APPENDIX 2C

VISIBLE PLUME MODEL DESCRIPTION

APPENDIX 2C

VISIBLE PLUME MODEL DESCRIPTION

The mathematical model used to predict the configuration and characteristics of the visible plumes resulting from the operation of natural-draft cooling towers is based on the work of L. N. Fan and G. Abraham[1,2]. The basic assumptions and mathematical formulations of turbulent, round, buoyant jets are adopted and applied to determine the configuration of a visible cooling tower plume. The method takes into account the entrainment of the cooler ambient air, momentum of the balanced system, and buoyant force and heat content of the plume.

The governing equations, basic assumptions, and a definitive sketch for the turbulent jet method are presented on Figure 2C-1.

The variables used in the equations on Figure 2C-1 are defined as follows:

d	=	Increment of distance along plume path, m
b	=	Radius of plume jet, m
U	=	Horizontal wind velocity, m/sec
V	=	Vertical velocity of plume, m/sec
θ	=	Angle of plume trajectory with respect to the horizontal direction, deg
$\propto_m$	=	Entrainment coefficient for a momentum jet-constant (dimensionless)
$\propto_t$	=	Entrainment coefficient for a thermal-constant (dimensionless)
C_d	=	Drag coefficient (dimensionless)
g	=	Acceleration of gravity, m/sec^2
ρa	=	Density of ambient air, g/m^3
ρ	=	Density of plume, g/m^3
X	=	Horizontal coordinate of the plume centerline from the center of the tower, m
Z	=	Vertical coordinate of the plume centerline from the top of the tower,

A further discussion of plume predictions with comparisons to observations based on photographs of emitted plumes from five natural-draft cooling tower sites under varying meteorological conditions has been published recently[3]. In comparison to seven other models tested in this independent verification study, the model described above ranked second in its height predictions and third in its length predictions, with the best absolute log mean ratio. Based upon these verifications, it is concluded that the overall configuration and size of cooling tower plumes are well simulated by the mathematical model used.

The turbulent jet method is based on the following assumptions:

1. Substitution of a mixing and entrainment mechanism for a dispersion mechanism.

2. Gaussian distribution for heat, mass density, and velocity profiles.

3. Conservation of mass and momentum within plume boundaries.

As shown on Figure 2C-1, a round, buoyant plume rises at a velocity, V, into ambient air with a velocity of U. The temperature and density of the plume at any given distance downwind, and the temperature and density of the ambient air, are represented by T, ρ, T_a, and ρa, respectively.

The trajectory of the plume is curved in the downwind direction due to the effects of a tower-induced low-pressure region. The angle between the axis of the plume and the horizontal is θ. The entrainment, or lateral mixing of the surrounding ambient air, is balanced by deceleration of the entire central portion of the plume. Since these portions cannot be sharply defined, a local characteristic length, b (linearly related to the standard deviation), is represented. The plume size is then calculated as $2\sqrt{2b}$. The entrainment coefficients used for continuity of mass and conservation of momentum are those recommended in Reference 2. The effect of the presence of the pressure field can be lumped into a gross drag term proportional to the square of the velocity component of the airflow normal to the plume axis. The drag coefficient (C_d) is assumed to be a constant. Buoyant forces can arise due to density differences, whether they are due to plume temperature or moisture content. The buoyancy of the cooling tower plume plays an important role in the analysis, since a large quantity of heat and moisture is rejected from the tower. The effects of aerodynamic downwash are not included in the model due to the large emission height of a natural-draft cooling tower which precludes downwashing of the plume.

Numerical analysis is used to solve the seven ordinary differential equations listed on Figure 2C-1. The parameters

defining the visible plume behavior (Figure 2C-1) are obtained from the solution of these equations.

Assuming a 100-percent heat load, the predicted natural-draft cooling tower performance curves are shown on Figures 2C-2 and 2C-3, which were used to develop Figures 2.3-1 through 2.3-25.

For given cooling tower operating conditions and specified meteorological conditions, the mathematical model calculates the size and configuration of the visible plume. The plume is visible as fog when the air in the plume is at or below its saturation temperature. Ambient air at 100-percent relative humidity is not included as a given meteorological input to the model because it is assumed that fog occurs naturally during this condition. Based on 3 yr (January 1, 1974 to December 31, 1976) of onsite meteorological data, 100-percent relative humidity occurred 4 percent of the time. The mathematical model described above is constructed to accept input meteorological parameters grouped into the classes presented in Table 2C-1.

Given the above information, the model calculates the visible plume spatial extent in terms of plume length, trajectory, and radius for each combination of variables. These data are summarized for all meteorological combinations on a grid, whose dimensions are 1,500 ft (vertical) by 5,000 ft (horizontal), showing the frequency of occurrences of visible plumes by hours and by percent of total time.

The frequency of visible plume occurrence was calculated using all combinations of meteorological conditions (except 100-percent relative humidity) for each of four wind directions, utilizing the performance curves shown on Figures 2C-2 and 2C-3 and based on a design wet-bulb temperature of 74°F.

REFERENCES

1. Fan, L. N. Turbulent Buoyant Jets into Stratified or Flowing Ambient Fluid. California Institute of Technology, Report No. KH-R-15, 1967.

2. Abraham, G. The Flow of Round Buoyant Jets Issuing Vertically into Ambient Fluid Flowing in a Horizontal Direction. Presented at the Fifth International Water Pollution Research Conference, July-August 1970.

3. Policastro, A. J., Carhart, R. A. and DeVantier, B. Validation of Selected Mathematical Models for Plume Dispersion from Natural Draft Cooling Towers. Presented at the Waste Heat Management and Utilization Conference, Miami, FL, May 9-11, 1977.

TABLE 2C-1

CLASSES OF METEOROLOGICAL PARAMETERS
USED AS INPUT TO THE MATHEMATICAL MODEL

Air Temperature (°F)	Relative Humidity (%)	Wind Speed (Knots)
-20 to -10	0 to 25	0 to 2
-9 to 0	26 to 40	3 to 7
1 to 10	41 to 50	8 to 12
11 to 20	51 to 60	13 to 17
21 to 30	61 to 70	18 to 22
31 to 40	71 to 75	23 to 27
41 to 50	76 to 80	28 to 32
51 to 60	81 to 85	≥32
61 to 70	86 to 90	
71 to 80	91 to 93	
81 to 90	94 to 96	
91 to 100	97 to 99	
>100		

APPENDIX 2D

SALT DRIED MODEL DESCRIPTION

APPENDIX 2D

SALT DRIFT MODEL DESCRIPTION

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APPENDIX 2D

SALT DRIFT MODEL DESCRIPTION

2D.1 INTRODUCTION

As the normal service and circulating water flows through the fill section of a cooling tower, the impact of the falling water on the splash bars creates small water droplets, some of which are carried away by the air stream moving through the tower. When these entrained droplets, called drift, leave the cooling tower, the exit velocity and buoyancy of the warm exit air provide the energy necessary to propel the drift particles aloft. The downward force on the particles is the force of gravity, and its effect depends on the mass of the particles. Some of the drift droplets exiting the tower are so small (<50 microns) that gravitational forces on them are negligible and atmospheric turbulence dominates their movement. Larger droplets are initially affected by gravity, but some evaporate sufficiently so that they also become affected entirely by atmospheric turbulence. Ambient temperature and moisture content determine the reduction of particle size due to evaporation, and the particle terminal velocity is governed by the particle size and the air viscosity.

As the plume disperses and cools, and the buoyancy in the plume is dissipated, evaporation of the droplets begins. A separation then takes place between the settleable drift particles, which eventually deposit dissolved salts (salt drift) and water (water drift) on the ground, and those particles which remain suspended. A mathematical model was developed to determine both salt and water drift deposition rates and to predict downwind suspended and airborne particulate concentration contributions from the cooling tower drift. A discussion of the mathematical theory employed and the assumptions made in the model is presented below.

2D.2 TOWER PERFORMANCE

The performance of a natural-draft cooling tower is entirely determined by ambient air relative humidity and wet-bulb temperature. The air draft through the tower is induced by the density difference between the air inside and the ambient air outside of the tower. Cooling tower performance criteria, defining the exit air volume and exit temperature for a given ambient wet-bulb temperature and relative humidity, are obtained from cooling tower manufacturers. The volume of exit air is proportional to relative humidity and inversely proportional to wet-bulb temperature. The temperature of the exit air is proportional to wet-bulb temperature and inversely proportional to relative humidity.

2D.3 DRIFT RATE AND DRIFT DROPLET CONCENTRATION

The airflow through the tower entrains droplets formed by mechanical breakdown of the cooling water splashing through the tower fill. Those droplets that pass through the drift eliminators exit the tower as drift and contain the same concentration of total dissolved solids as the circulating water and the blowdown. The total dissolved solids of the circulating water system consist of the ambient dissolved solids in the makeup water concentrated by evaporative cooling, plus small chemical additions for biofouling control and pH adjustment. The drift rate is expressed as a percentage of the total circulating waterflow and is obtained from the manufacturer.

2D.4 DROPLET SIZE DISTRIBUTION

The drift droplets cannot become buoyant particles unless they are entrained by an air draft velocity at least as great as the fall velocity. Since droplet fall velocity is a function of droplet size, the spectrum of droplet sizes leaving the tower is controlled by the airflow through the tower. Therefore, the range of droplet sizes exiting a natural-draft tower varies as the air flows through the tower, while the distribution of droplets leaving a mechanical-draft tower is constant.

The typical shape of the curve expressing the droplet size distribution spectrum above the drift eliminators of a natural-draft cooling tower from the Jersey Central Power and Light plant (Forked River) report has been used as guidance to formulate a basis for the Stone and Webster Engineering Corporation (SWEC) salt drift model[1]. The SWEC droplet size distribution for natural-draft towers is approximated by the six classes of droplet sizes shown on Figure 2D-1 (center panel). Each of these droplet classes is expressed as a percentage of the total drift mass, and the size distribution is a function of hourly ambient relative humidity and wet-bulb temperature. The range of diameters spanned by each of these classes is calculated as a fixed percentage of the maximum droplet diameter (D_{max}), which is calculated as the droplet size that has a settling velocity equal to the upward air velocity at the tower drift eliminators. Velocities increase beyond the drift eliminators and should be able to support the same droplet sizes. There is also evidence that there is no appreciable droplet growth by condensation or decay by mechanical breakdown to change the size distribution until the droplets fall out of the plume[2,3]. Thereafter, evaporation phenomena govern each droplet class.

A representative droplet size distribution for mechanical draft cooling towers with state-of-the-art drift eliminators was chosen from measurements taken at the Turkey Point facility[2]. This distribution is shown on Figure 2D-1 (upper panel) and is represented by 14 classes of droplet sizes.

These distributions for natural- and mechanical-draft cooling towers are used as representative distributions for conceptually designed towers where no tower-specific information is available from the manufacturer. Distributions supplied by the vendor for a specific drift eliminator design can also be utilized by the model when applicable.

2D.5 PLUME AND DROPLET RISE

The method for computing the plume rise from a cooling tower is based on a recent set of equations developed by Briggs[3]. Symbols used are defined as follows:

h_t = Cooling tower height, m

Δh = Plume rise, m

F = Buoyancy flux, m^4/sec^3

$\bar{u}$ = Average wind speed, m/sec

x = Downwind distance, m

S = Stability parameter, $sec.^{-2}$ = $\frac{g}{T}\frac{\partial\theta}{\partial z}$ T ∂z

g = Gravitational acceleration, m/sec^2

T = Average ambient air temperature, °C

$\partial\theta/\partial z$ = $\Delta T/\Delta z + \Gamma$ = Atmospheric vertical potential temperature gradient, °C/m

$\Delta T/\Delta z$ = Atmospheric vertical temperature gradient, °C/m

Γ = Dry adiabatic lapse rate, °C/m

$x^* = 34\ F_{0.4}$ = Distance at which atmospheric turbulence begins to dominate entrainment, m

For unstable or neutral atmospheric conditions:

$$\Delta h = 1.6\,F^{1/3}\,x^{2/3}\,\bar{u}^{-1} \qquad \text{for } x < 3.5x^*$$

$$\Delta h = 1.6\,F^{1/3}\,(3.5x^*)^{2/3}\,\bar{u}^{-1} \qquad \text{for } x \geq 3.5x^* \qquad (2D\text{-}1)$$

For stable atmospheric conditions:

$$\Delta h = 1.6\, F^{1/3}\, x^{2/3}\, \bar{u}^{-1} \qquad \text{for } x < \pi\, \bar{u}\, S^{-1/2}$$

$$\Delta h = 2.4\, F^{1/3}\, \bar{u}^{-1/3}\, S^{-1/3} \qquad \text{for } x \geq \pi\, \bar{u}\, S^{-1/2} \qquad (2D\text{-}2)$$

The height of the plume above the ground at any applicable downwind distance $\Delta h + h_t$.

For any calm wind condition near the ground, $\bar{u}$ is set equal to 1.0 m/sec (3.3 fps) (a value considered representative at the height at which the plume occurs) and the last valid preceding hourly wind direction is coupled with this 1.0 m/sec wind speed.

Some droplets within the plume are large enough so that they are unable to follow the centerline of the plume. The departure of these droplets from the plume s centerline as a function of downwind distance was estimated using the following equations[3]:

$$r = 0.5z + r_0 \qquad (2D\text{-}3)$$

$$s = V_d x / \bar{u} \qquad (2D\text{-}4)$$

Where:

r = Radius of plume, m

s = Droplet departure distance from plume centerline, m

x = Downwind distance, m

$\bar{u}$ = Average wind speed, m/sec

r_0 = Tower top radius, m

V_d = Fall velocity of droplet, m/sec

z = Rise of the plume centerline, m

The droplet trajectories within the plume are computed. As s becomes equal to r for specific large droplets, they leave the plume and begin to evaporate at that height and distance downwind. Droplets remaining within the plume to the downwind distance of the final plume rise are assumed to begin to evaporate at a height of $h_t + h - s$.

2D.6 DROPLET TRAJECTORY

Once the droplets leave the plume, their trajectory is determined by the ambient horizontal wind velocity and the droplet vertical fall velocity. In general, small droplets are transported farther from the tower by the wind than large droplets since they are carried higher by the cooling tower plume, and also because

their fall velocity is smaller than that for large droplets. Similarly, large droplets do not rise as high above the tower and fall closer to the tower than small droplets. Evaporation decreases the droplet size and the fall velocity. The slope of the droplet trajectory decreases until the equilibrium diameter is attained, or until the droplet can be treated as a suspended particulate (i.e., diameter ≤50 microns).

2D.7 DROPLET FALL VELOCITY

The drift droplet falls at a terminal fall velocity when the vertical drag force balances the gravitational force. This velocity is largely dependent upon the droplet size. The fall velocity for a droplet between 50 and 80 microns in diameter is computed according to Stokes Law[4]:

$$V = \frac{2r^2 g}{9}\ \frac{S_1 - S_2}{V} = \frac{0.22\ r^2 g\ S_1}{V} \qquad (2D\text{-}5)$$

Where:

V = Fall velocity, cm/sec

v = Dynamic viscosity of air, (poises)

g = Acceleration of gravity, cm/sec^2

S_1 = Droplet density, g/cm^3

S_2 = Ambient air density, g/cm^3

r = Droplet radius, cm

Since the ambient air density is much smaller than the water density, the S_1-S_2 term approaches S_1.

The dynamic viscosity is independent of atmospheric pressure for the range of pressures occurring near the plume. However, the dynamic viscosity is a function of temperature. The Sutherland equation describes viscosity as a function of absolute temperature[4]:

$$\frac{v}{v_o} = \left[\frac{T_o + C}{T + C}\right]\left(\frac{T}{T_o}\right)^{3/2} \qquad (2D\text{-}6)$$

Where:

v_0 = 1.8325 x 10^{-4} (poises) at T_0

T_0 = Representative temperature = 296.16 °K

T = Air temperature, °K

C = Sutherland's constant = 120.0°C = 393.16°K

The terminal velocity for a droplet larger than 80 microns in diameter is based on the empirical results for distilled water droplets in stagnant air[4]. Droplets less than 50 microns in diameter remain suspended.

2D.8 DROPLET EVAPORATION

The mass evaporation rate of freely falling water droplets is expressed as a product of two terms (Figure 2D-2)[4]:

$$\frac{dM}{dt} = \left[4\pi r \left(1 + \frac{Fr}{S} \right) \right] \left[K \left(\rho_a - \rho_b \right) \right] \qquad (2D\text{-}7)$$

Where:

M = Mass, g

t = Time, sec

π = 3.141592654

r = Radius of droplet, cm

S = Equivalent thickness of transition shell outside the droplet, cm

F = Dimensionless coefficient

K = Coefficient of diffusion, cm^2/sec

ρa = Saturated vapor density at the surface of the droplet, g/cm^3

ρa = Ambient vapor density, g/cm^3

The first term in Equation 2D-7 is a function of droplet diameter and ambient air temperature. Since the effect of the ambient air temperature is slight, the factor is expressed in terms of droplet diameter at a mean temperature of 15°C. The second term is a function of ambient air temperature and relative humidity. The evaporation is considered to be zero if the air temperature is below freezing or the relative humidity is above 98.6 percent[1].

The evaporation of saline droplets is limited by the hygroscopic properties of the solution[5]. As water evaporates from a droplet, the concentration of dissolved solids in the droplet

solution increases. For high ambient relative humidities, evaporation ceases when the droplet vapor pressure reaches equilibrium with the atmosphere. Intermediate relative humidity levels allow the droplet to evaporate to a saturated or even supersaturated solution. Under conditions of low humidity, evaporation occurs until supersaturation, when the solution changes phase and crystallizes into a dry particle. Figure 2D-3 depicts the equilibrium diameter as a function of the concentration of dissolved solids and the ambient relative humidity. The transition from droplet to dry particle occurs for relative humidities of less than 40 percent.

2D.9 DISPERSION OF DRIFT

Droplets larger than 50 microns in diameter are dispersed as described in Section 2D.6. In addition, these droplets are assumed to be uniformly dispersed laterally across the downwind sector of 22.5 deg. The drift mass is divided into droplet size classes, and the area of deposition for each size class is bounded by the deposition distances of the largest and smallest droplets contained in each class. The droplets of each class are assumed to be uniformly dispersed over the area of deposition.

Droplets equal to or smaller than 50 microns in diameter, whether emitted initially from the tower at that size or formed through evaporation of larger droplets, are considered to be suspended particulates and are consequently dispersed according to Gaussian principles.

The total ground-level suspended particulate concentration at any downwind distance is the sum of the contributions of each droplet size class whose diameters are 50 microns or less. The basis for using the 50-micron diameter size can be traced to the hivol sampler (the standard suspended particulate measurement instrument), which measures particles of approximately this size and smaller. Furthermore, Roffman and Van Vleck, in a salt drift deposition review treatise, refer to depositing drift as being >50 microns in diameter[5].

An additional parameter calculated by the model is airborne concentration. This concentration is the sum of the suspended particle concentration and the settleable particle concentration. Settleable particle concentration is calculated by dividing the deposition rate of a certain particle size class by the final fall velocity of the median droplet size in that class. The airborne concentration at each grid point is then the sum of the contributions of each depositing size class to that grid point.

The results of the drift model are produced at 76.2-m (250-ft.) intervals out to a distance of about 8 km (5 mi) from the tower in each of the 16 downwind directions. Monthly and annual drift deposition rates are calculated at each grid point.

2D.10 References

1. Jersey Central Power Light Company. Salt Water Cooling Tower Report. Forked River Nuclear Generating Station Unit 1, Environmental Report, Docket No. 50-363, Appendix B, Attachment 5, January 1972.

2. Schreoker, G. L; Webb R. 0.; Rutherford, D. A.; and Shotner, F. M. Drift Data Acquired on Mechanical Salt Water Cooling Devices. Prepared for the National Environmental Research Center, Report No. EPA-650/2-75-060, July 1975.

3. Briggs, G. A. Some Recent Analyses of Plume Rise Observations. Proceedings of the 2nd International Clean Air Congress, Editor, Englund, H. M. and Berry, W. T., Academic Press, NY, 1971.

4. List, R. J. Smithsonian Meteorological Tables, No. 5014. Smithsonian Institute, Washington, DC, 1966.

5. Roffman, A. and Van Vleck, D. L. The State of the Art of Measuring Cooling Tower Drift and Its Deposition. APCA Journal, Vol. 24, No. 9, September 1974.

APPENDIX 2E

DESCRIPTION OF RELATIVE HUMIDITY AUGMENTATION MODEL

APPENDIX 2E

DESCRIPTION OF RELATIVE HUMIDITY AUGMENTATION MODEL

The model is based on the Gaussian diffusion equation for calculating ground-level concentrations from an elevated buoyant source, which is:

$$\chi_v = \Delta\rho_w = \frac{C_\chi Q_v}{\pi\sigma_y\sigma_z\bar{u}} \exp\left[-\frac{1}{2}\left(\frac{h_{ct}+\Delta h-h_t}{\sigma_z}\right)^2\right]\left[\frac{x}{x+2.5D}\right] \quad (2E\text{-}1)$$

Where:

χ_v = Ground-level concentration of water vapor, g/m^3

Q_v = Emission rate of water vapor, g/sec

C_χ = Time-averaging correction factor = 0.7

σ_y = Horizontal diffusion coefficient, m

σ_z = Vertical diffusion coefficient, m

h_{ct} = Cooling tower height, m

Δh = Plume rise from cooling tower, m

h_t = Topographic height, m

$\bar{u}$ = Mean wind speed, m/sec

x = Downwind distance, m

D = Cooling tower exit diameter, m

$\Delta\rho_w$ = Increase in Water vapor density, g/m^3

The term

$$\frac{x}{x+2.5D}$$

geometrically accounts for initial dispersion from the area source of a cooling tower (virtual point correction to a volume source). The resultant increase in relative humidity can now be calculated from:

$$\Delta RH = \frac{\Delta \rho_w}{\rho_{ws}(T, T_w)} \qquad (2E\text{-}2)$$

Where:

RH = Relative humidity increase (percent)

ρ_{ws} = Saturation vapor density as a function of ambient temperature (T) and wet-bulb temperature (T_w)

Equation 2E-1 is applicable to short-term concentrations only. For greater time periods, the water vapor concentration is sector-averaged according to the expression:

$$\left(\Delta \rho_w\right)_i = \frac{2.032}{N} \sum_{j=i}^{N_{ii}} \frac{Q_V}{\sigma_z \bar{u} x} \exp\left[-\frac{1}{2}\left(\frac{h_{ct} + \Delta h + h_t}{\sigma_z}\right)^2\right] \qquad (2E\text{-}3)$$

The plume rise from the tower is calculated using Briggs' plume rise equations (Appendix 2D), and the dispersion coefficients σ_y and σ_z are obtained from Turner's curves[1]. The hourly emission rate of water vapor (Q_V) is based on evaporation performance curves obtained from the cooling tower manufacturers.

The input data to the model consist of tower-specific information obtained from the manufacturers and 1 year's onsite meteorological data. For each hour of meteorological data, the ground-level water vapor concentration due to cooling tower operation is calculated at specific downwind intervals from the tower. The resultant increase in relative humidity is then calculated according to Equation 2E-2, based on the ambient meteorological conditions for that hour. Annual, monthly, daily, and hourly relative humidity increases are calculated for each of the sixteen 22.5-deg sectors.

Reference

1. Turner, D. B. Workbook of Atmospheric Dispersion Estimates. Air Resources Field Research Office, Environmental Science Services Administration, 1969.

APPENDIX 2F

CONSERVATIVE AND REALISTIC SHORT TERM DIFFUSION ESTIMATES FOR HYPOTHETICAL RELEASES FROM THE UNIT 2 MAIN STACK, COMBINED RADWASTE AND REACTOR BUILDING VENT, AND THE MAIN STEAM TUNNEL BLOWOUT PANELS

APPENDIX 2F

CONSERVATIVE AND REALISTIC SHORT-TERM DIFFUSION ESTIMATES FOR HYPOTHETICAL RELEASES FROM THE UNIT 2 MAIN STACK, COMBINED RADWASTE AND REACTOR BUILDING VENT, AND THE MAIN STEAM TUNNEL BLOWOUT PANELS

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TABLE 2F-1

LOCATIONS AND DISTANCES ASSESSED
FOR A HYPOTHETICAL ACCIDENT

Sector Bearing	22 1/2-Deg Sector Distance		45-Deg Sector Distance	
	m	ft	m	ft
Distance to EAB - Main Stack				
E	1,555	5,100	1,555	5,100
ESE	1,600	5,250	1,555	5,100
SE	1,783	5,850	1,600	5,250
SSE	2,286	7,500	2,134	7,000
S	2,256	7,400	2,256	7,400
SSW	2,027	6,650	1,936	6,350
SW	1,615	5,300	1,615	5,300
WSW	1,615(2)	5,300(2)	1,615(2)	5,300(2)
WSW(1)	1,013(2)	3,325(2)	405(2)	1,330(2)
W(1)	187	615	117	385
WNW(1)	98	320	88	290
NW(1)	81	265	75	245
NNW(1)	75	245	75	245
N(1)	75	245	75	245
NNE(1)	75	245	75	245
NE(1)	91	300	81	265
ENE(1)	139	455	107	350
Distance to EAB - Combined Radwaste/Reactor Building Vent				
E	-	-	1,686	5,530
ESE	-	-	1,686	5,530
SE	-	-	1,743	5,720
SSE	-	-	2,094	6,870
S	-	-	1,945	6,380
SSW	-	-	1,695	5,560
SW	-	-	1,381	4,530
WSW	-	-	1,381(2)	4,530(2)
WSW(1)	988	3,240	747(2)	2,450(2)
W(1)	402	1,320	334	1,095
WNW(1)	293	960	256	840
NW(1)	227	745	201	660
NNW(1)	187	615	187	615
N(1)	192	630	187	615
NNE(1)	207	680	204	670

TABLE 2F-1 (Cont'd.)

Sector Bearing	22 1/2-Deg Sector Distance		45-Deg Sector Distance	
	m	ft	m	ft
Distance to EAB - Combined Radwaste/Reactor Building Vent				
NE[(1)] ENE[(1)]	285 419	935 1,375	241 334	790 1,095

Sector Bearing	Main Stack		Combined Radwaste/ Reactor Building Vent	
	m	ft	m	ft
Distance to Outer LPZ Boundary				
All	6,116	20,064	6,116	20,064

Population Distances for Both the Main Stack and the Combined Radwaste and Reactor Building Vent	
m	ft
1,000	3,281
3,000	9,843
5,000	16,404
7,000	22,966
9,000	29,528
15,000	49,213
30,000	98,425
50,000	164,042
70,000	229,659

TABLE 2F-1 (Cont'd.)

Emergency Planning Distances for the Main Stack	
M	ft
400	1,312
800	2,625
1,200	3,937
1,600	5,249
2,400	7,874
3,200	10,499
4,000	13,123
4,800	15,748
5,600	18,373
6,400	20,997
7,200	23,622
8,000	26,247

Note: Distances from the release point to the EAB are based on the shortest distance within each of the 16 sectors centered on the 16 cardinal compass directions.

(1) Emergency planning for the EAB considers both the land sectors and the coastline values for the lake sectors. However, in accordance with Figure 2.1-2, the EAB for the lake sectors is not at the coastline, but extends out into Lake Ontario. The Chapter 15 accident analysis addresses the EAB at the eight land sectors only.

TABLE 2F-1 (Cont'd.)

(2) The WSW sector is considered both a land and a coastline sector. The two values provided for the EAB distance reflect the nearest point on the EAB, within the land portion and on the coastline, within the sector. The land sector distance is greater than that for the coastline sector.

TABLE 2F-1a

CR AND TSC RELEASE POINT/INTAKE DISTANCES
USED TO DETERMINE ATMOSPHERIC DISPERSION COEFFICIENTS

Release/Intake	Horizontal Distance (ft)	Horizontal Distance (m)	Sector Bearing Relative to True North
NMP2 Releases to the NMP2 Control Room (CR)			
NMP2 Main Stack/NMP2 CR West-High	937	286	225°SW
NMP2 Main Stack/NMP2 CR West-Low	919	280	225°SW
NMP2 Main Stack/NMP2 CR East-High	843	257	202.5°SSW
NMP2 Main Stack/NMP2 CR East-Low	846	258	202.5°SSW
NMP2 RW/Rx Building Vent/NMP2 CR West-High	250.21	76.26	186.34°S
NMP2 RW/Rx Building Vent/NMP2 CR West-Low	218.91	66.72	188.39°S
NMP2 RW/Rx Building Vent/NMP2 CR East-High	210.86	64.27	161.63°SSE
NMP2 RW/Rx Building Vent/NMP2 CR East-Low	210.86	64.27	161.63°SSE
NMP2 Main Steam Tunnel/NMP2 CR West-High	240.72	73.37	182.23°S
NMP2 Main Steam Tunnel/NMP2 CR West-Low	208.88	63.67	183.75°S
NMP2 Main Steam Tunnel/NMP2 CR East-High	209.85	63.96	156.19°SSE
NMP2 Main Steam Tunnel/NMP2 CR East-Low	209.85	63.96	156.19°SSE

TABLE 2F-1a (Cont'd.)

Release/Intake	Horizontal Distance (ft)	Horizontal Distance (m)	Sector Bearing Relative to True North
NMP2 Releases to the NMP2 Control Room (CR) (Cont'd.)			
NMP2 SGT Building/NMP2 CR West-High	411.83	125.52	204.71°SSW
NMP2 SGT Building/NMP2 CR West-Low	384.85	117.30	207.29°SSW
NMP2 SGT Building/NMP2 CR East-High	334.79	102.04	193.49°SSW
NMP2 SGT Building/NMP2 CR East-Low	334.79	102.04	193.49°SSW
NMP2 PASS Panel/NMP2 CR West-High	423.74	129.15	176.13°S
NMP2 PASS Panel/NMP2 CR West-Low	391.42	119.31	176.44°S
NMP2 PASS Panel/NMP2 CR East-High	393.81	120.03	161.85°SSE
NMP2 PASS Panel/NMP2 CR East-Low	393.81	120.03	161.85°SSE
NMP2 Releases to the Technical Support Center (TSC)			
NMP2 Main Stack/TSC	1182	360.29	234.87°SW
NMP2 RW/Rx Building Vent/TSC	461.01	140.51	255.58°WSW
NMP2 Main Steam Tunnel/TSC	441.30	134.51	256.01°WSW
NMP2 SGT Building/TSC	637.97	194.45	247.88°WSW
NMP2 PASS Panel/TSC	485.55	148.00	233.49°SW

TABLE 2F-1b

RELEASE POINT/INTAKE ELEVATIONS USED TO DETERMINE CR/TSC ATMOSPHERIC DISPERSION COEFFICIENTS

Point of Interest	Elevation (ft)	Elevation (m)
NMP2 Main Stack	429	130.8
NMP2 Radwaste/Reactor Building Vent	187	57
NMP2 Main Steam Tunnel	45.08	13.7
NMP2 Standby Gas Treatment Building	23.5	7.2
NMP2 PASS Panel	82	25
NMP2 Control Room Intake West – High	36	11
NMP2 Control Room Intake West – Low	15.5	4.7
NMP2 Control Room Intake East – High	52.75	16.1
NMP2 Control Room Intake East – Low	19	5.8
Technical Support Center	21	6.4

TABLE 2F-2

CONSERVATIVE SHORT-TERM DIFFUSION ESTIMATES
0.5-PERCENT PROBABILITY LEVEL

<table>
<tr><th colspan="2">Release</th><th>0-2 Hour X/Q at the EAB[1,2]
(sec/m^3)</th></tr>
<tr><td colspan="2">Main stack
Ground level (radwaste/reactor building, SGT building, PASS panel, and main steam tunnel)</td><td>2.96E-05
1.19E-04</td></tr>
<tr><td colspan="3">X/Q at Outer LPZ Boundary[2]</td></tr>
<tr><th>Period</th><th>Main Stack
(sec/m^3)</th><th>Ground Level (Radwaste/Reactor Building, SGT Building, PASS Panel, and Main Steam Tunnel)
(sec/m^3)</th></tr>
<tr><td>0-8 hr</td><td>1.42E-05</td><td>1.62E-05</td></tr>
<tr><td>8-24 hr</td><td>5.41E-07</td><td>1.09E-05</td></tr>
<tr><td>1-4 days</td><td>2.31E-07</td><td>4.59E-06</td></tr>
<tr><td>4-30 days</td><td>7.65E-08</td><td>1.33E-06</td></tr>
</table>

TABLE 2F-2 (Cont'd.)

ARCON96 Results – X/Q Values for the NMP2 Control Room					
Release Point	X/Q Dispersion Coefficients (s/m^3)				
	0-2 Hr	2-8 Hr	8-24 Hr	1-4 Days	4-30 Days
West-Upper Intake					
NMP2 Main Stack	7.04E-05	3.95E-05	1.49E-05	9.96E-06	7.46E-06
NMP2 RW/Rx Building Vent	8.24E-04	6.29E-04	2.28E-04	1.56E-04	1.26E-04
NMP2 Main Steam Tunnel	1.13E-03	7.49E-04	2.76E-04	1.90E-04	1.49E-04
NMP2 SGT Building	3.62E-04	2.59E-04	9.48E-05	6.16E-05	4.42E-05
NMP2 PASS Panel	3.36E-04	2.00E-04	7.31E-05	5.53E-05	4.04E-05
East-Upper Intake					
NMP2 Main Stack	8.03E-05	4.48E-05	1.68E-05	1.20E-05	8.83E-06
NMP2 RW/Rx Building Vent	1.09E-03	7.23E-04	2.46E-04	1.92E-04	1.47E-04
NMP2 Main Steam Tunnel	1.47E-03	8.80E-04	3.32E-04	2.26E-04	1.68E-04
NMP2 SGT Building	5.31E-04	3.70E-04	1.35E-04	9.16E-05	6.70E-05
NMP2 PASS Panel	3.74E-04	2.05E-04	7.08E-05	5.41E-05	3.88E-05
West-Lower Intake					
NMP2 Main Stack	7.15E-05	4.01E-05	1.52E-05	1.01E-05	7.55E-06
NMP2 RW/Rx Building Vent	9.03E-04	6.93E-04	2.50E-04	1.71E-04	1.36E-04
NMP2 Main Steam Tunnel	1.46E-03	9.74E-04	3.63E-04	2.45E-04	1.90E-04
NMP2 SGT Building	4.05E-04	2.95E-04	1.08E-04	6.98E-05	5.00E-05
NMP2 PASS Panel	3.84E-04	2.28E-04	8.23E-05	6.28E-05	4.57E-05

TABLE 2F-2 (Cont'd.)

ARCON96 Results – X/Q Values for the NMP2 Control Room (Cont'd.)					
Release Point	X/Q Dispersion Coefficients (s/m^3)				
	0-2 Hr	2-8 Hr	8-24 Hr	1-4 Days	4-30 Days
East-Lower Intake					
NMP2 Main Stack	7.78E-05	4.31E-05	1.64E-05	1.16E-05	8.61E-06
NMP2 RW/Rx Building Vent	9.43E-04	6.34E-04	2.13E-04	1.67E-04	1.29E-04
NMP2 Main Steam Tunnel	1.46E-03	8.70E-04	3.32E-04	2.23E-04	1.68E-04
NMP2 SGT Building	5.33E-04	3.72E-04	1.36E-04	9.17E-05	6.72E-05
NMP2 PASS Panel	3.67E-04	2.01E-04	6.95E-05	5.32E-05	3.83E-05

ARCON96 Results – X/Q Values for the TSC					
Release Point	X/Q Dispersion Coefficients (s/m^3)				
	0-2 Hr	2-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NMP2 Main Stack	4.95E-05	2.69E-05	1.03E-05	6.67E-06	4.85E-06
NMP2 RW/Rx Building Vent	2.70E-04	1.64E-04	5.41E-05	3.86E-05	2.86E-05
NMP2 Main Steam Tunnel	3.27E-04	2.41E-04	8.38E-05	5.95E-05	4.76E-05
NMP2 SGT Building	1.62E-04	1.19E-04	4.28E-05	2.72E-05	2.24E-05
NMP2 PASS Panel	2.69E-04	1.91E-04	7.19E-05	4.22E-05	3.40E-05

(1) The site boundary, EAB, and RAB are the same for Unit 2.
(2) The highest of the downwind land sectors and the overall 5-percent X/Q values.

TABLE 2F-2a

CONSERVATIVE SHORT-TERM DIFFUSION ESTIMATES
0.5-PERCENT PROBABILITY LEVEL

Release – Main Stack

Sector[1] Bearing	Distance[2]		0-2 Hr X/Q at the Exclusion Area Boundary (EAB)[3] (sec/m^3)
	(m)	(ft)	
WSW[4,5]	405	1,330	9.33E-05
W[5]	117	385	2.86E-04
WNW[5]	88	290	3.30E-04
NW[5]	75	245	3.30E-04
NNW[5]	75	245	3.30E-04
N[5]	75	245	3.30E-04
NNE[5]	75	245	3.30E-04
NE[5]	81	265	3.30E-04
ENE[5]	107	350	3.11E-04
E	1,555	5,100	2.90E-05
ESE	1,555	5,100	2.97E-05
SE	1,600	5,250	2.97E-05
SSE	2,134	7,000	2.29E-05
S	2,256	7,400	2.24E-05
SSW	1,936	6,350	2.50E-05
SW	1,615	5,300	2.95E-05
WSW[4]	1,615	5,300	2.74E-05

(1) All 16 downwind sectors are assessed as 22 1/2-deg sectors using distances derived from 45-deg sector widths at the 0.5-percent probability level. The overall 5-percent probability level is not assessed at each of the EAB distances.

(2) Those sectors where the distance to the EAB is less than 100 m (328 ft) have been assessed at 100 m (328 ft).

(3) The site boundary, EAB, and RAB are the same for Unit 2.

(4) The WSW sector is considered both a downwind land and downwind coastline sector in determining distances to the EAB. Two separate distances and X/Qs are provided for this

TABLE 2F-2a (Cont’d.)

sector. When only land or only coastline sectors are being considered in an analysis, the corresponding distance and X/Q should be used. In an analysis considering all 16

sectors, the more conservative coastline X/Q value for the sector should be used.

(5) Emergency planning for the EAB considers both the land sectors and these coastline values for the lake sectors. However, in accordance with Figure 2.1-2, the EAB for the lake sectors is not at the coastline, but extends out into Lake Ontario. The Chapter 15 accident analyses address the EAB at the eight land sectors only.

TABLE 2F-2b

CONSERVATIVE SHORT-TERM DIFFUSION ESTIMATES
0.5-PERCENT PROBABILITY LEVEL

Release – Main Stack

Sector[1] Bearing	Distance[2] (m)	Distance[2] (ft)	0-2 Hr X/Q at the Exclusion Area Boundary (EAB)[3] (sec/m^3)
WSW[4]	1,013	3,325	4.08E-05
W[4]	187	615	1.87E-04
WNW[4]	98	320	3.30E-04
NW[4]	81	265	3.30E-04
NNW[4]	75	245	3.30E-04
N[4]	75	245	3.30E-04
NNE[4]	75	245	3.30E-04
NE[4]	91	300	3.30E-04
ENE[4]	139	455	2.46E-04

(1) Only the nine downwind coastline sectors are assessed as 22 1/2-deg sectors centered on the 22 1/2-deg cardinal compass directions derived from 22 1/2-deg sector widths at the 0.5-percent probability level. The overall 5-percent probability level is not assessed at each of the EAB coastline distances.

(2) Those sections where the distance to the EAB is less than 100 m (328 ft) have been assessed at 100 m (328 ft).

(3) The site boundary, EAB, and RAB are the same for Unit 2.

(4) Emergency planning for the EAB considers both the land sectors and these coastline values for the lake sectors. However, in accordance with Figure 2.1-2, the EAB for the lake sectors is not at the coastline, but extends out into Lake Ontario. The Chapter 15 accident analyses address the EAB at the eight land sectors only.

TABLE 2F-2c

CONSERVATIVE SHORT-TERM DIFFUSION ESTIMATES
0.5-PERCENT PROBABILITY LEVEL

Release – Combined Radwaste/Reactor Building Vent

Sector Bearing	Distance (m)	Distance (ft)	0-2 Hr X/Q at the Exclusion Area Boundary (EAB)[1] (sec/m^3)
WSW[2,3,5]	988	3,240	1.20E-04
W[3,5]	402	1,320	9.70E-04
WNW[3,5]	293	960	1.95E-03
NW[3,5]	227	745	3.00E-03
NNW[3,5]	187	615	4.60E-03
N[3,5]	192	630	3.30E-03
NNE[3,5]	207	680	1.45E-03
NE[3,5]	285	935	5.80E-04
ENE[3,5]	419	1,375	3.10E-04
E[4]	1,686	5,530	7.20E-05
ESE[4]	1,686	5,530	4.80E-05
SE[4]	1,743	5,720	4.80E-05
SSE[4]	2,094	6,870	2.80E-05
S[4]	1,945	6,380	9.30E-05
SSW[4]	1,695	5,560	4.70E-05
SW[4]	1,381	4,530	7.90E-05
WSW[4]	1,381	4,530	8.50E-05

(1) The site boundary, EAB, and RAB are the same for Unit 2.

(2) The WSW section is considered both a land and coastline sector in determining distances to the EAB. Two separate distances and X/Qs are provided for this sector. When only land or only coastline sectors are being considered in an analysis, the corresponding distance and X/Q should be used. In an analysis considering all 16 sectors, the more conservative coastline X/Q valve for the sector should be used.

TABLE 2F-2c (Cont'd.)

(3) Only the nine downwind coastline sectors are assessed as 22 1/2-deg sectors centered on the 22 1/2-deg cardinal compass directions derived from 22 1/2-deg sectors widths at the 0.5-percent probability level. The overall 5-percent

probability level is not assessed at each of the EAB coastline distances.

(4) Only the eight downwind land sectors are assessed as 22 1/2-deg sectors centered on the 22 1/2-deg cardinal compass directions using distances derived from 45-deg sector widths.

(5) Emergency planning for the EAB considers both the land sectors and these coastline values for the lake sectors. However, in accordance with Figure 2.1-2, the EAB for the lake sectors is not at the coastline, but extends out into Lake Ontario. The Chapter 15 accident analyses address the EAB at the eight land sectors only.

TABLE 2F-3

REALISTIC SHORT-TERM DIFFUSION ESTIMATES AT THE EAB
BY SECTOR FOR RELEASES FROM THE MAIN STACK*

Probability Level: 50 Percent

Sector Bearing	Distance		Accident X/Q Values (sec/m3)			
	m	ft	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
E	1,555	5,100	3.95E-08	3.59E-08	2.90E-08	2.14E-08
ESE	1,555	5,100	5.39E-08	4.73E-08	3.56E-08	2.37E-08
SE	1,600	5,250	8.44E-08	7.08E-08	4.83E-08	2.80E-08
SSE	2,134	7,000	9.54E-08	7.60E-08	4.65E-08	2.30E-08
S	2,256	7,400	1.16E-07	9.33E-08	5.80E-08	2.93E-08
SSW	1,936	6,350	7.29E-08	5.93E-08	3.79E-08	2.00E-08
SW	1,615	5,300	4.25E-08	3.58E-08	2.47E-08	1.44E-08
WSW	1,615	5,300	5.53E-09	5.10E-09	4.28E-09	3.33E-09

* Only the eight downwind land sectors are assessed as 22 1/2-deg sectors centered on the 22 1/2-deg cardinal compass directions using distances derived from 45-deg sector widths.

TABLE 2F-4

REALISTIC SHORT-TERM DIFFUSION ESTIMATES AT THE LPZ
BY SECTOR FOR RELEASES FROM THE MAIN STACK

Distance: 6,116 m (3.8 mi)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	1.44-07	1.07-07	5.62-08	2.23-08
NE	1.31-07	9.83-08	5.32-08	2.20-08
ENE	1.67-07	1.31-07	7.76-08	3.66-08
E	1.88-07	1.51-07	9.41-08	4.78-08
ESE	2.05-07	1.59-07	9.17-08	4.16-08
SE	3.08-07	2.35-07	1.30-07	5.58-08
SSE	3.39-07	2.51-07	1.30-07	5.08-08
S	4.32-07	3.21-07	1.69-07	6.73-08
SSW	3.79-07	2.76-07	1.40-07	5.24-08
SW	2.76-07	2.01-07	1.01-07	3.77-08
WSW	2.07-07	1.43-07	6.46-08	2.06-08
W	1.70-07	1.21-07	5.71-08	1.95-08
WNW	1.52-07	1.12-07	5.81-08	2.25-08
NW	1.41-07	1.11-07	6.54-08	3.07-08
NNW	1.26-07	9.79-08	5.63-08	2.55-08
N	1.48-07	1.16-07	6.83-08	3.20-08
Highest Overall	1.94-07	1.57-07	9.78-08	4.98-08

NOTE: 1. The highest overall 50-percent values represent the maximum concentration of the overall 50-percent values at the LPZ.
2. 1.44-07 = 1.44×10^{-7}.

TABLE 2F-5

THIS TABLE HAS BEEN DELETED

TABLE 2F-6

EMERGENCY PLANNING SHORT-TERM DIFFUSION ESTIMATES
MAIN STACK RELEASE

Distance: 400 m (1,312 ft)
Probability Level: 0.5 Percent

Sector Bearing	Accident X/Q (sec/m^3)	
	0-8 Hr	8-24 Hr
NNE	4.72-05*	3.35-09*
NE	4.72-05*	7.40-10*
ENE	4.72-05*	3.21-09*
E	4.83-05	6.68-08
ESE	4.74-05	2.58-07
SE	4.75-05	4.72-07
SSE	4.76-05	6.42-07
S	4.88-05	7.56-07
SSW	4.72-05	7.64-08
SW	4.72-05*	1.01-08*
WSW	4.83-05*	1.01-08*
W	4.83-05*	2.59-09*
WNW	4.72-05*	3.15-09*
NW	4.72-05*	8.64-09*
NNW	4.72-05*	1.11-08*
N	4.72-05*	8.13-09*
Overall 5 percent	4.35-07	3.43-07

TABLE 2F-6 (Cont'd.)

Distance: 800 m (2,625 ft)
Probability Level: 0.5 Percent

Sector Bearing	Accident X/Q (sec/m^3)	
	0-8 Hr	8-24 Hr
NNE	2.53-05*	2.22-09*
NE	2.53-05*	7.44-10*
ENE	2.53-05	1.04-07
E	2.60-05	2.29-07
ESE	2.60-05	2.40-07
SE	2.67-05	3.62-07
SSE	2.67-05	3.98-07
S	2.68-05	4.39-07
SSW	2.67-05	2.80-07
SW	2.65-05	2.69-08
WSW	2.58-05*	1.69-09*
W	2.58-05*	1.81-09*
WNW	2.53-05*	2.74-09*
NW	2.53-05	9.41-08
NNW	2.54-05	1.88-07
N	2.53-05	1.41-07
Overall 5 percent	4.28-07	3.17-07

TABLE 2F-6 (Cont'd.)

Distance: 1,200 m (3,937 ft)
Probability Level: 0.5 Percent

Sector Bearing	Accident X/Q (sec/m^3)	
	0-8 Hr	8-24 Hr
NNE	1.75-05	1.44-08
NE	1.75-05	1.08-08
ENE	1.76-05	1.74-07
E	1.86-05	3.10-07
ESE	1.86-05	2.86-07
SE	1.86-05	2.94-07
SSE	1.85-05	2.41-07
S	1.94-05	2.81-07
SSW	1.94-05	1.71-07
SW	1.84-05	8.50-08
WSW	1.79-05	8.67-09
W	1.79-05	8.72-09
WNW	1.75-05	1.03-08
NW	1.76-05	8.01-08
NNW	1.76-05	1.29-07
N	1.76-05	1.39-07
Overall 5 percent	3.65-07	2.64-07

TABLE 2F-6 (Cont'd.)

Distance: 1,600 m (5,249 ft)
Probability Level: 0.5 Percent

Sector Bearing	Accident X/Q (sec/m^3)	
	0-8 Hr	8-24 Hr
NNE	1.35-05	5.10-08
NE	1.35-05	4.55-08
ENE	1.36-05	1.95-07
E	1.44-05	3.04-07
ESE	1.47-05	2.90-07
SE	1.51-05	2.89-07
SSE	1.50-05	2.02-07
S	1.50-05	2.17-07
SSW	1.50-05	1.74-07
SW	1.42-05	1.27-07
WSW	1.38-05	3.36-08
W	1.38-05	3.66-08
WNW	1.35-05	6.66-08
NW	1.36-05	1.19-07
NNW	1.36-05	1.33-07
N	1.36-05	1.65-07
Overall 5 percent	3.67-07	2.67-07

TABLE 2F-6 (Cont'd.)

Distance: 2,400 m (7,874 ft)
Probability Level: 0.5 Percent

Sector Bearing	Accident X/Q (sec/m^3)	
	0-8 Hr	8-24 Hr
NNE	9.44-06	1.23-07
NE	9.43-06	1.14-07
ENE	9.50-06	2.23-07
E	1.03-05	3.80-07
ESE	1.03-05	3.41-07
SE	1.08-05	3.43-07
SSE	1.07-05	2.57-07
S	1.08-05	3.10-07
SSW	1.05-05	2.64-07
SW	9.96-05	2.25-07
WSW	9.89-06	1.18-07
W	9.68-06	1.16-07
WNW	9.46-06	1.49-07
NW	9.49-06	1.99-07
NNW	9.49-06	1.90-07
N	9.50-06	2.18-07
Overall 5 percent	4.58-07	3.39-07

TABLE 2F-6 (Cont'd.)

Distance: 3,200 m (10,499 ft)
Probability Level: 0.5 Percent

Sector Bearing	Accident X/Q (sec/m^3)	
	0-8 Hr	8-24 Hr
NNE	7.33-06	1.81-07
NE	7.32-06	1.72-07
ENE	7.40-06	2.85-07
E	8.29-06	4.92-07
ESE	8.48-06	4.62-07
SE	8.67-06	4.48-07
SSE	9.11-06	3.62-07
S	9.18-06	4.56-07
SSW	9.14-06	3.97-07
SW	8.41-06	3.52-07
WSW	7.88-06	1.81-07
W	7.52-06	1.65-07
WNW	7.35-06	2.07-07
NW	7.38-06	2.58-07
NNW	7.37-06	2.31-07
N	7.39-06	2.71-07
Overall 5 percent	6.36-07	4.63-07

TABLE 2F-6 (Cont'd.)

Distance: 4,000 m (13,123 ft)
Probability Level: 0.5 Percent

Sector Bearing	Accident X/Q (sec/m^3)	
	0-8 Hr	8-24 Hr
NNE	6.06-06	2.18-07
NE	6.05-06	2.05-07
ENE	6.13-06	3.25-07
E	6.88-06	5.46-07
ESE	6.97-06	4.56-07
SE	1.08-05	8.84-07
SSE	1.07-05	6.86-07
S	1.13-05	9.24-07
SSW	8.32-06	5.11-07
SW	6.91-06	3.52-07
WSW	6.50-06	2.05-07
W	6.20-06	2.03-07
WNW	6.07-06	2.29-07
NW	6.11-06	2.91-07
NNW	6.08-06	2.53-07
N	6.12-06	3.11-07
Overall 5 percent	9.14-07	6.52-07

TABLE 2F-6 (Cont'd.)

Distance: 4,800 m (15,748 ft)
Probability Level: 0.5 Percent

Sector Bearing	Accident X/Q (sec/m^3)	
	0-8 Hr	8-24 Hr
NNE	5.16-06	2.22-07
NE	5.16-06	2.26-07
ENE	5.24-06	3.37-07
E	5.86-06	5.12-07
ESE	6.14-06	4.78-07
SE	9.82-06	7.84-07
SSE	9.73-06	6.47-07
S	9.85-06	8.00-07
SSW	7.10-06	4.74-07
SW	5.91-06	3.49-07
WSW	5.51-06	2.18-07
W	5.26-06	2.16-07
WNW	5.22-06	2.45-07
NW	5.22-06	3.05-07
NNW	5.19-06	2.66-07
N	5.24-06	3.30-07
Overall 5 percent	8.95-07	6.32-07

TABLE 2F-6 (Cont'd.)

Distance: 5,600 m (18,373 ft)
Probability Level: 0.5 Percent

Sector Bearing	Accident X/Q (sec/m^3)	
	0-8 Hr	8-24 Hr
NNE	4.51-06	2.24-07
NE	4.51-06	2.21-07
ENE	4.58-06	3.22-07
E	5.14-06	5.01-07
ESE	5.50-06	4.18-07
SE	8.52-06	6.53-07
SSE	8.93-06	5.84-07
S	9.10-06	8.02-07
SSW	7.94-06	5.93-07
SW	5.82-06	4.31-07
WSW	4.84-06	2.24-07
W	4.61-06	2.12-07
WNW	4.52-06	2.33-07
NW	4.55-06	2.88-07
NNW	4.54-06	2.67-07
N	4.57-06	3.13-07
Overall 5 percent	9.10-07	6.30-07

TABLE 2F-6 (Cont'd.)

Distance: 6,400 m (20,997 ft)
Probability Level: 0.5 Percent

Sector Bearing	Accident X/Q (sec/m^3)	
	0-8 Hr	8-24 Hr
NNE	4.02-06	2.22-07
NE	4.01-06	2.19-07
ENE	4.08-06	3.16-07
E	4.58-06	4.62-07
ESE	4.89-06	4.06-07
SE	7.59-06	6.04-07
SSE	8.75-06	5.97-07
S	9.84-06	8.50-07
SSW	7.06-06	5.49-07
SW	5.15-06	3.97-07
WSW	4.29-06	2.03-07
W	4.10-06	2.05-07
WNW	4.02-06	2.25-07
NW	4.06-06	2.85-07
NNW	4.04-06	2.51-07
N	4.08-06	3.11-07
Overall 5 percent	8.99-07	6.19-07

TABLE 2F-6 (Cont'd.)

Distance: 7,200 m (23,622 ft)
Probability Level: 0.5 Percent

Sector Bearing	Accident X/Q (sec/m^3)	
	0-8 Hr	8-24 Hr
NNE	3.62-06	2.07-07
NE	3.63-06	2.16-07
ENE	3.67-06	2.90-07
E	4.14-06	4.52-07
ESE	4.83-06	4.56-07
SE	6.91-06	5.61-07
SSE	7.85-06	5.32-07
S	8.91-06	7.99-07
SSW	6.38-06	5.09-07
SW	5.33-06	4.51-07
WSW	3.88-06	2.02-07
W	3.69-06	1.93-07
WNW	3.63-06	2.12-07
NW	3.67-06	2.78-07
NNW	3.64-06	2.35-07
N	3.69-06	3.05-07
Overall 5 percent	8.82-07	6.01-07

TABLE 2F-6 (Cont'd.)

Distance: 8,000 m (26,247 ft)
Probability Level: 0.5 Percent

Sector Bearing	Accident X/Q (sec/m^3)	
	0-8 Hr	8-24 Hr
NNE	3.23-06	1.07-07
NE	3.30-06	2.02-07
ENE	3.35-06	2.77-07
E	3.77-06	4.16-07
ESE	4.40-06	4.20-07
SE	6.29-06	5.21-07
SSE	7.53-06	4.99-07
S	8.07-06	6.89-07
SSW	5.79-06	4.50-07
SW	4.83-06	3.95-07
WSW	3.54-06	2.02-07
W	3.36-06	1.83-07
WNW	3.29-06	1.90-07
NW	3.35-06	2.67-07
NNW	3.31-06	2.22-07
N	3.37-06	3.01-07
Overall 5 percent	5.42-07	3.06-07

* The 0 to 8 hr value is derived from the average of the annual and 0 to 2 hr fumigation X/Q values. The 8 to 24 hr value is conservatively assumed to be the annual X/Q value. These deviations from the suggested procedures in Regulatory Guide 1.145 are necessary since the annual accident X/Q value for these sectors is higher than the 0 to 2 hr non-fumigation value.

NOTE: 4.72-05 = 4.72 X 10^{-5}

TABLE 2F-7

REALISTIC SHORT-TERM DIFFUSION ESTIMATES
FOR RELEASES FROM THE MAIN STACK

Distance: 1,000 m (3,281 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	1.95E-09	1.95E-09	1.95E-09	1.95E-09
NE	9.00E-10	9.00E-10	9.00E-10	9.00E-10
ENE	5.79E-09	5.79E-09	5.79E-09	5.79E-09
E	1.25E-08	1.25E-08	1.25E-08	1.25E-08
ESE	1.26E-08	1.26E-08	1.26E-08	1.26E-08
SE	1.76E-08	1.74E-08	1.70E-08	1.64E-08
SSE	1.71E-08	1.66E-08	1.57E-08	1.44E-08
S	1.76E-08	1.74E-08	1.69E-08	1.64E-08
SSW	1.05E-08	1.05E-08	1.05E-08	1.05E-08
SW	6.97E-09	6.97E-09	6.97E-09	6.97E-09
WSW	2.03E-09	2.03E-09	2.03E-09	2.03E-09
W	1.66E-09	1.66E-09	1.66E-09	1.66E-09
WNW	2.67E-09	2.67E-09	2.67E-09	2.67E-09
NW	5.39E-09	5.39E-09	5.39E-09	5.39E-09
NNW	6.42E-09	6.42E-09	6.42E-09	6.42E-09
N	6.40E-09	6.40E-09	6.40E-09	6.40E-09

NOTE: All time frames are for some sectors conservatively assumed to be the annual average X/Q value. These deviations from the suggested procedures in Regulatory Guide 1.45 are necessary since the annual accident X/Q value for these sectors is higher than the 50-percent 0- to 2-hr value.

TABLE 2F-7 (Cont'd.)

Distance: 3,000 m (9,843 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	4.05-08	3.33-08	2.17-08	1.18-08
NE	4.12-08	3.38-08	2.21-08	1.20-08
ENE	1.13-07	9.16-08	5.85-08	3.08-08
E	1.56-07	1.28-07	8.41-08	4.59-08
ESE	1.84-07	1.47-07	9.00-08	4.45-08
SE	2.29-07	1.78-07	1.03-07	4.69-08
SSE	1.66-07	1.28-07	7.24-08	3.20-08
S	1.82-07	1.41-07	8.21-08	3.76-08
SSW	1.83-07	1.41-07	7.97-08	3.51-08
SW	1.59-07	1.22-07	6.89-08	3.02-08
WSW	9.06-08	6.81-08	3.68-08	1.52-08
W	4.79-08	3.80-08	2.30-08	1.12-08
WNW	6.36-08	5.07-08	3.10-08	1.53-08
NW	5.26-08	4.47-08	3.14-08	1.88-08
NNW	4.33-08	3.68-08	2.59-08	1.56-08
N	5.15-08	4.42-08	3.17-08	1.97-08

TABLE 2F-7 (Cont'd.)

Distance: 5,000 m (16,405 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	1.26-07	9.53-08	5.20-08	2.18-08
NE	1.22-07	9.28-08	5.14-08	2.20-08
ENE	1.64-07	1.30-07	7.88-07	3.84-08
E	2.19-07	1.76-07	1.09-07	5.51-08
ESE	2.21-07	1.73-07	1.02-07	4.76-08
SE	4.05-07	3.08-07	1.70-07	7.24-08
SSE	3.63-07	2.69-07	1.41-07	5.54-08
S	4.63-07	3.44-07	1.80-07	7.14-08
SSW	3.79-07	2.78-07	1.43-07	5.48-08
SW	2.19-07	1.62-07	8.45-08	3.31-08
WSW	1.98-07	1.39-07	6.45-08	2.15-08
W	1.55-07	1.12-07	5.48-08	1.97-08
WNW	1.50-07	1.12-07	5.88-08	2.35-08
NW	1.32-07	1.05-07	6.36-08	3.10-08
NNW	1.17-07	9.21-08	5.46-08	2.57-08
N	1.33-07	1.08-07	6.50-08	3.20-08

TABLE 2F-7 (Cont'd.)

Distance: 7,000 m (22,967 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	1.52-07	1.12-07	5.74-08	2.21-08
NE	1.39-07	1.03-07	5.47-08	2.18-08
ENE	1.54-07	1.21-07	7.19-08	3.39-08
E	1.90-07	1.51-07	9.18-08	4.50-08
ESE	2.19-07	1.69-07	9.57-08	4.24-08
SE	2.71-07	2.06-07	1.14-07	4.83-08
SSE	2.90-07	2.14-07	1.11-07	4.33-08
S	3.75-07	2.78-07	1.46-07	5.75-08
SSW	3.34-07	2.43-07	1.22-07	4.55-08
SW	2.67-07	1.95-07	9.84-08	3.70-08
WSW	1.88-07	1.31-07	5.91-08	1.90-08
W	1.81-07	1.27-07	5.83-08	1.91-08
WNW	1.55-07	1.13-07	5.75-08	2.17-08
NW	1.45-07	1.13-07	6.55-08	2.99-08
NNW	1.30-07	1.00-07	5.65-08	2.49-08
N	1.51-07	1.18-07	6.82-08	3.12-08

TABLE 2F-7 (Cont'd.)

Distance: 9,000 m (29,529 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	1.44-07	1.05-07	5.33-08	2.01-08
NE	1.36-07	1.00-07	5.18-08	2.01-08
ENE	1.45-07	1.13-07	6.54-08	2.99-08
E	1.63-07	1.28-07	7.71-08	3.71-08
ESE	1.66-07	1.28-07	7.29-08	3.24-08
SE	2.02-07	1.53-07	8.41-08	3.56-08
SSE	2.19-07	1.62-07	8.44-08	3.30-08
S	2.75-07	2.04-07	1.07-07	4.22-08
SSW	2.50-07	1.82-07	9.15-08	3.41-08
SW	2.95-07	2.12-07	1.04-07	3.72-08
WSW	1.83-07	1.25-07	5.50-08	1.69-08
W	1.52-07	1.07-07	4.94-08	1.63-08
WNW	1.38-07	1.00-07	5.05-08	1.88-08
NW	1.42-07	1.09-07	6.18-08	2.73-08
NNW	1.27-07	9.67-08	5.34-08	2.27-08
N	1.53-07	1.17-07	6.58-08	2.87-08

TABLE 2F-7 (Cont'd.)

Distance: 15,000 m (49,215 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	1.15-07	8.27-08	4.07-08	1.47-08
NE	1.02-07	7.47-08	3.80-08	1.44-08
ENE	1.01-07	7.82-08	4.46-08	1.99-08
E	1.06-07	8.38-08	5.03-08	2.41-08
ESE	1.27-07	9.90-08	5.75-08	2.64-08
SE	1.10-07	8.35-08	4.61-08	1.96-08
SSE	1.22-07	9.12-08	4.82-08	1.93-08
S	1.39-07	1.03-07	5.46-08	2.19-08
SSW	1.47-07	1.06-07	5.25-08	1.91-08
SW	1.64-07	1.18-07	5.69-08	2.01-08
WSW	1.25-07	8.54-08	3.71-08	1.12-08
W	1.11-07	7.74-08	3.52-08	1.14-08
WNW	1.08-07	7.72-08	3.74-08	1.32-08
NW	1.10-07	8.34-08	4.60-08	1.96-08
NNW	1.01-07	7.59-08	4.06-08	1.66-08
N	1.15-07	8.74-08	4.81-08	2.04-08

TABLE 2F-7 (Cont'd.)

Distance: 30,000 m (98,430 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	6.65-08	4.76-08	2.30-08	8.09-09
NE	9.95-08	7.20-08	3.57-08	1.30-08
ENE	9.58-08	7.65-08	4.70-08	2.34-08
E	6.70-08	5.48-08	3.55-08	1.90-08
ESE	5.40-08	4.31-08	2.63-08	1.30-08
SE	4.53-08	3.48-08	1.96-08	8.58-09
SSE	4.29-08	3.24-08	1.77-08	7.39-09
S	5.25-08	3.95-08	2.12-08	8.71-09
SSW	6.89-08	5.01-08	2.52-08	9.36-09
SW	8.57-08	6.08-08	2.89-08	9.93-09
WSW	7.98-08	5.31-08	2.20-08	6.20-09
W	6.99-08	4.77-08	2.08-08	6.34-09
WNW	5.60-08	4.00-08	1.92-08	6.71-09
NW	6.23-08	4.69-08	2.53-08	1.04-08
NNW	6.48-08	4.76-08	2.44-08	9.33-09
N	6.27-08	4.73-08	2.57-08	1.07-08

TABLE 2F-7 (Cont'd.)

Distance: 50,000 m (164,050 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	9.39-08	6.78-08	3.35-08	1.21-08
NE	9.25-08	6.82-08	3.53-08	1.37-08
ENE	4.62-08	3.69-08	2.28-08	1.14-08
E	3.22-08	2.64-08	1.72-09	9.23-09
ESE	2.45-08	1.97-08	1.22-09	6.17-09
SE	2.15-08	1.66-08	9.50-09	4.26-09
SSE	1.98-08	1.51-08	8.43-09	3.64-09
S	2.74-08	2.09-08	1.16-08	5.00-09
SSW	3.67-08	2.70-08	1.38-08	5.28-09
SW	4.98-08	3.65-08	1.86-08	7.02-09
WSW	7.37-08	4.85-08	1.96-08	5.32-09
W	4.49-08	3.04-08	1.30-08	3.86-09
WNW	3.67-08	2.58-08	1.21-08	4.03-08
NW	4.26-08	3.15-08	1.64-08	6.38-09
NNW	3.87-08	2.83-08	1.44-08	5.48-09
N	2.74-08	3.45-08	1.81-08	7.18-09

TABLE 2F-7 (Cont'd.)

Distance: 70,000 m (229,670 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	5.79-08	4.21-08	2.10-08	7.73-09
NE	5.46-08	4.05-08	2.13-08	8.41-09
ENE	2.89-08	2.31-08	1.43-08	7.14-09
E	2.07-08	1.69-08	1.09-08	5.83-09
ESE	1.60-08	1.28-08	7.87-09	3.92-09
SE	1.41-08	1.10-08	6.43-09	2.99-09
SSE	1.30-08	1.00-08	5.66-09	2.50-09
S	1.74-08	1.33-08	7.36-09	3.15-09
SSW	2.21-08	1.65-08	8.67-09	3.45-09
SW	3.11-08	2.28-08	1.16-08	4.41-09
WSW	6.21-08	4.14-08	1.71-08	4.83-09
W	3.12-08	2.11-08	9.08-09	2.70-09
WNW	2.85-08	2.00-08	9.26-09	3.06-09
NW	3.74-08	2.77-08	1.45-08	5.69-09
NNW	2.81-08	2.05-08	1.03-08	3.85-09
N	3.20-08	2.37-08	1.24-08	4.92-09

NOTE: 1.98-13 = 1.98x10-13

TABLE 2F-8

REALISTIC SHORT TERM DIFFUSION ESTIMATES AT THE EAB BY SECTOR FOR RELEASES FROM THE COMBINED RADWASTE AND REACTOR BUILDING VENT

Probability Level: 50 Percent

Sector Bearing	Distance		Accident X/Q Values (sec/m^3)			
	m	ft	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
E	1,686	5,530	6.60-06	5.37-06	3.42-06	1.79-06
ESE	1,686	5,530	5.25-06	4.17-06	2.54-06	1.24-06
SE	1,743	5,720	5.36-06	4.26-06	2.58-06	1.26-06
SSE	2,094	6,870	4.59-06	3.41-06	1.79-06	7.11-07
S	1,945	6,380	7.64-06	5.65-06	2.93-06	1.14-06
SSW	1,695	5,560	1.02-05	7.42-06	3.76-06	1.42-06
SW	1,381	4,530	2.04-05	1.52-05	7.98-06	3.16-06
WSW	1,381	4,530	2.19-05	1.58-05	7.76-06	2.80-06
Highest Overall	1,381	4,530	1.94-05	1.58-05	1.02-05	5.46-06

(1) Only the eight downwind land sectors are assessed as 22 1/2-deg sectors centered on the 22 1/2-deg cardinal compass directions using distances derived from 45-deg sector widths.

(2) The highest overall 50-percent values represent the maximum concentration of the overall 50-percent values at EAB distances.

(3) 6.60-06 = 6.60×10^{-6}.

TABLE 2F-9

REALISTIC SHORT TERM DIFFUSION ESTIMATES AT THE LPZ
BY SECTOR FOR RELEASES FROM THE COMBINED RADWASTE AND
REACTOR BUILDING VENT

Distance: 6,116 m (3.8 mi)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	2.75-06	2.00-06	1.00-06	3.70-07
NE	1.97-06	1.44-06	7.30-07	2.75-07
ENE	1.35-06	1.06-06	6.22-07	2.90-07
E	1.04-06	8.39-07	5.26-07	2.69-07
ESE	7.57-07	6.01-07	3.65-07	1.78-07
SE	7.63-07	6.09-07	3.73-07	1.84-07
SSE	9.37-07	6.95-07	3.64-07	1.44-07
S	1.55-06	1.13-06	5.72-07	2.15-07
SSW	1.66-06	1.20-06	5.89-07	2.12-07
SW	2.75-06	1.99-06	9.98-07	3.69-07
WSW	4.17-06	2.85-06	1.25-06	3.85-07
W	6.48-06	4.58-06	2.15-06	7.27-07
WNW	3.91-06	2.96-06	1.62-06	6.85-07
NW	3.45-06	2.71-06	1.60-06	7.52-07
NNW	4.45-06	3.36-06	1.83-06	7.65-07
N	3.43-06	2.66-06	1.53-06	6.93-07
Highest Overall	2.50-06	2.02-06	1.28-06	6.66-07

NOTE: 1. The highest overall 50-percent values represent the maximum concentration of the overall 50-percent values at the LPZ.

2. 2.75-06 = 2.75×10^{-6}.

TABLE 2F-10

THIS TABLE HAS BEEN DELETED

TABLE 2F-11

REALISTIC SHORT TERM DIFFUSION ESTIMATES FOR
RELEASES FROM COMBINED RADWASTE AND REACTOR BUILDING VENT

Distance: 1,000 m (3,281 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	2.94-05	2.19-05	1.16-05	4.64-06
NE	2.32-05	1.72-05	9.05-06	3.59-06
ENE	1.75-05	1.39-05	8.35-06	4.03-06
E	1.34-05	1.09-05	7.07-06	3.78-06
ESE	1.09-05	8.68-06	5.34-06	2.65-06
SE	1.10-05	8.83-06	5.49-06	2.78-06
SSE	1.29-05	9.65-06	5.15-06	2.09-06
S	2.02-05	1.50-05	7.79-06	3.04-06
SSW	2.20-05	1.61-05	8.17-06	3.09-06
SW	2.89-05	2.17-05	1.17-05	4.82-06
WSW	3.87-05	2.76-05	1.33-05	4.65-06
W	5.16-05	3.84-05	2.02-05	8.08-06
WNW	4.12-05	3.20-05	1.86-05	8.51-06
NW	3.58-05	2.89-05	1.81-05	9.29-06
NNW	4.38-05	3.42-05	2.00-05	9.21-06
N	3.71-05	2.95-05	1.78-05	8.66-06

TABLE 2F-11 (Cont'd.)

Distance: 3,000 m (9,843 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	7.00-06	5.13-06	2.62-06	9.99-07
NE	5.34-06	3.92-06	2.00-06	7.66-07
ENE	3.82-06	2.99-06	1.77-06	8.31-07
E	2.77-06	2.25-06	1.44-06	7.52-07
ESE	2.26-06	1.79-06	1.08-06	5.23-07
SE	2.33-06	1.85-06	1.12-06	5.49-07
SSE	2.56-06	1.91-06	1.01-06	4.07-07
S	3.94-06	2.91-06	1.51-06	5.91-07
SSW	4.89-06	3.52-06	1.73-06	6.25-07
SW	7.05-06	5.19-06	2.67-06	1.03-06
WSW	1.05-05	7.30-06	3.29-06	1.05-06
W	1.45-05	1.04-05	5.08-06	1.81-06
WNW	9.87-06	7.52-06	4.17-06	1.79-06
NW	9.24-06	7.25-06	4.29-06	2.01-06
NNW	1.00-05	7.68-06	4.33-06	1.90-06
N	8.56-06	6.69-06	3.92-06	1.82-06

TABLE 2F-11 (Cont'd.)

Distance: 5,000 m (16,404 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	3.55-06	2.59-06	1.30-06	4.83-07
NE	2.66-06	1.94-06	9.76-07	3.65-07
ENE	1.73-06	1.36-06	8.05-07	3.80-07
E	1.26-06	1.02-06	6.54-07	3.44-07
ESE	1.06-06	8.39-07	5.03-07	2.41-07
SE	1.02-06	8.12-07	4.97-07	2.45-07
SSE	1.17-06	8.74-07	4.64-07	1.87-07
S	2.03-06	1.49-06	7.53-07	2.84-07
SSW	2.27-06	1.64-06	7.99-07	2.86-07
SW	3.60-06	2.62-06	1.32-06	4.89-07
WSW	5.80-06	3.95-06	1.71-06	5.18-07
W	8.04-06	5.70-06	2.71-06	9.27-07
WNW	5.15-06	3.90-06	2.13-06	8.92-07
NW	4.44-06	3.49-06	2.06-06	9.73-07
NNW	5.71-06	4.32-06	2.35-06	9.84-07
N	4.55-06	3.52-06	2.02-06	9.08-07

TABLE 2F-11 (Cont'd.)

Distance: 7,000 m (22,966 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	2.23-06	1.63-06	8.18-07	3.05-07
NE	1.70-06	1.24-06	6.21-07	2.31-07
ENE	1.11-06	8.67-07	5.11-07	2.40-07
E	8.10-07	6.57-07	4.17-07	2.17-07
ESE	9.22-08	8.85-08	8.11-08	7.14-08
SE	6.30-07	5.02-07	3.07-07	1.52-07
SSE	7.26-07	5.42-07	2.88-07	1.16-07
S	1.24-06	9.07-07	4.62-07	1.76-07
SSW	1.44-06	1.03-06	5.03-07	1.79-07
SW	2.23-06	1.62-06	8.13-07	3.02-07
WSW	3.51-06	2.40-06	1.05-06	3.21-07
W	5.48-06	3.87-06	1.81-06	6.12-07
WNW	3.37-06	2.55-06	1.39-06	5.81-07
NW	2.90-06	2.27-06	1.34-06	6.32-07
NNW	3.67-06	2.78-06	1.52-06	6.39-07
N	2.93-06	2.27-06	1.30-06	5.85-07

TABLE 2F-11 (Cont'd.)

Distance: 9,000 m (29,528 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	1.59-06	1.16-06	5.83-07	2.17-07
NE	1.22-06	8.84-07	4.43-07	1.64-07
ENE	7.95-07	6.22-07	3.65-07	1.70-07
E	5.61-07	4.56-07	2.91-07	1.52-07
ESE	4.41-07	3.50-07	2.12-07	1.03-07
SE	4.44-07	3.54-07	2.16-07	1.07-07
SSE	5.27-07	3.93-07	2.07-07	8.28-08
S	9.07-07	6.62-07	3.35-07	1.26-07
SSW	9.39-07	6.78-07	3.35-07	1.21-07
SW	1.54-06	1.12-06	5.64-07	2.11-07
WSW	2.52-06	1.72-06	7.51-07	2.29-07
W	4.02-06	2.83-06	1.32-06	4.45-07
WNW	2.31-06	1.76-06	9.68-07	4.12-07
NW	2.14-06	1.68-06	9.87-07	4.60-07
NNW	2.59-06	1.97-06	1.08-06	4.59-07
N	2.10-06	1.62-06	9.31-07	4.19-07

TABLE 2F-11 (Cont'd.)

Distance: 15,000 m (49,213 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	8.39-07	6.08-07	3.02-07	1.11-07
NE	6.29-07	4.55-07	2.26-07	8.23-08
ENE	4.21-07	3.27-07	1.89-07	8.55-08
E	2.66-07	2.17-07	1.39-07	7.35-08
ESE	2.20-07	1.74-07	1.05-07	5.07-08
SE	2.21-07	1.76-07	1.07-07	5.22-08
SSE	2.51-07	1.88-07	9.96-08	4.02-08
S	4.39-07	3.21-07	1.63-07	6.14-08
SSW	4.41-07	3.19-07	1.59-07	5.80-08
SW	8.31-07	5.99-07	2.94-07	1.06-07
WSW	1.22-06	8.33-07	3.65-07	1.12-07
W	2.21-06	1.54-06	7.12-07	2.34-07
WNW	1.26-06	9.51-07	5.18-07	2.17-07
NW	1.10-06	8.63-07	5.07-07	2.36-07
NNW	1.42-06	1.08-06	5.84-07	2.43-07
N	1.08-06	8.33-07	4.77-07	2.14-07

TABLE 2F-11 (Cont'd.)

Distance: 30,000 m (98,425 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	3.60-07	2.58-07	1.25-07	4.44-08
NE	2.45-07	1.77-07	8.73-08	3.16-08
ENE	1.47-07	1.15-07	6.73-08	3.13-08
E	8.86-08	7.31-08	4.82-08	2.65-08
ESE	7.65-08	6.11-08	3.75-08	1.86-08
SE	6.61-08	5.38-08	3.43-08	1.80-08
SSE	9.04-08	6.79-08	3.65-08	1.50-08
S	1.57-07	1.16-07	5.95-08	2.29-08
SSW	1.80-07	1.29-07	6.31-08	2.24-08
SW	2.80-07	2.04-07	1.02-07	3.79-08
WSW	5.82-07	3.90-07	1.63-07	4.67-08
W	9.64-07	6.69-07	3.03-07	9.73-08
WNW	4.89-07	3.71-07	2.04-07	8.64-08
NW	4.57-07	3.56-07	2.08-07	9.61-08
NNW	6.19-07	4.64-07	2.49-07	1.01-07
N	4.50-07	3.46-07	1.96-07	8.67-08

TABLE 2F-11 (Cont'd.)

Distance: 50,000 m (164,042 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	1.67-07	1.20-07	5.93-08	2.15-08
NE	1.16-07	8.38-08	4.17-08	1.53-08
ENE	6.79-08	5.34-08	3.17-08	1.49-08
E	4.58-08	3.76-08	2.45-08	1.33-08
ESE	3.65-08	2.92-08	1.80-08	9.00-09
SE	3.57-08	2.87-08	1.80-08	9.16-09
SSE	4.08-08	3.10-08	1.70-08	7.17-09
S	7.16-08	5.31-08	2.78-08	1.10-08
SSW	9.38-08	7.19-08	4.03-08	1.75-08
SW	1.50-07	1.16-07	6.65-08	2.99-08
WSW	3.05-07	2.18-07	1.05-07	3.66-08
W	5.18-07	3.82-07	1.98-07	7.70-08
WNW	2.73-07	2.20-07	1.38-07	7.06-08
NW	2.59-07	2.14-07	1.41-07	7.76-08
NNW	3.73-07	2.94-07	1.76-07	8.38-08
N	2.52-07	2.06-07	1.32-07	6.97-08

TABLE 2F-11 (Cont'd.)

Distance: 70,000 m (229,659 ft)
Probability Level: 50 Percent

Sector Bearing	Accident X/Q Values (sec/m^3)			
	0-8 Hr	8-24 Hr	1-4 Days	4-30 Days
NNE	1.13-07	8.09-08	3.92-08	1.39-08
NE	7.77-08	5.59-08	2.74-08	9.82-09
ENE	4.15-08	3.27-08	1.95-08	9.24-09
E	2.78-08	2.29-08	1.50-08	8.21-09
ESE	2.30-08	1.84-08	1.13-08	5.65-09
SE	2.10-08	1.70-08	1.08-08	5.61-09
SSE	2.73-08	2.06-08	1.11-08	4.62-09
S	4.24-08	3.16-08	1.68-08	6.79-09
SSW	4.99-08	3.61-08	1.79-08	6.57-09
SW	8.01-08	5.85-08	2.96-08	1.11-08
WSW	1.68-07	1.13-07	4.80-08	1.40-08
W	3.13-07	2.18-07	9.86-08	3.17-08
WNW	1.61-07	1.22-07	6.71-08	2.83-08
NW	1.52-07	1.18-07	6.87-08	3.15-08
NNW	1.98-07	1.49-07	8.04-08	3.31-08
N	1.47-07	1.13-07	6.39-08	2.81-08

APPENDIX 2G

LONG TERM (ROUTINE) DIFFUSION ESTIMATES FOR THE MAIN STACK AND COMBINED RADWASTE AND REACTOR BUILDING VENT

APPENDIX 2G

LONG-TERM (ROUTINE) DIFFUSION ESTIMATES FOR THE MAIN STACK AND COMBINED RADWASTE AND REACTOR BUILDING VENT

LIST OF TABLES

TABLE 2G-1

POPULATION DISTANCES IN EACH 22.5-DEGREE SECTOR
FOR X/Q AND D/Q CALCULATIONS

Distance	
km	mi
1.0	0.6
3.0	1.9
5.0	3.1
7.0	4.4
9.0	5.6
15.0	9.3
30.0	18.7
50.0	31.1
70.0	43.6

Note: Distances in Appendix 2G tables are measured from the stated release point.

TABLE 2G-2

MAIN STACK X/Q AT GROUND LEVEL LONG TERM (ROUTINE) GASEOUS RELEASES
ANNUAL AVERAGE X/Q BY SECTOR POPULATION DISTANCES

(s/m^3)

WIND DIRECTION BEARING	SSW 22.5	SW 45.0	WSW 67.5	W 90.0	WNW 112.5	NW 135.0	NNW 157.5	N 180.0
DISTANCE METERS								
1000.00	1.306E-09	5.268E-10	3.779E-09	8.044E-09	8.122E-09	1.182E-08	1.015E-08	1.160E-08
3000.00	2.470E-09	2.526E-09	7.566E-09	1.215E-08	1.076E-08	1.028E-08	6.436E-09	7.736E-09
5000.00	4.155E-09	4.371E-09	1.012E-08	1.550E-08	1.248E-08	1.759E-08	1.118E-08	1.441E-08
7000.00	4.233E-09	4.428E-09	9.339E-09	1.323E-08	1.128E-08	1.248E-08	9.281E-09	1.244E-08
9000.00	4.014E-09	4.177E-09	8.307E-09	1.122E-08	9.080E-09	9.481E-09	7.390E-09	9.507E-09
15000.00	3.133E-09	3.237E-09	5.825E-09	7.878E-09	7.700E-09	5.448E-09	4.664E-09	5.331E-09
30000.00	1.820E-09	2.861E-09	9.948E-09	8.867E-09	5.194E-09	2.499E-09	2.007E-09	2.339E-09
50000.00	2.666E-09	4.285E-09	4.885E-09	4.325E-09	2.675E-09	1.310E-09	1.068E-09	1.757E-09
70000.00	1.795E-09	2.705E-09	3.062E-09	2.701E-09	1.672E-09	1.167E.09	9.197E-10	1.119E-09

WIND DIRECTION BEARING	NNE 202.5	NE 225.0	ENE 247.5	E 270.0	ESE 292.5	SE 315.0	SSE 337.5	S 360.0
DISTANCE METERS								
1000.00	7.337E-09	4.546E-09	9.800E-10	8.727E-10	1.635E-09	3.835E-09	4.707E-09	4.493E-09
3000.00	6.547E-09	5.355E-09	1.911E-09	1.664E-09	3.010E-09	4.893E-09	4.303E-09	5.416E-09
5000.00	1.062E-08	6.185E-09	2.724E-09	2.699E-09	4.448E-09	7.466E-09	5.964E-09	7.823E-09
7000.00	9.414E-09	7.384E-09	2.642E-09	2.733E-09	4.279E-09	7.412E-09	5.850E-09	7.681E-09
9000.00	7.436E-09	7.494E-09	2.435E-09	2.578E-09	3.901E-09	6.925E-09	5.461E-09	7.146E-09
15000.00	4.342E-09	4.517E-09	1.817E-09	1.989E-09	2.838E-09	5.258E-09	4.174E-09	5.409E-09
30000.00	2.215E-09	2.133E-09	1.018E-09	1.145E-09	1.534E-09	2.945E-09	2.379E-09	3.042E-09
50000.00	1.350E-09	1.796E-09	8.177E-10	6.997E-10	9.006E-10	1.748E-09	1.433E-09	1.972E-09
70000.00	1.065E-09	1.162E-09	7.775E-10	4.950E-10	6.678E-10	1.553E-09	9.986E-10	1.358E-09

TABLE 2G-3

COMBINED RADWASTE AND REACTOR BUILDING VENT X/Q AT GROUND LEVEL
LONG TERM ROUTINE GASEOUS RELEASES ANNUAL AVERAGE X/Q BY SECTOR POPULATION DISTANCES

(s/m^3)

WIND DIRECTION BEARING	SSW 22.5	SW 45.0	WSW 67.5	W 90.0	WNW 112.5	NW 135.0	NNW 157.5	N 180.0
DISTANCE METERS								
1000.00	1.055E-07	1.272E-07	2.488E-07	2.867E-07	1.798E-07	1.270E-07	6.843E-08	8.069E-08
3000.00	3.696E-08	4.196E-08	7.871E-08	9.175E-08	6.149E-08	4.800E-08	2.892E-08	3.518E-08
5000.00	2.689E-08	2.892E-08	4.964E-08	5.913E-08	3.951E-08	4.538E-08	3.223E-08	4.273E-08
7000.00	2.020E-08	2.140E-08	3.516E-08	4.059E-08	2.906E-08	2.913E-08	2.349E-08	3.151E-08
9000.00	1.602E-08	1.685E-08	2.685E-08	3.035E-08	2.136E-08	2.094E-08	1.741E-08	2.251E-08
15000.00	9.608E-09	1.005E-08	1.510E-08	1.767E-08	1.692E-08	1.123E-08	9.451E-09	1.131E-08
30000.00	4.557E-09	8.021E-09	1.304E-08	1.164E-08	7.128E-09	4.688E-09	3.670E-09	4.417E-09
50000.00	5.326E-09	5.591E-09	6.412E-09	5.681E-09	3.490E-09	2.324E-09	1.828E-09	2.280E-09
70000.00	3.372E-09	3.533E-09	4.020E-09	3.546E-09	2.182E-09	1.510E-09	1.180E-09	1.436E-09

WIND DIRECTION BEARING	NNE 202.5	NE 225.0	ENE 247.5	E 270.0	ESE 292.5	SE 315.0	SSE 337.5	S 360.0
DISTANCE METERS								
1000.00	8.599E-08	7.612E-08	2.754E-08	3.708E-08	8.572E-08	2.074E-07	1.814E-07	2.163E-07
3000.00	3.809E-08	3.505E-08	1.442E-08	1.597E-08	3.137E-08	6.864E-08	5.712E-08	7.093E-08
5000.00	3.371E-08	2.351E-08	1.188E-08	1.311E-08	2.215E-08	4.617E-08	3.817E-08	4.821E-08
7000.00	2.527E-08	2.165E-08	9.250E-09	1.030E-08	1.635E-08	3.357E-08	2.782E-08	3.525E-08
9000.00	1.842E-08	1.997E-08	7.516E-09	8.423E-09	1.281E-08	2.603E-08	2.165E-08	2.747E-08
15000.00	9.601E-09	1.068E-08	4.714E-09	5.348E-09	7.505E-09	1.496E-08	1.257E-08	1.598E-08
30000.00	4.377E-09	4.598E-09	2.346E-09	2.708E-09	3.465E-09	6.674E-09	5.718E-09	7.300E-09
50000.00	2.278E-09	2.841E-09	2.024E-09	1.598E-09	1.930E-09	3.594E-09	3.133E-09	4.439E-09
70000.00	1.441E-09	1.783E-09	1.636E-09	1.120E-09	1.461E-09	3.084E-09	2.096E-09	2.965E-09

TABLE 2G-4

MAIN STACK D/Q AT GROUND LEVEL LONG TERM GASEOUS RELEASES
ANNUAL AVERAGE D/Q BY SECTOR POPULATION DISTANCES

($1/m^2$)

WIND DIRECTION BEARING	SSW 22.5	SW 45.0	WSW 67.5	W 90.0	WNW 112.5	NW 135.0	NNW 157.5	N 180.0
DISTANCE METERS								
1000.00	2.369E-10	2.220E-10	1.025E-09	1.752E-09	1.790E-09	1.887E-09	1.276E-09	1.300E-09
3000.00	1.533E-10	1.892E-10	6.002E-10	8.493E-10	6.829E-10	6.083E-10	3.525E-10	3.795E-10
5000.00	8.793E-11	1.110E-10	3.407E-10	4.711E-10	3.650E-10	3.597E-10	1.941E-10	2.181E-10
7000.00	5.149E-11	6.510E-11	1.994E-10	2.754E-10	2.130E-10	2.049E-10	1.135E-10	1.262E-10
9000.00	3.453E-11	4.369E-11	1.337E-10	1.844E-10	1.424E-10	1.346E-10	7.447E-11	8.267E-11
15000.00	1.534E-11	1.936E-11	5.944E-11	8.223E-11	6.616E-11	5.666E-11	3.144E-11	3.445E-11
30000.00	4.962E-12	6.199E-12	4.106E-11	4.498E-11	3.173E-11	1.849E-11	1.056E-11	1.143E-11
50000.00	2.471E-12	9.219E-12	1.620E-11	1.775E-11	1.207E-11	8.384E-12	4.915E-12	6.811E-12
70000.00	1.981E-12	4.997E-12	8.783E-12	9.622E-12	6.534E-12	5.201E-12	3.132E-12	3.606E-12

WIND DIRECTION BEARING	NNE 202.5	NE 225.0	ENE 247.5	E 270.0	ESE 292.5	SE 315.0	SSE 337.5	S 360.0
DISTANCE METERS								
1000.00	7.791E-10	5.219E-10	1.280E-10	1.255E-10	3.057E-10	6.171E-10	7.184E-10	7.176E-10
3000.00	2.815E-10	2.342E-10	7.704E-11	8.289E-11	1.902E-10	3.270E-10	2.887E-10	3.422E-10
5000.00	1.489E-10	1.285E-10	4.386E-11	4.763E-11	1.087E-10	1.835E-10	1.557E-10	1.894E-10
7000.00	9.003E-11	7.510E-11	2.567E-11	2.789E-11	6.363E-11	1.073E-10	9.090E-11	1.107E-10
9000.00	5.987E-11	5.028E-11	1.721E-11	1.871E-11	4.266E-11	7.190E-11	6.081E-11	7.413E-11
15000.00	2.625E-11	2.244E-11	7.652E-12	8.308E-12	1.896E-11	3.202E-11	2.720E-11	3.306E-11
30000.00	8.664E-12	7.408E-12	2.484E-12	2.686E-12	6.144E-12	1.046E-11	9.049E-12	1.087E-11
50000.00	4.444E-12	7.630E-12	1.117E-12	1.198E-12	2.755E-12	4.760E-12	4.250E-12	5.001E-12
70000.00	3.893E-12	4.055E-12	8.629E-13	6.905E-13	1.589E-12	2.752E-12	2.471E-12	2.897E-12

TABLE 2G-5

COMBINED RADWASTE AND REACTOR BUILDING VENT D/Q AT GROUND LEVEL
LONG TERM ROUTINE GASEOUS RELEASES ANNUAL AVERAGE D/Q BY SECTOR POPULATION DISTANCES

($1/m^2$)

WIND DIRECTION BEARING	SSW 22.5	SW 45.0	WSW 67.5	W 90.0	WNW 112.5	NW 135.0	NNW 157.5	N 180.0
DISTANCE METERS								
1000.00	1.021E-09	1.609E-09	4.897E-09	6.977E-09	5.302E-09	4.461E-09	2.471E-09	2.559E-09
3000.00	2.579E-10	3.640E-10	1.046E-09	1.492E-09	1.106E-09	9.200E-10	5.026E-10	5.425E-10
5000.00	1.274E-10	1.732E-10	4.876E-10	6.700E-10	5.037E-10	4.214E-10	2.309E-10	2.767E-10
7000.00	7.308E-11	9.863E-11	2.770E-10	3.780E-10	2.836E-10	2.146E-10	1.635E-10	1.902E-10
9000.00	4.827E-11	6.479E-11	1.816E-10	2.466E-10	1.852E-10	1.637E-10	1.090E-10	1.250E-10
15000.00	2.071E-11	2.727E-11	7.630E-11	1.022E-10	9.854E-11	7.619E-11	4.751E-11	5.351E-11
30000.00	6.544E-12	3.397E-11	4.103E-11	4.493E-11	3.051E-11	2.422E-11	1.491E-11	1.744E-11
50000.00	8.392E-12	9.213E-12	1.620E-11	1.775E-11	1.205E-11	9.721E-12	5.965E-12	6.664E-12
70000.00	4.548E-12	4.997E-12	8.783E-12	9.622E-12	6.536E-12	5.200E-12	3.132E-12	3.608E-12

WIND DIRECTION BEARING	NNE 202.5	NE 225.0	ENE 247.5	E 270.0	ESE 292.5	SE 315.0	SSE 337.5	S 360.0
DISTANCE METERS								
1000.00	2.096E-09	1.677E-09	3.896E-10	3.803E-10	1.115E-09	2.902E-09	2.640E-09	2.640E-09
3000.00	4.570E-10	3.726E-10	1.104E-10	1.156E-10	2.935E-10	6.275E-10	5.428E-10	5.964E-10
5000.00	2.095E-10	1.728E-10	5.472E-11	5.986E-11	1.455E-10	2.954E-10	2.513E-10	2.849E-10
7000.00	1.317E-10	1.032E-10	3.136E-11	3.457E-11	8.345E-11	1.683E-10	1.430E-10	1.628E-10
9000.00	9.559E-11	8.763E-11	2.070E-11	2.295E-11	5.512E-11	1.106E-10	9.393E-11	1.073E-10
15000.00	4.899E-11	4.769E-11	8.775E-12	9.975E-12	2.359E-11	4,896E-11	4.002E-11	4.591E-11
30000.00	1.634E-11	1.977E-11	2.772E-12	3.185E-12	7.453E-12	1.481E-11	1.277E-11	1.460E-11
50000.00	6.239E-12	6.044E-12	3.715E-12	1.451E-12	3.259E-12	6.519E-12	5.750E-12	6.804E-12
70000.00	3.364E-12	3.314E-12	1.836E-12	9.259E-13	2.248E-12	9.957E-12	3.522E-12	4.679E-12

TABLE 2G-6

DISTANCE TO EAB, RAB, AND SITE BOUNDARY[1]

Sector Bearing	Distance From[2]							
	Main Stack				Combined Radwaste/ Reactor Building Vent			
	22 1/2° Sector		45° Sector		22 1/2° Sector		45° Sector	
	m	ft	m	ft	m	ft	m	ft
E	1,555	5,100	1,555	5,100	-	-	1,686	5,530
ESE	1,600	5,250	1,555	5,100	-	-	1,686	5,530
SE	1,783	5,850	1,600	5,250	-	-	1,743	5,720
SSE	2,286	7,500	2,134	7,000	-	-	2,094	6,870
S	2,256	7,400	2,256	7,400	-	-	1,945	6,380
SSW	2,027	6,650	1,936	6,350	-	-	1,695	5,560
SW	1,615	5,300	1,615	5,300	-	-	1,381	4,530
WSW[3]	1,615	5,300	1,615	5,300	-	-	1,381	4,530
WSW[3,4]	1,013	3,325	405	1,330	988	3,240	747	2,450
W[4]	187	615	117	385	402	1,320	334	1,095
WNW[4]	98	320	88	290	293	960	256	840
NW[4]	81	265	75	245	227	745	201	660
NNW[4]	75	245	75	245	187	615	187	615
N[4]	75	245	75	245	192	630	187	615
NNE[4]	75	245	75	245	207	680	204	670
NE[4]	91	300	81	265	285	935	241	790
ENE[4]	139	455	107	350	419	1,375	334	1,095

(1) For Unit 2, the exclusion area boundary (EAB), restricted area boundary (RAB), and site boundary are the same.

(2) Distances from the release point to the EAB are based on the shortest distance within each of the 16 sectors centered on the 22 1/2-deg cardinal compass directions.

(3) The WSW sector is considered both a land and a coastline sector. The two distances provided for the EAB location reflect the nearest point on the EAB, within the land portion and on the coastline, within the sector. The land sector distance is greater than that for the coastline sector.

TABLE 2G-6 (Cont'd)

(4) Emergency planning for the EAB considers both the land sectors and these coastline values for the lake sectors. However, in accordance with Figure 2.1-2, the EAB for the

lake sectors is not at the coastline, but extends out into Lake Ontario. The Chapter 15 accident analyses address the EAB at the eight land sectors only.

TABLE 2G-7

MAIN STACK X/Q AND D/Q AT GROUND LEVEL
LONG-TERM (ROUTINE) GASEOUS RELEASES
EAB BY SECTOR[1]

Sector Bearing[2]	Distance m	Distance ft	Annual X/Q (sec/m^3)	Annual D/Q (l/m^2)
E	1,555	5,100	8.81E-09	1.43E-09
ESE	1,555	5,100	8.74E-09	1.28E-09
SE	1,600	5,250	9.20E-09	1.20E-09
SSE	2,134	7,000	5.69E-09	5.42E-10
S	2,256	7,400	6.97E-09	5.39E-10
SSW	1,936	6,350	5.03E-09	4.40E-10
SW	1,615	5,300	3.69E-09	3.96E-10
WSW	1,615	5,300	1.09E-09	1.17E-10

Notes:
[1] EAB, RAB, and site boundary are the same for Unit 2.
[2] Only the eight downwind land sectors are assessed as 22 1/2-deg sectors centered on the 22 1/2-deg cardinal compass directions using distances derived from 45-deg sector widths.

TABLE 2G-7a

MAIN STACK X/Q and D/Q AT GROUND LEVEL
LONG-TERM (ROUTINE) GASEOUS RELEASES
FOR MECHANICAL VACUUM RELEASES[1]
EAB BY SECTOR[2,3]

Sector Bearing	Distance (m)	X/Q (sec/m^3)	D/Q (1/m^2)
E	1,555	4.21E-08	4.07E-09
ESE	1,555	4.93E-08	4.38E-09
SE	1,600	5.19E-08	4.36E-09
SSE	2,134	4.22E-08	2.36E-09
S	2,256	5.45E-08	2.31E-09
SSW	1,936	3.89E-08	1.88E-09
SW	1,615	5.30E-08	2.80E-09
WSW	1,615	1.17E-08	5.59E-10

(1) Four short-term outages x 80 hr per outage.
(2) EAB, RAB, and site boundary are the same for Unit 2.
(3) Only the eight downwind land sectors are assessed as 45-deg sectors, centered on the 22 1/2-deg cardinal compass directions.

TABLE 2G-8

COMBINED RADWASTE AND REACTOR BUILDING VENT
X/Q and D/Q AT GROUND LEVEL
LONG-TERM (ROUTINE) GASEOUS RELEASES
EAB BY SECTOR[1]

Sector Bearing[2]	Distance		Annual	
	m	ft	X/Q (sec/m^3)	D/Q (1/m^2)
E	1,686	5,530	1.60-07	3.51-09
ESE	1,686	5,530	1.04-07	2.63-09
SE	1,743	5,720	7.41-08	2.01-09
SSE	2,094	6,870	3.50-08	8.42-10
S	1,945	6,380	4.45-08	1.00-09
SSW	1,695	5,560	5.07-08	1.01-09
SW	1,381	4,530	5.33-08	1.08-09
WSW	1,381	4,530	1.90-08	2.40-10

NOTE: 1.60-07 = 1.60×10^{-7}

(1) EAB, RAB, and the site boundary are the same for Unit 2.
(2) Only the eight downwind land sectors are assessed, as 22 1/2-deg sectors centered on the 22 1/2-deg cardinal compass directions using distances derived from 45-deg sector widths.

TABLE 2G-9

SOURCE CHARACTERISTICS

Parameter	Main Stack	Combined Radwaste and Reactor Building Vent
Release height above grade		
Meters	130.8	57.0
Feet	429.0	187.0
Exit diameter		
Meters	2.2	3.4*
Feet	7.3	11.0*
Exit velocity		
Meters/second	10.7	17.8
Feet/second	35.0	58.3

*Equivalent diameter for the rectangular vent.

APPENDIX 2H

EXCAVATION MAPS

APPENDIX 2H

EXCAVATION MAPS

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APPENDIX 2H

EXCAVATION MAPS

The inspection and required mapping of bedrock surfaces exposed during excavation for the facility were performed by Stone & Webster Engineering Corporation (SWEC) geologists and verified on behalf of Niagara Mohawk Power Corporation (NMPC) by Dames & Moore geologists. This exploration was conducted in compliance with portions of the regulatory guides and responses to Nuclear Regulatory Commission (NRC) Questions addressed to the Preliminary Safety Analysis Report (PSAR). Excavations for all Category I structures, as well as excavations exposing anomalous geologic structures, were mapped in detail. All other excavations were inspected for the presence of unusual geologic features.

The geologic maps from this program, together with the limits of the excavations and the locations of safety-related facilities, are presented as Figures 2H-1 through 2H-101.

NOTES TO EXCAVATION MAPS
(Figures 2H-1 through 2H-95)

1. Stone & Webster (S&W) conducted systematic geologic mapping of site excavations for all Category and Seismic areas, and most other areas exhibiting anomalous features. All S&W maps are included in this set.

2. Dames & Moore (D&M) performed detailed investigations, studies, and interpretation of site geology, accompanied by some selective geologic mapping. D&M maps are not included in this set, but are attached to their geologic investigation reports of April 1978 and October 1980, and included separately elsewhere in the FSAR.

3. Extent of S&W and/or D&M involvement in geologic mapping of site excavations is as follows:

   A. <u>Areas Mapped Exclusively by S&W, and Maps Verified by D&M</u>:

      Predominant part of mapped excavations, except for areas listed in B. and C.

   B. <u>Areas Mapped Exclusively by D&M</u>:

      B/1. Cooling Tower Piping Trench, Soil Wall - Plate 4-11 of April 1978 D&M Report.

      B/2. Exploratory Excavations Along Trace of Cooling Tower Fault - Plates of April 1978 D&M Report:

- Pit 1, Soil Walls - Plates 4-7 and 4-8
- Trench III, Rock and Soil Walls - Plates 4-20, 4-21, 4-23, 4-25, and 4-28.
- Trench IV, Rock and Soil Walls - Plates 4-36, 4-38, 4-40, 4-41, 4-42, and 4-43.
- Trench V, All Surfaces - Plates 4-47, 4-48, 4-49, 4-51, and 44-52.

B/3. Relocated Cooling Tower - Plates 2.1-6, 2.1-7, and 2.1-8 of October 1980 D&M Report.

B/4. Exploratory Side-Trench in Southern Wall of North Exploratory Radwaste Trench - Plates 2.1-13, 2.1-14, and 2.1-15 of October 1980 D&M Report.

C. Areas Mapped by Both S&W and D&M:

C/1. Drainage Ditch - Plates 3-5 and 3-6 of April 1978 D&M Report, corresponding to S&W Figure 50 of this set.

C/2. North Radwaste Trench - Plates 3-13 and 3-17 of April 1978 D&M Report, corresponding to S&W Figure 29 of this set.

C/3. North Exploratory Radwaste Trench Plates 2.1-9, 2.1-10, 2.1-11, and 2.1-12 of October 1980 D&M Report, corresponding to S&W Figure 30 of this set.

C/4. Heater Bay - Plate 3-22 of April 1978 D&M Report, corresponding to S&W Figure 36 of this set.

C/5. Cooling Tower Piping Trench, Rock Floor and Wall-Plates 4-9 and 4-10 of April 1978 D&M Report, corresponding to S&W Figure 55 and 94 of this set.

C/6. Exploratory Excavations Along Trace of Cooling Tower Fault:

- Pit 1, Rock Floor - Plate 4-6 of April 1978 D&M Report, corresponding to S&W Figures 95 of this set.
- Trench III, Rock Floor - Plate 4-18 of April 1978 D&M Report, corresponding to S&W Figure 95 of this set.
- Trench IV, Rock Floor - Plate 4-35 of April 1978 D&M Report, corresponding to S&W Figure 95 of this set.

C/7. Circulating Water Piping Trench Plates 2.1-2, 2.1-3, 2.1-4, and 2.1-5 of October 1980 D&M Report, corresponding to S&W Figures 57 and 58 of this set.

C/8. Cooling Water Intake Shaft Plate 3-35 of April 1978 D&M Report, corresponding to S&W Figures 59 and 60 of this set.

C/9. Lake Water Tunnel No. 2 - Plates 2.1-18, 2.1-19, 2.1-20, 2.1-21, 2.1-22, 2.1-23, and 2.1-24 of October 1980 D&M Report, corresponding to S&W Figures 77, 79, 81, 83, 84, 85, and 86 of this set.

APPENDIX 2I

DEMSTER STRUCTURAL ZONE
WITH DISCUSSION ON ORIGIN AND EXTENT

Prepared for
NIAGARA MOHAWK CORPORATION

October 1982

Weston Geophysical Corporation

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1.0 INTRODUCTION

The northeast-trending Demster Structural Zone is a northwest-dipping, brittle fault/fold zone of limited vertical and lateral extent. Associated with this zone of intense fracturing and faulting is a sequence of apparently southwest-plunging, broad, asymmetric anticlines and synclines. This zone of complex deformation is in Late Ordovician Oswego strata, the youngest site area rock unit in outcrop and subcrop. Post-Ordovician deformation was identified during subregional and site subsurface mapping investigations at the New York State Electric & Gas Corporation (NYSE&G, 1979) proposed New Haven nuclear site approximately five miles southeast of Nine Mile Point (Figure 1-1).

Subsurface mapping defined and delimited the major bedrock structures within a five-mile radius of the New Haven site. Recently acquired deep well data (Bailey, 1982) for the region east of the New Haven site substantiates sub-surface interpretations reported in the 1979 investigations.

Field investigations, data synthesis and conclusions of the Haven site study are reported in NYSE&G's PSAR (1979). This section which is supplementary to the New Haven PSAR data base integrates results from recent geologic and geophysical literature.

Studies associated with the exploration of the Demster Structural Zone shown on Figure 1-1 included the following:

1. Twenty-nine diamond drill core borings (R-1 through R-29) including six angle borings, supplemented by offshore borings and site specific geologic borings;

2. Site area geologic mapping at a scale of 1:24,000 with supplemental reconnaissance mapping in and adjacent to the Adirondack Mountains;

3. Geologic mapping of a 240-foot long trench, excavated across the brittle fracturing of the Demster Structural Zone, exploratory pits within the trench, and the overlying surficial sediments;

4. Geophysical surveys including natural gamma logging of boreholes, offshore seismic refraction and reflection surveys, land refraction surveys, and land magnetic surveys, review and update of regional gravity and aeromagnetic data;

5. Mineralogical, petrographic, isotope and radiometric age analyses of representative samples obtained from the Demster fault zone;

6. Analysis and interpretation of available subsurface data in central and northern New York.

1.1 Background and Exploration History

NYSE&G commenced subsurface exploration at the New Haven site in Spring, 1976, with 7 shallow diamond drill core holes, B-1 to B-7, GEI (1976). In the spring of 1977, a comprehensive site drilling program was initiated along with four deep borings in the subregional area to provide stratigraphic information. Interpretation of data from the four subregional borings coupled with site stratigraphic information and known regional southerly homoclinal dips (50 feet per mile) indicated an elevation differential between identical subsurface map units in borings R-1 and R-2. The interpretation of this stratigraphic discrepancy was either folding and/or faulting.

Based on this apparent stratigraphic offset, NYSE&G undertook a detailed site area subsurface exploration program concomitant with detailed site boring and trenching studies. This exploration program extended from November, 1977 to November, 1978. Borings R-5 through R-9 were drilled during November, 1977 to January, 1978 to investigate a possible extension of the west-northwest trending faults mapped at the FitzPatrick and Nine Mile Point nuclear stations and to establish more definitive stratigraphic control.

Results of this exploration confirmed the 140-foot elevation differential of subsurface units between borings R-1 and R-2 (the Oswego-Pulaski contact in R-2 is 140 feet stratigraphically lower than R-1).

Subsequent borings R-10, R-11 and R-12 delimited a northeast-trending zone of intense brittle deformation and folding. During the spring and summer of 1978, further borings and trench excavations confirmed the existence of the deformation and resulted in the determination of the nature, style, and to a lesser degree, the extent of the fault and fold deformation.

In support of and integrated with these field geologic studies, geophysical exploration (Appendix 2.5I, NYSEG 1979) was undertaken to augment the direct investigative techniques. Geophysical data helped determine the length of the fault zone and the absence of deformed lake sediments along its offshore extension. In addition, laboratory and petrographic studies on selected samples from the deformed zone aided in the interpretation of age and the origin of deformation.

In summary, the interpretation and evaluation of the combined geologic and geophysical data support the following conclusions:

1. The Demster Structural Zone consists of complex folding and faulting; the structure is non-capable.

2. Broad folding, reverse faulting, and normal faulting associated with the Demster zone developed sequentially through a series of three events or phases separated by an indeterminate amount of geologic time.

3. Ordovician strata in the site area are folded into a series of sub-parallel, southwestward-plunging anticlines and synclines. The Demster Beach Anticline is intensely deformed and faulted within part of the eastern oversteepened limb herein designated the Demster Structural Zone. Stratigraphic offset is due primarily to folding, steeply northwest-dipping faults and fold axial fractures.

4. Assuming ambient depositional conditions, fluid inclusion data are indicative of calcite mineralization emplaced at temperatures greater than 100°C. Paragenetic and structural element correlation demonstrate the deposition of calcite after bacteriological reduction of sulphides, in part contemporaneous with and soon after the deformation. Early calcite is deformed prior to completion of structural development with the remainder of the paragenetically younger calcite undeformed.

2.0 DEMSTER STRUCTURAL ZONE GEOLOGIC SETTING

The area adjacent to and including the Demster Zone is underlain at a relatively shallow depth by crystalline rocks of the Precambrian basement. Deep drilling data in the immediate vicinity indicate these basement rocks are somewhat heterogeneous and are composed of calc-silicates, marbles, and biotite-quartz-feldspar gneiss (Van Tyne, 1978a). The basement complex is apparently similar to lithologically and genetically equivalent strata cropping out on the Canadian Shield and Adirondack Dome.

The Precambrian basement is overlain by approximately 1,500-1,800 feet of Cambrian-Ordovician strata which in the site area, from oldest to youngest, are the Theresa Sandstone, Black River Group, Trenton Group, Utica Shale, Whetstone Gulf Shale, Pulaski Shale, and the Oswego Sandstone. The Late Ordovician Queenston Formation, a sequence of red beds overlying the Oswego to the south of the site area, completes the progradational character of this sedimentary succession from limestone to shale to sandstone. This sedimentary sequence rests uncomfortably on a southward sloping (50'/mile) basement surface (Rickard, 1975), and is a southward-dipping homoclinal sequence of south and southwest thickening Paleozoic strata. The entire site area, except for infrequent exposures, is overlain by several types of glacial and Holocene deposits that include till, undifferentiated ice-contact

stratified drift, glaciolacustrine and peat deposits. The site area stratigraphic column is shown on Figure 2-1.

Subdivision of the near surface stratigraphic succession at both the Nine Mile and New Haven sites is nearly identical, although, the nomenclature is not. The nomenclature of correlative units is shown on Figure 2-2.

2.1 Stratigraphic Summary

The principal aspects of the stratigraphy of the Demster Structural Zone area and their implications for its geologic history and structural delineation are shown on Figure 2-1 and described below.

The Pulaski, immediately underlain by the Whetstone Gulf Shale and at greater depth by a thick sequence of marine shelf carbonates and shales, is the stratigraphically highest major unit in which sandstone is subordinate. Its black pyritic shales, rhythmic bedding, finely detailed textural and structural features, and benthonic faunal assemblage identify the Pulaski as a proximal marine shelf sequence which received frequent contributions of fine- to medium-grained sand. As uplift and marine regression accelerated, the basal strata of the Oswego began to offlap the Pulaski; the transition corresponds in Zone 1 to the appearance of thick bedding, an overall increase in grain size, green coloration, and the virtual disappearance of fossils. The prevalence of slump structures and poorly sorted lithologic types indicate that the basal Oswego was deposited rapidly as an influx of terrigenous detritus on the shallow marine shelf. Marine processes were not entirely effective in distributing the materials because of high rate of deposition, and adjustments to the depositional slope were effected by slumping of the unconsolidated deposits. This process generated turbidity flows from which sediment was redeposited as graded sequences, with settlement from suspension as an important mode of deposition.

Zone 1 strata were offlapped in turn by those of Zones 2 and 3. The appearance in the section of this sequence corresponds to a further increase in overall grain size and reflects a substantial increase in energy levels. Current-bedded coquinites, shale-clast conglomerates, washout structures, and a rarity of siltstone identify the dominant mode of deposition as bed load transport. Intercalated shale beds possibly are related to periodic advances of the strand, or to changes in the availability of sand size detritus. Zones 2 and 3 probably were deposited in a shallow subtidal setting characterized by frequent variation in current vector and velocity. Zone 3 reflects a somewhat less rigorous setting than Zone 2 and is transitional to and offlapped by Zone 4.

Zone 4 largely consists of thin to medium beds of sandstone and burrow-mottled mudstone in cyclic arrangement. A variety of

process-related structures indicate alternating periods of high and low energy in which bed load transport alternated with settlement from suspension as the depositional mode. On the basis of bedding patterns and biogenic and sedimentary structures, these strata are interpreted as mixed tidal flat deposits.

With continued retreat of the shoreline, the mixed tidal flat environment was replaced in the section by a thick sandstone sequence with complex internal geometry imparted by small and large scale primary structures. These include cross stratification, plunging troughs, washouts, scour pits, ripple marked surfaces, shale clast carpets, lensoid channel fillings, and various combinations of these structures; in association,these features describe an intertidal setting characterized by shoaling conditions in which sedimentary materials were acted upon by waves, fluvial currents, and tidal flow.

Additional strata of Zone 5 aspect and origin were deposited and then offlapped by the Queenston fluvial sequence, completing the transition from marine to nonmarine sedimentation. The Oswego-Queenston transition is not preserved in the vicinity of the site area but is well exposed along the lake shore farther to the west.

The local section is progradational from bottom to top and records the progressive marine withdrawal from the site area and surroundings in Late Ordovician time. According to Patchen (1966), continental replacement of the marine basin was accomplished by westward migration of the strand as the source lands shifted northwestward. Fisher (1977) postulates the Taconic uplift as the source of this detritus.

2.1.1 Pulaski-Oswego Formational Boundary

The principal purpose of the New Haven site area subsurface stratigraphic investigations was division of the section into mappable units to define the subsurface structure. The section represents a continuum of marine deposition in which unit boundaries are assumed to have been essentially horizontal as deposited, except on a very local scale and, therefore, are considered reliable horizons. Structure con tour maps of the unit boundaries, or key horizons, were constructed and examined for evidence of structural trends. The Pulaski-Oswego boundary was selected as the primary horizon because of its mappability and lithologic differences between the Oswego and Pulaski.

Identification and description of the Pulaski and Pulaski-Oswego boundary are based on an aggregate thickness of 3,200 feet of Pulaski section core recovered from 39 boreholes; an average of 82 feet and a maximum of 286 feet of Pulaski were penetrated. These borings are shown on Figure 2-3 and on a structure contour

map of the boundary on Figure 2-4. Exposures of the Pulaski along the Salmon River and Route 81 as well as exposures of the Oswego Sandstone above Bennett's Bridge in the Salmon River Gorge were analyzed and compared to site area outcrop and boring data. Exposures of Lorraine and Trenton rocks were examined in the Black River Valley.

Structurally, the top of the Pulaski Shale is a gently-sloping surface consistent with the marine conditions of its deposition, as modified by subsequent regional tilting. Within the areal limits of stratigraphic control, from boring R-6 on the east to Nine Mile Point on the west (Figure 2-3), the Pulaski appears to strike west-northwestward and dips to the south-southwest at about 60 feet/mile. Both the New Haven and Nine Mile plant sites overlie a gently-sloping, mildly-negative structural element whose south-southwest dip reflects the regional homoclinal structure.
Based on closely-spaced Pulaski control points, the contour pattern southeast of the Nine Mile site (Figure 2-4) are indicative of abrupt changes in the strike, dip, and dip direction of the Pulaski-Oswego boundary. These changes, together with the pronounced lineation and compression of the pattern, are evidence for faulting. Inclined borings in the zone of suspected faulting traversed a crushed zone several tens of feet wide, including intervals of gouge and breccia, confirming the occurrence of a fault zone. Deep exploration data east of the New Haven site confirm the Mexico Anticline and suggest deformation on the eastern limb of this fold.

The contour pattern of the formation boundary and boring data define the position and orientation of a northeast-trending fault zone and associated folding of indefinite extent, herein designated the Demster Structural Zone. Figure 2-5 indicates the effects of tectonism on the Pulaski-Oswego boundary on the eastern limb of the Demster Beach Anticline. Compression and linearity of the contour pattern are indicative of folding, rather than faulting, as the dominant process in the formation of the Demster Structural Zone. The fold is markedly asymmetrical to the east, with little net displacement on the fault. These structural relationships are illustrated on Figures 3-3 and 3-5 and on regional cross sections C-C' (Figure 2-6) and D-D' (Figure 2-7). Southward deflections of the contour pattern occur west-northwest and east-southeast of the New Haven site. To reestablish the regional strike and correlate with stratigraphic control at Nine Mile Point (borings 314, L-1, L-4, and L-8), the structural contours must return to a northerly trend (Figure 2-4). Stratigraphic control west of the New Haven site indicates a repeated pattern, similar to the southwest-trending zone delineated in Figure 2-4. The contour pattern is undulatory along regional strike. To the west of Nine Mile Point, the continuity of the pattern is uncertain. 2.1.2 Pulaski Shale

The Pulaski, as defined in the NYSEG PSAR (1979), is an alternating sequence of black, fissile shales, and medium-gray to pale-gray, fine- to very fine-grained, well sorted sandstones and coarse-grained siltstones. Layers are thinly laminated to medium bedded, but thin to very thin bedding is characteristic. Individual sandstones thicker than 2 feet are rare. The sandstone-shale ratio of most cycles and the unit in general is less than 1.0. The predominance of shale and absence of green coloration in sandstone are diagnostic of the Pulaski; the latter suggests a fundamental compositional difference between the Pulaski and Oswego and most probably corresponds to a change in the content of chloritic matter and metamorphic rock fragments.

Other characteristic properties of the Pulaski are pyrite content and fossiliferous aspect. These are discussed in Section 2.5.1.2.2.3 of the NYSE&G PSAR (1979).

Dark-gray to black shale and pale-gray to greenish-gray sandstone are the characteristic lithologic types of the Pulaski and Oswego Formations respectively, which represent near extremes on the scale of natural radioactivity. Accordingly, gamma-ray logging is particularly applicable to the problem of determining lithologic boundaries within this sequence.

In summary, the properties upon which identification of the Pulaski is based are:

1. Sandstone-shale ratios less than 1;

2. Gray, finely textured and structured, commonly fossiliferous sandstones;

3. Pyritic, black, fissile shale;

4. Relatively high natural radioactivity.

This association of properties, together with the cyclic sequence, served to firmly establish the identity of the Pulaski Shale and its boundary with the Oswego Sandstone.

The lithologic aspect of the Pulaski is relatively constant, both are really and stratigraphically, and no systematic site area changes or bases for subdivision were discerned.

2.1.3 Oswego Sandstone

Within the site area, all strata between the top of the Pulaski and the base of the glacial sediments are referred to as the Oswego Sandstone. Three hundred feet of Oswego recovered in boring R-19 (Figure 1-1) is the thickest sequence known to occur in the vicinity of the site, and is about 80 percent of the estimated total thickness of the formation (Patchen, 1975). At the New Haven site eastward along strike, the section is slightly

thinner and any of several deep borings there may be considered reference sections.

Stratigraphic analysis of the Oswego Sandstone is based on the examination of more than 13,000 feet of Oswego core from 144 boreholes, including the 39 Pulaski penetrations (Section 2.5.1.2.2.2, NYSE&G, 1979). According to associations of lithologic and sedimentologic properties and sequential relationships, the formation is divided into five mappable rock-stratigraphic units or zones of major rank, as defined by four selected intraformational marker horizons. In the Demster Structural Zone, further subdivision of the lowermost Oswego (Zone 1) was required for detailed structural analysis. These units of lesser rank were selected according to the same rationale and criteria as were the principal zones. The primary zonation of the Oswego Sandstone is as follows:

<u>Oswego Sandstone - Zone 1</u>

This unit conformably overlies the Pulaski Formation throughout the site area and, in turn, is conformably overlain by Zone 2. Twenty-three complete sections of Zone 1 provide a range in thickness of about 60 to 90 feet and an average thickness of about 80 feet; the unit thins gradually to the north and subcrops beneath till (Figure 2-9).

Zone 1 consists of a medium to very thick-bedded succession of pale gray to green sandstones, pale-green and olive siltstones and dark-gray shales, representing graded beds up to 10 feet or more in thickness. The basal sandstone, typically, is predominant within a sedimentary cycle, and ratios of sandstone to siltstone and shale average 2.5:1; these contrast sharply with those of the Pulaski which rarely exceed 1.

A more comprehensive description of Zone 1 appears in NYSE&G PSAR Section 2.5.1.2.4 (NYSEG 1979) while Section 3.2 contains a discussion of the subdivision of Zone 1 required for the stratigraphic/structural analysis of the Demster Structural Zone.

At Nine Mile Point, the upper part of Zone 1 becomes increasingly shaley, presumably reflecting basinward facies change within the rock unit. Correlations of boreholes to the east of Nine Mile Point (R-22, R-23, R-24, and R-25) and logs of Nine Mile Point borings (314, L-1, L-4, L-8) indicate that this change is accomplished through replacement of siltstone and other intermediate rock types by dark-gray to black shale. Bedding thickness, bed forms, and the overall aspect of the lower part of the unit remain relatively constant throughout the site area.

<u>Oswego Sandstone - Zone 2</u>

This zone conformably overlies Zone 1 and is overlain by Zone 3. With the exception of boring R-6, where an anomalously thin

section of 14 feet suggests an eastward thinning of the unit, Zone 2 is quite uniform in thickness, with a range of 25 to 38 feet and an average thickness of 29 feet.

Zone 2 sandstones are gray, pale greenish-gray, or yellowish-gray, fine- to medium-grained, typically hard and slightly calcitic. Bioclastic deposits are particularly evident at the base of thicker sandstones, associated with inclined lenticular bedding, relatively coarse sandstone matrix, ragged shale clasts, clay galls, and mud flasers. Many sandstones, up to 3 feet thick, are fossiliferous throughout; more commonly, they consist of several zones, alternately fossiliferous and barren. The upper, more finely textured part of the thicker sandstones may contain laminated siltstone, gradational through dark-gray or greenish-gray siltstone into black shale, or contain several planar, wavy, or broken shale laminae.

Diagnostic criteria for Zone 2, in addition to its stratigraphic position, are:

1. Sandstone-shale couplets;

2. Washout structures;

3. Current-bedded bioclastic deposits.

The Zone 2/Zone 3 boundary is placed at the top of the highest prominently fossiliferous cycle in this sequence.

Oswego Sandstone - Zone 3

This unit consists of a sequence of strata with neither the fossiliferous aspect of Zone 2 nor the burrowed aspect of Zone 4. It has no uniquely diagnostic features, but is defined mainly by its stratigraphic position and the absence of bioclastic and bioturbated bed forms. Given a section in which Zones 2 and 4 are recognizable, Zone 3 becomes mappable.

Zone 3 is lithologically similar to Zone 2, consisting mainly of gray to greenish-gray, fine-grained, hard sandstones and black shales, with a sandstone-shale ratio of about 1.5:1. Bedding and other sedimentary structures are as described for Zone 2, with the exception of features relatable to channel formation, relatively uncommon in Zone 3. The definition of the base of this zone is approached from down section by determining the top of Zone 2.

Oswego Sandstone - Zone 4

Zone 3 is overlain conformably throughout the site area by Zone 4, a sequence of thin- to medium-bedded strata identified on the basis of bed forms and biogenic structures. Zone 4 is overlain by Zone 5. The Zone 4/Zone 5 boundary, marked by pronounced

changes in bedding properties and sandstone-shale ratios, is considered a highly reliable and readily mappable marker horizon. It is the most thoroughly documented boundary at Nine Mile Point where the contour pattern is based on the examination of lake shore outcrops, core from 15 boreholes, and the reinterpretation of published logs (Patchen, 1966 and Dames & Moore, 1978). The Zone 4/Zone 5 boundary is a broadly undulating conformity. Zone 4 consists mainly of very thin- to medium-bedded cyclic repetitions of sandstone, siltstone, and shale. Bedding thickness and cyclicity set this sequence apart from Zones 3 and 5. Zone 4 sandstone-shale ratios generally lie between 1:1 and 2:1, a range similar to that of Zone 3 but considerably less than the majority of Zone 5 ratios. Additionally, the prevalence of burrowed strata and indistinct lithologic boundaries make this unit identifiable even out of stratigraphic context. Because of its distinctive association of properties and high stratigraphic position, Zone 4 provides reliable stratigraphic control at relatively shallow depths.

<u>Oswego Sandstone - Zone 5</u>

All strata between the top of Zone 4 and the base of the glacial deposits in the current data base are designated as Zone 5. This unit lies conformably upon Zone 4, and the boundary is a reliable marker horizon. The expression of the external form of Zone 5 is entirely consistent with its internal geometry as seen in the New Haven site Trench (Appendix 2.5H and Figure 2.5-33, NYSE&G, 1979), bedrock exposures (Figure 2-3), and an extensive core record.

Zone 5 is a sequence of thick to massive sandstone units ranging in color from dark greenish-gray through pale greenish-gray and pale gray to white, and texturally from fine to medium grained. The darkest colored units are the most silty, the softest, and the least calcitic, while pale-gray and white sandstones tend to be medium grained, hard to very hard, moderately calcitic, and cross stratified.

Examination of the individual structure contour maps indicates clearly the marked compression and linearity of all mapped horizons in the vicinity of the Demster zone. This anomalous contour pattern as well as the site area pattern indicate that the Upper Ordovician age strata are folded into a series of broad, low amplitude, southwest-plunging folds designated the Demster Beach Anticline, the Mexico Anticline, an unnamed inferred syncline at Nine Mile Point and the New Haven Syncline.

Along the eastern and apparently oversteepened limb of the Demster Beach Anticline, the structure contours on all horizons mapped indicate intense deformation. Eventually, this linear zone of considerable stratigraphic displacement was shown to be a relatively narrow zone of flexure, brittle deformation and

calcite mineralization separating the Demster Beach Anticline from the New Haven Syncline.

The configuration, location, trend and extent of these three structural elements are shown on Figure 2-3. The amount of stratigraphic offset due to broad folding between any two control points as well as the distribution of folded units is shown on structure contour maps and sections. Initial limits of the Demster zone were reconstructed from data solely derived from the R and P series borings. Dip angle and dip direction of the fault zone were defined through analysis of sedimentary and tectonic structures in core. Excavation of a 240-foot long trench (Trench II) exposed the bedrock across the deformed zone. Detailed studies were made of the type of deformation, the amount of stratigraphic displacement due to faulting, the relationship between faulting and broad folding, and the nature and condition of surficial units overlying the bedrock faults.

Concurrent with trench investigations, geophysical investigations and drilling exploration continued in adjacent areas to outline the lateral extent and length of the Demster Zone.

3.0 DETAILED GEOLOGIC STUDIES, TRENCH II AND VICINITY

Trench II excavations, detailed geophysical investigations, and drilling enabled an evaluation of mechanism, cause, style, extent, and apparent age of deformation. Bedrock exposure and overlying surficial deposits were mapped in detail and reported in Appendix 2.5I (NYSEG 1979). Trench II was the second bedrock trench excavated during the New Haven site studies. Figure 1-1 indicates trench locations and Appendix 2.5H (NYSEG 1979) provides Trench I descriptive geology.

Trench II was excavated on the R-1/R-2 boring alignment because of initial subsurface control provided by borings R-1, R-2, R-9, R-10, R-11, R-12, and R-18, minimal overburden thickness and ease of heavy equipment access. Trench centerline is on a 133° azimuth, essentially perpendicular to the deformed zone and anomalous trend of the structure contours. Subsequent to trench mapping, borings R-27 through R-29 provided additional data.

3.1 Surficial Geology

The site area is overlain by a series of unconsolidated deposits associated with Pleistocene continental glaciation. Since these deposits are extensive, bedrock is exposed infrequently. These deposits include stratified sediments, a lower and upper till, outwash deposits, lake sediments, aeolian deposits, peat, muck, and alluvial deposits. Details and descriptive geology of these units are discussed in detail in Section 2.5.1.2.4 NYSE&G PSAR (1979).

Surficial deposits in and adjacent to the Demster zone are similar to those mapped in the site area and site proper. In the Trench II excavation, the surficial deposits range in thickness from 9 feet to 18 feet with three major units identified. A lower till overlies the bedrock throughout the trench and is overlain by either an upper till and/or lake sediments. A thin layer of soil was stripped prior to excavation.

Lower till is the basal Pleistocene deposit throughout the length of Trench II of the New Haven site, most likely deposited during Wisconsinan time. Similar tills at the Nine Mile site are probably post-Huron stage (12,900-12,000 ybp, Dames and Moore, 1978). Typically, the till is dense, gray, variable in grain size, with up to 5 to 10 percent silt and cobble/boulders; its thickness ranges from 1 to 12 feet. Till fabric is apparently random.

The lower till aggregate is predominantly subangular consisting of locally derived fragments of dark gray siltstone and gray sandstone. Exotic lithologic pebbles of crystallines, carbonates and red sandstone make up a minor percentage of the aggregate.

An upper till, averaging 8 feet thick, discontinuously overlies the lower till. The distribution of the till is shown on Figure 3-1. Distinctly looser in texture than the lower till, the upper till is typically yellow-brown to locally light gray with an apparently random fabric. Variable in grain size with about 5 percent silt, the aggregate is round, iron stained and contains markedly greater percentages of exotic litholigies.

The lower and upper till are discontinuously overlain by lake sediments. Lake deposits are gray to yellow-brown, thinly laminated plastic clay, and silt with minor very fine-grained sand. Towards the surface, stratification becomes indistinct or mottled. Distinctive color and gradational textural changes were delineated within the sediments. Locally, up to five feet of thinly laminated, gray sediments containing abundant ice-rafted pebbles, cobbles and boulders overly the lower till. The occurrence of these pebbles and cobbles steadily decreases toward the present day ground surface.

Detailed profiles of surficial deposits in Trench II are shown on Figure 3-1. The bedrock/till interface at faults mapped on the trench floor was closely examined for evidence of displacement. The till fabric was random and the bedrock surface smooth over mapped faults. A distinct pair of silt laminae occur continuously near the base of the lake sediments over the fault between station 8+85 and 9+80 along the northeast trench wall. The laminae are undisturbed and follow the topography of the lower till upon which they were deposited. These laminae were most likely laid down in proglacial Lake Iroquois, 12,500-10,000 ybp (Dames and Moore, 1978).

The silt laminae are locally contorted and warped where draped over cobbles or boulders or where the rafted material has settled. Faulting and folding associated with the development of the Demster Structural Zone have not disturbed the overlying Pleistocene deposits exposed in Trench II.

3.2 Bedrock Stratigraphy - Trench II Vicinity

The stratigraphy in the Demster Structural Zone was determined by a sequential evaluation of data derived from site and regional core borings, five percussion borings, and Trench II. The locations of the borings and the trench are shown on Figures 3-2, 3-3, and 3-5. Because the Oswego-Pulaski boundary was found to be the only mappable horizon to span the structure, the stratigraphic section was subdivided to provide additional marker horizons for use in determination of the structural style (Figures 3-4 and 3-6). The key unit in the analysis is Oswego Sandstone Zone 1 (Section 2.1.3), subdivided on the basis of lithologic and bedding characteristics and gamma log patterns, into five mappable sub-zones, Units G, F, D/E, A/C, and B. The total stratigraphic sequence explored in the Demster Structural Zone consists of the following units, in order of increasing stratigraphic position.

3.2.1 Pulaski Shale

The Pulaski-Oswego boundary and underlying Pulaski Shale were penetrated in all borings drilled to delineate the Demster Structural Zone (Figures 1-1 and 3-2). Lithologically, the Pulaski Shale encountered in the fault investigations conforms to the description given in Section 2.1.2.

3.2.2 Oswego Sandstone

<u>Oswego Sandstone - Zone 1, Unit G</u>

The basal strata of the Oswego Sandstone, underlain by the Pulaski Shale and overlain by the relatively massive beds of Unit F, are designated Oswego Sandstone - Unit G. This interval, with an average thickness of 10 feet, comprises a very thin- to medium-bedded sequence of greenish-gray, fine-grained, non-fossiliferous sandstone; dark greenish-gray to dark gray siltstone; and dark gray to black platy shale. Slump structures involving all three rock types are common, as they are throughout the Oswego section. They are closely related to the occurrence of siltstone. The siltstone-slump structure association is particularly well-developed along the boring alignment of R-5/P-2.

Unit G sandstones typically are thinly laminated, except at their base; locally they are cross-laminated, shale clast bearing, pale gray and medium grained, or ripple-marked. Unit G shales are

mainly platy, soft, and commonly contain sandstone lenses and load structures.

The base of Unit G in most borings is a medium to thick sandstone bed; the top of the unit is the uppermost shale of this relatively thin-bedded sequence. Unit G is moderately radioactive appearing on the gamma ray log as a series of peaks of intermediate to low value.

Oswego Sandstone - Zone 1, Unit F

Unit F consists of about 20 feet of thick-bedded to massive sandstone with a distinctive gamma ray log signature, and is the most prominent sandstone interval below the base of Oswego Sandstone - Zone 5. Accordingly, it is readily identifiable in both core and in outcrop. Unit F immediately underlies the lower till a short distance northwest of the fault zone, as in boring R-9; the unit has been completely eroded along the 'crest' of the Demster Beach Anticline, but crops out at Duell's Sawmill and at Pleasant Point (Figure 2-3).

The sandstone in this interval is mainly pale greenish-gray to pale gray, fine grained, and relatively structureless, but ranges to dark greenish-gray and very fine grained locally. Subordinate lithotypes include dark-gray silty shale, olive clay shale, dark greenish-gray siltsone, and white, medium-grained sandstone. These occur as laminae to thin beds and typically are in gradational contact with predominant greenish-gray sandstones.

A typical Unit F cycle begins at an intercalation of siltstone or shale, or at a reactivation surface; its base consists of fine- to medium-grained sandstone containing small intraclasts of the underlying rock type. The sandstone becomes increasingly darker in color and more prominently laminated upward, and grades through interlamination or decreases in grain size into a siltstone- or sandstone-laminated silty shale. Alternatively, the cycle may terminate at a reactivation surface. Unit F appears on the gamma ray log as a pattern of low values bounded by prominent shale peaks (Figure 3-4). The base of the upper shale and the top of the lower shale are the limits of this unit.

Oswego Sandstone - Zone 1, Unit D/E

The relatively massive sandstone of Unit F is overlain by a medium- to thick-bedded alternating sequence of gray to greenish-gray, fine-grained, hard sandstones and black to greenish-black silty shales to shaly siltstones; olive clay shales and dark greenish-gray siltstone are subordinate lithologic types. The total unit has a thickness comparable to that of Unit F, and an overall sandstone-shale ratio of about 2:1. In general, shale is more prevalent in the lower part of the interval, and is replaced upward by sandstone. The uppermost

thick bed of sandstone (Sandstone D) is a persistent stratum, appearing on both detailed cross sections (Figures 3-3 and 3-5).

Sandstones in this interval tend to be thinly-laminated to cross-laminated, and to grade upward into silty shale. Thin, wavey bedded zones of shale clasts and bioclasts occur at several levels but tend to be concentrated within the upper one-half of the unit. Syngenetic pyrite is fairly common, and occurs in many of the sandstones as minute spherules.

The gamma ray response of Unit D/E is bounded by very prominent shale peaks, and includes an upper (sandstone) region of low values. The unit extends from the base of the lower shale to that of the higher shale, and thus appears to span the boundary between two major cycles of sedimentation.

Oswego Sandstone - Zone 1, Unit A/C

This unit consists mainly of dark gray to black, pyritic platy shales and shaly siltstones with intercalations of greenish-gray, fine- to very fine-grained, thinly-laminated sandstone occurring as laminae, narrow lenses, and thin to very thin, but remarkably persistent, beds. Micro-cross lamination and minute shale flasers and intraclasts are apparent within these sandstone intercalations, and small-scale sandstone load structures, pyritized fossils, and slumped bedding are common in the shales. A thick bed of fine- to medium-grained, cross-stratified, fossiliferous sandstone is prominent a few feet above the base of the shaley sequence, and in Trench II a second potential key bed (Sandstone A) occurs within the sequence about 5 feet from its top.

Unit A/C is intact southeast of the fault zone (Figures 3-3 and 3-4) mainly preserved within the disturbed zone, but is absent in boring R-9 a short distance northwest of the fault zone. Similarly, along the southern line of section, all but the basal few feet of this sequence have been removed by erosion at boring R-5. In general, this unit crosses the fault and was a key marker in determining its structural style. Unit A/C has been eroded from the crest of the broad fold as far westward as Pleasant Point (boring R-21).

On gamma ray logs, this unit appears as a pattern of moderate to high values bounded above and below by the pronounced signatures of Sandstone D and the overlying sandstone described below.

Oswego Sandstone - Zone 1, Unit B

Unit A/C is succeeded conformably by a thick sandstone-shale couplet constituting the top of Oswego Sandstone Zone 1 in the Demster Structural Zone. This couplet, Unit B, is overlain in turn by the basal strata of Oswego Sandstone - Zone 2. On a local scale, as seen in Trench II, the boundary is unconformable,

with the lenticular Zone 2 sandstones incised to various depths below the top of Unit B. For the most part, the upper shaley section of the unit has been destroyed, and the Zone 1/Zone 2 boundary is a sandstone-to-sandstone relationship.

Boring R-14 contains the complete unit. The base is a thick to very thick bed of greenish-gray, fine-grained sandstone, apparently structureless at the base, which becomes progressively darker in color and thinly-laminated upward. Planar reactivation surfaces and associated small intraclasts are minor exceptions to the graded aspect of the unit. The top of the sandstone is silty, dark gray, very thinly-laminated, and is overlain by a prominent zone of black shale and shaley siltstone with sandstone slump structures in its upper part. The gamma ray signature of Unit B is not distinctive and of very little value as an identifier in the absence of core.

Oswego Sandstone - Zone 2

Zone 2 overlies Zone 1 conformably on the scale of the site area, as indicated by the relatively constant thickness of both units. Locally, the top of Zone 1 (Unit B) has been partially removed, but stratigraphic relationships observed in Trench II indicate that the magnitude of the unconformity is very small, and certainly less than 5 feet. The complete Zone 2 section was exposed in Trench II, measured and described (Figure 3-4), and found to be quite similar in thickness, internal geometry, and lithology as the Zone 2 section described from cored borings for the site area (Section 2.1.3).

Oswego Sandstone - Zones 3, 4, and 5

With the exception of the few feet of Zone 3 exposed at the southeastern end of Trench II (Figure 3-3), these upper Oswego strata are absent.

3.2.3 Subsurface Structure

The effects of folding in subsurface are described and discussed in Section 2.0. NX, NQ, and HX diameter borings were cored and analyzed. Initial subsurface confirmation of the structural zone was provided by borings R-10 and R-12 on the R-2/R-8 boring alignment. R-13 and R-14 confirmed the fault zone on the R-5/P-2 alignment. These alignments are shown on Figure 3-2.

Stratigraphic and structural interpretation of boring data along the two alignments combined with Trench II excavations indicate that major stratigraphic offset is due to the development of the Demster Beach Anticline and not to faulting. As the site area structure contours indicate, the Oswego and Pulaski folding is not a single unique fold but a series of folds. Drilling, stratigraphic interpretation, and seismic studies (Appendix 2.5I, NYSEG 1979) surrounding the Demster zone, demonstrate an apparent

dying out of faulting to the northeast and southwest along the Demster zone. Only boring R-25 (Figure 1) to the west of the zone intersected minor faulting.

R-2/R-8 Boring Alignment

The location of the R-2/R-8 alignment is shown on Figure 3-2. Figure 3-3 details the R-9/R-11 stratigraphic and structural interpretation. Stratigraphic subdivision of these units is detailed in Section 3.2.

Specifically, along the R-2/R-8 boring alignment (Figures 2-6 and 3-3) the elevation differential between the Oswego-Pulaski contact from R-2/R-8 is 130 feet, while the differential between R-9/R-11 is 94 feet, R-2/R-10 is 60 feet, and R-12/R-9 is approximately 15 feet. In all instances, the stratigraphic elevation differential is of a reverse sense with the Oswego-Pulaski contact higher to the northwest. Stratigraphic offset of this contact between borings R-29 and R-27, drilled in Trench II, is approximately 16 feet of reverse slip. Subsurface stratigraphic control on either side of the main fault zone exposed in the trench at station 9+50 is provided by borings R-12 and R-27. These borings indicate a 10-foot northwest side down normal displacement. Further control by boring R-29, adjacent to the intensely deformed zone, also indicates normal movement. Thus, subsurface data show two styles and phases of deformation, reverse and normal, to account for the folding and stratigraphic offset.

Detailed analysis of the core to the west of boring R-12, (borings R-18, R-9, and R-2) demonstrates that the fracturing, calcite mineralization and faulting decrease away from the fault zone.

In particular, boring R-18 contains intense fracturing, numerous small-scale faults and calcite mineralization. Boring R-9 is moderately fractured, contains a high frequency of calcite-mineralized joints and no apparent faulting. Boring R-2 core is infrequently fractured, contains rare calcite and small, localized slip surfaces. To the east, from the fault, are borings R-11 and R-8. Boring R-8 contains rare joints and calcite mineralization, whereas fracturing and calcite mineralization increase in boring R-11 as the fault zone is approached.

R-5/P-2 Boring Alignment

Boring alignment R-5/P-2 is approximately 1,800 feet southwest of boring alignment R-2/R-8. Lack of bedrock control makes subsurface interpretation along this alignment more speculative than the R-2/R-11 alignment. However, the amount and style of offset along R-5/P-2 alignment (Figures 3-2 and 3-5) is similar to the R-2/R-11 alignment.

Boring R-14 provided the complete subsurface delineation of the fault zone in the R-5/P-2 alignment. Similar to R-12, the core from R-14 is intensely fractured, brecciated, and mineralized with calcite. Poor recovery, low RQD, broken core and numerous gouge zones are common. R-14 intersected the zone of intense deformation approximately from 202 feet to 240 feet downhole. R-13 core, also intensely deformed, intersects the fault zone at a relatively shallow depth and if extrapolated to R-14 indicates a 73°NW dip for the fault. Drilled on an angle oriented to the northwest away from the zone, R-17 core is moderately to weakly fractured, with small-scale gouge and breccia zones but in overall character, deformation was less than in borings R-13 and R-14. R-5 core is similar to R-17 and as in borings R-2 and R-9, the deformation to the NW of the main fault zone is weakly present and apparently related to compression and brittle fracturing.

Offsets along this alignment are similar to those of the R-2/R-11 alignment and apparently die out to the southwest toward boring R-19. Stratigraphic offset across the fault zone (Figure 3-5) from boring R-5 to P-2 is approximately 94 feet in a reverse sense. Similarly, the offset between borings R-17 and P-2 is 65 feet with the northwest side up. However, as in the R-2/R-11 alignment, stratigraphic correlation (Figure 3-4) adjacent to and in the zone of intense deformation indicate a normal offset. The R-14 to R-13 offset is approximately 15 feet of normal movement with the northwest side down. In conjunction with Trench II data, the R-5/R-2 boring alignment subsurface interpretation indicates that at least two phases of deformation are needed to account for the large scale reverse and small-scale normal offset.

At the fault zone proper, the exact amount of offset is uncertain due to complex folding, fracturing, and the necessary extrapolation of data. As depicted on Figure 3-5, the component of normal faulting is suspected to be no more than approximately 10 feet. This 10 foot normal throw is in agreement with the R-2/R-11 alignment data.

3.3 Structure Trench II

3.3.1 Introduction

Geological details of the trench floor and rock pits are shown on Figures 3-1, 3-7, and 3-8. Additional subsurface control subsequent to bedrock mapping was provided by borings R-27, R-28, and R-29 (Figure 3-8). Detailed bedrock mapping covered the entire trench subgrade from stations 8+00 to 10+40.

The entire 240 foot exposure of bedrock in the trench is affected by deformation of the two-phase movement (Section 3.2.3). Resultant bedrock deformation, in and adjacent to this exposed

zone of intense deformation, is principally due to areal folding and not faulting (Figure 2-6). The observed gentle bedding dips (2°-10°SE) reflect the fold structural dip and not the regional homoclinal dip. Dips in the trench area average 2°-10° SE and represent the southeast limb of a southwest-plunging asymmetric anticline (Figure 2-4).

Faulting exposed in the trench is not a single structural break, but a zone of variable deformation approximately 70 feet wide. The most intense zone of deformation and area of maximum fault movement in the trench is between stations 8+78 and 9+48. This deformed zone is bracketed by steeply northwest-dipping normal faults at stations 8+78 and 9+48 (Figures 3-1 and 3-3); the attitudes of these faults are N75°E, 78°NW and N45°E, 80°NW, respectively.

Detailed mapping indicates the bedrock structures exposed in Trench II can be subdivided into three small-scale structural domains for description and analysis. These domains are delineated on the basis of deformation style and structural elements. The continuity of these domains along the entire length of the fault is uncertain. However, similar domains are inferred for the R-5/P-2 boring alignment. The southeast domain, stations 9+48 to 10+40, is characterized by relatively steep southeast-dipping (locally up to 50°) strata. No faults or folds are observed in the southeast domain. Joints and minor bedding plane slips are the only structural elements recognized.

The central domain, bounded at stations 9+48 and 8+78 by faults with normal movement, is intensely-fractured, faulted, and folded. This domain contains the greatest amount of deformation exposed in the trench and characteristically, exhibits bedding plane gouge, flexural slip, folding, and high-angle faulting.

The northwest domain, stations 8+78 to 8+00, consists of gentle, southeast dipping, Zone 1 strata. Small-scale reverse faults and joints are the predominant structural elements. Shallow bedding dips recorded in this structural domain reflect the limb of the Demster Beach Anticline; this dip appears in core boring data northwestward to approximately boring R-2.

3.3.2 Southeast Structural Domain

The southeast structural domain, stations 9+48 to 10+40, reflects deformation from folding and reverse faulting in the central structural domain. However, no faults or folds occur within this domain, nor are they found in borings to the east.

From stations 10+40 to 10+20, Zone 3 strata are essentially a flat lying sequence of interbedded sandstones and shales structurally dipping 2°-6°SE. Joints are well developed, mineralized with calcite, minor sulfides (pyrite, marcasite, sphalerite, chalcopyrite and galena) and stained with iron oxides

that impart a distinct coloration to the bedrock. Details of sulfide occurrence, paragenesis, and textures are described in Section 3.4. Joints are invariably parallel to the main N45°E deformation trend (Figure 3-14). Between stations 10+20 and 9+98, Zone 3 strata increase in dip to 6°-15°SE. Steepening of the structural dip from the observed 2°-6°SE is due to folding and subsequent reverse faulting in the central domain. Zone 2 strata between stations 9+98 and 9+51 increase in dip from 15°-50°SE. Both jointing and amount of calcite mineralization also increase. Shales and siltstones here are intensely jointed and disintegrate rapidly upon exposure.

The Zone 1/Zone 2 contact at station 9+51 dips 40° to 35°E and is defined by marker Bed B, a thick finely-laminated sandstone. Subsurface data from borings R-27 and R-12 combined with the Trench II exposure indicate that the underlying strata strike approximately N45°E.

3.3.3 Central Structural Domain

The geology and structure of the central structural domain (stations 9+48 to 8+78) are shown on Figures 3-1 and 3-10. This domain documents two phases and styles of faulting. The principal structural feature of this domain is the fault zone, between stations 9+48 and 9+45, that exhibits the maximum amount of movement and deformation. Boring R-12 intersects this fault zone at a depth of 173 feet downhole. When correlated to bedrock data this results in a strike of N45°E, and a dip of 70°NW.

Stratigraphic correlation (Zone 1/Zone 2 boundary, Figure 3-1) and structural data (drag folding, Rock Pit I, Figure 3-7) indicate that at least two fault movements have contributed to structural development. Field data indicate the fault movement along this zone consists of an initial reverse faulting phase with associated northeast-plunging eastward-verging folds (Figures 3-1, 3-9, and 3-16).

The main fault zone (stations 9+45 to 9+48) is characterized by two distinct areas of gouge and breccia. The breccia consists of angular fragments of sandstone and minor shale cemented in a coarse matrix of sandstone and minor calcite. Samples T-II-7NH, and T-II-8NH were taken from this immediate area. Northwest of the breccia is approximately 2 feet of gray, plastic, calcareous, clayey-silt gouge. The gouge is somewhat heterogenous and appears to be essentially derived from shale with brecciated sandstone fragments present.

To the northwest and adjacent to the fault zone, Zone 2 strata crop out. If only reverse movement had taken place, Zone 2 strata would not be preserved here. Bedding dips here are 40°-50° SE with bedding slip and bedding plane gouge well developed.

At station 9+38, the Zone 1/Zone 2 contact crops out, conspicuously marked by intensely fractured and mineralized marker Bed B. Exposed between stations 9+38 and 9+21, Bed B is folded into a broad, northward-plunging, asymmetric anticline. The fold axis strikes approximately N40°E, plunges 14°NE with an axial plane dip 60°NW. The core of the fold contains prominent, closely-spaced, fracture cleavage mineralized with calcite and minor sulfides. Rock Pits I and II (Figures 3-7 and 3-8) provide a vertical exposure of this folding. At station 9+24, the shallow limb of this fold is offset 3 feet by a N45°E normal fault with brecciation and calcite mineralization common.

Between stations 9+21 and 9+12, the Zone 1/Zone 2 boundary is folded into an asymmetric, eastward-verging syncline which preserves a portion of Zone 2 fossiliferous strata. The northwest limb of this syncline becomes the steeply-dipping, locally-overturned southeast limb of an asymmetric, eastward-verging anticline. The of this shallow northeast plunging fold is exposed at station 8+91. Flexural slip and bedding plane gouge are prominent on both limbs of this fold and locally small-bedding thrusts offset the strata. The northwest limb of the fold exhibits shallow dips which are subsequently offset by a N76°E, 40°-70°NW normal fault at station 8+78 (Figure 3-1). This faulting approximates the northwest limit of the maximum deformation associated with tight folding and faulting. Maximum offset is 2.5 to 3 feet with northwest-side downthrown. Boring R-12 intersected this fault approximately 141 feet downhole. The fault deformation in core is similar to trench exposure and consists of brecciated sandstone and gouge.

Fracture spacing in this domain is close and tight. Joints are of a different pattern from those in the southeast domain and reflect the fold and fault deformation and in part the regional joint sets. Joints developed in this zone and in core are complex, are shown on Figures 3-14 and 3-15 and are described in Section 3.3.3.

3.3.4 Northwest Structural Domain

The northwest structural domain, stations 8+78 to 8+00, extends westward as shown on Figure 3.1. This structural domain exhibits minor reverse faulting, jointing, and a dip of 7°-8°SE. Minor reverse faulting crops out of the trench floor and in Rock Pit I at stations 8+52 and 8+42, respectively. Subsurface correlation with boring R-12 indicates this fault was intersected at 94 feet downhole. The northwest structural domain exhibits the least amount of deformation within the trench area and is part of the southeast limb of the Demster Anticline.

Jointing is prominent, but the frequency is markedly reduced compared to the other two structural domains (Figure 3-1). Calcite and associated sulfide assemblages occur in minor fault

zones. The top of marker Bed A has a distinct surface coating of euhedral pyrite crystals.

Bedding dip analysis (Figure 3-11) and a detailed examination of boring R-18 (Figure 3-3) core indicate a uniform southeastward dip to the strata. Northwest of station 8+00, stratigraphic correlation coupled with dip data (Figure 3-3) eliminate any significant faulting between borings R-18 and R-9. Extrapolated subsurface data indicate identical conditions between borings R-9 and R-2 as shown on Section C-C' (Figure 2-6). However, minor faulting is associated with the western limb of the Demster Beach anticline as revealed in the core of boring R-25 (Appendix 2.5C, NYSEG 1979).

3.3.5 Rock Pit

Rock Pit I excavated 20 feet to the south of the Trench II centerline (Figure 3-9) provided a three-dimensional evaluation of the fold/fault deformation and allowed sampling of geological materials for age analysis and observation of any crosscutting mineralization. The strata exposed in Rock Pit I are essentially upper Zone I with minor amounts of Zone 2 strata.

Detailed geologic sections and floor maps of Rock Pit (stations 8+40 to 9+55) are Figures 3-7 and 3-12. The excavated limits of Rock Pit I are primarily the central structural domain with limited vertical exposures of the other two structural domains.

The principal brittle structural features exposed in Rock Pit I are faulting, folding, and fracturing. Specifically, fold hinges exposed at station 8+85 exhibit 1/4-inch to 6-inch offsets in the shaley strata along the northwest-dipping axial plane. Individual sandstone layers also show offset, intense fracturing, and gouge development at the fold hinge. The distinctly eastward-verging asymmetric style of the folding appears to flatten out with depth. The tight nature of the fold becomes more open at station 8+80 (Figure 3-7) on the pit floor, and there is no apparent deformation on the fold hinge.

Broader, more open anticlinal and synclinal folding occurs between stations 9+00 and 9+45. However, the thickness and competence of Sandstone Bed B probably in part controlled this local folding style. In any case, subsurface projection (Figure 3-3) indicates folding dies out significantly with depth and particularly within the massive Zone 1 sandstones.

From stations 8+40 to 9+10, sandstone marker Bed A demonstrates the two phases of folding. Broad, open folding of the Demster Beach Anticline accounts for the shallow 7°-8°SW dip exposed in Rock Pit I and on the trench floor from stations 8+40 to 8+55. Marker Bed A, based on subsurface data (boring R-11), resumes a characteristic regional structural dip, southeastward from the

folding and faulting seen in the trench floor and in boring R-27 (Figure 2-5).

The second folding style (i.e., tight northeast-plunging asymmetric folds) is delineated by marker Beds A and B in Rock Pit I. Associated with this folding is well-developed axial cleavage at stations 9+30 and 9+10 and fan cleavage at station 8+85. This folding style is post-anticline development and interpreted as related to reverse faulting. The fractured sandstone units are invaded by calcite veinlets with associated sulfide assemblages, while the shaley units, although fractured, are generally barren of calcite.

The second prominent structural element exposed in Rock Pit I is faulting. Both reverse and normal faults are present. The dominant movement is normal with maximum offset of 7 to 10 feet at station 9+48. Faulting has developed a zone of gouge and breccia approximately 3 to 4 feet wide.

Structural and stratigraphic relationships indicate this fault zone has undergone two stages of development: an initial reverse phase of undeterminable displacement and a final normal phase. The normal offset recognized in Rock Pit II (Section 3.3.6) is approximately 15 feet. Variation in offset is related to the northeast plunge of adjacent folded strata in the central structural domain. This offset variation supports post-reverse motion.

Sandstones adjacent to the gouge zone are mineralized with epigenetic calcite and sulfide assemblages which were sampled and analyzed. Individual blocks and lenses of Zone 2 strata adjacent to the gouge are also mineralized. Calcite mineralization is rare or absent in the fractured Zone 2 shale and the gouge. However, no evidence of crosscutting calcite mineralization was found in the gouge or shale unit.

Calcite mineralization fills fractures and joints in sandstone marker Bed B and intrudes the gouge and breccia zone at station 9+42 (Sample T-II-42-NH). A calcite veinlet, approximately 1/2-inch thick, is part of a larger calcite vein system invading sandstone Bed B. Calcite mineralization extends approximately 3 inches into the gouge zone (Figure Al-15B, NYSEG 1979). A thin section study and megascopic observations show no calcite vein offset. Microscopically the calcite is twinned and the twins are slightly displaced.

Sectioned rock slabs of this veined sandstone (Figure 3-13) suggest the following sequence of structural events on the basis of offsetting relationships: (1) initial fracturing and development of gouge and breccia; (2) emplacement of gouge and breccia into open joints; (3) displacement of gouge and breccia-filled joints by a younger calcite-mineralized joint set

(Figure 3-13 details this relationship). The exact elapsed time of the fracturing and filling events is uncertain.

Other normal faults with stratigraphic offsets of 2.5 to 3 feet occur at centerline stations 9+22 and 8+52. Both are steeply northwest-dipping faults that offset the shallow northwest limbs of folds. Normal faulting based on crosscutting relationships (Figure 3-7) followed the tight folding phase recognized in the central structural domain.

3.3.6 Rock Pit II

Rock Pit II (Figure 3-9) was excavated along the toe of folding phase recognized in the central structural domain. The northeast trench wall from stations 9+48 to 9+15 to aid in evaluation of three-dimensional aspects of the deformation and to explore for crosscutting mineralization. The rock pit is in the central structural domain and primarily exposes folding, flexural slip, and normal faulting. Drag associated with the normal faulting is prominent on both walls at station 9+25. The dragged Zone 2 strata show minor small scale thrusts, and flexural and bedding slip (stations 9+40 to 9+47). Details of the geology and structure of Rock Pit II are shown on Figure 3-9.

Sandstone marker Bed B is folded into a tight, intensely fractured, northeast-plunging fold which is mineralized with calcite. The northwest limb of this fold is truncated by a younger normal fault with stratigraphic offset of approximately 3 feet.

The main fault zone is exposed between stations 9+45 and 9+48 and consists of two distinct units, gouge and breccia. The gouge, northwest of the breccia, is approximately 1-foot wide and composed of gray, calcareous, clayey silt. Gouge appears to be primarily derived from shale. No calcite mineralization crosscuts the gouge; however, the gouge is calcareous. The sandstone breccia, to the southeast of the gouge, consists primarily of angular blocks of sandstone cemented by calcite and a matrix of finer sandstone. The breccia varies in width from 0.2 feet to 2.0 feet.

3.3.7 Joints

An analysis of site area joints relative to the Demster Structural Zone is summarized on Figure 3-14. Six joint sets were identified and, in order of abundance, are as follows:

	Strike	Dip
Set I	N74°E	High-Angle Dip
Set II	N44°E	High-Angle Dip
Set III	N44°W	High-Angle Dip
Set IV	N13°E	High-Angle Dip

Set V	N38°E	Low-Angle Dip
Set VI	N69°W	High-Angle Dip

Joint Sets I, II, III, and IV are characteristic of the folded Oswego-Pulaski Formations of the site area including the Demster Structural Zone (Figure 2-3). Joint Set V appears in Trench II and core borings R-12, R-14, R-17, and R-18. Set V probably is confined to the zone of most intense deformation. Joint Set VI may be associated with small-scale faults at Nine Mile Point, Salmon River east of Pulaski, and also within the region at a number of thrust faults in Onondaga County (Chute, 1969). Also, this joint set is recognized in the Lowville/Carthage area (Figure 4-1).

Fractures in the immediate vicinity of the Demster Structural Zone (Sets I, II, III, IV and V) exhibit pervasive calcite and minor sulfide mineralization. Calcite mineralized joints are rare or infrequent away from the Demster zone. As the zone of faulting is approached in subsurface and in trench exposures the amount of calcite in joints increases

Within the Trench II area and Demster Structural Zone, the six joint sets were identified from bedrock exposures and borings (R-12, R-14, R-17, and R-18), and are discussed below.

Joint Set I, N74°E, is the most prominent trend and is well defined in sandstone Bed A in the northwest structural domain (Figure 3-1). Also, two faults of this trend are exposed in the northwest structural domain. Joints of this set frequently dip northwest and are also recognized at Nine Mile Point.

Joint Set II, N44°E, is essentially parallel to the faulting and marked compression of the strata. Set II is relatively linear, particularly in the steeply-dipping beds of the southeast structural domain. This set generally dips northwest in the vicinity of the fault.

Joint Set III, N44°W, is locally linear and may be more abundant than recorded because Trench II and the inclined borings are roughly parallel to this joint trend.

Joint Set IV, N13°E, generally occurs irregularly and discontinuously in Trench II. This set may be inclined northwestward within the fault zone. Some minor faults are parallel to the direction of Set IV (Figure 3-14). In Trench I (Appendix 2.5H, NYSEG 1979), Set IV is more linear and systematic than in Trench II.

Joint Set V, N38°E, has a variable strike and is characterized by low dips. The joint surfaces are commonly curved and slickensided. Some minor faults were observed in core samples (boring R-17) that parallel this trend.

Joint Set VI, N69°W, is a minor trend and frequently appears northwest of the main fault in Trench II and in inclined borings R-12 and R-18. Similar trending fractures and faults are discussed in FSAR Section 2.5.1.2.4.

Analysis of the joint trends suggests a relationship between folding, faulting, and jointing of the site area. Folds identified from analysis of boring data (Figures 2-3, 2-4, 2-6, and 2-9) trend approximately N45°E. Joint Sets II and III are essentially parallel and perpendicular, respectively, to the fold axis and are apparently tensional in origin. Joint Sets I and IV occur at approximately 30° angles to the N45°E fold trend and apparently originated due to shear.

Joint set V is mainly confined to the Demster Structural Zone and appears to be associated with flexuring and bedding plane slippage. These joints are probably contemporaneous with reverse faulting. Joint Set VI may be related to the folding.

Reverse fault movement appears to accentuate the dip of Set II in the upturned beds of the southeast domain. Also, faults coinciding with the trend of Set I reflect the reverse displacement observed throughout the northwest section of Trench II (stations 8+11 and 8+52). Thus it appears that joint sets I and II developed prior to reverse faulting and are related to folding.

Joint Sets I and II also served as planes of weakness during the normal phase of deformation. Within Trench II, these trends coincide with that of faulting located at stations 8+78, 9+24, and 9+48.

Joints characteristic of the Eastern Stable Platform Physiographic Province are Sets I and III, based on bedrock mapping and previous investigations (Dames & Moore, 1978). In the northeast corner of the Platform (St. Lawrence Valley), Barber and Bursnall (1978) recognize three joint set directions which are essentially those of Sets I, II, and III. In this area, the N46°E joints are parallel to a sequence of folds (Figure 4-1), and the other two directions, N74°E and N50°W, traverse the folds.

Joints characteristic of the Appalachian Plateau are given by Parker (1942) as follows:

	Strike	Dip	Correlation Demster Area
Set I	N2°E	High-angle dip	Set IV
Set II	N80°W	High-angle dip	Set IV
Set III	N59°E	(average direction)	Set II

Joint Sets I and II of Parker (1942) have a spatial relation to the Allegheny arcuate salients (Figure 4-1). The stresses which caused the large-scale, thin-skinned folding of the Plateau probably caused the prominent joint sets of central-south New York. Kindle (1909) described peridotite dikes of the Ithaca area confined to the north-south joint planes. These dikes are exposed in workings of the Cayuga salt mine (Firtree Point Anticline) and are offset by low-angle bedding plane thrusts. These dikes thus may be older than or emplaced during the waning stages of late Paleozoic folding and thrusting (Matson, 1915, Prucha, 1968).

Based on structural evidence from areas investigated, Joint Sets I, II, III, and IV appear to be contemporaneous with the regional northeast folding. These four sets were further accentuated during the subsequent reverse faulting phase, and Set V, localized joints, may develop at this time. Within the central structural domain, a readjustment of Joint Sets I and II occurred at the time of normal faulting, the second phase of deformation.

3.3.8 Mineralization

Epigenetic mineralization in the trench proper and adjacent borings is primarily calcite with varying amounts of sulfides. The petrological and mineralogical aspects of this mineralization are described in Section 3.4 and Attachment I, Appendix 2.5I (NYSEG 1979). Epigenetic calcite and sulfide assemblages are well developed in breccia zones, joints, and faults. This mineral assemblage is predominately associated with sandstones and, to a lesser extent, siltstones. Gouge and shales are generally barren of visible calcite veins but are calcareous.

Sulfide assemblages are essentially undeformed and generally predate calcite (Figure 3-17). Recognized sulfides are pyrite, marcasite, sphalerite, and chalcopyrite. Sulfur isotope analysis (Attachment 3, Appendix 2.5I, NYSEG 1979) indicates that these sulfides were derived primarily by bacteriological reduction of sulfate in the sedimentary environment. Thus isotope data preclude a hydrothermal source for these sulfides.

Fluid inclusion studies on vein calcite (Attachment 2, Appendix 2.5I, NYSEG 1979) indicate a range of temperatures from 75°C to 180°C. Diagenetic temperatures of the Oswego Sandstone are reported by Barnes (1977) to range from 147°C to 176°C. Fluid

inclusion data indicate that the vein calcite was deposited at temperatures similar to diagenesis; however, the actual source of the heat is unknown.

Based upon reconstructed stratigraphic thickness and thermal history of central New York, these temperatures are somewhat higher than expected by normal geothermal gradients. Other inclusion studies by Kinsland (1977) and Barnes (1977) found similar temperatures at Nine Mile Point and Rochester, New York. These data coupled with reconstructed stratigraphy indicate that approximately 2 km of overlying rock may have existed at the site and that the geothermal gradient perhaps was steepened due to diagenesis. Conodont color alteration index supports an overburden thickness from 1,220 to 2,440 m in the Oswego/Mexico area (Epstein, et al., 1977); however, the exact depth of burial and thermal history is uncertain.

Petrologic studies indicate a definite paragenetic sequence for the calcite mineralization (Figure 3-17). Field data (fracturing and brecciation) and paragenetic sequence indicate that deformation occurred after sediment lithification and prior to last stage of calcite mineralization.

The paragenesis of the vein calcite demonstrates two minor deformation events, but the last stage of calcite mineralization is post-deformation. Further evidence for this is recorded at station 9+42 in Rock Pit I where a small vein of calcite intrudes the main gouge zone (Attachment 1, Appendix 2.5I, NYSEG 1979, and Figures 3-17 and 3-7) and is not offset.

Zones of breccia and gouge are prominent in the trench, rock pit excavations and core. The main fault areas have maximum gouge and breccia development. K-Ar dating techniques were used to analyze the clay separates from these gouges. Attachment 5, Appendix 2.5I (NYSEG 1979) and Section 3.4.1.5 discuss the K-Ar techniques and data. K-Ar ages from gouge obtained in the trench excavation (Rock Pit I) at stations 8+50, 9+22, and 9+46 yield inferred ages of 407±14, 421±15, and 392±14 m.y.a. Similarly, K-Ar determinations from gouge in boring R-12 (152.3 feet downhole) and boring R-14 (215.8 feet downhole) yield inferred ages of 431±15 and 419±15 m.y.a. K-Ar age on undeformed shale in R-12, 96 feet downhole gave an age of 488± m.y.a. Petrologic and fluid inclusion data indicate that the post-lithification deformation and mineralization have not been disturbed since the formation of-late stage calcite.

3.4 Mineralogical Studies and Age Determination

3.4.1 Purpose and Scope

Mineralogy studies were undertaken to determine the type, origin, and possible age(s) of minerals associated with folding and faulting of the Demster Structural Zone. Several techniques and

investigations were utilized to identify the mineral assemblages, distinct mineralogical episodes and to determine the possible age(s) of faulting. These detailed results are reported in Attachments 1, 2, 3, 4, and 5 of the 2.5I Appendix (NYSEG 1979).

The studies consisted of two separate approaches: one examined the formation and nature of the vein minerals, and the other examined the gouge minerals for suitable material to be dated by the K-Ar method. Investigation of the vein minerals included: microscopic examination in transmitted and reflected light; inspection of the cathodoluminescence of the calcites; study of the fluid inclusions in the calcites; and an analysis of the sulfur isotope ratios from the sulfides. Investigation of the gouge minerals included x-ray diffraction and radiometric age determination by the K-Ar method. Detailed methodology, participants and conclusions are contained in Attachments to Appendix 2.5 (NYSEG 1979), while only summaries and conclusions are presented below. Sample locations and studies performed are summarized in Table 3-1.

3.4.1.1 Results of Studies

3.4.1.2 Mineralogy and Petrography

Petrographic examination revealed a distinct sequence of mineralization. This sequence is visible in thin sections from samples at several locations in the Trench II subgrade and in selected core samples (Figure 3-17). A distinctive mineral episode, a detritus event, occurs near the end of the sequence. No deformation of the calcite is visible after this event. A minor deformation event occurred prior to this final sequence as evidenced in some slides, but it is not extensive. In thin sections where no distinct sequence is evident and the calcite is disturbed and shows strain effects, however, sulfides are not deformed. Detailed descriptions and discussions are included in Attachment 1 (Appendix 2.5I, NYSEG 1979).

3.4.1.3 Fluid Inclusion Studies

Studies of fluid inclusions in calcite were performed to estimate the temperature of formation of the calcite veins; the results are presented in Table 3-2 and Attachment 2 (NYSEG 1979). The temperatures of formation for all of the inclusions studied ranged from 75°C to 180°C. Averages for the six individual samples studied, were from 114°C to 150°C, with standard deviations for these individual samples of 12°C to 28°C. From the 46 temperature determinations, 32 were in the range of 120°C to 160°C.

A similar range of temperatures is reported at Nine Mile Point (Barnes, 1977) and FSAR Section 2.5.1.1.3. Based upon the estimated depth of overlying rock (up to 2.2 km) at the time of deposition of the calcite, the temperatures from these

investigations and from other studies in the area are considered to be high. Barnes (1977) suggested a steepening of the normal geothermal gradient due to diagenetic reactions as a possible explanation for the discrepancy; however, other explanations are plausible.

Regardless of how the source of additional heat is explained, a significant amount of overlying rock must have existed during the episodes of mineralization. About 2.2 km of overlying rock are needed to account for the temperatures of the inclusions; this assumes a maximum normal geothermal gradient of 35°C/km (Schmucker, 1969) and a surface temperature of 15°C and induces a crystallization temperature of 90°C. This temperature is near the lower limit of the homogenization temperatures, as determined by the fluid inclusion studies.

3.4.1.4 Sulfur Isotope Studies

Sulfur isotope studies were undertaken to ascertain the nature of the sulfide mineralization and to correlate samples on the basis of their sulfur isotope ratio. Sulfur isotope data on the 12 samples are included in Attachment 3 (Appendix 2.5I, NYSEG 1979). A wide range of values were obtained; the most unusual aspect is the exceptionally high $\delta 34_s$ in the sulfide which indicates a bacterial reduction of sulfates by H_2S gas. Thus H_2S gas reacted with the available metals and precipitated the sulfide minerals. The large scatter of 34_s values indicates that seawater sulfate was the original source of sulfur for the sulfides. The wide scatter and high values support this conclusion (Faure, 1977).

3.4.1.5 K-Ar Method

Samples of gouge from selected core, Trench II, and rock pit areas were examined by x-ray diffraction. A determination of the type of minerals present was made in order to evaluate the feasibility of using the K-Ar method of radiometric dating; the results are included in Attachment 4 (Appendix 2.5I, NYSEG 1979).

A comparison of the clay mineralogy of the gouge and siltstone and sandstone control samples confirmed that the same clay minerals, lMd illite, and some chlorite occur in all samples. No evidence of any expandable layers was observed in any of the clay size fractions (see Attachment 4, NYSEG 1979).

Potassium-argon determinations were made on clay minerals from the gouge and rock samples. The clay minerals were removed from samples and these concentrates were checked for purity by x-ray diffraction. Results of the K-Ar dating are listed in Attachment 5 (Appendix 2.5I, NYSEG 1979). Figure 3-18 shows the time relations of the samples.

The undeformed siltstone sample has an inferred age of 488± m.y.a., which is older than the acknowledged depositional age of

the rock. An age older than the depositional age of the rock indicates that the clay minerals analyzed were not heated in past geologic history to a sufficient temperature that would allow the complete escape of radiogenic argon from the clay minerals. Only when radiogenic argon is completely lost from a sample during an event can that event be dated with certainty. Consequently, the incomplete loss of argon will yield an inferred age that is significantly older than the age of the actual event or the event was not "felt" by the sample. The excess age is proportional to the excess pre-event argon that did not escape and can represent an error of tens of millions of years.

Since the age of the siltstone sample is older than the age of diagenesis, it can be concluded that the heat produced during diagenesis was not sufficiently high to completely remove the excess argon produced in the clays prior to deposition. The six gouge samples give ages from 430 m.y.a. to about 392 m.y.a. The sample with the youngest age is from the largest area of gouge and zone of greatest movement. This would indicate that at least some resetting and possibly a complete resetting of the clay through argon release may have occurred. The difference of almost 100 m.y. between the control sample (siltstone) and the gouge sample (T-II-26-NH, Figure 3-18) indicates that a significant amount of resetting did take place. Whether enough heat was generated to completely reset the clays of the gouge samples is unknown.

3.4.2 Conclusions of Mineralogical Studies

An exact age of faulting and last movement cannot be assigned based on the mineralogical studies; yet, the cumulative evidence does demonstrate reasonable consistency.

Fluid inclusion studies indicate that the calcite formed at depth, possibly with an overlying rock column of 2 km or more. Sulfur isotope data indicate very high 34S values, and most of the sulfide was produced by bacterial reduction of limited sulfate. Sulfur isotope data eliminate the possibility of a hypothetical igneous mass as the source of the mineralizing fluid for the sulfides and calcite. Explanation of the fluid inclusion temperatures involving unknown magmatic activity must be precluded, because only nonmagnatic sulfides are present in the veins. Detailed petrographic studies of the vein minerals agree with this hypothesis.

All deformational features in the calcite are minor. Deformation occurred during the sequential calcite mineralization, but prior to the latest mineralization in that sequence. Furthermore, deformation was not sufficiently pervasive to open new fractures in the pre-existing mineralized areas. The last stages of the mineral sequence are not deformed. Detritus (Figure 3-17) deposited during this sequence may be related to the stress relaxation interval of the structures.

Potassium-argon age determinations yield an age of approximately 400 m.y. for samples of clays from gouge. However, similarities between the clay mineralogy of the gouge samples and control samples, and the probability of partial resetting of argon in the analyzed clays prevent a conclusive quantitative determination of the age of minerals and time of last movement of the Demster Structural Zone.

3.5 Structural Synthesis - Demster Structural Zone

Structural data substantiated by the stratigraphic sequence in the trench vicinity identified two phases of folding and faulting for the Demster Structural Zone. These multiple deformation events have resulted in three separate, small-scale structural zones. Each structural zone in part exhibits the effects of the overall fold/fault deformation and no movement has been identified since latest calcite mineralization.

Sequentially, the structural deformation appears to be of two stages or phases. The first stage of apparent compression resulted in a series of broad, low-amplitude, eastward-verging, southwest-plunging folds (Demster Beach and Mexico anticlines and New Haven Syncline) which account for the main stratigraphic offset. This stage is manifested by a gentle southeast dip at extremities of Trench II. With continuing compression, the steep limb of the Demster Beach anticline was faulted in a reverse sense. Associated with the reverse faulting are small-scale, eastward-verging, northeast-plunging folds. This folding style is recognized only in the intensely deformed strata of the central structural domain and may not have developed along the entire length of the Demster Structural Zone. The exact stratigraphic displacement due to reverse faulting could not be ascertained at the trench exposure because the second-stage structural element, normal faulting, modified the offset due to reverse faulting (Figure 3-16).

Normal faulting resulting from apparent extension, the final deformational event, truncated the limbs of the small-scale folds and displaced the main reverse fault at Trench II station 9+47. This relaxation of the compressional forces resulted in outliers of Zone 2 strata in the central structural domain.

Based on petrologic evidence and bedrock mapping of the structural features, the last stage of epigenetic calcite mineralization was emplaced after the normal fault movement. The earliest phases of mineralization may have occurred prior to the end of the deformation as shown by the twinning of calcite, crushing, and detritus events identified in the paragenetic sequence (Figure 3-17). Fracturing associated with the folding and faulting provided channelways for the calcite mineralization. The lack of prominent calcite mineralization in the core borings of the New Haven site and site area, except in the vicinity of

the Demster Structural Zone, does not support speculation regarding the presence of pervasive fracturing.

Subsurface data along the R-5/P-2 boring alignment correlate with the structural style exposed in Trench II. The stratigraphic offset along this alignment is apparently similar to the R-1/R-2 alignment. Normal faulting appears to die out to the southwest, and the main stratigraphic offset there is due to folding. Geophysical studies along the projected deformation trace indicated a lack of continuity of fracturing.

Fluid inclusion studies (Attachment 4, NYSEG 1979) indicate a range of temperatures from 75°C to 180°C for the formation of the calcite. Temperatures are higher than would be expected on the basis of reconstructed stratigraphic thicknesses and a reasonable post-Ordovician geothermal gradient. The lack of any documented magmatic activity in the site area at depth suggests that the geothermal gradient may have been steepened by the thermal effects of diagenesis. The development of this structural zone is inferred to be related to basement involvement.

4.0 DEMSTER STRUCTURAL ZONE - CORRELATION TO REGIONAL GEOLOGIC SETTING

4.1 Introduction

Oswego County bedrock geology is based on projection (Rickard and Fisher, 1970), specific geotechnical investigations (Niagara Mohawk and PASNY), and stratigraphic correlation between sporadic outcrops (Patchen, 1966, and Bretsky, 1970). Prior to the New Haven site subsurface investigations, known structures included small scale west-northwest trending brittle structures at Nine Mile Point. Although of limited extent, these structures, because of their proximity to the Nine Mile Point nuclear facility, have been intensely studied.

The New Haven site and subregional investigations established that the Upper Ordovician Oswego strata are broadly folded and locally faulted, especially on the eastern oversteepened limbs of the folds. Faulting is documented on the Demster anticlinal flank and inferred on the flank of the Mexico Anticline. Field investigations and subsurface data indicate the faulting associated with the Demster Anticline apparently dies out both to the northeast and southwest along strike. The true depth of the faulting is unknown. Faulting may extend into basement, but could be related to broad basement deformation without directly extending into basement.

Although the site area structural elements appear to be anomalous in context of work published prior to the Nine Mile Point and New Haven SAR investigations, correlation with geologic data from adjacent areas indicates the strata are perhaps more deformed then previously recognized. Geologic studies and data from

Rickard (1973), Chadwick (1915), Cushing (1910), Kay (1942), Isachsen and McKendree (1977), Barber and Bursnall (1978), Zartman (1977) and Murphy (1981), among others, demonstrate that post-Ordovician folding, faulting, and igneous activity have affected central and northern New York. The exact mechanism, correlation and timing of these various geologic elements is uncertain. Fisher (1969) and Megathlen (1938) propose a Middle to Late Silurian age for the deformation in the Mohawk Valley exclusive of the igneous activity.

The nearest well-documented folding and faulting of Paleozoic strata is south of the site area and directly related to Alleghanian deformation (Figure 4-1). The trend, style, and nature of the site area deformation are dissimilar to those of the Alleghanian structural style. Also, the site area strata are approximately 1500 feet stratigraphically below the Silurian decollement surface which in central New York is generally regarded as the base of Alleghanian style deformation. Summarily, from the outermost folds and thrusts attributed to Alleghanian shortening to the Ottawa-Bonnechere Graben in Canada, the intervening lower Paleozoic strata previously have been thought to be relatively undeformed.

Correlation of site area structural elements to deformation in adjacent areas of New York and Canada is based on similarity of structural style. Thus when the site area structural data are analyzed in a regional tectonic framework, coupled with regional geophysical and subsurface data, a coherent tectonic synthesis can be developed for the Demster zone.

4.1.1 Geologic Setting - Demster Structural Zone

The region surrounding the Nine Mile Point site area can be subdivided into three lithotectonic domains. A Grenville age Precambrian domain that can be divided into two units, a central Metasedimentary Lowlands Belt (Forsyth, 1981) and a Highland Belt of predominantly meta-igneous rocks (Buddington and Leonard, 1962; King, 1976). Separating these two domains is the northeasterly trending Colton-Carthage Mylonite Zone or Northern Border Fault of King (1976). Gravity, areomagnetics and bedrock mapping in Canada (Forsyth, 1981) and the Adirondacks (Geraghty, et al., 1981) demonstrate the probable continuation of the mylonite zone beneath the Paleozoic strata. Recrystallization which produced the dominant mylonitization occurred at hornblende granulite facies (630°C-760°C at 6 kb) and would have taken place at a depth of about 20 km (Geraghty et al., 1981). To the southwest these two Grenville age sequences are overlain by a southward thickening Paleozoic sedimentary wedge of the Appalachian Basin. In the site area, this sedimentary sequence includes the Upper Ordovician Oswego and Pulaski Formations while to the south, successively younger Silurian and Devonian units crop out. Depth to basement in the site area is variable and ranges from 1500 to 1000 feet below the present surface (Rickard,

1973). Basement structure contours in the site area are apparently uniform and dip to the south at approximately 50-90 feet/mile. Rickard (1973), however, depicts basement structure contour anomalies in Orleans, Genesee, and Wyoming counties related to the Clarendon-Linden structure while another basement anomaly is located in Ontario County (Figure 4-1). Details of the regional geologic setting are discussed in FSAR Section 2.5.1.1.3.

Before reviewing and integrating pertinent post-Ordovician structures in central New York, and the possible correlation of these tectonic elements to the Demster Structural Zone, it is appropriate to itemize the salient aspects of the Demster deformation:

1. Upper Ordovician strata are folded into a series of northeast-trending, low amplitude anticlines and synclines.

2. Locally, the eastern oversteepened limbs of the anticlines, particularly the Demster Beach and to a lesser extent the Mexico, are faulted.

3. The dominant mode of stratigraphic displacement across the Demster zone is due to folding and reverse faulting.

4. Subsequent to reverse fault deformation, small-scale normal faulting truncated and cut structural elements indicative of folding and reverse faulting.

5. The zone of deformation is mineralized with sulfides and calcium carbonate which has fluid inclusion temperatures indicative of a mineralization range from 170°C to 73°C.

6. Small-scale soft sediment structures are noted.

Structural style, fold vergence, and trend of the large scale site area deformation is indicative of an apparent southeast directed maximum compressive stress which is at variance to the documented north-northwest directed apparent maximum stress direction associated with Alleghanian shortening (Engelder and Geiser, 1979, and Engelder, 1979).

A review of the literature of post-Ordovician deformation in central New York, adjacent Adirondack region and Canada, demonstrates the following types and ages of tectonism and deformation (Selleck, 1980, Rickard, 1973, Murphy, 1981, Fisher, 1977, among others): post-Ordovician folding, post-Ordovician intrusive activity, and post-Ordovician faulting, all of which may have contributed in part to the site area deformation.

To define the Demster zone in the context of the development of this lithic domain, the structural elements of the region are examined. Structural elements of the region can be divided into separate and possibly temporally distinct deformation styles. These structural styles enable a correlation of the Demster zone to mapped structural elements of the region. Development of the Demster zone is directly related to post-Ordovician tectonism of the central New York Paleozoic section. Thus similar structures elsewhere in the region help to define and establish the relative age of site area structures.

In part, this post-Ordovician deformation may be inherited from pre-Paleozoic tectonism and may be related to slumping, compaction and faulting over Hadrynian extensional elements reported elsewhere (Fisher, 1977, and Faukindy, 1977). Selleck (1980) divided the post-metamorphic structural elements of the region into three broad tectonic categories subsequently discussed.

4.1.2 Post-Ordovician Deformation

Folding and faulting of the central and western New York Paleozoic section can be divided into two differing tectonic styles and geochronologic ages. FSAR Section 2.5.1.1.3 discusses in detail these structural styles. This subdivision is primarily a stratigraphic one based on structures associated with deformation above and below the Late Silurian Salina Group and, in particular, the Syracuse Formation. Above this structural and stratigraphic boundary (Salina decollement), the overlying strata are deformed into a series of low amplitude east-northeast to east-west trending folds and thrusts that die out near Syracuse, but increase southward in amplitude and frequency toward the Appalachian structural front. Apparent tectonic transport for the development of these folds and thrusts is from a southerly direction. In New York state, deformation associated with this shortening is not reported below the Salina Salt. Thus, below this decollement surface, the effects of Alleghanian style deformation are not recognized. However, using residual strain data in Devonian strata beyond the outer Appalachian foreland fold and thrust belt, and Silurian strata below the Salina Group, Engelder (1979) documented conflicting data. Strain data from the Devonian Onondaga and Silurian Lockport and Grimsby strata are indicative of north-northwest shortening normal to the Appalachian fold and thrust belt. This residual strain demonstrates tectonic stresses similar to the stresses responsible for Appalachian folding beyond the Appalachian folds (Engelder, 1979). To explain this apparent discrepancy, either a second decollement in the Ordovician shales (below the Oswego), or a general north-northwest shortening of the crust under the Plateau is suggested (Engelder, 1979). A possible decollement is recognized by Fisher (1980) in the Devonian Union Springs Shale in the central Mohawk Valley.

In contrast, a second group of folds and faults are identified particularly along the western and northern flanks of the Adirondack Mountains. Although the Paleozoic strata are considered essentially undeformed, a sequence of northeast-trending low amplitude folds as well as high angle faults are identified. These northeast to north-northeast trending structural elements are not recognized above the Silurian decollement. In the northwest Adirondack region, folds and faults have been mapped by Chadwick (1915), Cushing, et al, (1910) and Barber and Bursnall (1978).

The intervening area between the site and the Watertown district is mapped by Johnson (1971). No large scale fold or major faults are reported, but small-scale normal faults are documented near Carthage and Lowville (Figure 4-1) and increase in frequency and offset in the Mohawk River Valley. The prominent features of the Johnson mapping are the dominant northeast-trending map pattern of the Middle Ordovician carbonates and a distinct northeast topographic alignment. Further south along strike in the site area proper, northeast-trending folds and faults are documented and discussed in Section 3.0.

To the south and southwest of the site area, Silurian and Devonian units crop out as part of the southward thickening Appalachian homocline. Near the Finger Lakes district, Upper Silurian and younger strata are deformed into east-west, low amplitude folds and thrusts associated with Alleghanian shortening. Between the last documented Appalachian fold and the site area to the north, essentially east-west striking, gently southward-dipping Upper Ordovician, Silurian and Lower Devonian strata crop out. Extensive glacial deposits conceal bedrock; the only major structures delineated are the Clarendon-Linden zone with associated monoclinal elements (Van Tyne 1975, Chadwick 1915), localized small scale faults, and high angle pre-Devonian faults in the Mohawk Valley (Fisher 1977 and 1980, Megathlin 1938). None of the above involves surface rupture.

Thus, interpretation and correlation of the regional geology to the Demster zone require examination of deep drilling data, as well as regional geophysics and stratigraphic information.

4.1.2 Subsurface Structure

Fisher (1977) postulates that Hadrynian(?) age, Allens Falls and Nicholville strata are fault trough deposits related to the rupture of the North American Plate during late Hadrynian time. This apparent rupture and rifting resulted in a sequence of northeast-trending horsts and grabens filled with so-called "granite wash" as reported in deep drill holes from the Allegheny Plateau and Adirondack Lowlands (Fisher, 1977). Rifting and epeirogeny also occurred during the Quebecian or Penobscot Taphrogeny prior to closing of the Proto-Atlantic and the onset of the Taconic Orogeny.

Thus, stratigraphic and sedimentologic data infer early northeast-trending subsurface structure. Rickard (1973), using selected deep well data, studied the subsurface stratigraphy and structure of the Cambrian and Ordovician carbonates of New York. Structure contours were drawn on the tops of the Precambrian basement, the Knox unconformity, and the Trenton Group. As pointed out by Rickard (1973), subsurface data in many areas is sparse; however, his structure contour maps demonstrate apparent north-trending subsurface faulting and folding and may show only a small portion of those structures actually present. Figures 4-2, 4-3, and 4-4 detail those various contoured surfaces.

<u>Precambrian Structure Contours</u>

Structure contours drawn on the Precambrian surface (Figure 4-1) generally trend east-west with notable flexures in Oswego and eastern New York counties. The Precambrian surface dips approximately 50 ft per mile in central and western New York. In the site area depth to Precambrian is approximately 1,500 feet.

Also the Precambrian structure contour map (Figure 4-1) contains a series of north to north-northeast trending anomalies that Rickard interprets as a series of horsts and grabens.

The Clarendon-Linden and Mohawk River Valley faults are prominent structural elements outlined by this surface. In Ontario County, a horst is indicated near Canandaigua Lake. Identical structures are illustrated by the structural contours on the Knox unconformity (Figure 4-2). However, the Trenton structure contours, based on greater subsurface control, outline not only anomalies seen in the basement and on Knox surfaces, but also two essentially north-trending deflections in Cayuga County (Figure 4-3). Thus vertical stacking of three horizons demonstrates coincidence and upward continuation of the basement structural elements to at least the Trenton.

To confirm these structure contour anomalies and to contour horizons higher than the Trenton top and possibly relate these anomalies to the Demster zone, deep exploration boring data from Kreidler et al (1972) and Hartnagel (1938) were contoured. The tops of the Ordovician Trenton, Ordovician Queenston, Silurian Lockport, and Devonian Onondaga were chosen for contouring and are shown on Figures 4-4, 4-5, 4-6, and 4-7 respectively.

Subsurface data demonstrate three salient results: (1) Ordovician through Devonian strata are deformed by faulting and/or folding; however, the true style and nature of these structure contour flexures is indeterminate; (2) the apparent north-trending anomalies of Rickard (1973) are more north-northeast to northeast in orientation; and (3) the Clarendon-Linden structure, although not included on these maps, is expressed in all horizons up to Middle Devonian where the

structure apparently dies into a monoclinal element (Fakundiny, 1978 and Hutchinson et al, 1979).

Interpretation of the subsurface data not only verified Rickard's (1973) Trenton anomalies but extended the contours higher into the stratigraphic section. The northeasterly trend is coincident with regional geophysical and basement anomalies. Whether structure contour anomalies are due to faulting or folding or both, is uncertain. Many could be interpreted as faults and indeed drilling data, supported by geophysical data, infer basement involvement. Basement deformation is inferred where chlorite grade metamorphism of amphibolite grade Grenville basement is coincident with both structure contour and gravity anomalies. The deformation style of this apparent basement involvement on the overlying Paleozoics is uncertain and may include compaction structures, growth faulting, folding and faulting.

Trenton Structure Contours

Rickard's (1973) Trenton structure contours, shown on Figure 4-4, are similar to his basement and Knox unconformity contours. In addition, three other anomalous zones are identified. The Clarendon-Linden and Mohawk Valley structures, substantiated by field mapping, geophysics, and subsurface data are not discussed here. See Section 2.5.1.1.3 of the FSAR.

Reexamination and addition of other data to Rickard's base from Kreidler, et al (1972) and Hartnagel (1938) confirmed the anomalies in Ontario and Cayuga counties. They trend more northeasterly than previously reported. Also, other contour anomalies are located in Onondaga, Oneida, and Oswego counties as shown on Figure 4-4. The interpretation of these structure contours may be folds, faults, or both. Geophysical anomalies are also coincident with these contour deflections. The most prominent correlation is with the Cross Lake, Auburn, Syracuse and Camden gravity anomalies (Figure 4-8). Aeromagnetic correlation is excellent with the Cross Lake anomaly.

Queenston Structure Contours

Queenston (Upper Ordovician) structure contours are shown on Figure 4-5. The same northeast-trending anomalies revealed by the Trenton data are observed at this higher stratigraphic position and geophysical correlation is good. Specifically, the Cross Lake anomalies are most prominent. Where the Queenston is absent to the north in Oswego and Oneida counties, contouring and correlation to the Camden gravity anomaly is not possible.

Lockport Structure Contours

Lower Silurian Lockport outcrops further south than the Queenston, thus, mutual data points are less frequent. The

Lockport contours are deflected into a northeast trend near Cross and Canandaigua Lakes (Figure 4-6). Further south and west, Murphy (1981), shows the Lockport structure contours disturbed by the Clarendon-Linden and the Keuka Lake faults (Figure 4-9). Gravity anomalies are coincidental with structure contour deflections near Cross Lake and Auburn.

Onondaga Structure Contours

Figure 4-7 is the structure contour map of the top of the Onondaga. Well control to the north of the area is limited. Only a subtle hint of the Cross Lake anomaly is present. The most prominent deflection is due to the Keuka Lake fault. Murphy's (1981) Onondaga structure contours substantiate this interpretation and also show the Clarendon-Linden zone. Thrust faults, folds, domes, and strike slip faults associated with Alleghanian shortening are indicated (Figure 4-10). Murphy (1981) indicates the Keuka Lake fault cuts strata as old as Queenston and extends upward through the Middle Devonian Tully but apparently dies out in the overlying Upper Devonian shales.

Subsurface data indicate a southward continuation of the northeast structural fabric from the site area. The southern limit of these deep discontinuous anomalies is uncertain, but they could extend into Pennsylvania (Section 2.5.1.1.3). Although the exact nature of this deformation is unclear as to either folding or faulting, it is at least locally evident in central New York that the basement is involved. The coincidental vertical stacking extent of the deformation from Trenton to Queenston to Lockport and locally Onondaga suggests a deep source. Based on structure contours and literature review, only strata older than Middle to Late Devonian appear to be deformed by the north-northeast to northeast-trending fabric and thus appear to at least limit the age of these structure contour anomalies.

4.1.4 Igneous Activity

Post-Grenville igneous activity in central and western New York is rare. Documented igneous activity is confined to small-scale peridotite and alnoite dikes intruded into rocks as young as Devonian, numerous bentonite layers and diabase dikes. The diabase dikes range in age from late Proterozoic to Middle Cambrian and Middle Devonian (Fisher, 1980, and Geraghty, et al., 1979). These dikes crop out in the Grenville age units of the Adirondack Massif at Fonda and Rand Hill. Several thin bentonite beds in Middle Ordovician carbonates are interpreted by (Kay, 1953 and Brun and Chagnon, 1979) to be related to syn-Ordovician volcanic activity. Similar bentonite layers are reported in the Devonian Onondaga (Fisher 1980). Also, sporadic calcite and sulfide mineralization infills faults and fractures in Ordovician and perhaps younger sediments. Locally, this mineralization may be due to thermal reactivation of the Proterozoic basement

(Selleck, 1980) and may be a manifestation of the activity that produced the northeast-trending structure contour anomalies. Alternatively, Barnes (1977) hypothesizes on the role of fluid migration during burial.

Kimberlite and alnoite dikes are discussed by Smyth (1897), Matson (1905), Kemp (1891) and Megathlin (1938) among others. Location and distribution of the small tabular bodies are shown on Figure 4-9. These small-scale dikes are most abundant near Ithaca and Syracuse, New York with minor occurrences in the Mohawk River Valley and Thousand Islands region; however, none are recognized in the intervening area. These rocks have a distinctive chemistry and mineralogy presumably derived from great depth and perhaps the lower crust (Carmichael, et al, 1974) or upper mantle (Jackson, et al, 1982). Basu and Rubury (1980) indicate these dikes are geochemically similar to kimberlites from the Kimberley, South Africa area.

McHone and Corneille (1980) discuss the ages and distribution of Mesozoic alkaline dikes in the Champlain Valley. In the Burlington, Vermont area, no definitive evidence for post-dike faulting has been found and Stanley (1980) proposes an early Mesozoic age of faulting but postulates an older middle to late Paleozoic origin for the high-angle fault system.

In central New York, Zartman et al (1967), and Zartman (1977), using both K-Ar and Rb-Sr techniques obtained dates of 493-118 m.y.a. for these dikes. These dikes are exposed in Upper Devonian units, hence, there is an obvious discrepancy which Zartman et al, (1967) attribute to excess argon. Zartman (1977) assigns a Late Jurassic to Early Cretaceous age by regional comparisons.

Structural data (Prucha, 1968 and Matson, 1905) demonstrate in the Ithaca area that these kimberlitic dikes are offset and deformed by low-angle thrusting and folding associated with the Alleghanian deformation. Clearly, some of these dikes are more likely post-Devonian but pre-Alleghanian (300-250 m.y.a.). Elsewhere in central and northern New York these dikes apparently are not faulted. Megathlin (1938) reports an alnolite dike intruded into the Manheim Fault at East Canada Creek.

The limited occurrence of these dikes does not preclude the existence of more dikes beneath the extensive glacial cover of central and northern New York. None are identified in the site area. Zartman (1977) indicates a substantial portion of the Appalachian Basin was intruded by these distinctive rocks. The exact age of these dikes is poorly understood and may represent more than one phase of igneous activity. Age and structural data support a span of activity from at least middle Paleozoic to Middle Jurassic time. The distinct chemistry and mineralogy of these rocks are indicative of deep seated extensional environments related to rifting (Carmichael, et al, 1974).

Summarily, these dikes may infer middle Paleozoic to Middle Jurassic extensional rifting and possible mantle upwelling of the crust in central New York, which suggest the last tectonic event which may have contributed to the structural development of the Demster zone.

5.0 CORRELATION OF STRUCTURE CONTOUR ANOMALIES TO GEOPHYSICS

5.1 Introduction

The gravity and aeromagnetic data covering the region surrounding the Nine Mile Point site are mutually consistent in defining a northeast-trending structural fabric in the crystalline basement. Previously, Rickard (1973) had identified north-south basement trends based on limited boring data. The northeast trend is similar to the structural fabric of the Central Metasedimentary Belt (Forsyth, 1980) northeast of the site and the Clarendon-Linden structure (Hutchinson and others, 1979) west of the site.

The geophysical data consists of gravity and aeromagnetics. The gravity data are indicative of density changes, while magnetic data are indicate of changes in magnetic the susceptibility. Although it is an oversimplification, gravity variations in this area can be attributed to basement rock topography while aeromagnetics are more related to lithologic contrasts. In some instances, although they appear inconsistent, some gravity highs are coincident with magnetic lows, while in other locales gravity lows are located in the same area as magnetic highs. However, these inconsistencies are resolved with borehole data and regional geologic information. Several of the broad and "simple" gravity anomalies are characterized by a complex series of magnetic anomalies. The geophysical data indicate that the crystalline basement in this portion of New York state is composed of a complex assemblage of rock types within a dominantly northeast-trending structural framework.

5.1.1 Aeromagnetic Data

The aeromagnetic contour map (Figure 5-1) covering the region around the Nine Mile Point site is a composite of two data sets. The southwestern portion of the map was flown at 3000 feet above sea level along east-west flight lines spaced 2 miles apart with north-south tie lines spaced 15 miles apart. The northeastern section of the map was flown at 1000-foot ground clearance with east-west flight lines at a one mile interval and north-south tie lines approximately 20 miles apart.

5.1.2 Gravity Data

The Simple Bouguer Gravity Anomaly map (Figure 5-2) is composed of data acquired by many workers and compiled by the New York State Geological Survey (Revetta and Diment, 1971; Simmons and

Diment, 1972). The data points used in preparing the map are indicated and were reduced to a datum of sea level using a density of 2.67 gm/cm^3. Included on the map are the locations of selected wells which have penetrated the Precambrian basement.

5.2 Regional Geophysical Setting

The gravity and magnetic data for the northeastern United States and adjacent Canada contribute significantly to the understanding of the structural fabric of the crystalline basement of central New York state. The dominant trend of the magnetic data is complex as a result of numerous apparent intrusive bodies as well as lithologic and probable paleomagnetic variations. Alternately, the anomalies exhibited in the gravity data are indicative of deeper, regional structures and are therefore reliable indicators of the regional structural framework. Figure 2.5-8 is the regional gravity map for the northeastern United States and adjacent Canada with trends of selected gravity anomalies indicated. Some of the trends shown are those of Diment and others (1979) while the remainder are the result of the present interpretation and based upon evidence provided by Hutchinson, et al, (1979), Forsyth (1980) and Welch (1981). No attempt has been made to indicate all the anomalies in the data, but rather those which are interpreted as indicative of the regional structural and tectonic setting related to the development of the Demster style deformation.

Anomalies A through C and Line D (Figure 5-3) correspond to anomalies S, K and B and Line F, respectively, of Diment, et al, (1979). Anomaly A indicates the axis of the Scranton gravity high; B the Kane gravity high and C the Grenville gravity high. Line D corresponds to the northwest-trending Line F of Diment, et al, (1979) and the Schenectady-Wells Island Line (SWIL) of Welch (1981). The Scranton, Kane, and Grenville gravity highs are all interpreted as resultant from major crustal structures (Diment, et al, 1979). Line D is interpreted as a cross-cutting feature which truncates or offsets the northeast-trending anomalies (Diment, et al, 1979; Welch, 1981).

Anomalies E, E' and F (Figure 5-3) are interpreted differently than in the previous work (Diment et al, 1979, among others). The gravity highs E and E' correspond to the location of the Clarendon-Linden fault. Previous studies (Diment, et al, 1979; Hutchinson, et al, 1979) interpreted the Clarendon-Linden fault as a continuous, arcuate structure extending across Lake Ontario. The present interpretation depicts the Clarendon-Linden gravity anomaly and structure as a segmented feature, with E and E' denoting apparently en echelon segments of the arcuate trend. The nature of the segmentation is unclear. Discontinuous faulting is a possible interpretation although a west-northwest trend is indicated by the gradient east of the Clarendon-Linden and may be the result of an offsetting structure in this region; other explanations are possible.

Anomaly F was interpreted by Diment, et al, (1979) as a possible continuation of the Kane gravity high. Anomaly F is similar in magnitude and wavelength as well as parallel to the Kane gravity high. The separation of anomaly F from the Kane gravity high by an apparent northwest gravity low warrants a singular designation for anomaly K.

In summary, the regional geophysical setting is one of dominant northeast-trending and subordinate northwest-trending features. The wavelength and linearity of the gravity anomalies varies from linear, long wavelength anomalies in the southeast to arcuate, possibly discontinuous, shorter wavelength anomalies in the northwest.

5.3 Geophysical Anomalies in the Site Vicinity

Many of the anomalies evidenced in the gravity and aeromagnetic data for the region do not correspond with known geologic features. This is due primarily to the limited number of drillholes which have penetrated the Precambrian basement. The geophysical anomalies, particularly the aeromagnetic anomalies, are caused by lithologic inhomogeneities and possibly structural complexities in the crystalline basement.

The paucity of well data preclude unequivocal interpretation of the many geophysical features evidenced in the region. Interpretation of many of these anomalies based on the present available data would be speculative; those considered to be important are discussed here. Several of the larger geologic structures in the site region can be correlated with the geophysical data providing a geologic basis for the interpretation of the geophysical data.

5.3.1 Cross Lake Anomaly

This anomaly, informally termed the Cross Lake anomaly, is evidenced by coincident elongate gravity and magnetic highs located approximately 15-20 miles south of the Nine Mile Point site. The geophysical anomalies are coincident with a structural high interpreted from drilling data (Figure 5-4). One interpretation of the drilling data in the Cross Lake area is that of an elongate horst block. Gravity data support the presence of relatively higher crystalline basement in this area. Aeromagnetic data support the hypotheses of an uplifted block of basement material as well as lithologic variations associated with basement uplift.

The top of the basement surface, based on drill hole data, in the area of Cross Lake is 1000 feet lower than in the vicinity of Fair Haven. The total field intensity in the Cross Lake area is approximately 800 gammas higher than in the Fair Haven vicinity. This inverse relation between the aeromagnetic data and the top of Precambrian elevations together with the retrograde

metamorphism evidenced in this area (Figure 5-4) would indicate alteration and possibly intrusive activity associated with basement uplift.

5.3.2 Camden Anomaly

An elongate, northeast-trending, 8-milligal gravity anomaly is located northwest of Camden, New York. The aeromagnetic data for the same area indicate a complex series of magnetic highs and lows. The gravity high is approximately coincident with a structural high, interpreted by Willette (1979) on the basis of drilling data, near the abandoned Camden gas field.

5.3.3 Auburn Anomaly

Similar to the Cross Lake anomaly, this elongate 4-milligal gravity anomaly is coincident with structure contour deflections. Aeromagnetic data, however, indicate a magnetic low, an inverse relationship as compared to the Cross Lake anomaly.

5.4 Summary of Geophysical Data

The gravity and magnetic data for central New York provide confirmation of inferred structures and indicate a northeast fabric for the region. The geophysical data support the interpretation that the probable faulting in the Cross Lake area is related to basement uplift and probable alteration of the basement rocks along a northeast trend. The structural high inferred in the Camden area is supported by a gravity high at the same locality. The Demster zone proper does not have a specific geophysical signature; this would indicate limited or no direct basement control. However, it could have resulted from an indirect consequence of basement deformation.

6.0 CONCLUSION

Combined geologic and geophysical data clearly demonstrate, exclusive of Alleghenian deformation, that the central and northern New York Paleozoic sequence is deformed into a series of apparently discontinuous north-northeast to northeast trending structural elements. The Demster and Mexico structures are a portion of this deformation. Gravity anomalies, subsurface petrographic data and distinctive magmatic activity all suggest deep crustal or basement involvement in the development of this basic structural fabric. Although direct correlation of individual Paleozoic structures to a similar causative basement structure cannot be proven, for instance in the case of the Demster zone, it is apparent that this northeast-trending fabric is related to basement structure and, in particular, to a series of horsts and grabens related to crustal extension and uplift. Basement shortening, for example, may have caused the Paleozoic rock to deform in places where basement structures are not

present, for example, Engelder's (1979) second decollement theory.

As pointed out by Price (1966), extension in a basement complex results in a compressional tectonic fabric in the overlying sedimentary strata. Fisher (1977) has identified three taphrogenic episodes in New York which may have all contributed input to the structural fabric. These rifting events are the Hadrynian (650 m.y.a.), the Quebecian (470 m.y.a.) and the Chamhawkian (430 m.y.a.). Other episodes may be correlated to distinctive igneous activity.

No strata younger than Middle to Late Devonian reportedly are faulted by north-northeast to northeast trending structural elements (Hutchinson et al, 1979; Fakundiny et al, 1978; and Murphy, 1981). Middle Paleozoic to Middle Jurassic ages of peridotite and kimberlite dikes indicate deep seated crustal thermal activity and extension, followed by dike intrusion into the overlying Paleozoics. Structural data near Ithaca (Prucha, 1968, and Matson, 1905) indicate emplacement of these prior to late Paleozoic.

The conflict between structural and radiometric data suggests some igneous activity may have continued until Jurassic time, however, sulfur isotope data appear to preclude igneous activity in the vicinity of the Demster Structural Zone. No subsequent tectonic activity is documented along this trend.

Stress data interpretations (Yang and Aggrawal, 1981) indicate a west-southwest directed maximum compressive stress for this portion of New York (Figure 6-1). In apparent response to this stress, Adirondack and western New York earthquakes occur preferentially as thrusts along north-northwest and northwest striking faults (Yang and Aggarwal, 1981). Yang and Aggarwal offer no evidence for earthquakes along northeast-trending faults. Indeed, the area encompassed by these northeast structural elements in central New York is shown by Mitronovas (1980) to be part of the least seismically active region of New York.

6.1 Age of Demster Structural Zone

Based on deformation style, stratigraphic relationships and regional geologic setting, a number of possible hypotheses can be advanced to explain the folding and faulting relative to the Demster structures. Possible regional tectonic events that could have initiated this deformation or be related to it are:

1. a late Precambrian to Early Ordovician basement extension and rifting reactivated by subsequent tectonism;

2. the Taconic Orogeny (455-445 m.y.a.) induced compressional stresses followed by a relaxation period of tension. Vertical and perhaps strike-slip movements also may have occurred along pre-existing fractures in the Proterozoic basement (Fisher 1980);

3. the Acadian Orogeny (400-365 m.y.a.) which resulted in compressional deformation in eastern New York; conceivably deformation of crustal rocks may have extended to central New York;

4. extensional deformation associated with the Middle Silurian Chamhawkian Taphrogeny. This deformation is well documented in the Mohawk River Valley and on the margins of the Adirondack Mountains. Westward the Clarendon-Linden Fault may be, in part, a manifestation of this apparent tensional activity;

5. the Alleghenian Orogeny (350-300 m.y.a) in south central New York. Several peridotite dikes in the Cayuga Lake vicinity appear to have been emplaced during or preceding the waning stages of folding;

6. Mesozoic deformation associated with alkaline igneous activity in central New York, adjacent Canada and Vermont; Zartman (1977) reports early Paleozoic to Middle Jurassic ages for peridotite and kimberlite dikes in New York. However, structural relationships in the Cayuga Lake area are in conflict with radiometric data.

The broad folding and faulting of the site area cannot be directly related to the first two deformational events, as the sediments of the Queenston Formation are derived from detritus resulting from the Taconic Orogeny (Patchen, 1966; Fisher, 1977). Generally, the source of the Oswego Sandstone and Queenston clastics is considered to be the Martinsburg Formation (Patchen, 1966 and 1975) located to the southeast (McCann et al., 1968). The remaining four events may have contributed in part or together to the development of the Demster zone.

Structural and stratigraphic relationships show that the site area has been deformed by two sequences of tectonic activity: initial broad folding culminating in reverse faulting and later normal faulting. No other tectonic activity is documented at the Demster Structural Zone. Surficial sediments overlying the fault zone are not deformed and calcite paragenesis indicates no subsequent deformation.

Combined field and laboratory evidence indicates the Oswego Sandstone was overlain by approximately 2 km of rock at the time of deformation. The K-Ar data suggest a middle Paleozoic (Silurian) time of deformation for the Demster Structural Zone.

The reconstructed geologic column, associated geologic history, and other interpretations of data suggest a younger middle to late Paleozoic age. A younger Middle Jurassic age (Basu and Rubury, 1979) cannot be ruled out, although, the sulfur isotope data do not strongly support this age. The uncertainty of the timing of alkaline emplacement, lack of documented high angle late Mesozoic faulting and geochemical data place constraints on this time interval. Consequently, a middle to late Paleozoic age is inferred for the final development of the Demster Structural Zone.

The deformation style, northeast trend of the structural elements, regional stratigraphy, and analytical data are in agreement that the Ordovician strata in northern Oswego County and conceivably the underlying Cambrian/Ordovician strata in central New York have undergone broad areal folding, with variable reverse and normal faulting. Penecontemporaneous deformation is also present. This apparently discontinuous sequence of deformation may be more extensive than recognized to date throughout central New York and the Eastern Stable Platform, as bedrock structures are largely concealed by the glacial cover. Combined geologic, geophysical and seismological data indicate that the Demster structure is non-capable.

7.0 REFERENCES

1. Bailey, H., 1982, Subsurface data from borings 12398, 12399, 12447 and 12406, New York State Geological Survey: Personal communication to L. D. Schultz.

2. Barber, B. G. and Bursnall, J. T., 1978, Deformation structures in Lower Paleozoic rocks, northwest New York, in Guidebook, New York State Geological Association 50th Annual Meeting, Syracuse, New York: D. F. Merriam, editor, p. 48-57.

3. Barnes, H. L., 1977, Fluid inclusion analyses for Dames & Moore, Inc.: in Nine Mile Point Nuclear Station, Geologic Investigation, v. 1 (1978), Niagara Mohawk Power Corporation.

4. Basu, A. R., and Rubury, E., 1980, Tectonic significance of kimberlite dikes in central New York: Geological Society of America Abstracts with Programs, v. 12, no. 2, p. 23.

5. Bothner, W. E., Simpson, R. W. and Diment, W. H., 1980, Bouguer gravity map of northeastern United States and adjacent Canada: U. S. Geological Survey Open File Report 80-2012.

6. Brun, J., and Chagnon, A., 1979, Rock stratigraphy and clay mineralogy of volcanic ash beds from the Black River and

Trenton Groups (Middle Ordovician) of Southern Quebec: Canadian Journal of Earth Science, v. 16, p. 1499-1507.

7. Bretsky, P., 1970, Late Ordovician benthic marine communities in north-central New York: New York State Museum and Science Service Bulletin 414, 34 p.

8. Buddington, A. F. and Leonard, B. F., 1962, Regional geology of the St. Lawrence County magnetite district, Northwest Adirondacks, New York: U. S. Geological Survey Professional Paper 376, 145 p.

9. Carmichael, I. S. E., Turner, F. J., and Verhoogen, J., 1974, Igneous petrology: McGraw-Hill, New York, 739 p.

10. Chadwick, G. H., 1915, Post-Ordovician deformation in the St. Lawrence Valley, N. Y.: Geological Society of America Bulletin, v. 26, p. 287-294.

11. Chute, N. E., 1969, Structural features in the Syracuse area: in J. J. Prucha ed., New York State Geological Association 36 Annual Meeting Guidebook to Field Trips, p. 74-127.

12. Cushing, H. P., et al, 1910, Geology of the Thousand Island Region: New York State Museum Bulletin, No. 145, p. 4-187.

13. Dames & Moore, 1978, Geologic Investigation, Vol. I: Nine Mile Point Nuclear Station Unit 2, Niagara Mohawk Power Corporation.

14. Diment, W. H., Muller, 0. H., and Lavin, P. M., 1979, Basement tectonics of New York and Pennsylvania as revealed by gravity and magnetic studies, in D. R. Wones, ed., Proceedings of the Caledonides in the U.S.A.: I.G.C.P. Project 27, Caledonide Orogen, 1979 Meeting, Blacksburg, Virginia, Department of Geological Sciences, Virginia Polytechnic Institute and State University, Memoir No. 2, 1980, p. 221-227.

15. Engelder, T., 1979, The nature of deformation within the outer limits of the central Appalachian foreland fold and thrust belt in New York State: Tectonophysics, v. 55, p. 289-310.

16. Engelder, T., and Geiser, P., 1979, the relationship between pencil cleavage and lateral shortening within the Devonian section of the Appalachian Plateau, New York: Geology, v. 7, p. 460-464.

17. Epstein, A. G., Epstein, J. B., and Harris, L. D., 1977, Conodont color alteration - An index to organic metamorphism: U. S. Geological Survey Professional Paper 995, 27 p.

18. Faure, G., 1977, Principles of isotope geology, John Wiley, New York, 464 p.

19. Fakundiny, R. H., 1977, Clarendon-Linden Fault study: Empire State Geogram, v. 13, No. 1.

20. Fakundiny, R. H., et al, 1978, Clarendon-Linden Fault System of Western New York - Longest and oldest active fault in eastern United States: Geological Society of America Abstracts with Programs, v. 10, No. 2, p. 42.

21. Fisher, D. W., 1965, Mohawk Valley strata and structure, in Fisher, E. W. and Isachsen, Y. W., eds., Guidebook for fieldtrips in Mohawk Valley and Lake George region: New York State Museum and Science Service, Educational Leaflet No. 18.

22. Fisher, D. W., 1969, Paleozoic geology of the Lake George-Glens Falls-Fort Ann, New York Region: Geological Society of America Abstracts with Programs, v. 1, No. 1, p. 19.

23. Fisher, D. W., 1977, Correlation of the Hadrynian, Cambrian, and Ordovician rocks in New York State: New York State Geological Survey Map and Chart Series No. 25.

24. Fisher, D. W., 1980, Bedrock geology of the central Mohawk Valley, New York: New York State Geological Survey Map and Chart Series No. 33.

25. Forsyth, D. A., 1981, Characteristics of the western Quebec seismic zone: Canadian Journal of Earth Sciences, v. 18, p. 103-119.

26. Geotechnical Engineers, Inc., 1976, Confirmation study of site 4-3-11, for New York State Electric & Gas Corporation, New Site Project.

27. Geraghty, E. P., Isachsen, Y. W., and Wright, S. F., 1981, Extent and character of the Carthage-Colton Mylonite Zone, Northwest Adirondacks, New York: U.S. Nuclear Regulatory Commission Report NUREG/CR - 1865, p. 83.

28. Hartnagel, C. A., 1938, The Medina and the Trenton of Western New York: American Association of Petroleum Geologists Bulletin, v. 22, No. 1, p. 79-99.

29. Hutchinson, D. R., Pomeroy, P. W., Wold, R. J., and Halls, H. C., 1979, Geophysical investigation concerning the continuation of the Clarendon-Linden Fault across Lake Ontario: Geology, v. 7, p. 206-210.

30. Isachsen, Y. W., and McKendree, W. G., 1977, Preliminary brittle structure map of New York: New York State Geological Survey Map and Chart Series No. 31B.

31. King, P. B., 1976, Precambrian Geology of the United States; An Explanatory text to accompany the geologic map of the United States: U.S. Geological Survey Professional Paper 902, 85 p.

32. Jackson, D. E., Hunter, R. H., and Taylor, L. A., 1982, A Mesozoic window into the sub-Appalachian mantle: Kimberlite from eastern United States: Geological Society of America Abstracts with Programs, v. 14, Nos. 1 and 2, p. 28.

33. Johnson, K. G., 1971, Limestones (Middle Ordovician) of Jefferson County, New York: New York State Geological Survey Map and Chart Series No. 13.

34. Kay, M. G., 1942, Ottowa-Bonnechere Graben and Lake Ontario Homocline: Geological Society of America Bulletin, v. 53, p. 585-646.

35. Kay, M., 1953, Geology of the Utica quadrangle: New York State Geological Survey Bulletin No. 347, p. 9-117.

36. Kemp, J. K., 1891, Peridotite dikes in the Portage Sandstones near Ithaca, New York: American Journal of Science, 3rd Ser., Vol. XLII, p. 410-12.

37. Kindle, E. M., 1909, Geologic structure in Devonian rocks, in description of the Watkins Glenn-Catatonk district: U.S. Geological Survey Folio No. 169, p. 13-15.

38. Kinsland, G. L., 1977, Formation temperature of flourite in the Lockport Dolomite in Upper New York State as indicated by fluid inclusion studies - With a discussion of heat sources: Economic Geology, v. 72, p. 849-854.

39. Kreidler, W. L., Van Tyne, A. M., and Jorgensen, K. M., 1972, Deep Wells in New York State: New York State Geological Survey Bulletin No. 418A, 335 p.

40. Matson, G. C., 1905, Peridotite dikes near Ithaca, New York: Journal of Geology, v. 13, p. 264-275.

41. McCann, T. P., Privtasky, N., Stead, E., and Wilson, J. E., 1968, Possibilities for disposal of industrial wastes in subsurface rocks on the north flank of the Appalachian Basin in New York: in J. F. Galley, ed., Subsurface disposal in geologic basins. A study of reservoir strata: American Association of Petroleum Geologist, Memoir 10, p. 43-92.

42. McHone, J. G., and Corneille, E. S., 1980, Alkalic dikes of the Lake Champlain Valley: Vermont Geology, v. 1, p. 16-21.

43. Megathlin, G. R., 1938, Faulting in the Mohawk Valley: New York State Geological Survey Bulletin, No. 126, p. 85-122.

44. Mitronovas, W., 1980, Temporal and spatial variations in seismicity within New York and eastern United States: in J. E. Beavers, ed., Earthquakes and earthquake engineering: the Eastern United States, v. 1,: Ann Arbor Science Publishers Inc., The Butterworth Group, p. 143-160.

45. Murphy, P. J., 1981, Detachment structures in south-central New York: Northeast Geology, v. 3, No. 2, p. 105-115.

46. New York State Electric & Gas, 1979, Preliminary Safety Analysis Report for New York State Electric & Gas Units 1 and 2: Docket No. STN 50-596.

47. Parker, J. M., 1942, Regional systematic jointing in slightly deformed sedimentary rocks: Geological Society of America Bulletin, v. 53, p. 381-408.

48. Patchen, D. G., 1966, Petrology of the Oswego, Queenston and Grimsby Formations, Oswego County, New York: Master of Arts Thesis, S.U.N.Y. at Binghamton.

49. Patchen, D. G., 1975, Depositional environments of the Oswego Sandstone, Oswego County, New York: Geological Society of America Abstracts with Programs, v. 7, No. 1, p. 103-104.

50. Price, N. J., 1966, Fault and joint development in brittle and semi-brittle rocks: Pergamon Press, Elmsford, New York, 176 p.

51. Prucha, John J., 1968, Salt deformation and decollement in the Firtree Point Anticline of Central New York: Tectonophysics, v. 6, No. 4, p. 273-299.

52. Revetta, F. A., and Diment, W. H., 1971, Simple bouguer gravity anomaly map of western New York: New York State Geological Survey Map and Chart Series No. 17, 4 maps.

53. Rickard, L. V., and Fisher, D. W., 1970, Geologic map of New York, Finger Lakes Sheet: New York State Geological Survey Map and Chart Series No. 15.

54. Rickard, L. V., 1973, Stratigraphy and structure of the subsurface Cambrian and Ordovician carbonates of New York: New York State Geological Survey Map and Chart Series No. 18.

55. Rickard, L. V., 1975, Correlation of the Silurian and Devonian rocks in New York State: New York State Geological Survey Map and Chart Series No. 24.

56. Schmucker, U., 1969, Geophysical aspects of structures and composition of the earth, in K. H. Wedepohl, ed., Handbook of Geochemistry, v. 1, Springer-Verlag, New York, p. 134-223.

57. Selleck, B., 1980, The post-orogenic history of the Adirondack Mountain Region: A review: Geological Society of America Bulletin, v. 91, Part I, p. 120-124.

58. Simmons, G., and Diment, W. H., 1972, Simple bouguer gravity anomaly map of northern New York: New York State Geological Survey Map and Chart Series no. 17A.

59. Smyth, C. H., Jr., 1897, Weathering of alnoite in Manheim, New York: Geological Society of America Bulletin, v. 9, p. 257-268.

60. Stanley, R. S., 1980, Mesozoic faults and their environmental significance in western Vermont: Vermont Geology, v. 1, p. 22-32.

61. U.S. Geological Survey, 1975, Aeromagnetic survey of Ogdensburg and vicinity, New York: U. S. Geological Survey Open File Report 75-526.

62. U.S. Geological Survey, 1977, Aeromagnetic map of parts of Rochester and Utica 1 deg. x 2 deg. quadrangles, New York: U.S. Geological Survey Open File Report 77-553.

63. U.S. Geological Survey, 1979, Aeromagnetic map of central New York: U.S. Geological Survey Open File 79-653.

64. Van Tyne, A. M., 1978, Developments in New York in 1977: American Association of Petroleum Geologists Bulletin, v. 62, no. 8, p. 1445-1450.

65. Van Tyne, A. M., 1978a, Personal communication to Weston Geophysical Corporation.

66. Van Tyne, A. M., 1975, Subsurface investigation of the Clarendon-Linden structures, New York State Geological Survey Open File Report, p. 12.

67. Welch, C. W., 1981, Two geophysical lineations in northern New York of possible tectonic significance: Geological Society of America Abstracts with Programs, v. 13, no. 3, p. 183.

68. Willette, Paul D., 1979, A structural, stratigraphic, and hydrodynamic analysis of the Paleozoic section of central New York State: Ph.D dissertation, Syracuse University.

69. Yang, J. P. and Aggarwal, Y. P., 1981, Seismotectonics of Northeastern United States and adjacent Canada: Journal of Geophysical Research, v. 86, no. B6, p. 4981-4998.

70. Zartman, R. E., Brock, M. R., Heyl, A. V., and Thomas, H. H., 1967, K-Ar and Rb-Sr Ages of some alkaline intrusive rocks from central and western United States: American Journal of Science, v. 265, p. 848-870.

71. Zartman, R. E., 1977, Geochronology of some alkalic rock provinces in eastern and central United States: Annual Review of Earth and Planetary Sciences, v. 5, p. 257-286.

TABLE 1

Sample Identification, Location and Studies Performed

SAMPLE NO.	LOCATION	STUDY PERFORMED	STRUCTURE
T-II-1-NH	8+19.9, 4 ft NE of Trench CL*	Thin Section	
T-II-2-NH	8+19.9, 4 ft NE of Trench CL	Sulfur Isotope	
T-II-7-NH	9+49.4, 4 ft SW of Trench CL	Fluid Inclusion	R, N
T-II-8-NH	9+49.4, 4 ft SE of Trench CL	Thin Section	
T-II-19-NH	9+50, SW Wall Rock Pit I	Thin Section, Sulfur Isotope, Fluid Inclusion	R, N
T-II-20A-NH	9+52, 13 ft SW Trench CL	Sulfur Isotope	
T-II-21-NH (A)	9+45, NE Wall, Rock Pit I	Thin Section, Sulfur Isotope, Fluid Inclusion	R, N
T-II-25-NH	9+40, 25 ft SW of Trench CL	Sulfur Isotope Fluid Inclusion	R, N
T-II-26-NH	9+47, 2.5 ft SW of NE Wall Rock Pit I	X-Ray Diffraction, K-Ar Age	
T-II-29-NH	9+40, 24 ft SW of Trench CL	Thin Section	
T-II-31A-NH	9+15, SW Wall, Rock Pit I	Thin Section	
T-II-36-NH	9+14, NE Wall, Rock Pit I	Thin Section, Sulfur Isotope	
T-II-38-NH	8+50, Floor Rock Pit I	X-Ray Diffraction, K-Ar Age	
T-II-39-NH	8+48, Floor Rock Pit I CL	Fluid Inclusion	N
T-II-40-NH	9+46, SW Wall, Rock Pit I	X-Ray Diffraction, K-Ar Age	
T-II-42-NH (A)	9+42, 3 ft SW Rock Pit CL	Thin Section, Sulfur Isotope, Fluid Inclusion	R,N
T-II-45-NH	9+45, NE Wall, Rock Pit I	Sulfur Isotope	
T-II-48-NH	9+40, 1 ft NE of Wall, Rock Pit I	Sulfur Isotope	
T-II-50-NH	9+42, SW Wall, Rock Pit I	Thin Section, Sulfur Isotope	
T-II-51-NH	9+42, SW Wall, Rock Pit I	Thin Section, Sulfur isotope	
T-II-58-NH	9+22, Floor Rock I	X-Ray Diffraction, K-Ar Age	
T-II-59-NH	9+42, NE Wall Rock Pit II	Sulfur Isotope	

TABLE 1 (Cont’d.)

NOTES: 1. *CL is defined as centerline
2. N, normal movement
3. R, reverse movement

TABLE 1 (Cont'd.)

SAMPLE NUMBER	BORING NUMBER	DEPTH (ft)	METHOD/ANALYSIS
NH-1	R-12	78.0-78.4	X-Ray
NH-2	R-12	79.6-80.0	X-Ray, K-Ar Age
NH-3	R-12	112.7-113.1	X-Ray
NH-4	R-12	113.7-114.0	Thin Section
NH-6	R-12	152.3-152.6	X-Ray, K-Ar Age
NH-7	R-12	180.0-180.2	Thin Section
NH-16	R-13	67.8-67.9	X-Ray
NH-17	R-13	81.5-81.8	X-Ray
NH-26	R-10	30.3-30.6	Thin Section
NH-31	R-14	215.7-215.9	X-Ray, K-Ar Age
NH-33	R-27	79.6-80.0	Thin Section
NH-34	R-27	38.6-39.0	Thin Section

TABLE 2

Homogenization Temperatures – Fluid Inclusions
Demster Structural Zone

	T-II-21A-NH	T-II-42-NH	T-II-19-NH	T-II-39-NH	T-II-7-NH	T-II-25-NH
SAMPLE #	Inclusion # T°C	Inclusion # T°C	Inclusion # T°C	Inclusion # T°C	Inclusion # T°C	Inclusion # T°
1	38 157.2	24a 157.9	18b 159.9	55 179.6	44 148.5	6 170.4
2	35a 149.4	31a 155.4	15 158.3*	59 163.8	43 144.6	6b 170.4
3	37 138.8*	24b 154.3	16 147.8	56 155.6	45 128.8*	5b 155.1
4	40 137.8	23a 141.8	10 128.3	54 150.4	46a 118.9	9b 152.5
5	36a 121.7	31c 138.3	22b 127.2*	61c 135.2	49 93.1	5a 152.0
6	35b 103.1	31f 137.8	18a 124.6	50 132.5	46b 92.0	1 125.2
7	36b 101.0	31e 129.1	21 124.6	61b 116.2	42 75.7*	4 122.5
8	35c 99.2	31d 124.3	22a 114.2*			
9	33 98.3					
Mean	122.9°C	142.4°C	135.6°C	147.6°C	114.5°C	149.7°C
Std. Dev.	23.4	12.5	17.2	21.3	28.1	19.3

1. *Inclusions found in milky areas
2. See Appendix 2.5I, Attachment 2 (NYSEG 1979) for details

WESTON GEOPHYSICAL

TABLE 3

SUBSURFACE BORING INFORMATION

Boring #	Ground El.	Top of Trenton		Top of Queenston		Top of Lockport		Top of Onondaga		County
		Downhole	Elev.	Downhole	Elev.	Downhole	Elev.	Downhole	Elev.	
4607	+1050	--	--	2418	-1368	1868	-818	785	+265	Ontario
3999	+1183	--	--	2662	-1479	2118	-935	1045	+138	Ontario
3866	+1739	--	--	3832	-2093	3240	-1501	1965	-226	Ontario
6395	+1080	4284	-3204	2474	-1394	1940	-860	--	--	Ontario
5056	+852	--	--	2286	-1434	--	--	632	+220	Ontario
4160	+770	--	--	2121	-1351	1560	-790	495	+275	Ontario
4871	+556	2813	-2257	1062	-506	567	-11	--	--	Ontario
4409	+785	--	--	1825	-1040	1286	-501	--	--	Ontario
4449	+906	--	--	2132	-1226	1628	-722	534	+372	Ontario
4754	+499	2500	-2001	774	-275	280	+219	--	--	Wayne
5116	+587	2432	-1845	735	-148	201	+386	--	--	Wayne
5041	+423	2347	-1924	665	-242	148	+275	--	--	Wayne
5114	+487	2485	-1998	750	-263	230	+257	--	--	Wayne
5032	+473	2746	-2273	996	-523	438	+35	--	--	Wayne
6719	+392	2786	-2394	1040	-648	512	-120	--	--	Wayne
5031	+433	2253	-1820	594	-161	58	+375	--	--	Cayuga
4624	+449	1922	-1473	296	+153	--	--	--	--	Cayuga
6779	+450	2577	-2127	929	-479	303	+147	--	--	Cayuga
4999	+580	3110	-2530	1409	-829	845	-265	--	--	Cayuga
4512	+532	--	--	1551	-1019	970	-438	--	--	Cayuga
4365	+742	--	--	1812	-1070	1236	-494	--	--	Cayuga
6780	+451	2550	-2099	904	-453	357	+94	--	--	Cayuga
5000	+427	2555	-2128	874	-447	342	+85	--	--	Cayuga
5467	+449	2621	-2172	952	-503	403	+46	--	--	Cayuga
4715	+513	3252	-2739	1506	-993	937	-424	33	+480	Cayuga
4652	+517	--	--	1510	-993	933	-416	--	-	Cayuga
6644	+628	--	--	1845	-1217	1268	-640	178	+450	Cayuga
4043	+825	--	--	--	--	1600	-775	475	+350	Cayuga

WESTON GEOPHYSICAL

TABLE 3 (Cont'd.)

Boring #	Ground El.	Top of Trenton		Top of Queenston		Top of Lockport		Top of Onondaga		County
		Downhole	Elev.	Downhole	Elev.	Downhole	Elev.	Downhole	Elev.	
5095	+400	2856	-2456	1105	-705	568	-168	--	--	Seneca
4524	+483	--	--	1427	-944	860	-377	--	--	Seneca
4768	+464	--	--	1544	-1080	972	-508	--	--	Seneca
4600	+500	--	--	1719	-1219	1191	-691	111	+389	Seneca
4244	+660	--	--	2060	-1400	1454	-794	384	+276	Seneca
4797	+828	--	--	2538	-1710	1908	-1080	840	-12	Yates
4795	+884	--	--	2718	-1834	--	--	1031	-147	Yates
4796	+961	--	--	2876	-1915	2285	-1324	1104	-143	Yates
3994	+990	--	--	--	--	--	--	1226	-236	Yates
4410	+1100	--	--	--	--	--	--	1715	-615	Yates
5063	+1417	--	--	--	--	--	--	2208	-791	Steuben
3890	+526	--	--	--	--	--	--	1335	-809	Schuyler
5017	+875	--	--	--	--	--	--	1476	-601	Tomkins
3938	+590	--	--	--	--	--	--	1228	-638	Tomkins
4051	+1075	--	--	--	--	--	--	1760	-685	Tomkins
4130	+1454	7300	-5846	5345	-3891	4427	-2973	2500	-1046	Tomkins
5012	+310	1430	-1120	--	--	--	--	--	--	Oswego
4209	+462	1614	-1152	--	--	--	--	--	--	Oswego
4208	+500	1482	-982	--	--	--	--	--	--	Oswego
4357	+730	841	-111	--	--	--	--	--	--	Oswego
12398*	+390	971	-581	--	--	--	--	--	--	Oswego
12399*	+335	732	-397	--	--	--	--	--	--	Oswego
12447*	+300	683	-383	--	--	--	--	--	--	Oswego
12406*	+330	758	-428	--	--	--	--	--	--	Oswego
4201	+419	458	-39	--	--	--	--	--	--	Oswego
4520	+306	632	-326	--	--	--	--	--	--	Oswego
4150	+1783	1054	+729	--	--	--	--	--	--	Lewis
4902	+1070	--	--	2471	-1401	1899	-829	616	+454	Onondaga

WESTON GEOPHYSICAL

TABLE 3 (Cont'd.)

Boring #	Ground El.	Top of Trenton		Top of Queenston		Top of Lockport		Top of Onondaga		County
		Downhole	Elev.	Downhole	Elev.	Downhole	Elev.	Downhole	Elev.	
4049	+1401	--	--	--	--	--	--	960	+441	Madison
4085	+1565	--	--	2783	-1218	2190	-625	943	+622	Madison
4556	+1604	--	--	--	--	1768	-164	718	+886	Madison
3970	+1544	4568	-3024	3049	-1505	2560	-1016	1265	+279	Madison
3963	+1485	--	--	--	--	--	--	--	--	Madison
1173	+1252	3300	-2048	--	--	--	--	--	--	Madison
4032	+1505	4023	-2518	--	--	--	--	1098	+407	Madison
4714	+1569	6895	-5326	5120	-3551	4440	-2871	2652	-1083	Cortland
4050	+1530	--	--	--	--	--	--	2062	-532	Otsego
3928	+1319	3418	-2099	--	--	--	--	487	+832	Oneida

1. *Data received through personal communication with Henry Bailey, N.Y.S.G.S.
2. Elevations given in feet
3. Data taken from Kreilder, et al (1972)

WESTON GEOPHYSICAL

TABLE 4

BORINGS FOR TRENTON FM.
FROM HARTNAGEL (1938)

BORING #	GROUND ELEV.	TOP OF TRENTON		COUNTY
		Downhole Depth	Elevation	
56	+300	1,196	-896	Oswego
57	+320	1,370	-1,050	Oswego
45	+409	1,700	-1,291	Oswego
58	+380	1,400	-1,020	Oswego
46	+420	1,609	-1,189	Oswego
44	+500	1,535	-1,035	Oswego
49	+1,165	1,040	+125	Oswego
24	+623	935	-312	Oneida
25	+597	928	-331	Oneida
26	+913	1,164	-251	Oneida
27	+1,122	1,165	-43	Oneida
28	+485	525	-40	Oneida
29	+900	320	+580	Oneida
30	+400	1,520	-1,120	Oneida
31	+520	1,400	-880	Oneida
32	+455	562	-107	Oneida
19	+1,220	3,328	-2,108	Madison
33	+861	3,350	-2,489	Onondaga
34	+415	2,696	-2,281	Onondaga
35	+480	2,700	-2,220	Onondaga
36	+425	2,618	-2,193	Onondaga
37	+410	2,250	-1,840	Onondaga
38	+420	2,250	-1,830	Onondaga
39	+430	2,270	-1,840	Onondaga
40	+1,013	3,730	-2,717	Onondaga
41	+425	2,404	-1,979	Onondaga
14	+605	6	+599	Jefferson
15	+623	33	+590	Jefferson
16	+1,700	602	+1,098	Lewis
17	+1,340	1,082	+258	Lewis
18	+1,752	726	+1,026	Lewis

1. Data given in feet