Miles

Sector	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	4.135E-08	2.465E-08	1.726E-08	1.073E-08	7.580E-09	5.763E-09	4.597E-09	3.794E-09	3.211E-09	2.771E-09	2.428E-09
SSW	3.303E-08	1.972E-08	1.388E-08	8.722E-09	6.223E-09	4.774E-09	3.840E-09	3.193E-09	2.721E-09	2.363E-09	2.082E-09
SW	2.325E-08	1.368E-08	9.507E-09	5.853E-09	4.106E-09	3.106E-09	2.467E-09	2.029E-09	1.712E-09	1.474E-09	1.288E-09
WSW	1.978E-08	1.140E-08	7.837E-09	4.777E-09	3.339E-09	2.521E-09	2.001E-09	1.645E-09	1.387E-09	1.194E-09	1.043E-09
W	2.603E-08	1.561E-08	1.093E-08	6.765E-09	4.750E-09	3.590E-09	2.848E-09	2.339E-09	1.970E-09	1.692E-09	1.477E-09
WNW	3.025E-08	1.750E-08	1.201E-08	7.268E-09	5.039E-09	3.775E-09	2.976E-09	2.431E-09	2.039E-09	1.746E-09	1.519E-09
NW	2.380E-08	1.405E-08	9.773E-09	6.016E-09	4.216E-09	3.185E-09	2.527E-09	2.076E-09	1.750E-09	1.504E-09	1.313E-09
NNW	1.836E-08	1.147E-08	8.248E-09	5.287E-09	3.804E-09	2.929E-09	2.359E-09	1.961E-09	1.669E-09	1.448E-09	1.274E-09
N	1.724E-08	1.091E-08	7.886E-09	5.067E-09	3.640E-09	2.795E-09	2.244E-09	1.859E-09	1.578E-09	1.365E-09	1.197E-09
NNE	1.616E-08	1.027E-08	7.432E-09	4.768E-09	3.419E-09	2.619E-09	2.099E-09	1.736E-09	1.471E-09	1.271E-09	1.114E-09
NE	1.633E-08	1.048E-08	7.707E-09	5.102E-09	3.756E-09	2.945E-09	2.407E-09	2.027E-09	1.745E-09	1.528E-09	1.357E-09
ENE	1.259E-08	8.389E-09	6.250E-09	4.166E-09	3.064E-09	2.394E-09	1.948E-09	1.633E-09	1.400E-09	1.221E-09	1.079E-09
E	1.136E-09	7.459E-09	5.508E-09	3.633E-09	2.653E-09	2.062E-09	1.671E-09	1.396E-09	1.193E-09	1.038E-09	9.153E-10
ESE	2.276E-08	1.471E-08	1.080E-08	7.091E-09	5.173E-09	4.020E-09	3.258E-09	2.723E-09	2.328E-09	2.026E-09	1.789E-09
SE	2.640E-08	1.648E-08	1.188E-08	7.676E-09	5.564E-09	4.310E-09	3.490E-09	2.915E-09	2.493-09	2.170E-09	1.917E-09
SSE	2.889E-08	1.823E-08	1.318E-08	8.505E-09	6.071E-09	4.643E-09	3.728E-09	3.091E-09	2.651E-09	2.316E-09	2.028E-09

I/cah

Table 2.3-24 Relative Deposition per Unit Area (D/Q) - Reactor Building Vent Releases

Reactor Building Vent
Corrected for Open Terrain Recirculation
Relative Deposition per Unit Area (M**-2) at Fixed Points by Downwind Sectors

Distance in Miles

Sector	0.25	0.50	0.75	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50
S	8.092E-08	3.151E-08	1.761E-08	8.946E-09	3.746E-09	1.900E-09	1.135E-09	7.688E-10	5.686E-10	4.375E-10	3.536E-10
SSW	3,154E-08	1.295E-08	7.461E-09	3.869E-09	1.609E-09	8.979E-10	5.352E-10	3.563E-10	2.567E-10	1.965E-10	1.583E-10
SW	3.300E-08	1.377E-08	7.966E-09	4.147E-09	1.735E-09	9.762E-10	5.841E-10	3.907E-10	2.836E-10	2.443E-10	2.629E-10
WSW	2.055E-08	9.475E-09	5.706E-09	3.047E-09	1.281E-09	7.625E-10	4.563E-10	3.047E-10	2.200E-10	1.693E-10	1.459E-10
W	2.502E-08	1.056E-08	6.179E-09	3.225E-09	1.349E-09	7.579E-10	4.517E-10	3.013E-10	2.184E-10	1.685E-10	1.366E-10
WNW	5.235E-08	2.088E-08	1.177E-08	5.991E-09	2.437E-09	1.320E-09	7.849E-10	5.228E-10	4.494E-10	3.415E-10	2.717E-10
NW	6.974E-08	2.703E-08	1.504E-08	7.583E-09	2.914E-09	1.492E-09	9.284E-10	6.290E-10	4.606E-10	3.515E-10	2.816E-10
NNW	6.209E-08	2.360E-08	1.286E-08	6.399E-09	2.543E-09	1.281E-09	7.729E-10	5.142E-10	3.680E-10	2.787E-10	2.281E-10
N	7.209E-08	2.676E-08	1.434E-08	7.046E-09	2.712E-09	1.364E-09	8.121E-10	5.491E-10	4.003E-10	3.078E-10	2.480E-10
NNE	5.609E-08	2.149E-08	1.150E-08	5.643E-09	2.168E-09	1.092E-09	6.510E-10	4.314E-10	3.073E-10	2.310E-10	1.807E-10
NE	3.345E-08	1.350E-08	7.297E-09	3.601E-09	1.354E-09	6.904E-10	4.220E-10	2.798E-10	1.994E-10	1.498E-10	1.171E-10
ENE	3.671E-08	1.447E-08	7.753E-09	3.811E-09	1.429E-09	7.286E-10	4.441E-10	2.946E-10	2.098E-10	1.573E-10	1.227E-10
E	3.616E-08	1.380E-08	7.441E-09	3.674E-09	1.383E-09	7.040E-10	4.220E-10	2.802E-10	1.993E-10	1.490E-10	1.157E-10
ESE	7.702E-08	2.887E-08	1.555E-08	7.653E-09	2.863E-09	1.450E-09	8.654E-10	5.727E-10	4.064E-10	3.034E-10	2.352E-10
SE	9.530E-08	3.536E-08	1.903E-08	9.380E-09	3.520E-09	1.787E-09	1.108E-09	7.322E-10	5.211E-10	3.917E-10	3.070E-10
SSE	1.223E-07	4.534E-08	2.479E-08	1.237E-08	4.704E-09	2.399E-09	1.438E-09	9.546E-10	6.786E-10	5.068E-10	3.929E-10

Distance in Miles

Sector	5.00	7.50	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00
S	2.971E-10	1.641E-10	1.127E-10	6.546E-11	4.158E-11	2.793E-11	1.993E-11	1.486E-11	1.148E-11	9.147E-12	7.448E-12
SSW	1.323E-10	7.175E-11	4.870E-11	2.806E-11	1.782E-11	1.201E-11	8.596E-12	6.434E-12	4.986E-12	3.982E-12	3.250E-12
SW	2.105E-10	9.662E-11	5.959E-11	3.100E-11	1.909E-11	1.291E-11	9.317E-12	7.044E-12	5.505E-12	4.427E-12	3.634E-12
WSW	1.213E-10	6.451E-11	4.329E-11	2.471E-11	1.570E-11	1.062E-11	7.637E-12	5.741E-12	4.466E-12	3.580E-12	2.930E-12
W	1.154E-10	6.493E-11	4.495E-11	2.636E-11	1.680E-11	1.129E-11	8.061E-12	6.013E-12	4.646E-12	3.701E-12	3.013E-12
WNW	2.243E-10	1.166E-10	7.775E-11	4.381E-11	2.752E-11	1.845E-11	1.315E-11	9.804E-12	7.573E-12	6.024E-12	4.898E-12
NW	2.345E-10	1.257E-10	8.501E-11	4.874E-11	3.086E-11	2.075E-11	1.483E-11	1.109E-11	8.579E-12	6.843E-12	5.578E-12
NNW	1.892E-10	9.973E-11	6.677E-11	3.794E-11	2.401E-11	1.623E-11	1.168E-11	8.812E-12	6.897E-12	5.559E-12	4.588E-12
N	2.073E-10	1.125E-10	7.670E-11	4.423E-11	2.805E-11	1.887E-11	1.349E-11	1.008E-11	7.817E-12	6.237E-12	5.088E-12
NNE	1.461E-10	6.935E-11	4.359E-11	2.340E-11	1.477E-11	1.024E-11	7.634E-12	5.990E-12	4.874E-12	4.079E-12	3.502E-12
NE	9.447E-11	4.440E-11	2.767E-11	1.482E-11	9.433E-12	6.640E-12	5.023E-12	3.996E-12	3.291E-12	2.782E-12	2.410E-12
ENE	9.867E-11	4.581E-11	2.835E-11	1.505E-11	9.545E-12	6.726E-12	5.108E-12	4.086E-12	3.391E-12	2.886E-12	2.519E-12
E	9.243E-11	4.165E-11	2.516E-11	1.293E-11	8.073E-12	5.669E-12	4.320E-12	3.483E-12	2.928E-12	2.518E-12	2.228E-12
ESE	1.878E-10	8.431E-11	5.083E-11	2.596E-11	1.690E-11	1.118E-11	8.386E-12	6.635E-12	5.466E-12	4.613E-12	3.999E-12
SE	2.489E-10	1.199E-10	7.608E-11	4.100E-11	2.565E-11	1.747E-11	1.273E-11	9.745E-12	7.737E-12	6.321E-12	5.291E-12
SSE	3.136E-10	1.405E-10	8.434E-11	5.267E-11	3.273E-11	2.225E-11	1.622E-11	1.342E-11	1.457E-11	1.291E-11	1.047E-11

I/cah

Table 2.3-25 Relative Deposition per Unit Area (D/Q) - Plant Stack Releases

Offgas Stack
Corrected for Open Terrain Recirculation
Relative Deposition per Unit Area (M**-2) at Fixed Points by Downwind Sectors

Distance in Miles

Sector	0.25	0.50	0.75	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50
S	8.898E-09	7.159E-09	5.968E-09	4.054E-09	1.953E-09	1.193E-09	8.045E-10	5.771E-10	4.319E-10	3.739E-10	3.038E-10
SSW	5.688E-09	4.432E-09	3.478E-09	2.236E-09	1.025E-09	6.119E-10	4.918E-10	3.371E-10	2.454E-10	1.925E-10	1.510E-10
SW	1.821E-09	1.550E-09	1.419E-09	1.038E-09	5.308E-10	3.322E-10	2.875E-10	2.048E-10	1.483E-10	1.123E-10	8.902E-11
WSW	2.098E-09	1.769E-09	1.596E-09	1.155E-09	5.895E-10	3.655E-10	3.111E-10	2.140E-10	1.561E-10	1.241E-10	9.717E-11
W	1.487E-09	1.348E-09	1.350E-09	1.050E-09	5.609E-10	3.570E-10	3.036E-10	2.255E-10	1.633E-10	1.236E-10	9.681E-11
WNW	4.723E-09	3.809E-09	3.189E-09	2.174E-09	1.051E-09	6.427E-10	5.445E-10	3.870E-10	2.798E-10	2.117E-10	1.658E-10
NW	5.707E-09	4.661E-09	3.991E-09	2.772E-09	1.361E-09	8.380E-10	5.676E-10	4.081E-10	3.058E-10	2.692E-10	2.172E-10
NNW	7.648E-09	5.852E-09	4.428E-09	2.743E-09	1.212E-09	7.115E-10	4.696E-10	3.330E-10	2.477E-10	1.909E-10	1.511E-10
N	7.157E-09	5.428E-09	4.032E-09	2.450E-09	1.060E-09	6.161E-10	4.043E-10	2.858E-10	2.122E-10	1.634E-10	1.294E-10
NNE	8.998E-09	6.737E-09	4.863E-09	2.863E-09	1.196E-09	6.828E-10	4.434E-10	3.115E-10	2.307E-10	1.774E-10	1.404E-10
NE	6.944E-09	5.171E-09	3.688E-09	2.141E-09	8.802E-10	4.980E-10	3.217E-10	2.254E-10	1.666E-10	1.280E-10	1.013E-10
ENE	6.176E-09	4.591E-09	3.263E-09	1.885E-09	7.710E-10	4.350E-10	2.805E-10	1.963E-10	1.451E-10	1.115E-10	8.822E-11
E	5.361E-09	4.032E-09	2.939E-09	1.749E-09	7.403E-10	4.253E-10	2.773E-10	1.952E-10	1.447E-10	1.113E-10	8.813E-11
ESE	6.035E-09	4.770E-09	3.848E-09	2.538E-09	1.192E-09	7.196E-10	4.824E-10	3.449E-10	2.577E-10	1.989E-10	1.575E-10
SE	8.324E-09	6.599E-09	5.355E-09	3.552E-09	1.676E-09	1.014E-09	6.806E-10	4.870E-10	3.640E-10	2.810E-10	2.225E-10
SSE	7.413E-09	6.241E-09	5.616E-09	4.058E-09	2.056E-09	1.282E-09	8.739E-10	6.305E-10	4.732E-10	3.660E-10	2.897E-10

Distance in Miles

Sector	5.00	7.50	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00
S	2.446E-10	1.114E-10	6.564E-11	3.308E-11	2.074E-11	1.466E-11	1.116E-11	8.927E-12	7.412E-12	6.290E-12	5.463E-12
SSW	1.217E-10	5.567E-11	3.292E-11	1.671E-11	1.053E-11	7.563E-12	5.836E-12	4.727E-12	3.969E-12	3.402E-12	2.986E-12
SW	7.162E-11	3.229E-11	1.879E-11	9.304E-12	5.797E-12	4.085E-12	3.138E-12	2.557E-12	2.174E-12	1.890E-12	1.690E-12
WSW	7.819E-11	3.531E-11	2.059E-11	1.022E-11	6.374E-12	4.485E-12	3.431E-12	2.776E-12	2.342E-12	2.020E-12	1.790E-12
W	7.788E-11	3.515E-11	2.044E-11	1.009E-11	6.253E-12	4.377E-12	3.335E-12	2.694E-12	2.270E-12	1.959E-12	1.739E-12
WNW	1.335E-10	6.042E-11	3.541E-11	1.776E-11	1.113E-11	7.835E-12	5.961E-12	4.770E-12	3.971E-12	3.378E-12	2.942E-12
NW	1.748E-10	7.937E-11	4.658E-11	2.335E-11	1.460E-11	1.028E-11	7.816E-12	6.248E-12	5.191E-12	4.410E-12	3.837E-12
NNW	1.222E-10	5.853E-11	3.613E-11	1.925E-11	1.225E-11	8.921E-12	6.812E-12	5.396E-12	4.378E-12	3.623E-12	3.046E-12
N	1.047E-10	5.019E-11	3.102E-11	1.657E-11	1.056E-11	7.732E-12	5.931E-12	4.702E-12	3.821E-12	3.165E-12	2.663E-12
NNE	1.137E-10	5.462E-11	3.383E-11	1.817E-11	1.163E-11	8.582E-12	6.621E-12	5.270E-12	4.294E-12	3.563E-12	3.002E-12
NE	8.210E-11	3.948E-11	2.448E-11	1.318E-11	8.450E-12	6.265E-12	4.847E-12	3.865E-12	3.153E-12	2.619E-12	2.207E-12
ENE	7.148E-11	3.439E-11	2.133E-11	1.149E-11	7.373E-12	5.474E-12	4.239E-12	3.382E-12	2.760E-12	2.293E-12	1.933E-12
E	7.135E-11	3.425E-11	2.120E-11	1.136E-11	7.261E-12	5.343E-12	4.113E-12	3.269E-12	2.661E-12	2.207E-12	1.858E-12
ESE	1.273E-10	6.078E-11	3.740E-11	1.979E-11	1.252E-11	8.999E-12	6.821E-12	5.363E-12	4.333E-12	3.575E-12	3.000E-12
SE	1.797E-10	8.583E-11	5.280E-11	2.792E-11	1.765E-11	1.268E-11	9.605E-12	7.548E-12	6.096E-12	5.029E-12	4.219E-12
SSE	2.339E-10	1.114E-10	6.831E-11	3.586E-11	2.255E-11	1.598E-11	1.200E-11	9.368E-12	7.532E-12	6.193E-12	5.185E-12

I/cah

Table 2.3-26 Site Boundary X/Q and D/Q - Reactor Building Vent Releases

Reactor Building Vent
Corrected for Open Terrain Recirculation
Specific Points of Interest

Release ID	Type of Location	Sector	Distance (Miles)	Distance (Meters)	X/Q (Sec/Cub Meter) No Decay Undepleted	X/Q (Sec/Cub Meter) 2.260 Day Decay Undepleted	X/Q (Sec/Cub Meter) 8.000 Day Decay Depleted	D/Q (Per Sq Meter)
R	Site Boundary	S	0.34	547.	4.04E-06	4.03E-06	3.79E-06	5.36E-08
R	Site Boundary	SSW	0.32	515.	1.92E-06	1.92E--06	1.813-06	2.31E-08
R	Site Boundary	SW	0.32	515.	2.05E-06	2.05E-06	1.93E-06	2.43E-08
R	Site Boundary	WSW	0.35	563.	1.17E-06	1.17E-06	1.11E-06	1.43E-08
R	Site Boundary	W	0.48	772.	9.97E-07	9.96E-07	9.31E-07	1.11E-08
R	Site Boundary	WNW	0.68	1094.	1.33E-06	1.33E-06	1.24E-06	1.36E-06
R	Site Boundary	NW	0.43	692.	2.49E-06	2.49E-06	2.32E-06	3.34E-08
R	Site Boundary	NNW	0.53	853.	1.57E-06	1.57E-06	1.45E-06	2.17E-08
R	Site Boundary	N	0.51	821.	1.76E-06	1.75E-06	1.62E-06	2.60E-08
R	Site Boundary	NNE	0.58	933.	1.23E-06	1.22E-06	1.13E-06	1.72E-08
R	Site Boundary	NE	0.65	1046.	6.74E-07	6.73E-07	6.26E-07	9.13E-09
R	Site Boundary	ENE	0.83	1336.	5.55E-07	5.53E-07	5.14E-07	6.05E-09
R	Site Boundary	E	0.59	950.	9.09E-07	9.08E-07	8.39E-07	1.08E-08
R	Site Boundary	ESE	0.59	950.	1.81E-06	1.80E-06	1.67E-06	2.25E-08
R	Site Boundary	SE	0.61	982.	1.91E-06	1.91E-06	1.75E-06	2.62E-08
R	Site Boundary	SSE	0.43	692.	4.38E-06	4.38E-06	4.06E-06	5.65E-08

Table 2.3-27 Site Boundary X/Q and D/Q -Plant Stack Releases

Offgas Stack
Corrected for Open Terrain Recirculation
Specific Points of Interest

Release ID	Type of Location	Sector	Distance (Miles)	Distance (Meters)	X/Q (Sec/Cub Meter) No Decay Undepleted	X/Q (Sec/Cub Meter) 2.260 Day Decay Undepleted	X/Q (Sec/Cub Meter) 8.000 Day Decay Depleted	D/Q (Per Sq Meter)
O	Site Boundary	SSW	0.31	499.	6.50E-07	6.44E-07	6.48E-07	5.48E-09
O	Site Boundary	SW	0.33	531.	2.96E-08	2.96E-08	2.96E-08	1.75E-09
O	Site Boundary	SW	0.33	531.	2.96E-08	2.96E-08	2.96E-08	1.75E-09
O	Site Boundary	WSW	0.38	612.	3.54E-08	3.54E-08	3.54E-08	1.94E-09
O	Site Boundary	W	0.56	901.	2.49E-08	2.49E-08	2.46E-08	1.33E-09
O	Site Boundary	NW	0.78	1255.	5.70E-08	5.69E-08	5.61E-08	3.83E-09
O	Site Boundary	NW	0.53	853.	5.93E-08	5.92E-08	5.86E-08	4.55E-09
O	Site Boundary	NNW	0.61	982.	7.02E-08	7.02E-08	6.92E-08	5.12E-09
O	Site Boundary	N	0.59	950.	6.60E-08	6.60E-08	6.51E-08	4.83E-09
O	Site Boundary	N	0.63	1014.	6.33E-08	6.32E-08	6.23E-08	4.60E-09
O	Site Boundary	NNE	0.65	1046.	8.84E-08	8.83E-08	8.68E-08	5.49E-09
O	Site Boundary	ENE	0.78	1255.	4.96E-08	4.96E-08	4.86E-08	3.05E-09
O	Site Boundary	E	0.50	805.	6.12E-08	6.11E-08	6.06E-08	4.03E-09
O	Site Boundary	ESE	0.50	805.	3.42E-07	3.37E-07	3.37E-07	4.77E-09
O	Site Boundary	SSE	0.51	821.	9.11E-08	9.10E-08	9.02E-08	6.20E-09
O	Site Boundary	S	0.36	579.	4.78E-07	4.74E-07	4.77E-07	8.24E-09

2.4 Hydrology

2.4.1 Surface Water

The Monticello sites lies about one-third of the river distance from Elk River, Minnesota to St. Cloud, Minnesota. Stream flow records of the Mississippi were kept at Elk River by the U.S. Geological Survey. The gauging station at Elk River was about 2500 feet downstream from the confluence of the Elk River (the only significant river entering the Mississippi River between the cities of Elk River and St. Cloud) and the Mississippi River. The Elk River Station has closed and the U.S. Geological Survey established a gauging station on the Mississippi River at St. Cloud in 1989.

In Table 2.4-1, the number of years of record, the average annual flow, the minimum recorded flow, the maximum recorded flow at each gauging station are tabulated. From this data, and with information on Elk River flows, the following flow statistics are estimated for the Mississippi River at the Monticello site:

Average Flow - 4600 ft^3/sec
Minimum Flow - 240 ft^3/sec
Maximum Flow - 51,000 ft^3/sec

The average velocity of flow at the site varies between 1.5 to 2.5 ft/sec for flows below 10,000 cfs.

Figure 2.4-1 is a flow duration curve for the Mississippi River at St. Cloud. From this curve, the flow at Monticello is expected to exceed 1100 ft^3/sec 90% of the time, and 300 ft^3/sec 99% of the time.

Based on past temperature records from the Whitney Steam Plant at St. Cloud (since retired and removed) the average river temperature for these summer months is 71°F.

Because of possible low stream flow conditions, and high natural river water temperatures, two cooling towers are included in the plant design in order to meet the standards of the Minnesota Pollution Control Agency. At times of extremely low flow, the plant operates on a closed cycle and the makeup requirement of about 54 ft^3/sec is withdrawn from the river. At times of substantial flow and high ambient river temperature conditions, the cooling tower may be employed to control the temperature of discharged water.

All existing cooling towers are operated whenever the ambient river temperature measured at some point unaffected by the plant’s discharge is consistently at or above 20°C (68°F), except in the event the cooling towers are out of service due to equipment failure or performance of maintenance to prevent equipment failure.

The spring flood of 1965 exceeds all flood flows on record to date. Figure 2.4-2 shows the location of three flood stage boards which recorded this record flood. The stage at the site was about 916 ft msl for an estimated flow of 51,000 ft^3/sec. Figure 2.4-3 shows the results of a flood frequency study. The 1000 year flood has an estimated stage of 920 ft msl.

A study was made by the Harza Engineering Company to determine the predicted flood discharge flow and flood level at the site resulting from the maximum probable flood as defined by the U.S. Army Corps of Engineers (Policies and Procedures Pertaining to Determination of Spillway Capacities and Freeboard Allowances for Dams, Engineer Circular No. 1110-2-27, Enclosure 2, August 1, 1966 (Reference 33), Department of the Army, Office of the Chief of Engineers). Refer to Appendix G.

The probable maximum discharge was determined to be 364,900 ft^3/sec and to have a corresponding peak stage of elevation 939.2 ft msl. The flood would result from meteorological conditions which could occur in the spring and would reach maximum river level in about 12 days. It was estimated the flood stage would remain above elevation 930.0 ft msl. for approximately 11 days.

The normal river stage at the plant site is about 905 ft msl. At a distance 1-1/2 mile upstream, the normal river elevation is about 910 ft msl, and at an equal distance downstream, the river is at 900 ft msl. Thus, the hydraulic slope is about 3-1/3 ft/mile.

2.4.2 Public Water Supplies

2.4.2.1 Surface Water

The nearest domestic water supply reservoir with a free surface open to the air is the Minneapolis Water Works Reservoir. This reservoir is located north of Minneapolis, and is about 37 miles from the site. St. Paul uses a chain of lakes in its water supply system. These lakes, located north of St. Paul, are about 40 miles from the site.

The major supply of water for these reservoirs is the Mississippi River. The St. Paul intake is about 33 river miles from the site and the Minneapolis intake is about 37 miles from the site. Harza Engineering Company made a study of pollutant dispersion of a slug waste in the river (Reference 35) between the Monticello Plant site and the Minneapolis and St. Paul water intakes. The results of this study were given in Answer to Question 3.3 of Amendment 4 and all of Amendment 8 of the Monticello Facility Description and Safety Analysis Report.

In the event of a contaminated Mississippi River, the Minneapolis water supply would be more critical than the St. Paul water supply, because Minneapolis has about a 2 day water supply and St. Paul a 4+week supply. Under the emergency, withdrawal of river water for the Minneapolis system could be suspended for about 48 hours without curtailment of non-essential use. This period could be extended to about 100 hours if non-essential use is curtailed.

Between 1960 and 1980, recreational use of the reach of river near Monticello has increased significantly.

River water is used for irrigation in a limited way between the site and Minneapolis. Twenty-six water appropriation permits have been issued by the Minnesota Department of Natural Resources for this reach of the river.

At Elk River, the river water is used for cooling purposes for an electric generating plant. The next industrial water user is Xcel Energy in north Minneapolis.

2.4.2.2 Ground Water

The outwash drift on both sides of the Mississippi in general yields large quantities of water. The water table under normal circumstances is higher than the river, thus ground water as well as run-off from rainfall feeds the river. The drift water usually is quite hard containing calcium, magnesium, and bicarbonates, with small amounts of sodium, potassium, sulfates, and chlorides. Between the plant site and Minneapolis, the cities of Monticello, Elk River, Anoka, Coon Rapids, Champlin, Brooklyn Center, Brooklyn Park, and Fridley obtain groundwater from the bedrock formations for their domestic water supply as of 1981.

Numerous shallow wells supply water for residences and farms along the river terrace.

The closest public water supply wells are the city of Monticello wells. These wells are 16 inches in diameter and 250 feet deep. The 1200 gpm capacity is limited by the installed pumps. The wells have been tested to 2000 gpm. They are located in the main part of the city of Monticello.

The wells which obtain their water from the drift are recharged by local precipitation, while the wells which withdraw water from the bedrock are recharged by precipitation where the bedrock is at or near the land surface. The largest increment of recharge occurs during the spring thaw.

A review of Figure 2.5.2, “Location of Original Borings,” and Figure 2.5.5, “Log of Borings,” shows that the groundwater table in the area surrounding the plant site ranges from about 908 ft. msl to about 942 ft. msl, with the site itself at approximately 908 ft. msl. Since the normal river is at about 905 ft msl, groundwater flow is to the river. This usual case of groundwater flow to the river may not exist during floods.

2.4.3 Plant Design Bases Dependent on Hydrology

Water movements passing the site are subject to large variations in the course of a year. Plant design with respect to operation and liquid waste disposal takes into account large variations in water flow from less than 200 ft^3/sec to flood level up to plant grade (about 930ft msl) which is well above record historical floods.

2.4.4 Water Use Permits and Appropriations Relevant to Plant Operation

The ground and surface water appropriations are pursuant to permits issued by the Minnesota Department of Natural Resources. The requirements for groundwater include domestic use for over 25 persons, industrial use to seal pumps in the plant intake structure and plant make up water. River water is required for condenser cooling, service water cooling, and plant makeup.

2.4.5 Surface Water Quality

Water samples were taken upstream, downstream and at the plant discharge on February 28, 1972. The chemical analyses of the samples were as follows:

	Upstream Mississippi	Downstream Mississippi	Plant Discharge
P Alkalinity - ppm $CaCO_3$	0	0	0
M Alkalinity - ppm $CaCO_3$	170	169	165
Ammonia Nitrogen - ppm N	0.05	0.02	0.02
Organic Nitrogen - ppm N	0.933	0.61	0.65
Nitrate Nitrogen - ppm N	0.28	0.37	0.37
Nitrite Nitrogen - ppm N	0.001	0.003	0.002
Chloride - ppm	1.4	0.9	1.0
Sulfate - ppm SO_4	7.8	6.6	7.3
Color - Units	35	35	35
Turbidity - JTU	3.9	2.0	2.5
Total Hardness - ppm $CaCO_3$	177	178	178
Calcium Hardness - ppm $CaCO_3$	122	114	122
pH	7.5	7.9	7.8
Total Solids - ppm	288	272	247
Non-Filterable Solids - ppm	12	3	5
Dissolved Solids - ppm	276	269	242

	Upstream Mississippi	Downstream Mississippi	Plant Discharge
Fixed Non-Filterable Solids - ppm	8	2	3
Volatile Solids - ppm	4	1	2
Total Soluble Phosphorus - ppm P	0.035	0.026	0.024
Total Chlorophyll - mg/m^3	5.7	1.5	1.6
Conductivity - mmhos (25°C)	364	357	364
Temp. °C	0.2	8.3	15.5
D.O. mg/l	8.4	8.6	8.2
BOD mg/l	0.9	1.0	0.9

Cooling towers not operating

Paper pulp (Sartell and Little Falls) facilities were located upstream of the plant when the study was done. Sewage treatment facilities (St. Cloud and others) are located upstream of the plant. 01101248

2.4.6 Environmental Assessment

An environmental assessment (EA) of MNGP operation at Extended Power Uprate (EPU) conditions was submitted to the NRC (Reference 45, Enclosure 4). The assessment was subsequently updated by Reference 47. Approval of the updated EA was completed in May 2013 (Reference 46). The assessment includes the environmental effect of plant water use and cooling tower operation at EPU conditions. 01101248

Table 2.4-1 Mississippi River Flows at Elk River and St. Cloud, Minnesota

	Location	
	Elk River[1]	St. Cloud[2]
Number of Records, years	38	40
Average Annual Flow, ft^3/sec	5,260	4,360
Minimum Recorded Flow, ft^3/sec	278	220
Maximum Recorded Flow, ft^3/sec	49,200	46,780
	(4-12-52)	(4-15-65)

1. Data from Hydrologic Atlas of Minnesota, Bulletin #10, Minnesota Department of Conservation, April 1959, at U.S. Geological Survey, Recorder 2755. Station discontinued October 31, 1957 (Reference 36).

2. Data from Northern States Power Company records from July 1, 1925, to December 31, 1965, at Whitney Steam Plant, St. Cloud, Minnesota (Reference 37).

2.5 Geology and Soil Investigation

2.5.1 General

Dames and Moore, consultants in applied earth sciences, analyzed the geology and foundation conditions of the plant site.

2.5.2 Regional Geology

Rocks dating as early as Precambrian time underlie the region of Minnesota which includes the plant site. Pleistocene glaciation, probably less than 1,000,000 years in age, as well as recent alluvial deposition have mantled the older rocks with a variety of unconsolidated materials in the form of glacial moraines, glacial outwash plains, glacial till, and river bed sediments. This cover of young soil rests upon a surface of glacially-carved bedrock consisting of sandstone and shale strata underlain by deeply weathered granite rocks. Volcanics also form portions of the bedrock sequence in certain areas. The bedrock surface is irregular and slopes generally to the east or southeast.

The geologic column showing the age relationships of the various bedrock units and surficial deposits of the region is presented in Table 2.5-1. Figure 2.5-1a and 2.5-1b show the regional extent of the consolidated formations.

The principal structural feature in this part of Minnesota is a deep trough formed during Precambrian time in the granite and associated crystalline rocks. This basin extended from Lake Superior into Iowa, and provided a site for the deposition of thick sequences of Precambrian and later Paleozic sediments and volcanics. Strata of Paleozoic age are now exposed along the southern half of the structural trough. In the Minneapolis-St. Paul area, they form a circular basin containing artesian groundwater.

The ice fronts or glacial lobes advanced across this region during the last stage of glaciation, named the Wisconsin Stage. One lobe came from the general area of Lake Superior and deposited terminal moraines immediately south of the present course of the Mississippi River. A later ice front advanced across the area from the southwest, overriding the earlier moraines. Erosion of these glacial sediments by the Mississippi River has been active since the final retreat of the ice.

The present course of the Mississippi has no relation to the streams that flowed through the area prior to glaciation. There are therefore, old river channels which cross the region and which may be substantially deeper than the present river channel.

A major fault system of Precambrian age has been inferred from regional geophysical surveys. This fault system is associated with the Precambrian structural trough. The major movements along this fault system, which amount to thousands of feet, appear to have been restricted to Precambrian time. Minor fault displacements occurred during the Paleozoic era, but faulting within the last few million years is not in evidence.

2.5.3 Site Geology

The site occupies a bluff which forms the southwest bank of the Mississippi River. Several flat alluvial terraces comprise the main topographical features on the property. These terraces lie at average elevations of 930 and 918 ft msl and in general, slope very slightly away from the river.

The present surface drainage of the immediate plant site area is mainly to the southwest, away from the river. Surface run-off will tend to collect in the depression at the south end of the terrace where it is bounded by higher ground, then flow easterly to the river.

At the time of start of construction, most of the site was under cultivation, which has since been discontinued, with the remainder of the site area covered by scattered low brush and small trees.

The pattern of the present meander system suggests that the channel to the south of the islands in the river is now the main channel. It is possible that the channel to the north of the islands may eventually be abandoned. If this occurs during the lifetime of the plant it probably will result in increased erosion along the bluff at the plant site; however, this erosion is not a matter of concern because the actual amount would be small and not interfere with any structures.

The site is located on the extreme western edge of the Precambrian structural trough previously discussed under Regional Geology. A well in the town of Monticello about 2-3/4 miles east of the site which was drilled to a depth of 500 ft did not encounter granite. Other well information generally indicates that 150 to 200 ft of unconsolidated alluvium and drift overlies sandstone and red shale of unknown thickness at Monticello. All the rock and soil units present at the site therefore slope eastward and thicken toward the sedimentary basin and its artesian groundwater aquifers.

Decomposed granite and basic rocks of Precambrian age comprise the oldest formation at the site, within the depth investigated. This material lies below the ground surface at a depth of about 75 to 122 ft. (See Figures 2.5-1a through 2.5-5) Resting directly upon the weathered Precambrian crystalline rocks is approximately 10 to 15 ft of medium-grained quartz sandstone which, in general, is moderately well cemented. The upper surface of underlying rock can support unit foundation loads up to 15,000 pounds per square foot.

Above the sandstone is a series of alluvial strata about 50 ft thick which consists predominately of clean sands with gravel, as well as a few layers of clay and glacial till. This alluvial sequence represents successive depositions of glacial outwash, moraine, and more recently, sediments laid down by the Mississippi River. During its history this river has meandered as much as 1-1/2 miles south of its present channel.

The distribution of the unconsolidated materials in the locality of the site is shown on Figure 2.5-1b.

The nearest known or inferred fault is the Douglas fault, located approximately 23 miles southeast of the site as shown on Figure 2.5-1a. It is probable that the site has not experienced any activity within recent geologic times.

2.5.4 Groundwater

Large supplies of groundwater are available from the Mississippi River sediments, the glacial deposits, and the underlying sandstones in the area. Most of the private wells in the area are shallow, and penetrate either the river alluvium or the glacial deposits. The town of Monticello derives its water supply from a well approximately 237 ft deep which is believed to penetrate sandstone aquifers. The communities of Big Lake, Albertville, and Elk River also recover water from this formation.

The general path of deep groundwater flow is to the southeast across the region surrounding the site for the plant. The regional gradient, therefore, broadly parallels the trend of the topography and the principal surface drainage. Groundwater at shallower depths moves toward the Mississippi River or its tributaries at variable gradients depending on local conditions.

The water table beneath the low terraces which border the Mississippi River usually lies at about river elevation and slopes very slightly toward the river during periods of normal stream flow. Such is the case at the site.

Movement of groundwater takes place within the three principal rock and soil materials at the site. In the decomposed, clayey granitic rocks, which are very low in permeability relative to the overlying materials, the rate of ground water movement is extremely slow.

2.5.5 Foundation Investigation

The location of the principal structures including the turbine and reactor buildings, intake structure, stack and diesel building and soil borings are shown in Figures 2.5-1a through 2.5-5.

Dynamic soil tests were not considered because the probability of liquefaction is very low under the cyclic loadings produced by the 1952 Taft earthquake (refer to Section 2.6.3), considering the density of the sand and overburden pressure.

Sands which are typically vulnerable to liquefaction are saturated, under low confining pressures, and have standard penetration test values of about N=5. Laboratory studies by Seed and Lee (Liquefaction of Saturated Sands during Cyclic Loading, Journal Soil Mechanics and Foundation Division, ASCE, November 1966, Volume 92, No. SM6) (Reference 38) demonstrate that sands denser than the critical void ratio can be made to liquefy under cyclic loading. Consequently liquefaction has an extremely low statistical possibility in a cemented sand with standard penetration test values of N=80 or more, and could only occur under a very large number (e.g., 10,000) of very high stress cycles. The number of stress cycles that could be expected due to the Taft earthquake is estimated to be less than 1000 cycles.

2.5.6 Conclusions

No unusual features of the site geology are evident. Underlying formations are adequate for foundation for the plant structures.

The geology and soil conditions have been investigated and found stable. Consequently, no special plant design features pertaining to the site geology were necessary.

Table 2.5-1 Geologic Formations in the General Area of the Site

Geologic Age: ERA	Geologic Age: Period	Geologic Name	Description	Remarks
Cenozoic	Quaternary	Recent Deposits	Unconsolidated clay, silt, sand, and gravel	Largely Mississippi River deposits
		Pleistocene	Unconsolidated clay, silt, sand, gravel, and boulders deposited as till, outwash, lake deposits, & loess	Largely from Superior and Grantsburg lobes of Wisconsin glaciation
Paleozoic	Cambrian	Franconia Formation (St. Croix Series)	Sandstone and shale, some aquifer zones	May not be present in immediate area of site
		Dresbach Formation (St. Croix Series)	Sandstone, siltstone and shale, aquifer zone	May not be present in immediate area of site
Precambrian	Keweenawan	Hinckley Formation	Sandstone	Thin in the immediate area of the site. An important aquifer where sufficiently thick
		Red Clastic Series	Sandstone and red shale	Probably not present in immediate area of site
		Volcanics	Mafic lava flows with thin layers of tuff and breccia	Probably not present in immediate area of site
		Granite and Associated Intrusives		Present at site

2.6 Seismology

2.6.1 General

John A. Blume, Associates, analyzed the seismology of the plant site. A copy of the Blume report is included in Appendix A.

2.6.2 Seismic History

In Table 2.6-1 are listed numerically the earthquakes in the general region in and around Minnesota. Those more applicable to the site are plotted on Figure 2.6-1. The earliest earthquake on record occurred in 1860 in central Minnesota; thus over 100 years of records exist. During that period, earthquakes have had little effect at the site. Since compilation of Table 2.6-1, there has been no observed evidence of seismic activity in the plant area.

2.6.3 Faulting in Area

The nearest known or inferred fault - the Douglas Fault - is 23 miles southeast of the site (Figure 2.5-1a). According to referenced geological information, there is no indication that faulting has affected the area of the site in the last few million years. The major fault system of Precambrian age, which is associated with the Precambrian structural trough, is seen on Figure 2.6-2. Major movements of thousands of feet along this system appear to have been restricted to Precambrian time, with minor displacements having occurred during the Paleozoic era. Faulting within recent geologic time is not in evidence.

Richter's Seismic Regionalization Map (Figure 2.6-3) shows the area of the site in a probable maximum intensity of VIII, Modified Mercalli.

This intensity has been based on the area's relationship to the Canadian shield. Stable shields in other continents are usually fringed by belts of moderate seismicity, with occasionally large earthquakes. Historically, this area is too young to prove or disprove such seismic activity. The Modified Mercalli scale is explained in Table 2.6-2.

The Coast and Geodetic Survey's Seismic Probability Map of the United States (Figure 2.6-4) assigns the area to Zone 0 - no damage.

It is considered that neither the regionalization nor the probability map is satisfactory in determining a proper seismic factor if considered alone. Each, however, is based on judgment and fact which, when weighed with other data, become more meaningful. In the case at hand, the assignment of an VIII as the largest probable intensity for the general area must be tempered by the fact that the intensity at or near the underlying sandstone will be much less than that experienced in areas of less competent material, where invariably the maximum damage is sustained.

Earthquakes can and do occur in this region away from faults, and probably result from residual stresses due to recent glaciers. A quake similar to No. 12 and 24 in Table 2.6-1 was postulated near the site and using the dynamic response data obtained insitu, the Taft earthquake of July 21, 1952, North 69 West component with an applied factor of 0.33 was selected as best representative for the design earthquake. Figure 2.6-5 shows single-mass spectra when averaged.

2.6.4 Design Criteria

Design criteria which utilize this earthquake record are discussed in Section 12. Section 12 also gives specific design information related to the seismic analysis of the building and equipment.

2.6.5 Seismic Monitoring System

The Seismic Monitoring System annunciates the occurrence and records the severity of significant seismic events.

The system is composed of three subsystems: the relatively simple annunciators and peak-recording accelerometers, and the more sophisticated acceleration sensors located in the drywell, on the refueling floor and in the seismic shed (located to the north of the warehouse).

Each of the peak-recording accelerometers is a self-contained unit. The sensing mechanism is a permanent magnet stylus attached to the end of a torsional accelerometer. Low frequency accelerations cause the magnet to erase pre-recorded lines on a small (approximately 1/4 inch square) piece of magnetic tape. Because an erasure is permanent, only the peak acceleration that the tape has been subjected to can be deduced when the tape is developed. Each peak recording accelerometer unit contains three torsional accelerometers and magnetic tapes - one each for longitudinal, transverse, and vertical accelerations.

The magnetic tapes can be removed from the accelerometers, developed, and evaluated by plant personnel for a rapid determination of the severity of a seismic disturbance.

The accelerograph recording system gives a more detailed record of a disturbance than the peak recording accelerometers - it records accelerations in three directions (longitudinal, transverse, and vertical, as above) at each of the three sensor locations on magnetic tape cartridges. This system has five major components: trigger, three sensors, and the recording and control equipment. When the trigger (located in the No. 12 125 Vdc battery room) senses the beginning of a seismic disturbance, (an acceleration $\geq$.01 g), it initiates the system power-on sequence and causes the EARTHQUAKE alarm to annunciate in the control room. The recorder then converts the nine analog acceleration signals (three sensors with three directions/sensor) into frequency modulated tones and records them on the magnetic tapes (one for each triaxial sensor). The recorder will run for 10 seconds after each trigger signal, up to a maximum of 30 minutes. The resulting tape gives a detailed record of the disturbance, but must be sent off-site to be fully processed.

The control room EARTHQUAKE annunciator is also initiated by any seismic switch of the Seismic Annunciator System. In addition to this, there are two more alarms initiated by the Seismic Annunciator System. The first of these is the Operational Basis Earthquake (OBE) alarm which annunciates when its seismic switch senses an acceleration $\geq$.03g. The second is the Design Basis Earthquake (DBE) alarm, which annunciates when its switch senses an acceleration $\geq$.06g. These two switches do not activate the accelerograph recording system.

Table 2.6-1 Seismic History of the Region

(Page 1 of 2)

No.	Date	Location: Place	Location: N Lat.	Location: W Long.	Intensity (M.M.)	Remarks
* 1	1860	Central Minn.	-	-	Unknown	Felt over 3,000 square miles
2	10/9/1872	Sioux City, Iowa	42.7	97.0	V	Felt over 140,000 square miles
3	11/15/1877	East Nebraska	41.0	97.0	VII	Felt over 140,000 square miles.
4	7/28/1902	East Nebraska	42.5	97.5	V	Felt over 35,000 square miles.
5	7/26/1905	Calumet, Mich.	47.3	88.4	VII	Felt over 16,000 square miles.
6	5/9/1906	Washabaugh County, S. D.	43.0	101.0	VI	Felt over 8,000 square miles.
7	5/26/1906	Keweenaw Peninsula, Michigan	47.3	88.4	VIII	Felt over 1,000 square miles.
8	5/15/1909	Canada, felt to South	50.0	105.00	VIII	Felt over 500,000 square miles.
9	5/26/1909	Dixon, Illinois	42.5	89.0	VII	Felt over 40,000 square miles.
10	10/22/1909	Sterling, Illinois	41.6	89.8	IV-V	
11	6/2/1911	South Dakota	44.2	98.2	V	Felt over 40,000 square miles.
12	9/3/1917	Minnesota	46.3	94.5	VI	Felt over 10,000 square miles.
*13	2/28/1925	Canada	48.2	70.8	VIII	Felt over 2,000,000 square miles.
14	10/6/1929	Yankton, S. Dakota	42.8	97.4	V (est.)	
15	1/17/1931	White Lake, S. Dakota	43.8	98.7	V (est.)	
*16	11/12/1934	Rock Island & Moline, Illinois Davenport, Iowa	41.4	90.5	V	
17	3/1/1935	Eastern Nebraska	40.3	96.2	VI	Felt over 50,000 square miles.
*18	11/1/1935	Canada	46.8	79.1	IX and over	Felt over 1,000,000 square miles, felt in Minnesota.
19	11/1/1935	Egan, S. Dakota	44.0	96.6	V (est.)	
20	10/1/1938	Sioux Falls, S. Dakota	43.5	96.6	V	Felt over 3,000 square miles.

* Indicates epicenter not plotted on map.

I/djm

Table 2.6-1 Seismic History of the Region

(Page 2 of 2)

		Location				
No.	Date	Place	N Lat.	W Long.	Intensity (M.M.)	Remarks
21	1/28/1939	Detroit Lake, Minn.	46.9	95.5	V (est.)	
22	6/10/1939	Fairfax, S. Dakota	43.1	98.8	VI (est.)	
23	7/23/1946	Wessington, S. Dakota	44.5	98.7	VI (est.)	
24	5/6/1947	Milwaukee Area	42.9	87.9	VII	Felt Sheboygan to Kenosha, Wis.
25	2/15/1950	Alexandria, Minn.	45.7	94.8	V-VI (est.)	
26	1/6/1955	Hancock, Michigan	47.3	88.4	V	
27	12/3/1957	Mitchell, S. Dakota	43.8	98.0	V	
28	1/12/1959	Doland, S. Dakota	44.9	98.0	V	
29	12/31/1961	W. Pierre, S. Dakota	44.4	100.5	VI	

Table 2.6-2 Modified Mercalli Intensity Scale of 1931 (Abridged)

I.	Not felt except by a very few under especially favorable circumstances
II.	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III.	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.
IV.	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed, walls make creaking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V.	Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
VI.	Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
VII.	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.
VIII.	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbs persons driving motor cars.
IX.	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
X.	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.
XI.	Few, if any (masonry), structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII.	Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

2.7 Radiation Environmental Monitoring Program (REMP)

2.7.1 Program Design and Data Interpretation

The purpose of the Radiation Environmental Monitoring Program (REMP) at the Monticello Nuclear Generating Plant is to assess the impact of the plant on its environment (References 7 and 42). For this purpose, samples are collected from the air, terrestrial, and aquatic environments and analyzed for radioactive content. In addition, ambient gamma radiation levels are monitored by thermoluminescent dosimeters (TLDs).

Sources of environmental radiation include the following:

a. natural background radiation arising from cosmic rays and primordial radionuclides;

b. fallout from atmospheric nuclear detonations;

c. releases from nuclear power plants.

In interpreting the data, effects due to the Plant must be distinguished from those due to other sources. To accomplish this, the program uses the control-indicator concept suggested by NRC Guidelines.

2.7.2 Program Description

The sample types and locations included in the current Radiation Environmental Monitoring Program (REMP) at the Monticello Nuclear Generating Plant are listed in the Offsite Dose Calculation Manual (ODCM, Reference 8).

Sample locations are chosen to provide measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides which lead to the highest potential radiation exposures off site. The technique for establishing sample locations conforms to guidance provided by the NRC.

The air environment is monitored by continuous air samplers which filter out airborne radioactive particulates and adsorb airborne radioiodine.

Ambient gamma radiation is monitored at thermoluminescent dosimeter (TLD) stations located in a circular array around the plant. TLD stations are also located around the site's Independent Spent Fuel Storage Installation (ISFSI). 01123676

The terrestrial environment is monitored through samples of groundwater and locally produced food products.

The aquatic environment is monitored through sampling sediment and water from the Mississippi River at locations upstream and downstream of the plant. Drinking water from the city of Minneapolis, which is drawn from the river, is also sampled.

2.7.3 Interlaboratory Comparison Program

Monticello participates in an Interlaboratory Comparison Program to ensure the precision and accuracy of radioactivity measurements of environmental samples. This program is described in the ODCM.

2.8 Ecological and Biological Studies

On August 26, 1977 the Minnesota Pollution Control Agency, the permitting agency under the U. S. Environmental Protection Agency, issued the National Pollution Discharge Elimination System (NPDES) Permit No. MN0000868 covering the Monticello Nuclear Generating Plant. This permit is reissued with any modifications required every 5 years. The NPDES effluent limitations and monitoring requirements, thermal studies and ecological monitoring requirements provide appropriate protection for the environment. There are no ecological or biological monitoring requirements under NRC jurisdiction. Pre-operational and early operational ecological and biological studies are described in the FSAR.

An environmental assessment (EA) of MNGP operation at Extended Power Uprate (EPU) conditions was submitted to the NRC (Reference 45, Enclosure 4). The assessment was subsequently updated by Reference 47. Approval of the updated EA was completed in May 2013 (Reference 46). The assessment evaluated the continued applicability of ecological and biological studies for EPU operation. 01101248

2.9 Consequences of Hypothetical Local Catastrophes

2.9.1 Toxic Chemical Spills

Due to the toxicity of commonly used chemicals, which may be transported near the Monticello Nuclear Generating Plant by railroad or highway, a survey was performed to predict which chemicals may become hazardous in the event of a spill. The analysis was performed in conformance with the guidance set forth by Regulatory Guide 1.78 (Reference 40) and NUREG 0570 (Reference 41). The analysis results were submitted to the NRC for review as required by NUREG 0737, Item III D.3.4 (References 10, 11, 12, 13).

A new toxic chemical survey (Reference 16) was performed in 1993 which identified toxic chemicals in sufficient quantities stored on-site, stored in the vicinity of the site, or shipped near the plant at sufficient frequency to warrant further evaluation. For chemicals meeting these criteria, evaluation indicated that Control Room personnel would have at least two minutes to don breathing apparatus before incapacitation limits were exceeded. The results of the 1993 survey and evaluation were submitted (References 17 and 43) and approved by the NRC (Reference 44).

In 1998, the list of postulated spills was reviewed. The 1993 methodology was used, with updated Control Room air intake rates and volume, to determine event duration. These event durations were then used to size the Control Room Breathing Air System (see Section 10.3.11).

In 2002, an update to the 1998 study using the most recent information available for on-site and off-site chemical sources was performed. This update did not identify any new threat to the site.

In 2008 an update to the 2002 study was completed with no additional threat identified.

In 2014 an update to the 2008 study was completed (EC 23401) using more current on-site and off-site chemical source listings obtained from BNSF, Sherburne & Wright Counties, plant walkdowns, warehouse inspections, and site chemical listings. This survey found no new threats that would challenge Control Room Habitability in event of a postulated accident.

01435004

2.10 References

1. Deleted.
2. “Tornado Probabilities”, H C S Thom, Office of Climatology, U.S. Weather Bureau, published in Monthly Weather Review, October-November 1963, 91, Nos. 10-12, Pages 730-736.
3. General Electric Report, APED-5696, “Tornado Protection for Spent Fuel Storage Pool”, D R Miller and W A Williams, November 1968.
4. “Air Pathway Exposure Model Validation Study at the Monticello Nuclear Generating Plant”, J E Partridge, et al., Eastern Environmental Radiation Facility, Montgomery, Alabama and C B Nelson, Environmental Analysis Division, U.S. Environmental Protection Agency.
5. General Electric Report, NEDO-21159-1, “Airborne Releases from BWR’s for Environmental Impact Evaluations, Amendment 1”, T R Marrero, September 1976.
6. NUS Report, “Monticello Short Term (Accident) Diffusion Factors”, D A Sullivan, Environmental Safeguards Division, Rockville, Maryland, August 1976.
7. NSP (L O Mayer) letter to the NRC, License Amendment Request - “Radioactive Effluent Technical Specification”, dated May 1, 1979.
8. Monticello Nuclear Generating Plant, Offsite Dose Calculation Manual (ODCM).
9. NSP (L O Mayer) letter to the NRC (D L Zieman), “MNGP Appendix I Filing”, dated June 4, 1976.
10. Bechtel Report, “Monticello Nuclear Generating Plant Main Control Room, Toxic Chemical Study”, January 1981.
11. NSP (D M Musolf) letter to the NRC, “Revision 1 to License Amendment Request dated April 3, 1984”, dated August 17, 1984.
12. NRC (J A Zwolinski) letter to NSP (D M Musolf), ”Request for Additional Information - Control Room Ventilation System (TAC 56977)”, dated November 5, 1986.
13. NSP (D M Musolf) letter to the NRC, “Revision 3 to License Amendment Request dated April 3, 1984”, dated February 19, 1987.
14. NUREG/CR-2919, “XOQDOQ, Computer Program for the Meteorological Evaluation of Routine Effluent Release at Nuclear Power Stations”, September 1982.
15. KLD Engineering, P.C., "Monticello Nuclear Generating Plant Development of Evacuation Time Estimates", dated November 2012.
16. Tenera Report, “Monticello Nuclear Generating Plant Control Room Habitability - Toxic Chemical Study”, Final Report”, June 11, 1993.
17. NSP (R O Anderson) letter to the NRC, “License Amendment Request, Removal of Chlorine Detection Requirements and Changes to Control Room Ventilation System Requirements”, dated November 30, 1993.

18. Housing and Home Finance Agency (HHFA) study conducted in 1952.

19. American Telephone and Telegraph Company study, conducted 1917-18 to 1924-25.

20. Edison Electric Institute study, conducted 1926-27 to 1937-38.

21. Association of American Railroads study, conducted 1928-29 to 1936-37.

22. Quartermaster Research and Engineering Command Study, U.S. Army, 1959.

23. “Rainfall Intensity - Duration - Frequency Curves”, U.S. Weather Bureau Technical Paper No. 25, (1955).

24. “Climatological Data with Comparative Data, Minneapolis - St. Paul, Minnesota, 1953-1956”, U.S. Weather Bureau (2 publications).

25. “Climatological Data with Comparative Data, St. Cloud, Minnesota 1953 - 1965”, U.S. Weather Bureau (2 publications).

26. “Climatography of the United States”, No. 86-17, Minnesota, U.S. Weather Bureau.

27. “Local Climatological Data with Comparative Data, 1965”, U.S. Weather Bureau.

28. “Snow Load Studies”, Housing Research Paper 19, Housing and Home Finance Agency, 1952.

29. “Glaze, Its Meteorology and Climatology, Geographical Distribution and Economic Effects”, Quartermaster Research and Engineering Center, 1959.

30. “Climatography of the United States”, No. 60-21, Minnesota, U.S. Weather Bureau.

31. Mean Annual Tornado Frequency figures published by the U.S. Department of Commerce, Weather Bureau.

32. Deleted.

33. Department of the Army, Office of the Chief of Engineers, Engineer Circular No. 1110-2-27, “Policies and Procedures Pertaining to Spillway Capacities and Freeboard Allowances for Dams”, August 1, 1966 .

34. Deleted.

35. Harza Engineering Company study of pollutant dispersion of a slug waste in the Mississippi River.

36. “Hydrologic Atlas of Minnesota”, Bulletin #10, Minnesota Department of Conservation, April 1959, at U.S. Geological Survey, Recorder 2755.

37. Northern States Power Company records from July 1, 1925, to December 31, 1965, at Whitney Steam Plant, St. Cloud, Minnesota.

38. “Liquefaction of Saturated Sands during Cyclic Loading”, Laboratory studies by Seed and Lee, ASCE, Journal, Soil Mechanics and Foundation Division, Volume 92, No. SM6, November 1966.

39. Regulatory Guide 1.23, “Meteorological Programs in Support of Nuclear Power Plants”, Proposed Revision 1, September 1980.

40. Regulatory Guide 1.78, “Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During A Postulated Hazardous Chemical Release”, June 1, 1974.

41. NUREG 0570, “Toxic Vapor Concentrations in the Control Room Following a Postulated Accidental Release”, June 1, 1979.

42. NRC (D B Vassallo) letter to NSP (D M Musolf), Amendment 15 to Facility Operating License DPR-22 dated December 17, 1982.

43. NSP (R O Anderson) letter to the NRC, “Additional Information to Support License Amendment Request dated November 30, 1993”, dated June 30, 1994.

44. NRC (B A Wetzel) letter to NSP (R O Anderson), “Issuance of Amendment Re: Removal of Chlorine Detector Requirements from Technical Specifications (TAC No. M88602)”, dated August 25, 1994.

45. NSPM Letter L-MT-08-052 (T J O'Connor) to NRC, "License Amendment Request: Extended Power Uprate (TAC MD9990)," dated November 5, 2008.

46. NRC (M C Wong) memorandum to NRC (R D Carlson), "Environmental Review Complete for Monticello Nuclear Generating Plant, Unit 1 Extended Power Uprate Application (MD9990)," dated May 2, 2013. 01101248

47. NSPM Letter L-MT-13-020 (M A Schimmel) to NRC, "Monticello Extended Power Uprate (EPU): Second Supplement for Gap Analysis Updates (TAC MD9990)," dated February 27, 2013.

FIGURES

Figure 2.2-1 Monticello Property Map

Reference Section 15 USAR Drawings
ND-95208 Monticello Property Map

Figure 2.3-1 Return Period of Extreme Short-Interval Rainfall, Minneapolis, MN

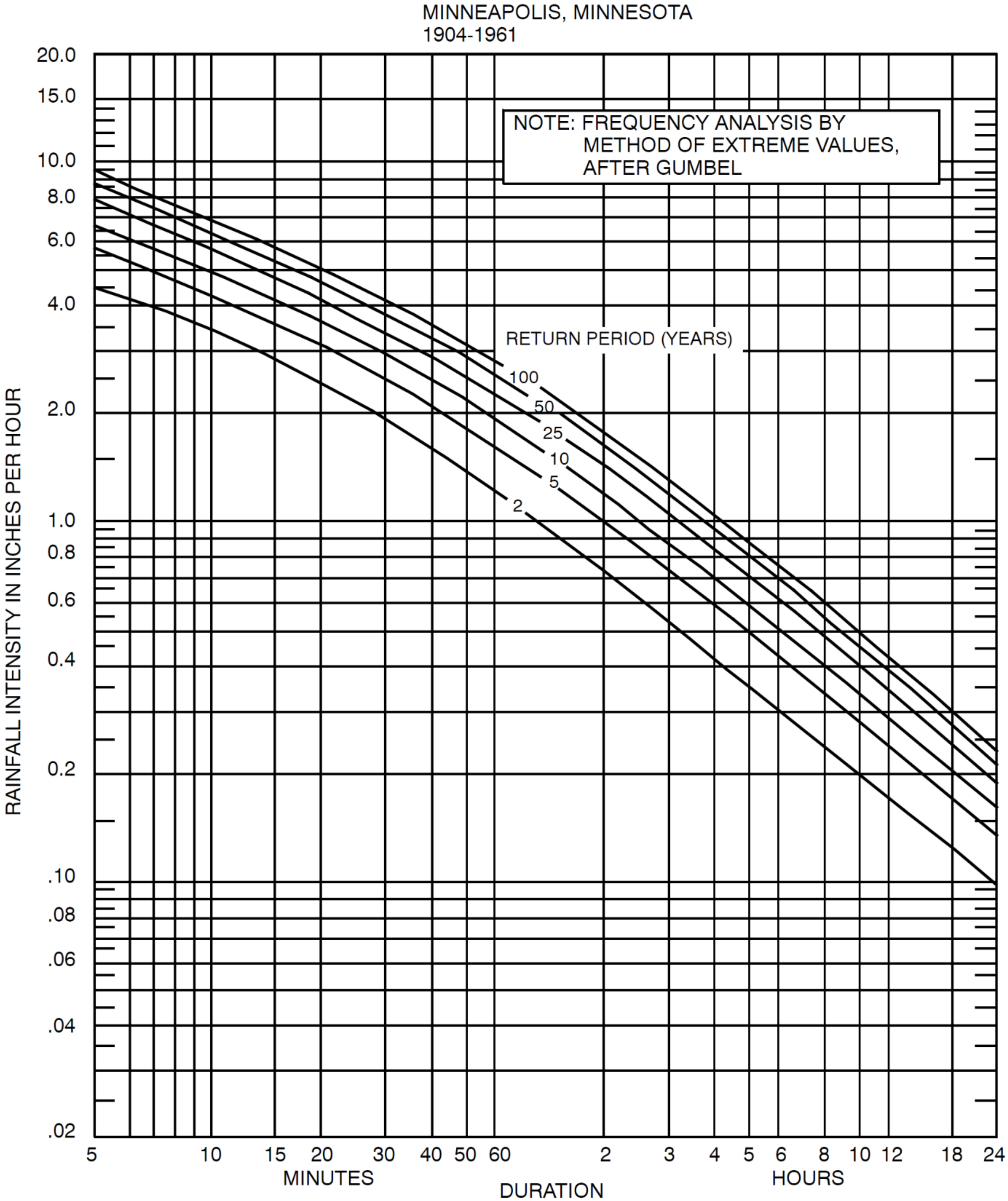

Figure 2.4-1 Flow Duration Curve, Mississippi River at St. Cloud, MN

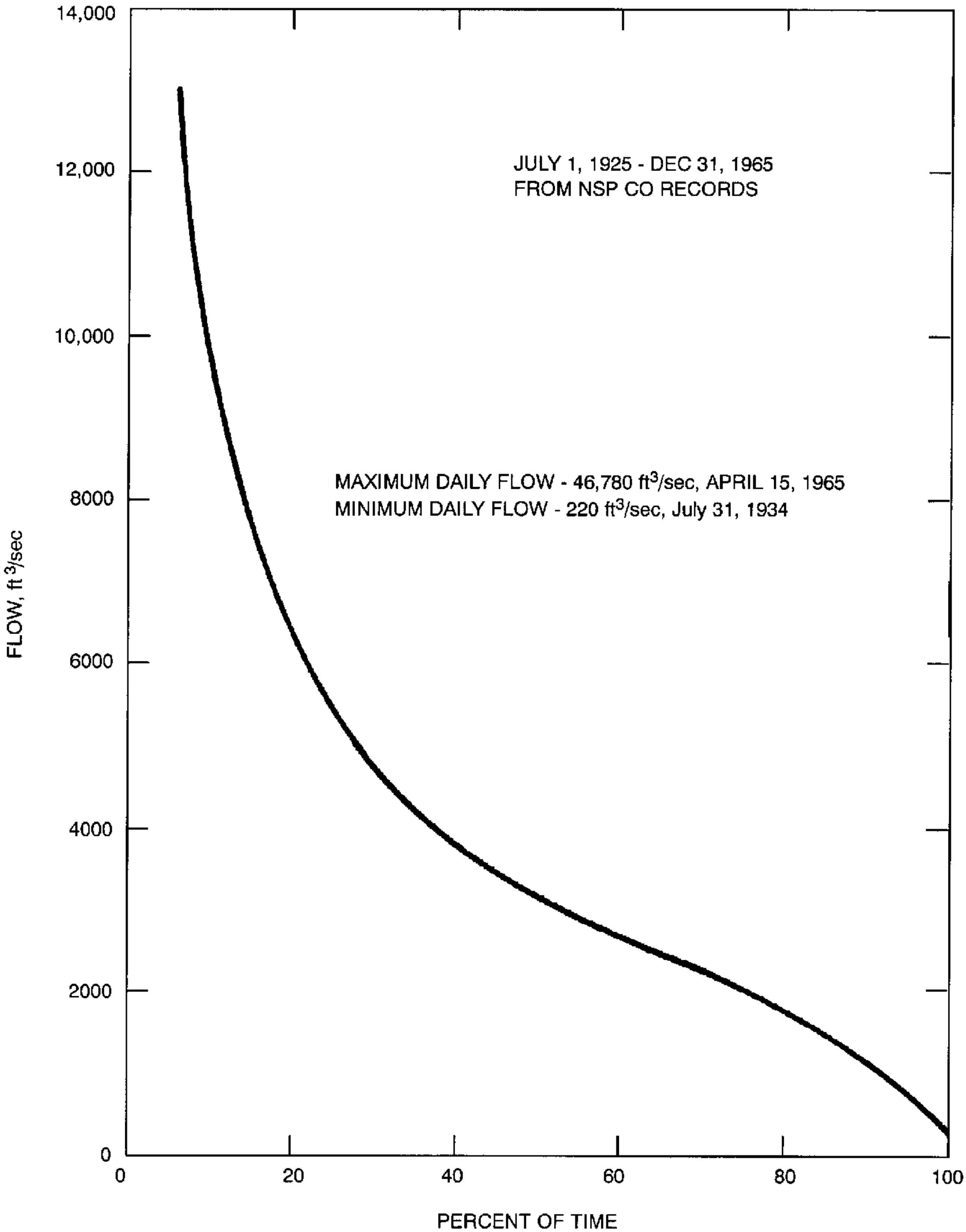

Figure 2.4-2 1965 Spring Flood at Monticello Site

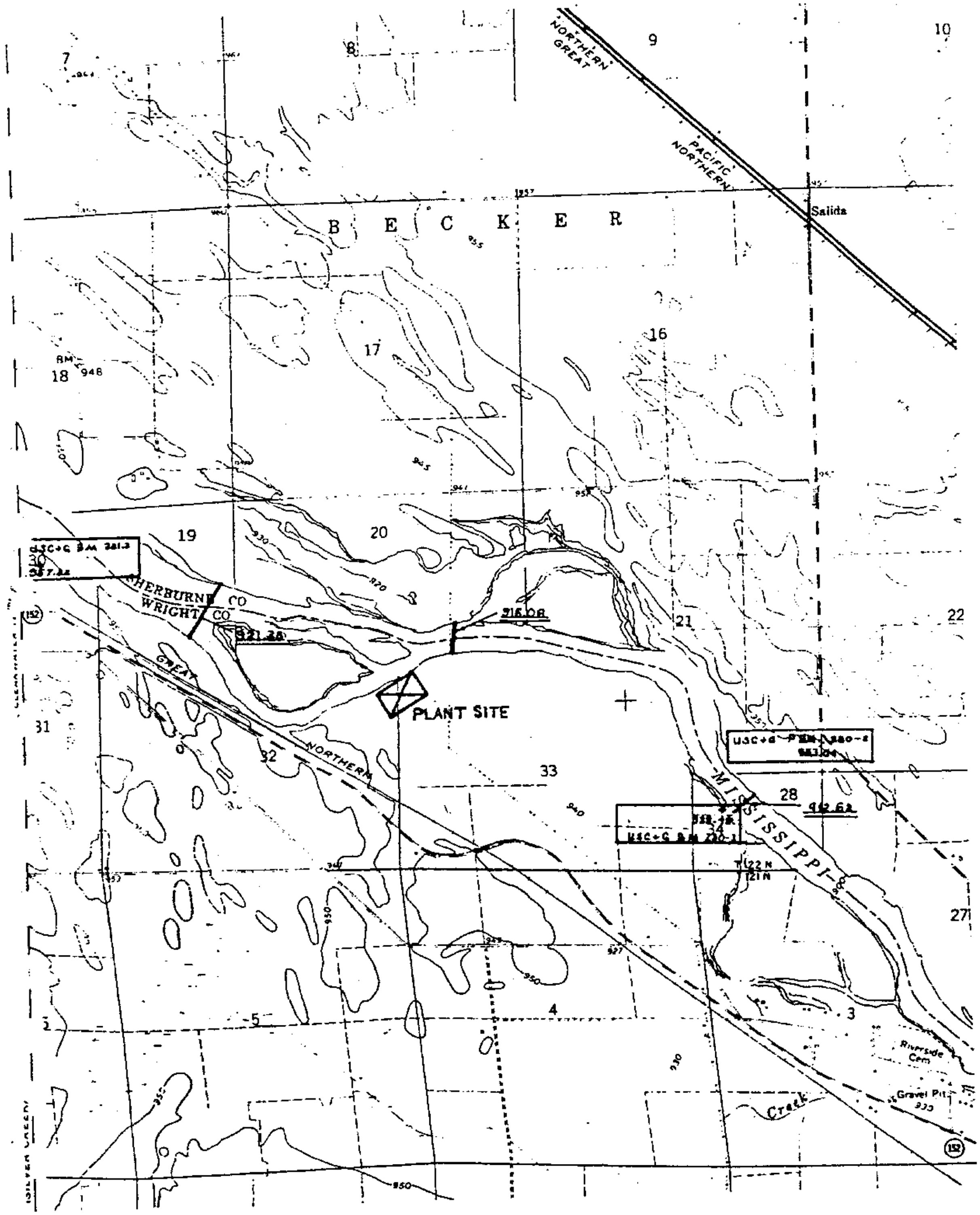

Figure 2.4-3 Flood Frequency Study - Mississippi River at Monticello Site

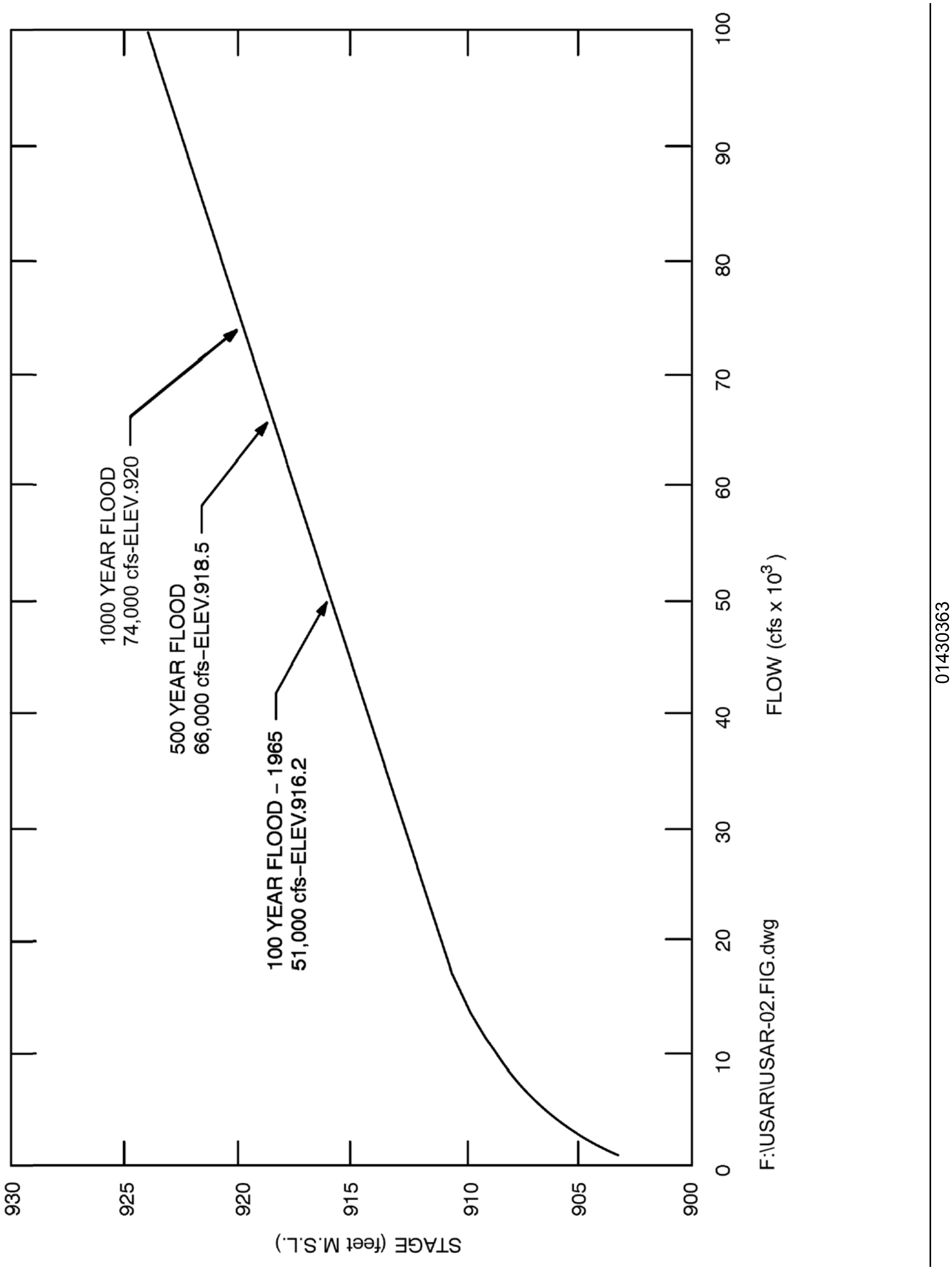

Figure 2.5-1a Overlay Regional Tectonic Map

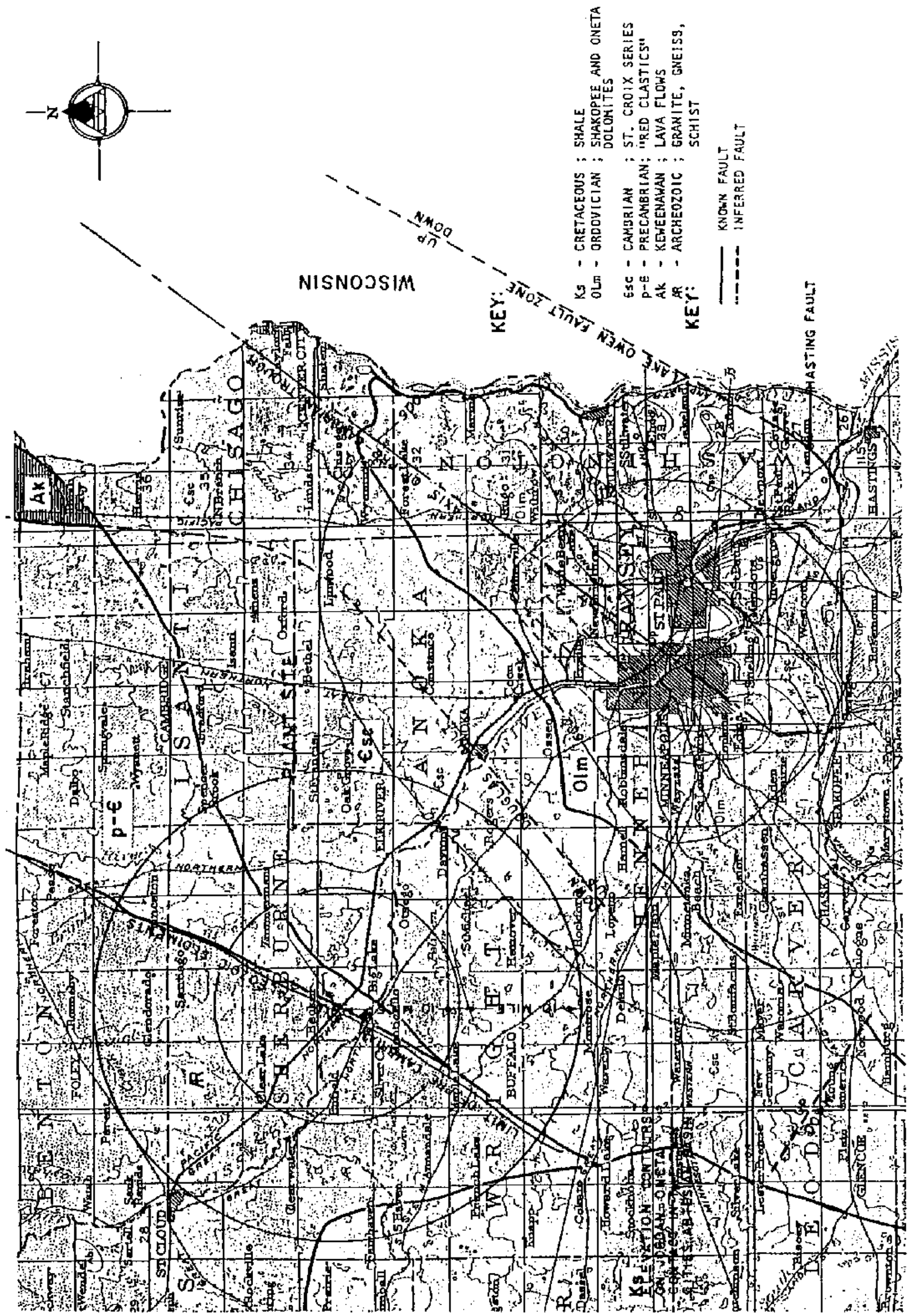

Figure 2.5-1b Regional Geology Map

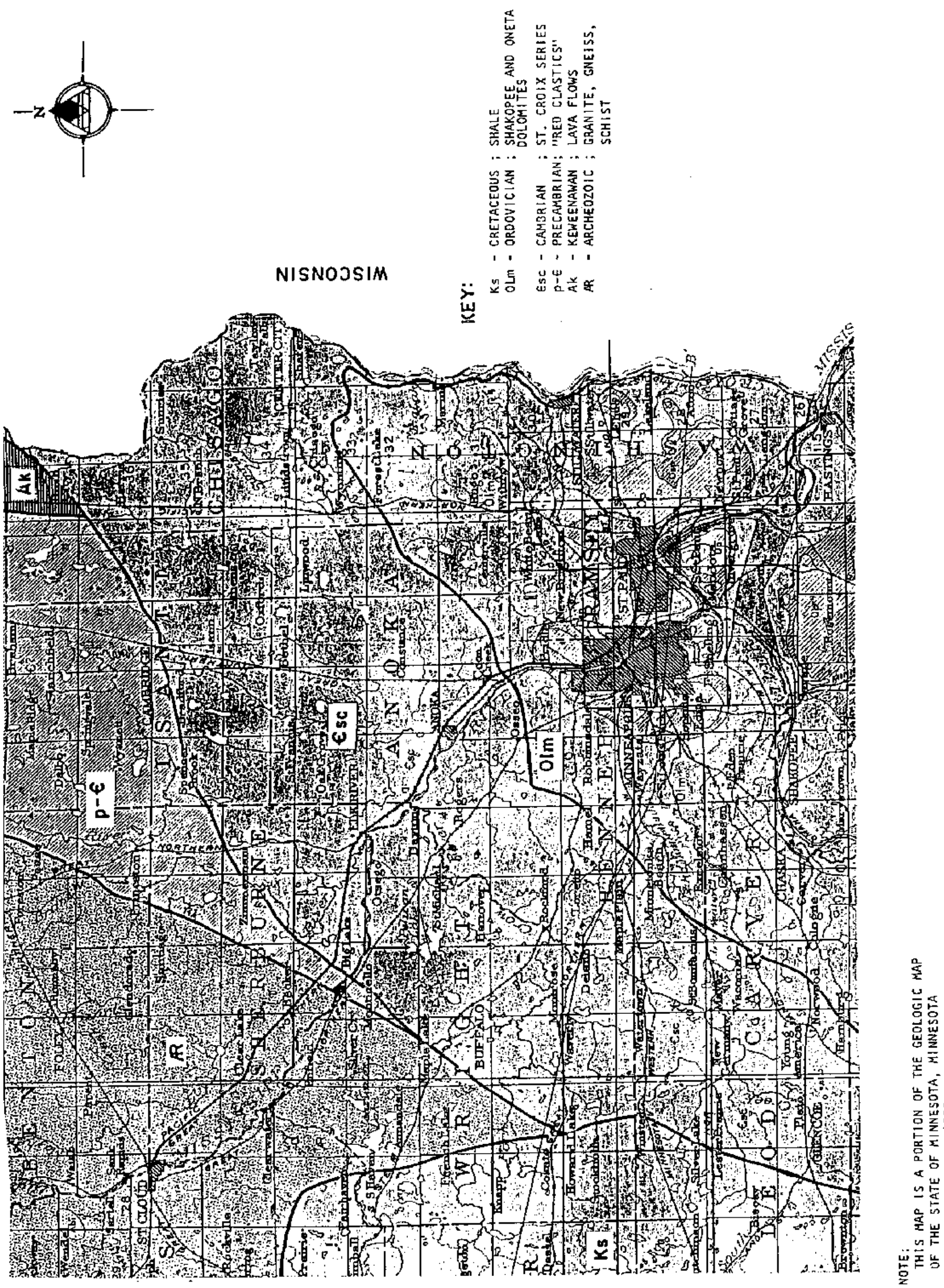

Figure 2.5-2 Location of Original Borings

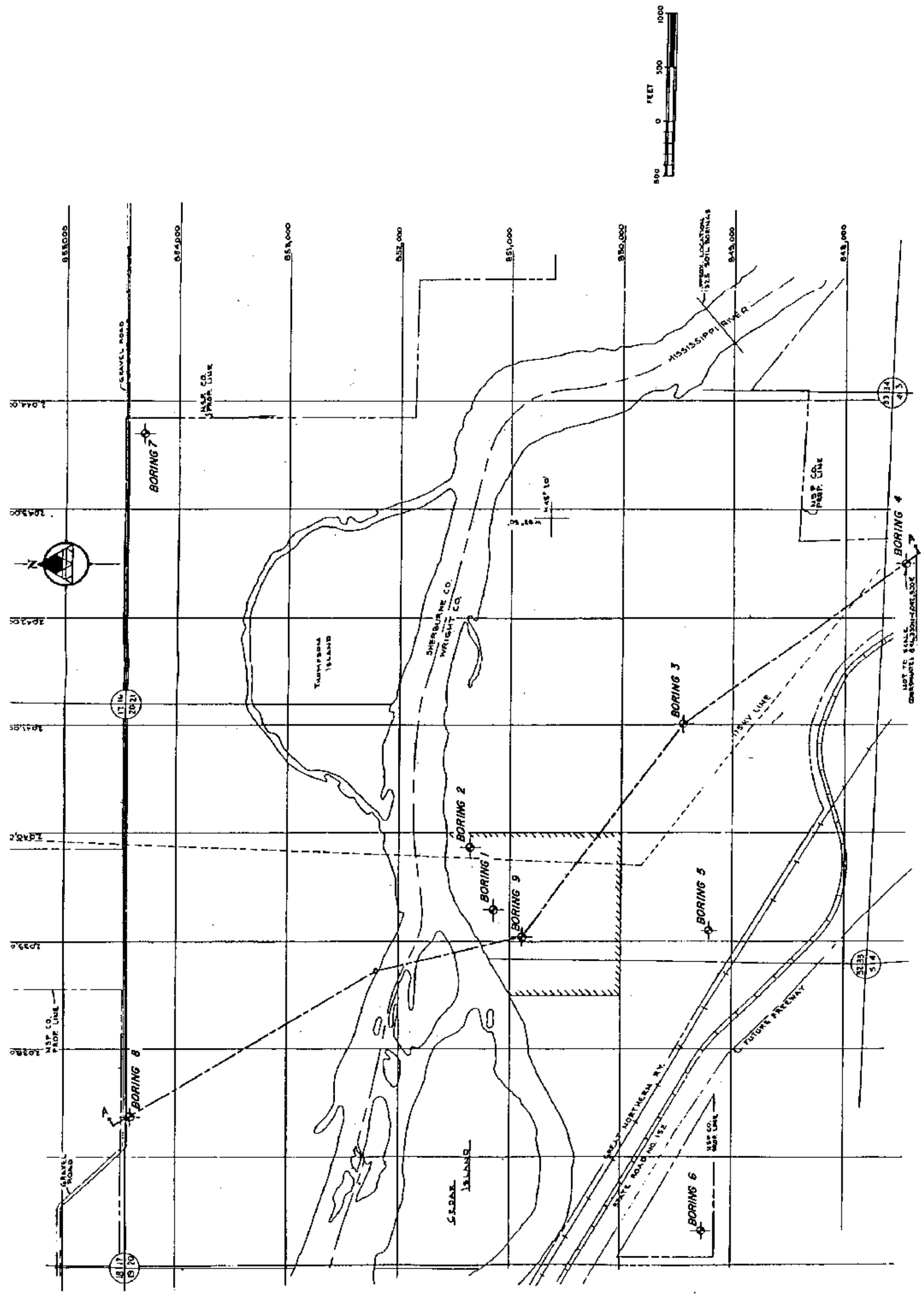

Figure 2.5-3 Geologic Cross Section A-A

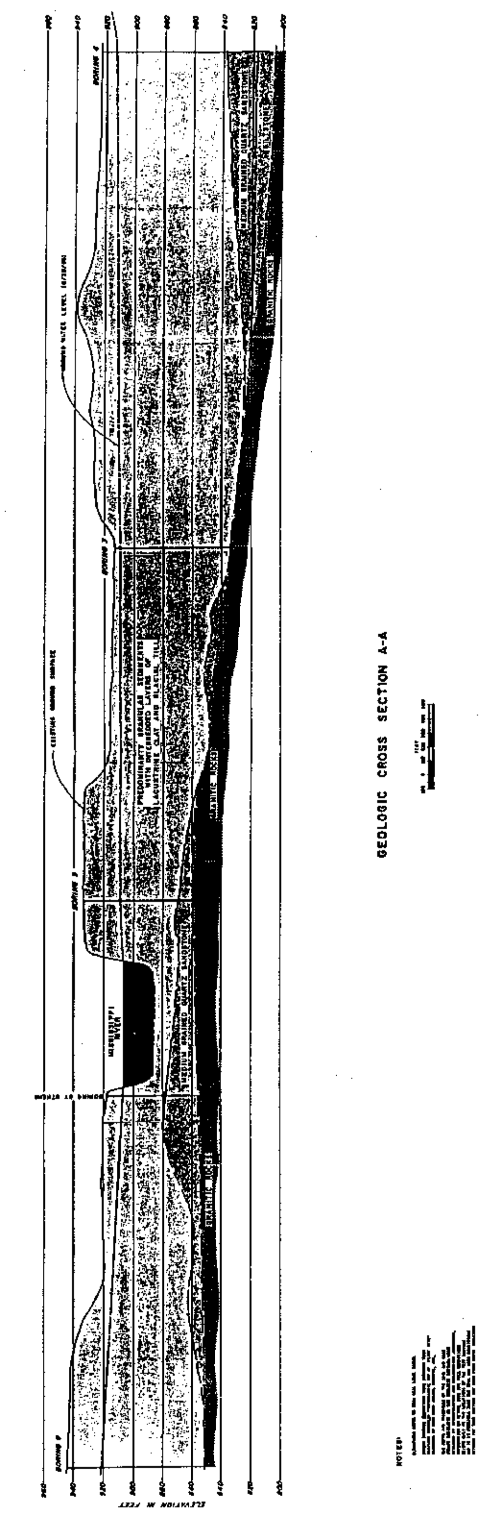

Figure 2.5-4 Log of Borings Sheet 1

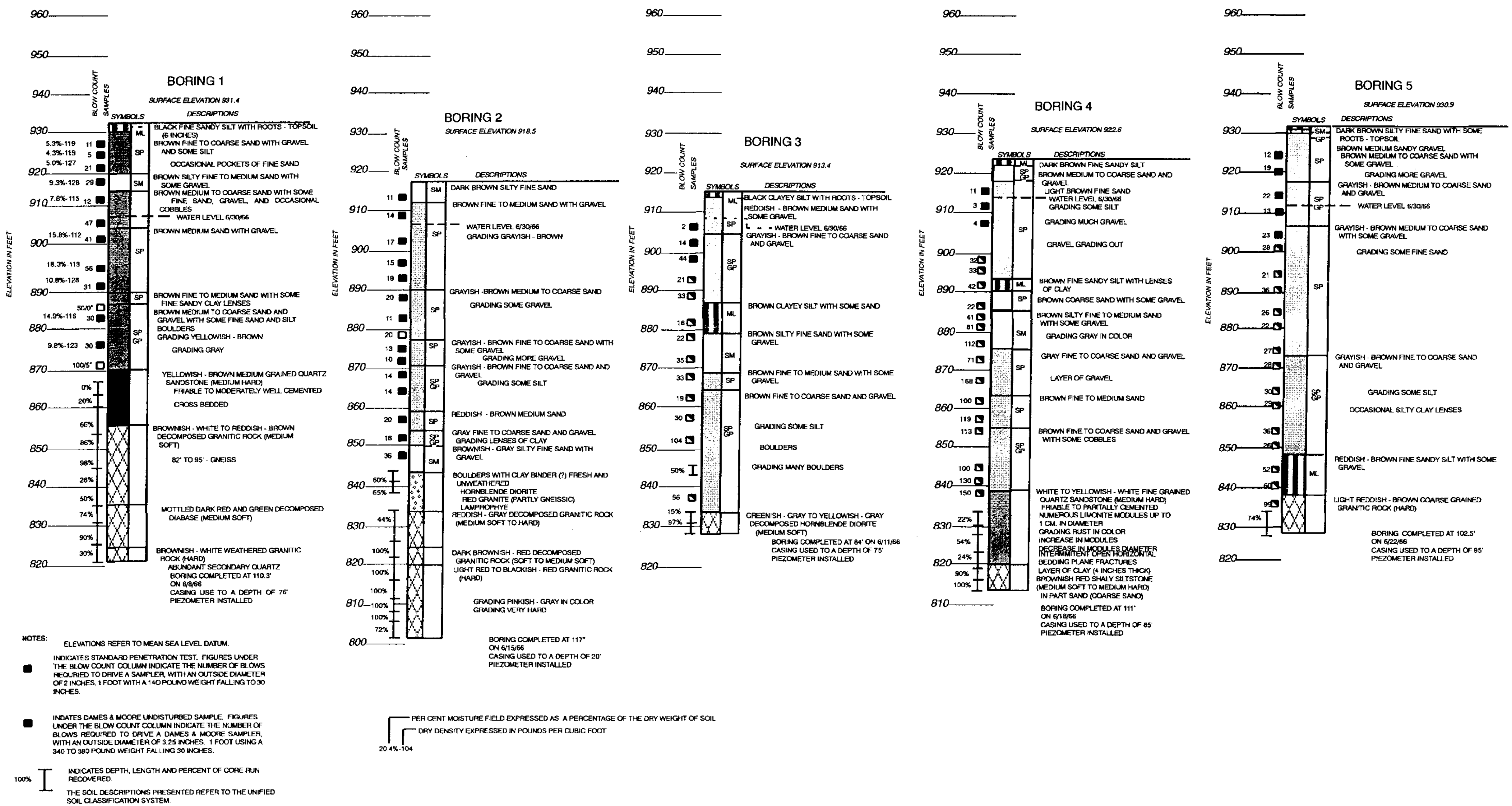

Figure 2.5-5 Log of Borings Sheet 2

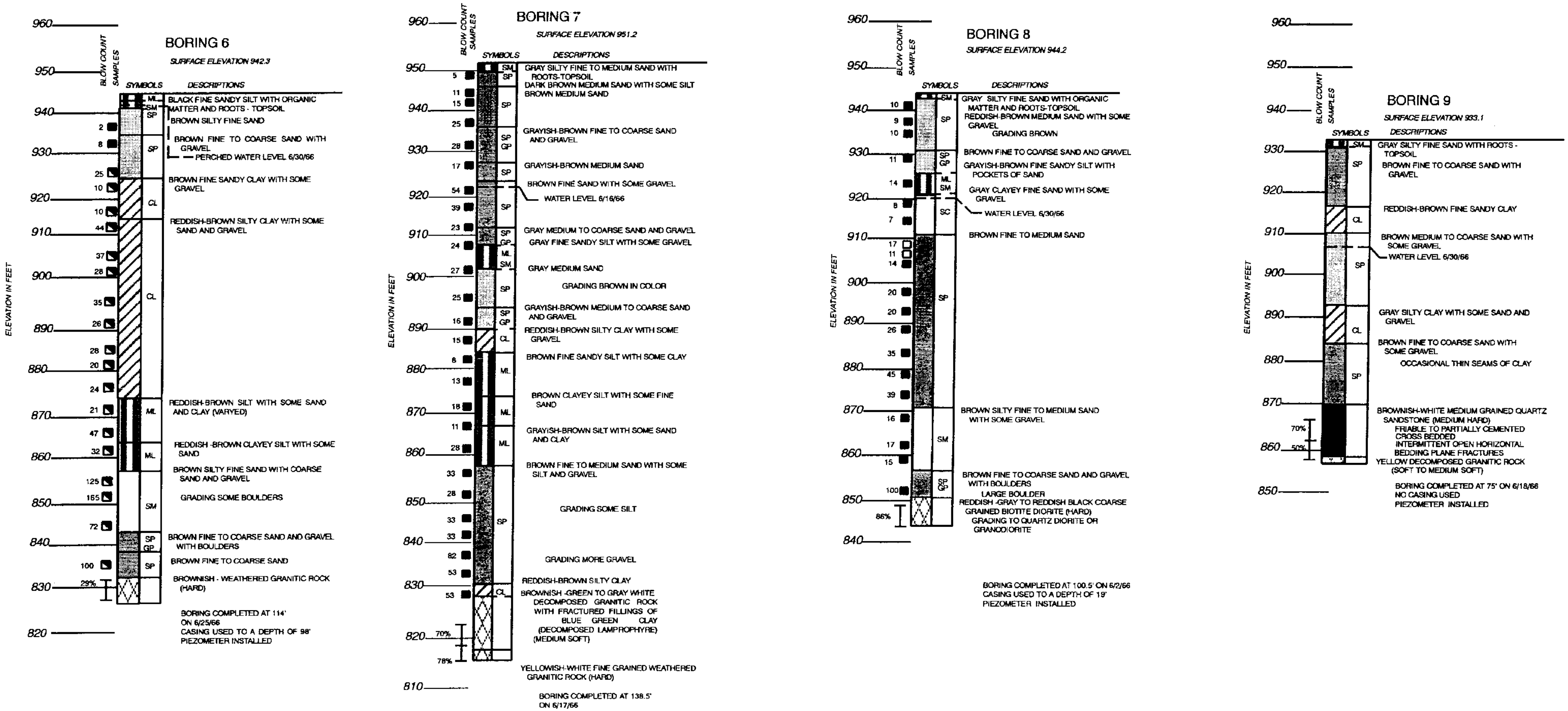

Figure 2.6-1 Principal Earthquakes - Minnesota Region

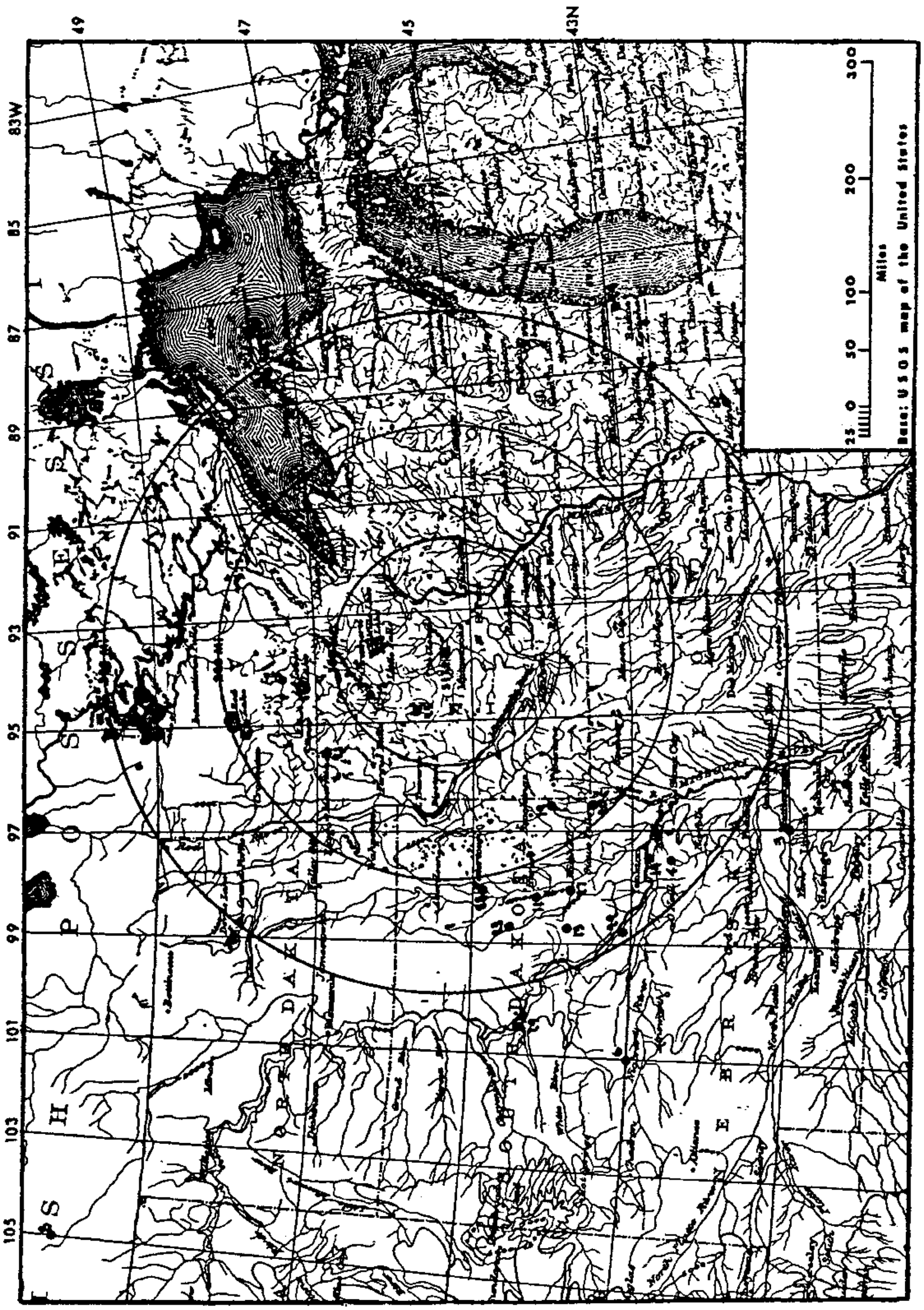

Figure 2.6-2 Tectonic Map of Minnesota Region

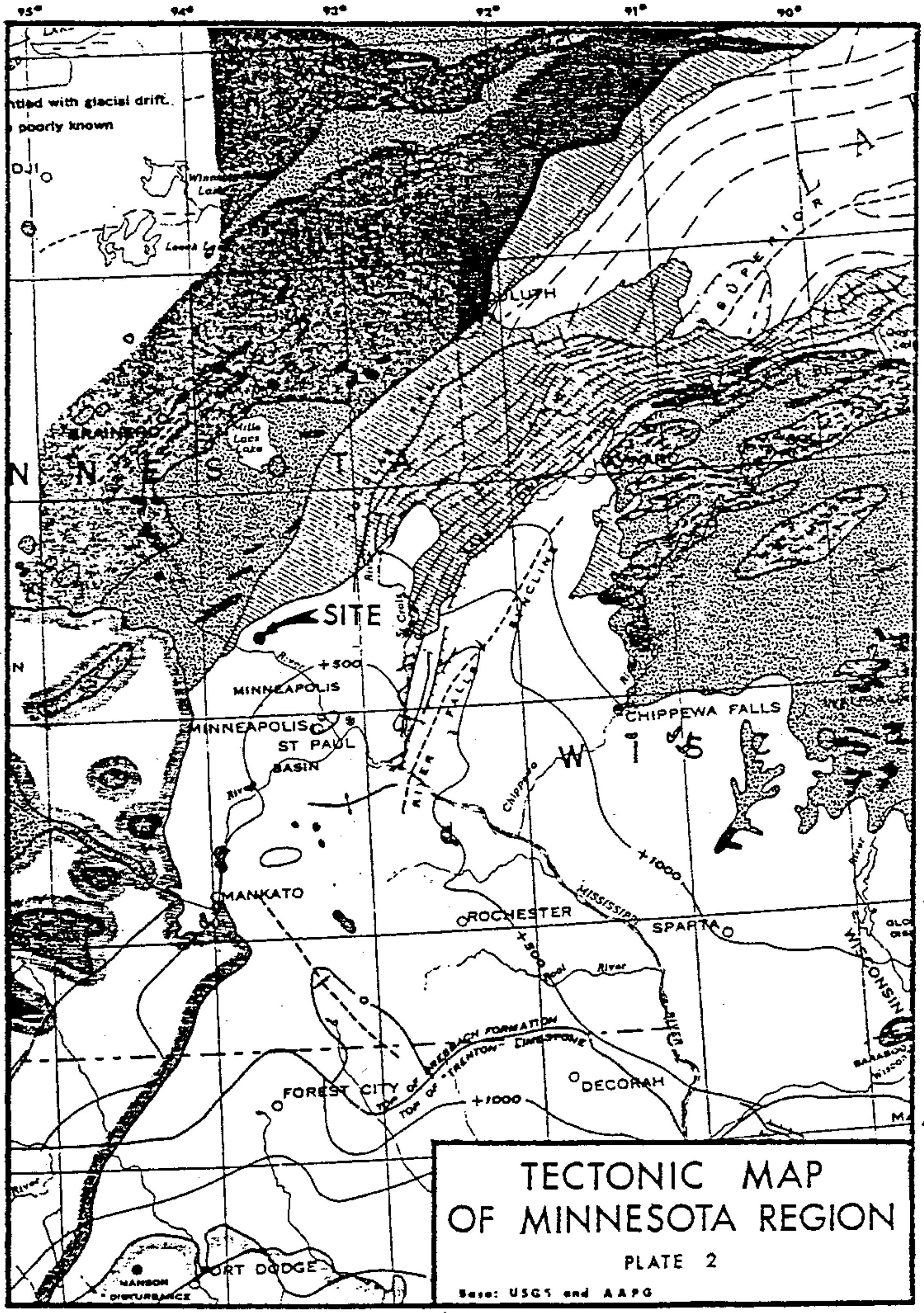

Figure 2.6-3 Seismic Regionalization U.S.A.

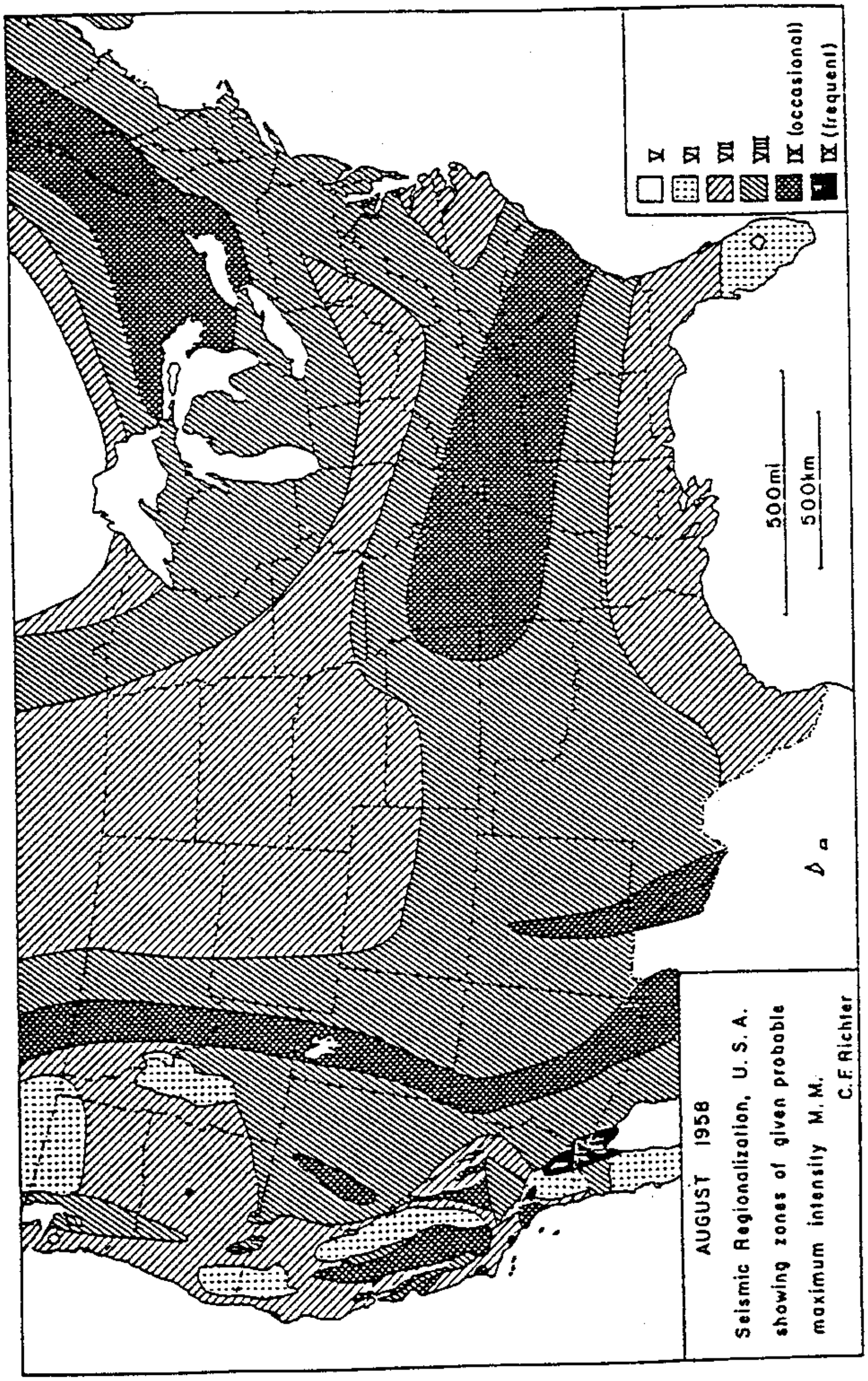

Figure 2.6-4 Seismic Probability Map of U.S.A.

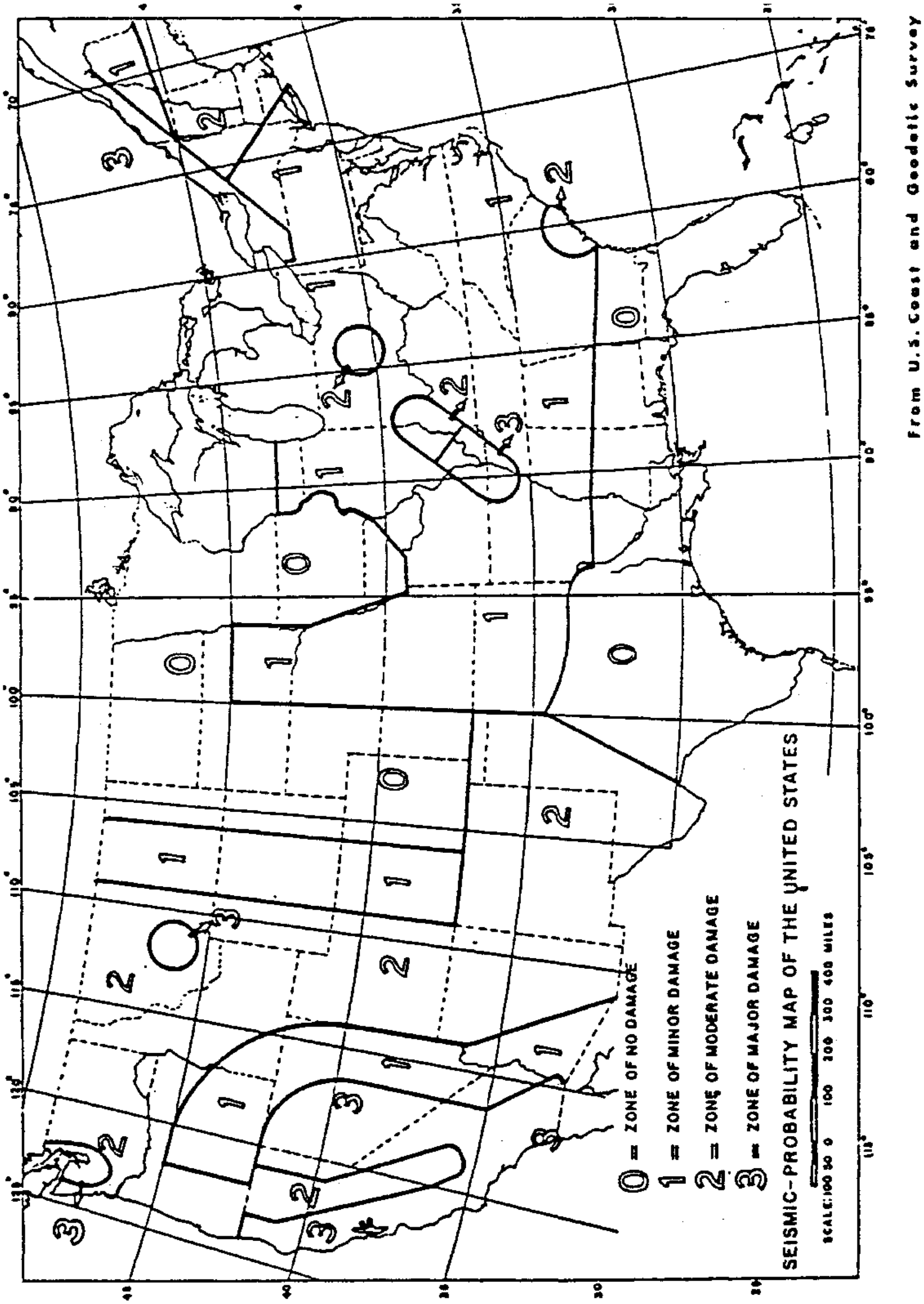

Figure 2.6-5 Seismic Response Spectra