COVER SHEET

SUBJECT: MNGP Toxic Chemical Analysis
Probability Analysis of Trucking Accidents

PROJECT: MNGP Toxic Chemical Study Update

CLIENT: Northern States Power Company

- ☐ ECP-2.1 DESIGN
- ☒ ECP-2.2 CALCULATION
- ☐ ECP-2.3 ENG. EVALUATION
- ☐ OTHER

CONT. I.D NO. 1961-2.2-004

NO. OF SHTS. ~~17~~ 16 (1)

PURPOSE/DESCRIPTION

The purpose of this calculation is to conservatively determine the probability that a trucking accident on highways near the Monticello Nuclear Generating Plant involving hazardous materials will incapacitate the control room operators and result in a radioactive release in excess of 10 CFR 100 guidelines. The calculation will use probabilistic techniques to determine the probability of such an occurrence and will compare this probability to the acceptance criteria stated in Section 2.2.3 of the NRC Standard Review Plan.

REVISION 1 INCORPORATES CLIENT COMMENTS REGARDING TRUCK TRAFFIC ON OTHER HIGHWAYS, TYPES OF TRUCKS EVALUATED, AND THE FRACTION OF TRUCKS CARRYING HAZARDOUS MATERIALS. REVISION 1 ALSO INCORPORATES VARIOUS EDITORIAL COMMENTS.

DESCRIPTION OF DOCUMENT VERIFICATION

Reviewed calculation method, confirmed accuracy of design inputs from reference material, and confirmed calculations numerically correct.

Revision 1: Reviewed changes to design inputs, references for correctness and confirmed revised calculations are numerically correct.

REV. NO.	ORIGINATOR (Signature)	DATE	VERIFIED BY (Signature)	DATE	APPROVED BY (Signature)	DATE
0	S. Kellet	3/30/93	David G. Lee	3/30/93	David G. Lee	3/30/93
1	S. Kellet	4/5/93	David G. Lee	4/11/93	David G. Lee	4/11/93

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SUBJECT MNOP Toxic Chemical Analysis - Probability Analysis of Trucking Accidents

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1.0 Purpose

The purpose of this calculation is to conservatively determine the probability that a trucking accident involving hazardous materials will incapacitate the Monticello Nuclear Generating Plant (MNGP) control room operators and result in a radioactive release in excess of 10 CFR 100 guidelines.

NRC Standard Review Plan (SRP) Section 2.2.3 (Ref. 1) states in regard to offsite hazards that "the expected rate of occurrence of potential exposures in excess of the 10 CFR Part 100 guidelines of approximately 10^{-6} per year is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower." This calculation will demonstrate that this criterion is met for trucking accidents involving hazardous materials in the vicinity of the MNGP.

2.0 References

1. U.S. NRC Standard Review Plan, Section 2.2.3, "Evaluation of Potential Accidents," Revision 2, July 1981.

2. "Truck Trends in Minnesota - An Examination of Truck Traffic and Accidents from 1984 thru 1990," July 1991, Truck and Economic Studies Section, Minnesota Department of Transportation.

3. MNGP Drawing NF-108565-2, Revision B.

4. Publication No. FHWA-RD-89-013, "Present Practices of Highway Transportation of Hazardous Materials," May 1990, U.S. Department of Transportation, Federal Highway Administration.

5. TENERA Correspondence File 1961-2.4-013, confirmation letter from C. Dahlin (MN Dept. of Transportation) regarding truck traffic information on Interstate 94 and Highway 10.

6. NSP Nuclear Analysis Department calculation for MNGP, "Level 1 Sensitivity Studies," Calculation No. II.SMR.90.026.

7. TENERA Calculation 1934-2.2-005, "Chlorine and Ammonia Probability Analysis," Revision 1, August 12, 1991.

8. TENERA Calculation 1934-2.2-006, "Revised Chlorine and Ammonia Spill Estimates," Revision 1, December 11, 1991.

9. Monticello Calculation CA-92-012, Attachment 5, "Monticello Toxic Chemical Study Update - Accidental Chlorine Release Analysis," Preliminary issue.

10. TENERA Calculation 1961-2.2-001, "Verification of TOXPUFF and TOXEVAP Lotus 1-2-3 Spreadsheets," Revision 0, March 15, 1993.

11. TENERA Calculation 1961-2.2-002, "Analysis of Toxic Chemical Spills Using the Lotus 1-2-3 Spreadsheet TOXPUFF," Revision 0, March 15, 1993.

12. TENERA Calculation 1961-2.2-003, "Analysis of Toxic Chemical Spills Using the Lotus 1-2-3 Spreadsheet TOXEVAP," Revision 0, March 15, 1993.

13. U.S. NRC Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," June 1974.

14. U.S. AEC Safety Evaluation for Monticello Nuclear Generating Plant Unit No. 1, Full Term Operating License, February 5, 1973 (DSS Sequence #HEJ00501).

15. Monticello Procedures Manual A4, Volume 2, "Chemical Spill/Hazardous Materials Procedures."

16. Telecon between G. Kellund (TENERA) and W. Martinson (MN DOT), "Highway Traffic Data on Highways 25 and 75," April 2, 1993. | Δ

3.0 Methodology

The probability that a release from a trucking accident involving hazardous materials would incapacitate the control room operators and result in a radioactive release in excess of the 10 CFR 100 guidelines is determined by the solution of the following equation:

$$P_{>100} = (T_{AR}) \times (D_{RISK}) \times (N_{TRUCKS}) \times (F_{HAZ}) \times (R_{ACC}) \times (R_{OI}) \times (P_{OI})$$

where

$P_{>100}$ = Probability of a release in excess of 10 CFR 100 guidelines per year due to a trucking accident involving hazardous materials.

T_{AR} = Trucking accident rate per mile.

D_{RISK} = Length of highway segment (in miles) where a release in this segment could potentially result in transport to the control room and operator incapacitation. This value is also weighted to account for wind direction probability at any point in the segment.

N_{TRUCKS} = Number of commercial trucks traveling on highways of concern per year.

F_{HAZ} = Fraction of commercial trucks that carry hazardous material.

R_{ACC} = Fraction of trucking accidents involving hazardous materials that result in a release or spill.

R_{OI} = Fraction of hazardous materials releases that are severe enough to potentially result in control room operator incapacitation.

P_{OI} = Probability of exceeding 10 CFR 100 guidelines given operator incapacitation (per shift).

Each of the above terms will be discussed in detail in Section 7.0 of this calculation.

4.0 Acceptance Criteria

As noted in Section 1.0 above, a probability of exceeding 10 CFR 100 guidelines due to operator incapacitation resulting from a trucking accident of 10^{-6} per year is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower. If this criterion is met, no actions or measures are required to protect the operators from this event.

5.0 Assumptions

Assumptions used in the development of this calculation are as follows: Δ

1. Accident rates for combination trucks are representative of all truck types that may carry hazardous materials. The majority of hazardous material transported by truck in quantities sufficient to pose a risk to the MNGP is transported by combination trucks (i.e. large shipments of toxic liquids and gases constitute the primary threat; these materials are typically transported by tanker truck). Also, the accident rate for other truck types is not expected to be significantly different from that for combination trucks.

2. All severe releases within a five mile radius of the MNGP are conservatively assumed to incapacitate the control room operators if the wind is blowing in the direction of the MNGP.

3. Only Interstate 94 and Highway 10 carry sufficient truck traffic in the vicinity of the MNGP to warrant consideration in the calculation. Justification for this assumption is provided in the discussion of the D_{RISK} term in Section 7.0.

4. Reference 4 states that "between 5 percent and 15 percent of all trucks on the road at any given time carry hazardous materials." Table 35 of Reference 4 notes ✓ that 5.2% of all truck accidents involve hazardous shipments. Consequently, this calculation will assume that 5.2% of all truck traffic carries hazardous materials. △

5. Any release that does not meet the U.S. Department of Transportation definition of "severe" is not capable of incapacitating the control room operators. This assumption is supported by the fact that in order to incapacitate the operators, a release would have to travel at least one-half mile (the closest approach of a highway to the MNGP) and would necessarily incapacitate anyone in that one-half mile long path. It is doubtful that any release capable of incapacitating anyone up to one-half mile away would not meet the definition of "severe."

6. The operators did not initiate a plant transient (i.e. a reactor scram) prior to incapacitation. This assumption is consistent with operating procedures and operator training. The procedures for handling toxic gas releases [Ref. 15] do not direct the operators to scram the reactor.

7. The probability of core damage resulting from operator incapacitation is conservatively assumed to equal the probability of radioactive releases exceeding 10 CFR 100 guidelines.

8. No outside intervention or assistance occurs for the remainder of the shift following operator incapacitation.

6.0 Design Inputs

Design inputs used in this calculation (as noted in Section 3.0) were obtained from the references given in Section 2.0. The specific source and applicability of each design input used will be noted in the appropriate part of Section 7.0 of this calculation.

7.0 Calculation

As stated above, the probability that a release from a trucking accident involving hazardous materials would incapacitate the control room operators and result in a radioactive release in excess of the 10 CFR 100 guidelines is determined by the solution of the following equation:

$$P_{>100} = (T_{AR}) \times (D_{RISK}) \times (N_{TRUCKS}) \times (F_{HAZ}) \times (R_{ACC}) \times (R_{OI}) \times (P_{OI})$$

This calculation will be performed separately for each highway of concern near the MNGP. The results for each highway will then be summed to produce the overall probability for all trucking accidents.

Each term in the equation, and the source of the value used is discussed below.

T_{AR}: The trucking accident rate per mile was obtained from Reference 2. This reference was used because it provided a breakdown of accident rates by road type (interstate or principal arterial) and by location (urban or rural).

Interstate 94 is in a rural location in the vicinity of the MNGP and passes within approximately one-half mile of the MNGP. Reference 2 provides an overall accident rate of 0.80 per 10^6 miles for semitrailer trucks on rural interstates, and 1.27 per 10^6 miles for twin trailer trucks on rural interstates. Since semitrailer trucks account for approximately 98% of the total rural interstate miles traveled by combination trucks in Minnesota (per Ref. 2), a scaled overall trucking accident rate of 0.81×10^{-6} per mile provides a realistic estimate for rural interstate highways. This value will be used for the overall trucking accident rate on Interstate 94. It should be noted that in the vicinity of the MNGP, Interstate 94 is quite straight and flat and could be expected to have an accident rate less than the value used here.

The other highway of concern for this calculation is Highway 10. Highway 10 passes within approximately two miles of the MNGP and is treated as a principal arterial highway for the purposes of this calculation. Reference 2 provides an overall accident rate of 1.27 per 10^6 miles and 1.20 per 10^6 miles for semitrailer trucks and twin trailer trucks, respectively, on rural principal arterial highways. This calculation will conservatively use the higher value of 1.27×10^{-6} per mile for the overall trucking accident rate for Highway 10.

The accident rate values given above for combination trucks can be assumed to be representative of all truck types that may carry hazardous materials for the following reasons: The majority of hazardous material transported by truck in quantities sufficient to pose a risk to the MNGP is transported by combination trucks (i.e. large shipments of toxic liquids and gases constitute the primary threat; these materials are typically transported by tanker truck). Also, the accident rate for other truck types is not expected to be significantly different from that for combination trucks.

D_{RISK}: The length of highway segment where a release could potentially transport to the control room and incapacitate the operators was determined from Reference 3 by assuming all portions of a highway within five miles of the MNGP could produce such a release. The boundary was set at five miles to be consistent with the guidance given in Regulatory Guide 1.78 [Ref. 13]. This is clearly a very conservative assumption since References 10, 11, and 12 demonstrated that the release of highly incapacitating materials (e.g. chlorine) from a rail accident two miles from the MNGP and in much larger quantities than those transported by truck did not produce operator incapacitation.

In order to account for the potential effects of wind direction on the probability of release transport to the control room, the D_{RISK} term is weighted by multiplying the fraction of the time that the wind is in a particular sector by the highway miles in that sector. This is performed for each sector that the highway passes through within five miles of the MNGP. The results for each sector are then summed to produce an equivalent length of highway where the wind direction is always toward the MNGP. The sectors of concern were obtained from Reference 3 and are shown graphically in Figures 1 and 2 for Interstate 94 and Highway 10, respectively. Wind direction data from 1984 to 1991 was obtained from

Reference 9 and is tabulated in Table 1. Table 1 also shows the "equivalent miles" of highway length.

It should be noted that only Interstate 94 and Highway 10 were included in this calculation since all other roads within five miles of the MNGP are much smaller than these highways and have considerably less truck traffic.

The only other roads in this area that could potentially carry significant amounts of truck traffic are Highways 25 and 75. According to traffic data supplied by the Minnesota Department of Transportation [Ref. 16], Highway 25 carries approximately 450 heavy commercial vehicles per day in the Monticello area. This traffic volume is much less than the combined traffic volume carried by Highways 94 and 10; further, since the point of closest approach of Highway 25 to the MNGP is approximately 3.5 miles, the D_{RISK} term for this highway is small. Also, since the point of closest approach is over three miles from the plant, the potential for operator incapacitation from a spill is quite small. Consequently, since truck traffic on Highway 10 contributes only approximately 15% of the total risk, truck traffic on Highway 25 will have an insignificant contribution to the total risk. For reasons similar to those given above, truck traffic on Highway 75 will have an insignificant contribution to the total risk. Although no data on commercial vehicle traffic is available for this roadway, total vehicle traffic on this road is substantially less than that on Highway 25. Further, as noted in Reference 16, very few heavy commercial vehicles would be expected on Highway 75 due to its size and location.

It should also be noted that since other roads tend to carry local traffic, very little hazardous material is transported on them. Further, any hazardous material transported in this area by truck is almost certain to enter the area via Interstate 94 or Highway 10 and would then be accounted for in this calculation.

N_{TRUCKS}: The number of commercial trucks travelling on Interstate 94 and Highway 10 per year was obtained from the Minnesota Department of Transportation [Ref. 5]. Interstate 94 carries an average of 3,325 heavy commercial vehicles per day (both directions) north and south of the Highway 25 interchange at Monticello. Highway 10 carries an average of 700 heavy commercial vehicles per day (both directions) in the vicinity of Monticello.

According to Reference 16, heavy commercial vehicles are defined as vehicles of 2-1/2 ton size and larger. This category also includes buses. Consequently, essentially all trucks larger than pickups are accounted for in this calculation.

F_{HAZ}: Reference 4 states that "between 5 percent and 15 percent of all trucks on the road at any given time carry hazardous materials." Table 35 of Reference 4 notes that 5.2% of all truck accidents involve hazardous shipments. Consequently, this calculation will assume that 5.2% of all truck traffic carries hazardous materials.

R_{ACC}: The fraction of trucking accidents involving hazardous materials that result in a release were obtained from Table 35 of Reference 4 which documents that for the period 1981 to 1985, a total of 15.2 percent of truck accidents involving hazardous materials resulted in a release.

R_{OI}: The fraction of hazardous materials releases that are severe enough to potentially result in control room operator incapacitation was determined as follows: Reference 4, page 95, states that for the period 1981 to 1985, 13,547 hazardous materials releases were reported to have occurred on U.S. highways. Of this total, 633 were considered to be "severe" which is defined by the U.S. Department of Transportation (Ref. 4, page 96) as releases that involve either (1) a fatality or injury caused by the release; (2) property damage of $50,000 or more caused by the release; or (3) a fire or explosion. For the purposes of this calculation, it is assumed that any release that does not meet the definition of "severe" stated above is not capable of incapacitating the control room operators. This assumption is supported by the fact that in order to incapacitate the operators, a release would have to travel at least one-half mile (the closest approach of a highway to the MNGP) and would necessarily incapacitate anyone in that one-half mile long path. It is doubtful that any release capable of in apacitating anyone up to one-half mile away would not meet the definition of "severe."

Consequently, the R_{OI} term is calculated as follows:

$$R_{OI} = (633)/(13,547) = 0.047$$

P_{OI}: The probability of experiencing core damage when operator incapacitation is assumed was determined previously [Ref. 6]. Its value was determined to be 0.158 per year. This probability accounts for all potential core

damage initiating events (e.g. LOCA, Main Steam Line Break, Control Rod Drop). Other accidents that have the potential for offsite releases that do not involve core damage are an offgas storage tank rupture and a fuel handling accident. The rupture of an offgas storage tank was evaluated previously [Ref. 14], and determined to fall well within 10 CFR 100 guidelines. A fuel handling accident concurrent with or resulting from operator incapacitation due to a toxic release is considered to be an extremely low probability event that does not require further consideration. Its extremely low probability is due to the small amount of time taken by fuel handling activities in a year, the low probability of operator incapacitation per year, and the low probability of significant offsite exposures given a fuel handling accident without operator intervention.

It should also be noted that the calculation performed in Reference 6 assumed that the operators did not initiate a plant transient (i.e. a reactor scram) prior to incapacitation. This assumption is consistent with operating procedures and operator training. The procedures for handling toxic gas releases [Ref. 15] do not direct the operators to scram the reactor. Consequently, the use of the 0.158 per year probability value obtained in Reference 6 is appropriate for this calculation.

For the purposes of this calculation, this probability value of 0.158 yr^{-1} is conservatively assumed to equal the probability of exceeding 10 CFR 100 guidelines. To be meaningful for this calculation, this value must be converted to a per shift basis since for the consideration of this term the release is assumed to have occurred, been transported to the control room intake, and incapacitated the operators. At this point, the probability of exceeding 10 CFR 100 guidelines during the shift that the operators are incapacitated must be determined. This calculation assumes a 12 hour operating shift and conservatively assumes that no outside intervention or assistance occurs for the remainder of the 12 hour shift following operator incapacitation. Since operator incapacitation has an equal probability of occurring anytime during the 12 hour shift, then the average amount of vulnerable time remaining in the shift following operator incapacitation is 6 hours.

In this case, the P_{OI} term is:

P_{OI} = (0.158/yr) X (12 hrs/shift) X (6 hrs/12 hrs/shift)/(8760 hrs/yr)

= $1.08X10^{-4}$ per shift

Checker's Note: using 8766 to account for leap years does not change results. D.A.

Consequently, the probability per year of exceeding 10 CFR 100 limits due to a trucking accident is:

Interstate 94 probability:

$P_{>100}$ = ($0.81X10^{-6}$ acc/mi) X (0.78 mi) X (3,325 trucks/day) X (365 day/yr) X (0.052 haz/truck) X (0.152 release/haz) X (0.047 OI/release) X ($1.08X10^{-4}$ 10CFR100/OI)

= $3.08X10^{-8}$ per year

Highway 10 probability:

$P_{>100}$ = ($1.27X10^{-6}$ acc/mi) X (0.54 mi) X (700 trucks/day) X (365 day/yr) X (0.052 haz/truck) X (0.152 release/haz) X (0.047 OI/release) X ($1.08X10^{-4}$ 10CFR100/OI)

= $7.03X10^{-9}$ per year

Total Probability = $3.08X10^{-8}$ per year + $7.03X10^{-9}$ per year

= $3.78X10^{-8}$ per year

8.0 Conclusion

The probability of a radioactive release from the MNGP in excess of 10 CFR 100 guidelines due to a trucking accident involving hazardous materials is less than 3.78×10^{-4} per year. This is well below the acceptance criterion of approximately 10^{-6} per year stated in Reference 1. Further, the actual probability is lower than the calculated value due to the numerous conservatisms used throughout the calculation. A further conservatism is the assumption that all "severe" releases will result in operator incapacitation. References 10, 11, and 12 demonstrated that operator incapacitation will not occur for a wide variety of hazardous materials released from rail accidents in quantities much larger than those transported by truck. Consequently, no actions are required to protect the control room operators at the MNGP from hazardous materials transported by truck.

Table 1

Wind Direction Frequencies and Equivalent Highway Miles

Highway	Wind Sector	Wind Frequency in Sector (%)	Highway Miles in Sector	Equivalent Miles in Sector
I-94	SE	6.4	3.8	0.24
	SSE	7.5	1.4	0.10
	S	9.1	0.4	0.04
	SSW	7.6	0.3	0.02
	SW	4.2	0.2	0.01
	WSW	3.9	0.3	0.01
	W	5.6	0.7	0.04
	WNW	7.0	4.5	0.32
				Total: 0.78 miles
Hwy 10	E	4.0	2.9	0.12
	ENE	3.7	1.1	0.04
	NE	4.4	0.9	0.04
	NNE	4.1	1.0	0.04
	N	5.0	1.7	0.09
	NNW	9.8	2.1	0.21
				Total: 0.54 miles

Note: Equivalent Miles are calculated as follows:

Equivalent Miles = (Wind Frequency in Sector) X (Highway Miles in Sector) ÷ 100

Figure 1

Wind Sectors of Concern
for Interstate 94

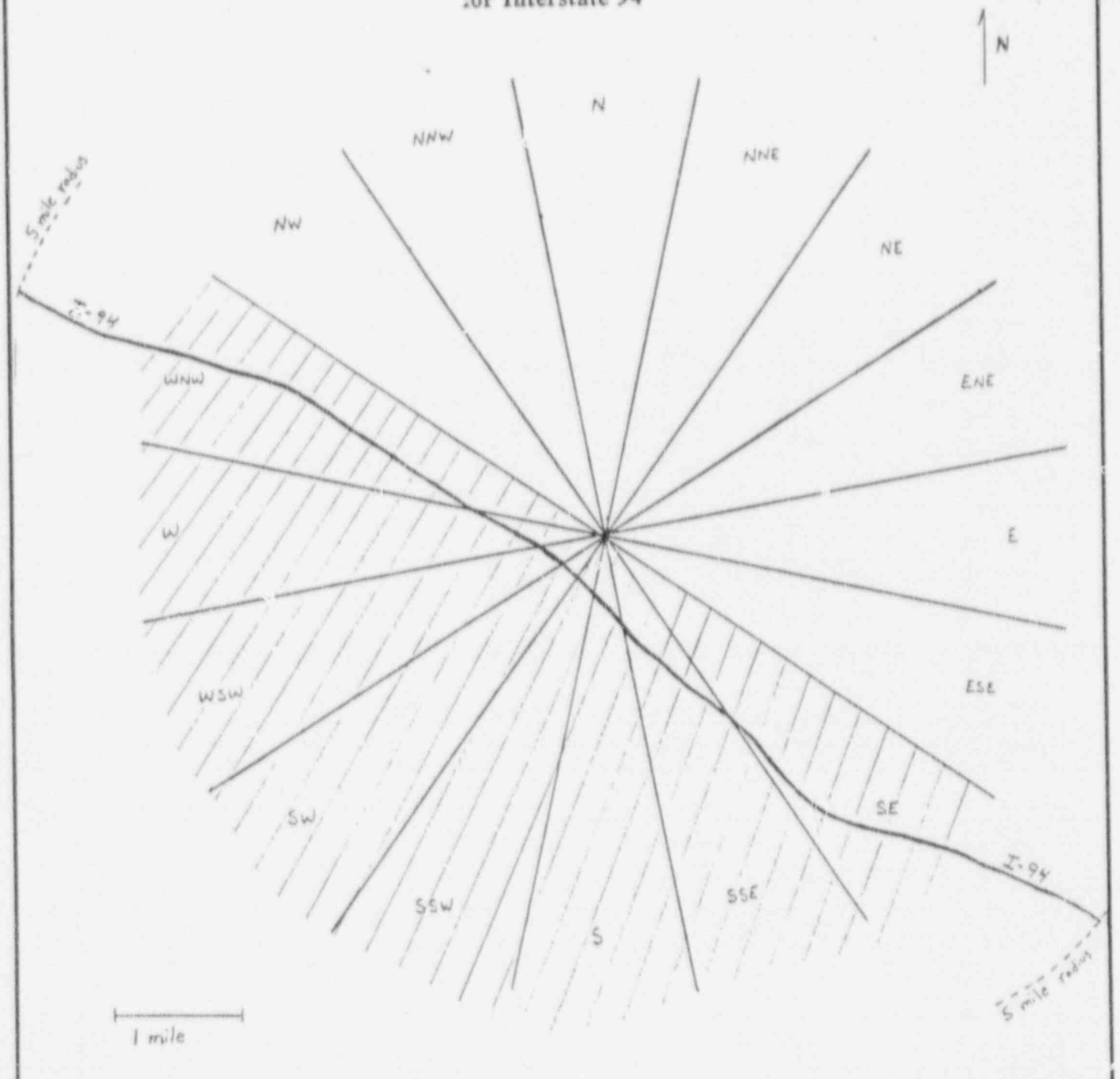

Figure 2

Wind Sectors of Concern
for Highway 10