BSC

Design Calculation or Analysis Cover Sheet

Complete only applicable items.

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2. Page 1

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General Public Atmospheric Dispersion Factors

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TAP 8/13/07

Attachments	Total Number of Pages
Attachment I – Listing of Computer Files Contained in Attachment III	8
Attachment II – E-Mail from GIS Requests (Audrey Rager) to Jorge Schulz (Reference 2.2.15)	2
Attachment III – Three Compact Disks (CD) containing the EXCEL spreadsheets and ARCON96 files used in the calculation process.	3 CD-ROM

RECORD OF REVISIONS

9. No.	10. Reason For Revision	11. Total # of Pgs.	12. Last Pg. #	13. Originator (Print/Sign/Date)	14. Checker (Print/Sign/Date)	15. EGS (Print/Sign/Date)	16. Approved/Accepted (Print/Sign/Date)
00A	Initial Issue	136	II-2	Jorge Schulz	Dale Dexheimer	Sen-Sung Tsai	Mark Wisenburg
00B	Revised the definition of general environment and the calculation of atmospheric dispersion factors in the general environment.	142	II-2	Jorge Schulz [signature] 8/9/2007	Dale Dexheimer [signature] 8/9/07	Sen-Sung Tsai [signature] 8/9/2007	Mark Wisenburg [signature] 8/9/2007

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1) CACN-001, DATED 03/03/2008

Disclaimer

The calculations contained in this document were developed by Bechtel SAIC Company, LLC (BSC) and are intended solely for the use of BSC in its work for the Yucca Mountain Project.

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ACRONYMS AND ABBREVATIONS

BSC	Bechtel SAIC Company
cm	centimeter
CFR	Code of Federal Regulations
CRWMS	Civilian Radioactive Waste Management System
DOE	U.S. Department of Energy
DTN	Data tracking number
EPA	U.S. Environmental Protection Agency
FHF	Fuel Handling Facility
GROA	Geologic Repository Operations Area
hr	hour
IHF	Initial Handling Facility
km	kilometer
m	meter
NAD	North American datum
NRC	U.S. Nuclear Regulatory Commission
PCSA	Preclosure Safety Analyses
χ/Q	atmospheric dispersion factor
sec	second
YMP	Yucca Mountain Project

1. PURPOSE

The objective of this calculation is to determine downwind atmospheric dispersion factors (χ/Q) for acute (short-term) and chronic (long-term) exposures of a radioactive material from a ground-level point release. Sector dependent atmospheric dispersion factors are calculated along the Yucca Mountain repository site boundary for general public exposures, at the minimum distance from a release point to the restricted area boundary for onsite public exposures, from the subsurface exhaust shafts to the surface facilities, and from the surface facilities to the subsurface exhaust shafts. These atmospheric dispersion factors are calculated using the most current qualified meteorological data and are intended for use in consequence analyses.

Atmospheric dispersion factors for surface facilities include a building wake effect based on the minimum cross-sectional area of the proposed Initial Handling Facility (IHF) building. Dry deposition during transit to the receptor location is included in the calculation.

In addition to determining the χ/Qs, depleted χ/Q, and deposition rates, this calculation manipulates the meteorological data to generate meteorological data files for use by the computer codes ARCON96 (ARCON V. 96) and GENII.

Calculations in this document were developed by Preclosure Safety Analyses (PCSA) for the sole use of performing the preclosure safety analysis. However, there are no limitations on the use of the results of this calculation. The results can be used in other calculations and analyses that require χ/Q values at the calculated distances.

2. REFERENCES

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2.2.9 BSC 2005. *Preclosure Consequence Analyses for License Application.* 000-00C-MGR0-00900-000-00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20050805.0003; ENG.20050817.0010; ENG.20050825.0023.

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2.3 DESIGN CONSTRAINTS

There are no design constraints for this calculation.

2.4 DESIGN OUTPUTS

This calculation does not support a specific engineering drawing, specification, or design list. The results of this calculation may be used in other preclosure safety analyses.

3. ASSUMPTIONS

3.1 ASSUMPTIONS REQUIRING VERIFICATION

3.1.1 Land Withdrawal Area Boundary (Site Boundary)

The coordinates of the YMP land withdrawal area are obtained from DTN: MO9905COV99168.000 (Reference 2.2.30 [DIRS 176475]). These coordinates are based on Nevada State Plane Coordinate System, Central Zone, North American Datum of 1927 (NAD27). The coordinates are presented in Table 1 and shown graphically on Figure 1.

Table 1 — YMP Land Withdrawal Area Coordinates

Point	East (ft)	North (ft)
1	533,431.5000	795,309.1875
2	596,232.3125	794,944.1875
3	596,881.6875	794,811.7500
4	597,025.6875	761,691.8750
5	598,713.9375	761,556.1250
6	598,635.8125	699,918.7500
7	579,349.5625	699,037.0625
8	546,975.6250	699,149.0625
9	538,897.3750	701,540.5625
10	531,444.5000	706,140.2500
11	531,288.4375	761,699.3750
12	533,695.0625	761,698.0000
13	533,655.6875	772,137.0000

Rationale: The cited reference provides the land withdrawal coordinates for use at the repository. This is the best available data. This information is consistent with the proposed land withdrawal presented in Section 7.4 of the *Site Development Plan,* 000-PLN-MGR0-00100-000-001 (Reference 2.2.14 [DIRS170191].

This assumption is used in sections 6.3.1.1 and 6.3.2.1.

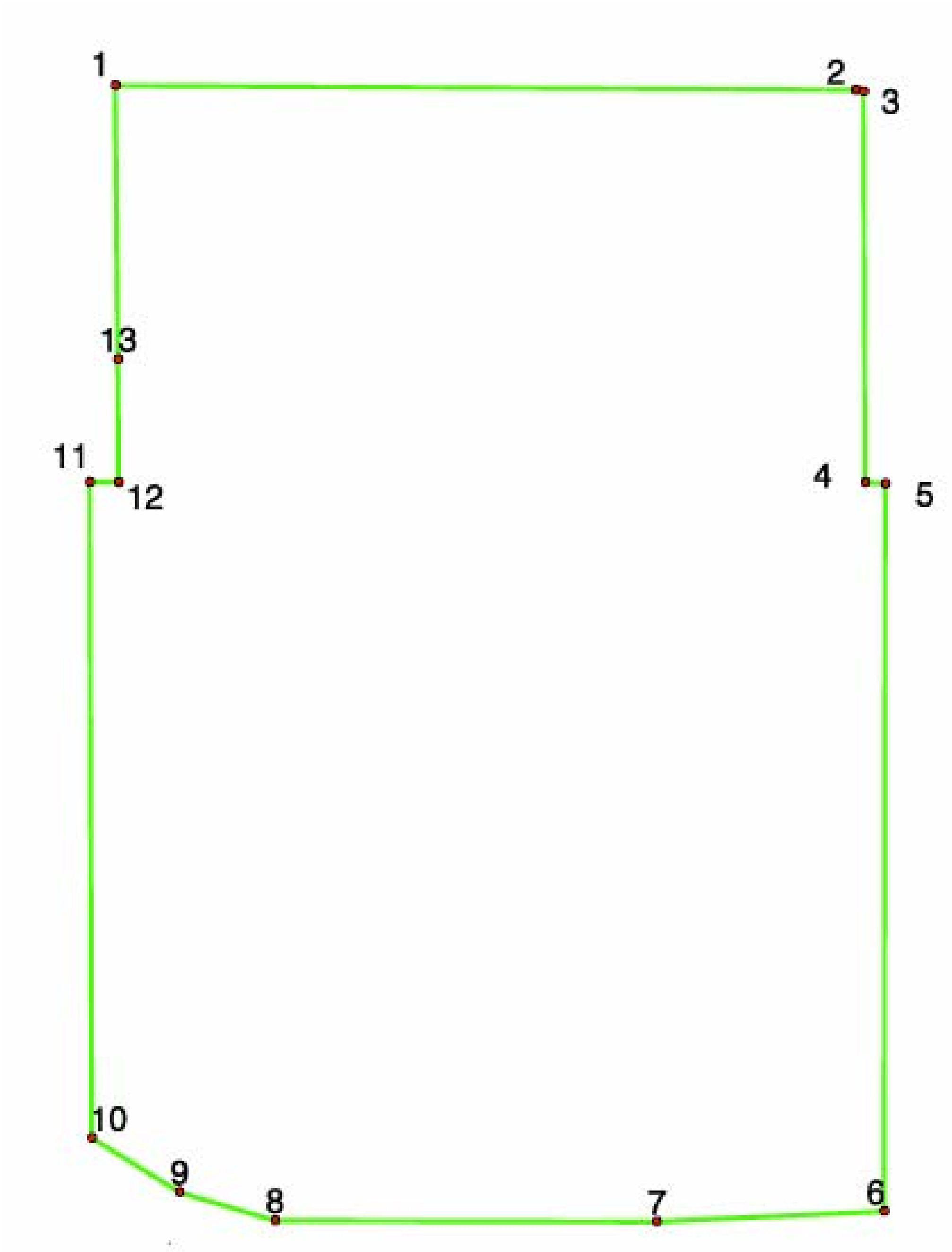

Figure 1 — YMP Land Withdrawal Area Boundary (Site Boundary)

Note – The points 1 through 13 identified in Figure 1 correspond to the points presented in Table 1.

3.1.2 Coordinates of the Nearest Resident

The location of the nearest resident is given in Design Input 6.1.6 as the intersection of U.S. Highway 95 and Nevada State Route 373. The coordinates of the intersection of these two highways in the State Plane, Datum NAD27 coordinate system was provided in Reference 2.2.15.

Reference 2.2.15 states that the location was converted to the State Plane, Datum NAD27 coordinates using a 1:24,000 scale roads coverage (DTN:MO9908COV97558.000, Reference 2.2.31 [DIRS 177334]). The coordinates are:

578,368.58 ft East
689,421.97 ft North

Rationale: The cited reference provides the coordinates of the nearest resident. This is the best available data.

This assumption is used in sections 6.5.1 and 6.5.2.

3.2 ASSUMPTIONS NOT REQUIRING VERIFICATION

3.2.1 GROA Boundary

Assumption: The Geologic Repository Operations Area (GROA) is assumed to be contained in the North Portal area. This area is bounded by a square 5,000 feet on each side. This square is bounded on the west by coordinate E 570,000; east by coordinate E 575,000; north by coordinate N 767,500, and south by coordinate N 760,000. These coordinates are based on Nevada State Plane Coordinate System, Central Zone, North American Datum of 1927 (NAD27) as implemented in drawing 100-C00-MGR0-00501-000-00B (Reference 2.2.10).

Rationale: The repository above ground facilities are in preliminary design stages, and the locations may change as the design progresses. Using a GROA boundary that conservatively encompasses the potential locations of the facilities allows for changes without requiring revisions of this calculation.

Confirmation: This assumption does not require further confirmation by testing, design, or analysis.

Usage: This assumption is used in sections 4.3.2, 6.3.2.1, 6.3.3.1, 6.4.1, and 6.9.2.

3.2.2 Effluent Release Height

Assumption: The effluent release from the surface facilities and from the subsurface exhaust shafts is assumed to be at ground level.

Rationale: Regulatory Guide 1.111 (Reference 2.2.21 [DIRS 103765]) requires that a release be 2 times the height of adjacent solid structures and Regulatory Guide 1.145 (Reference 2.2.22 [DIRS 103651]) requires that the release be 2.5 time the height of adjacent solid structures in order to be considered elevated releases. The repository above ground facilities are in preliminary design stages, and the location of the release points with respect to the height of the buildings may change as the design progresses. Therefore, it is conservative to consider that the releases will be at ground level because ground level releases result in higher concentrations at 100 meters and along the site boundary.

Confirmation: This assumption does not require further confirmation by testing, design, or analysis.

Usage: This assumption is used in sections 4.4, 4.5, and 6.9.2.

3.2.3 On-Site Receptor Height

Assumption: The on-site dose receptor is assumed to be at ground level.

Rationale: ARCON96 (Reference 2.2.5 [DIRS 164784]) calculates a "stretched string" distance to determine the χ/Q values. Any elevation difference between the release point and the receptor would result in longer distances, thus lower χ/Q values. Therefore, it is conservative to consider that the receptor will be at ground level because ground level releases result in higher concentrations at on-site locations (e.g. 200 feet).

Confirmation: This assumption does not require further confirmation by testing, design, or analysis.

Usage: This assumption is used in sections 6.4 and 6.9.2.

3.2.4 On-Site Effluent Flow and Velocity

Assumption: The effluent flow and effluent velocity is assumed to be zero.

Rationale: ARCON96 (Reference 2.2.5 [DIRS 164784]) can calculate χ/Q values including credit for effluent flow and velocity. These credits result in lower a χ/Q values than values calculated without effluent flow and velocity. Therefore, it is conservative to consider that the effluent flow and velocity are zero because it results in higher concentrations at on-site locations (e.g. 100 meters).

Confirmation: This assumption does not require further confirmation by testing, design, or analysis.

Usage: This assumption is used in section 6.9.2.

3.2.5 Building Wake Parameters

Assumption: The building wake parameters corresponding to the Initial Handling Facility (IHF) are used to determine the atmospheric dispersion factors.

Rationale: The repository above ground facilities are in preliminary design stages, and the locations and building sizes may change as the design progresses. The Initial Handling Facility (IHF) is the smallest of the currently proposed surface facilities as shown on drawing 100-C00-MGR0-00501-000-00B (Reference 2.2.10). The building height and projected area of the IHF produces the smallest building wake effect; therefore it is conservative for the purposes of this calculation.

Confirmation: This assumption does not require further confirmation by testing, design, or analysis.

Usage: This assumption is used in section 6.1.7.

3.2.6 Location of Members of the Public in the General Environment

Assumption: Members of the public in the general environment can be located beyond the site boundary of the repository in lands that are not government controlled. Therefore, no member of the public in the general environment is assumed to reside on the Nevada Test Site or on the Nellis Air Force Range. Therefore, members of the public in the general environment may be residing to the west and south of the repository boundary as shown in Figure 2.

Rationale: 10 CFR 63.202 (Reference 2.1.1 [DIRS 180319]) defines the general environment as "everywhere outside the Yucca Mountain site, the Nellis Air Force Range, and the Nevada Test Site." Per 10 CFR 63.204, DOE must ensure that no member of the public in the general environment receives more than an annual dose of 15 mrem. Therefore, the member of the public in the general environment may be to the west and south of the repository site.

Confirmation: This assumption does not require further confirmation by testing, design, or analysis.

Usage: This assumption is used in sections 6.3.3 and 6.6.

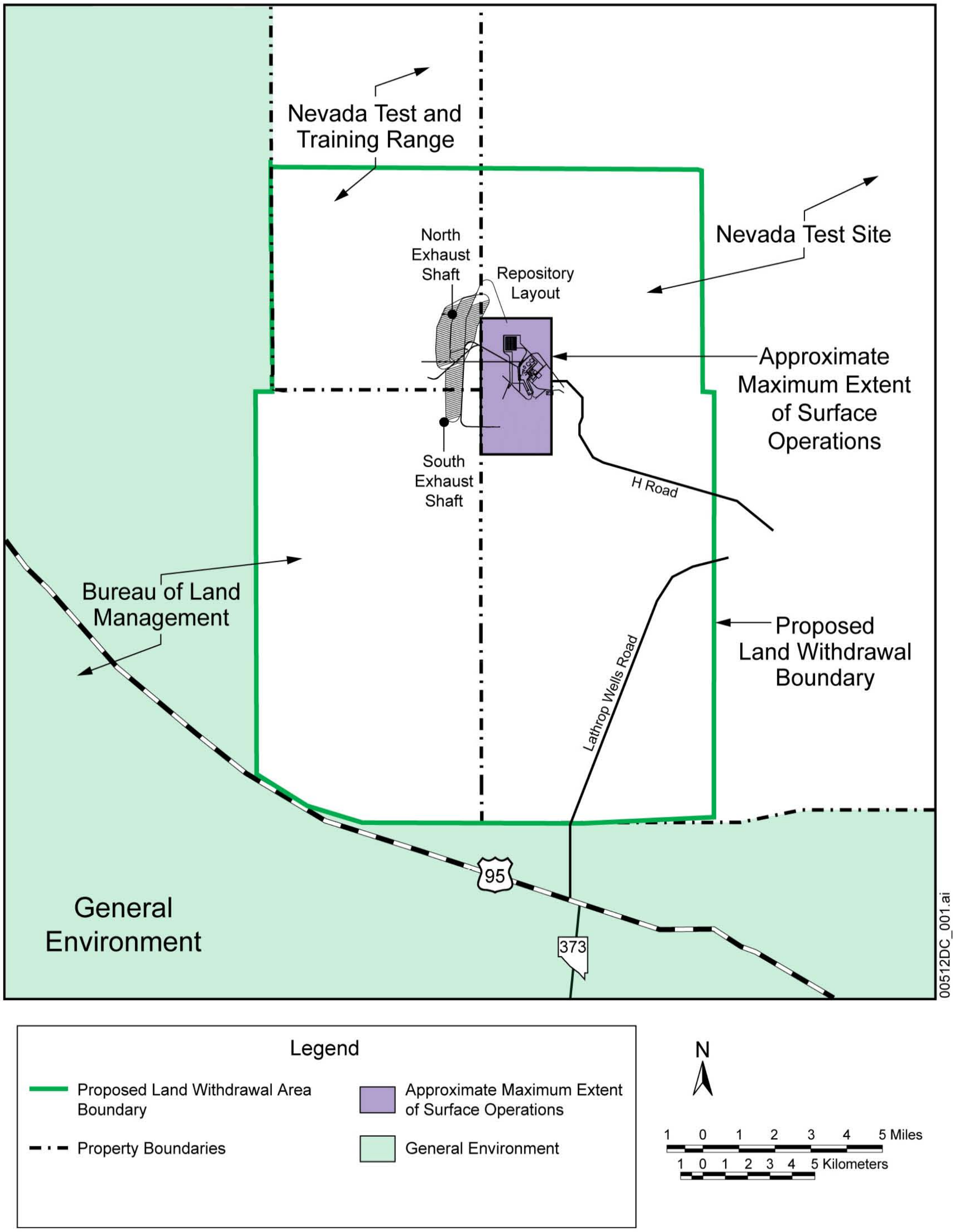

Figure 2 — Location of the General Environment

3.2.7 Onsite Member of the Public Location

Assumption: The maximally exposed onsite individual member of the public is assumed to be located outside the restricted area and within the site boundary at a distance that corresponds to the approximate distance between the surface facility or the subsurface repository and the nearest point on the restricted area boundary. For surface facility releases that distance is assumed to be 200 feet. For subsurface releases that distance assumed to be 100 m for restricted areas surrounding the subsurface exhaust vents. Since this individual can be anywhere on the repository site, all 16 meteorological sectors are considered in the determination of the atmospheric dispersion factors.

Rationale: The repository above ground facilities are in preliminary design stages, and the locations may change as the design progresses. Using a minimum distance of 200 feet from a release location to a point on the restricted area boundary allows for flexibility during the design process. The subsurface exhaust shafts ventilation systems are in the preliminary design stages, therefore a distance of 100 m from the release point to a point on the restricted area allows for flexibility during the design process. These distances allow for calculation of doses to the maximally exposed onsite individual without requiring revisions of this calculation.

Confirmation: This assumption does not require further confirmation by testing, design, or analysis.

Usage: This assumption is used in sections 6.4.1, 6.4.2, 6.4.3, 6.6, 6.6.7, 6.9.2, 7.3, and 7.4.

3.2.8 Deposition

Assumption: Only dry deposition is considered.

Rationale: Deposition as the plume travels from the source to the receptor location can occur by two mechanisms, dry deposition and wet deposition by rainout. The YMP site is located in a dry desert; therefore, wet deposition will be infrequent. As shown in section 6.10.2, only 1.6% of the total hours contain measurable precipitation. Therefore, for the purposes of this calculation wet deposition is not significant and because it would reduce the dispersion coefficients this is conservative.

Confirmation: This assumption does not require further confirmation by testing, design, or analysis.

Usage: This assumption is used in section 4.6.

3.2.9 Particle Size for Deposition

Assumption: The released particles are assumed to have a diameter of 1 μm or less.

Rationale: The deposition velocity is a function of the particle size and density. Larger particles can deposit quicker than smaller particles; thus less radioactive material would be available for exposures at the site boundary. Conservatively, small particles are used in this calculation to determine the deposition velocity.

Confirmation: This assumption does not require further confirmation by testing, design, or analysis.

Usage: This assumption is used in section 4.6.1

3.2.10 Precipitation Form

Assumption: The precipitation at the Yucca Mountain site is assumed to be liquid precipitation.

Rationale: A review of the meteorological data provided in section 6.1.2 shows that in the five-year period covered by the data there were no instances with precipitation when the temperature was below freezing. Therefore, it is reasonable to assume that all precipitation is in the form of liquid precipitation.

As described in section 5.3.5.2 of the *GENII Version 2 Software Design Document* (Reference 2.2.17 [DIRS 179908]), the wet deposition model for gases assumes that the gases are dissolved rapidly by the precipitation. Implicitly the *GENII Version 2 Software Design Document* assumes that the precipitation is liquid or at least has a liquid exterior because the rate of exchange of gases between air and ice is sufficiently low to be negligible.

Usage: This assumption is used in section 6.10.4.1. It is used to develop the GENIIv2 parameter *RAIN, average daily rain rate*.

4. METHODOLOGY

This calculation determines atmospheric dispersion factors, χ/Qs, for offsite dose assessments using hourly meteorological data. Hourly average χ/Qs for each combination of wind speed, direction and stability class are calculated for each sector for a given distance (such as the site boundary) using the methodologies of Regulatory Guides 1.111 (Reference 2.2.21 [DIRS 103765]) and 1.145 (Reference 2.2.22 [DIRS 103651]). For short distances, such as the onsite public at 100 m from surface facilities, where the building wake effects are pronounced, the methodologies of Regulatory Guides 1.111 and 1.145 are extremely conservative. For this case, the ARCON96 code (Reference 2.2.5 [164784]) is used. Annual average χ/Qs and 5%ile χ/Qs are calculated, for all locations considered.

4.1 QUALITY ASSURANCE

The χ/Q values will be used to support consequence analysis for the License Application. Therefore, this calculation is subject to the Quality Management Directive (Reference 2.1.2 [DIRS 180474]). This calculation was performed in accordance with procedures EG-PRO-3DP-G04B-00037, *Calculations and Analyses* (Reference 2.1.3), LS-PRO-0201, *Preclosure Safety Analyses Process* (Reference 2.1.6), and PA-PRO-0301, *Managing Technical Product Inputs* (Reference 2.1.4).

4.2 USE OF COMPUTER SOFTWARE

4.2.1 Software Tracked by Configuration Management

The ARCON96 code (Reference 2.2.5 [164784]) is used to calculate the relative atmospheric concentrations (χ/Q) for the onsite public at a distance of 100 meters from the surface facilities. ARCON96 is listed on the Repository Project Management Automation Plan (Reference 2.1.7). The software specifications are as follows:

Program Name: ARCON
Version/Revision Number: V. 96
Platform/Operating System: PC/Windows 2000
Software Tracking Number/Status: 10912-96-00/Qualified
This version is installed on a Dell Optiplex GX260 personal computer running Microsoft® Windows 2000 with CPU number 152876

In this calculation, ARCON96 is used for the χ/Q calculations of ground level releases. The use is appropriate and within the range of validation as documented. (Reference 2.2.4 [DIRS 168741], Table 3, Table 4, and Attachment I: Tests 1). The software was obtained from Software Configuration Management in accordance with IT-PRO-0011, *Software Management* (Reference 2.1.5).

The ARCON96 test cases were run, and the output (log and cfd) files were compared to the files provided with the code package. The results of this comparison are available in files *complog.txt* and *compcfd.txt* provided in Attachment III.

The input and output files for the ARCON96 calculations are listed and contained on a compact disc, which is part of Attachment III of this calculation.

There are two Software Problem Reports (SPR) issued for ARCON96, SPR026820040902 (Reference 2.2.36) and SPR011020070607 (Reference 2.2.37).

SPR026820040902 indicates that in some occasions the cfd file may be scaled incorrectly by a factor of 10 for time intervals greater than 8 hours. A review of the cfd files provided in Attachment III indicates that this condition has not occurred in this calculation.

SPR011020070607 concerns a discrepancy found in test case 6 of the validation tests. As discussed in the SPR this is only a discrepancy in the input file, that, when corrected provides correct results. Therefore, there are no impacts to this calculation.

4.2.2 Commercial off-the-Shelf Software

Microsoft® Excel software was used for performing calculations. The use of Microsoft® EXCEL 2000 is classified as Level 2 software per procedure IT-PRO-0011, *Software Management* (Reference 2.1.5 Attachment 12) and is not required to be qualified in accordance with procedure IT-PRO-0011. Details of the software are given below:

Title: Excel
Version/Revision Number: Microsoft® Excel 2000, 9.0.6926 SP-3
This version is installed on a Dell Optiplex GX260 personal computer running Microsoft® Windows 2000 with CPU number 152876.

User-defined formulas, input, and results are documented in sufficient detail in Section 6 to allow an independent checker to reproduce or verify the results without recourse to the originator. This information was verified by checks using hand calculations.

The Excel files used to perform the calculations are included in Attachment III (Attachment I gives the file information for Attachment III).

All figures developed for this calculation were visually inspected and verified to be accurate for the purposes of this calculation.

4.3 CALCULATION OF DISTANCES TO THE SITE BOUNDARY

4.3.1 Distance from a Point to the Site Boundary

The calculation of distances from any point within the GROA or subsurface exhaust shaft to a site boundary line segment is determined using simple trigonometric relationships. Figure 3 illustrates the methodology used. The selected point is located at [x_0, y_0]. A portion of the site boundary is a line segment from point [x_1, y_1] to point [x_2, y_2]. The distance, R is to be calculated for an angle θ from north (θ is positive in the clockwise direction).

x_1, y_1

Site boundary line
$y = mx + b$

N

R_1

Distance to site boundary line at angle θ, R

x_2, y_2

θ_1

R_2

θ

θ_2

x_0, y_0

Point of interest

Figure 3 — Distance from a Point to the Site Boundary Line

The boundary line is of the form:

$$y = mx + b \qquad \textbf{Equation 1}$$

Using points x_1, y_1 and x_2, y_2 the slope m and the intercept b can be calculated:

$$y_1 = mx_1 + b$$
$$y_2 = mx_2 + b$$
$$y_1 - y_2 = m(x_1 - x_2)$$

For $x_1 \neq x_2$, the slope is:

$$m = \frac{y_1 - y_2}{x_1 - x_2} \qquad \textbf{Equation 2}$$

The intercept is:

$$b = y_1 - mx_1 \qquad \textbf{Equation 3}$$

The coordinates for the intercept of the boundary line and the distance vector are:

$$y = R\cos\theta + y_0 \qquad \textbf{Equation 4}$$

$$x = R\sin\theta + x_0 \qquad \textbf{Equation 5}$$

Combining Equation 1 with Equation 4 and Equation 5

$$R\cos\theta + y_0 = m(R\sin\theta + x_0) + b \qquad \textbf{Equation 6}$$

Solving for R:

$$R = \frac{mx_0 + b - y_0}{\cos\theta - m\sin\theta} \qquad \textbf{Equation 7}$$

For $x_1 = x_2$, the distance R is:

$$R = \frac{|x_1 - x_0|}{\sin\theta} \qquad \textbf{Equation 8}$$

As shown in Figure 3, the boundary line is valid only for angles between θ_1 and θ_2. Those angles can be determined from the distances R_1 and R_2 calculated as follows:

$$R_1 = \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2} \qquad \textbf{Equation 9}$$

$$R_2 = \sqrt{(x_2 - x_0)^2 + (y_2 - y_0)^2} \qquad \textbf{Equation 10}$$

Using Equation 5 with Equation 9 and Equation 10 and solving for the angles θ_1 and θ_2:

$$x_1 = R_1\sin\theta_1 + x_0$$

$$\sin\theta_1 = \frac{x_1 - x_0}{R_1}$$

$$\theta_1 = \sin^{-1}\left(\frac{x_1 - x_0}{R_1}\right)$$

$$\theta_1 = \sin^{-1}\left(\frac{x_1 - x_0}{\sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2}}\right) \quad \textbf{Equation 11}$$

Similarly, θ_2 is then:

$$\theta_2 = \sin^{-1}\left(\frac{x_2 - x_0}{\sqrt{(x_2 - x_0)^2 + (y_2 - y_0)^2}}\right) \quad \textbf{Equation 12}$$

4.3.2 Distance from a GROA Line Segment to the Site Boundary

In this section the methodology for calculating the minimum distance from a GROA line segment to the site boundary is discussed. Per assumption 3.2.1, the GROA is assumed to be contained in a square. This square bounds the release locations of the above ground facilities at the repository.

Figure 4 illustrates the methodology used to determine the distances R_1 and R_2 from the endpoints of a GROA line segment to the site boundary for any given angle θ from the north. This methodology is only valid if the rays at angle θ from the GROA line segment endpoints intercept only one site boundary line segment as shown in Figure 4. See section 4.3.3 for the methodology used when the rays from the GROA line segment endpoints intercept two different site boundary line segments.

The distances R_1 and R_2 can be obtained using Equation 7 and substituting the GROA endpoint coordinates as follows:

$$R_1 = \frac{mx_{01} + b - y_{01}}{\cos\theta - m\sin\theta} \quad \textbf{Equation 13}$$

$$R_2 = \frac{mx_{02} + b - y_{02}}{\cos\theta - m\sin\theta} \quad \textbf{Equation 14}$$

The minimum distance from the GROA line segment to the site boundary at angle θ is the minimum of R_1 and R_2.

x_1, y_1

Site boundary line
y = mx + b

N

x_2, y_2

R_1 R_2

θ θ

x_{01}, y_{01} x_{02}, y_{02}

GROA boundary line segment

Figure 4 — Distances from a GROA Boundary Line Segment to Site Boundary Line

4.3.3 Distance from a GROA Segment to the Site Boundary with an Inflection Point

In the case where rays from the endpoints of the GROA line segment at angle θ meet the site boundary on two different line segments as shown in Figure 5, the methodology presented in section 4.3.2 is modified below.

The distances R_1 and R_2 can be obtained using Equation 7 and substituting the GROA line segment endpoint and site boundary line coordinates as follows:

$$R_1 = \frac{m_1 x_{01} + b_1 - y_{01}}{\cos\theta - m_1 \sin\theta}$$ **Equation 15**

$$R_2 = \frac{m_2 x_{02} + b_2 - y_{02}}{\cos\theta - m_2 \sin\theta}$$ **Equation 16**

In addition to the distances to the site boundary lines for the GROA line segment end points, the distance from the inflection point [x_2, y_2] from the GROA boundary line segment at angle θ is calculated. The distance, R_p, from this point can be calculated using Equation 4 or Equation 5. Equation 4 is used for the north and south GROA boundary line segments (y is constant), and Equation 5 is used for the east and west GROA boundary line segments (x is constant).

x_1, y_1

N

Site boundary line
$y = m_1x + b_1$

x_2, y_2

R_1

R_p

R_2

Site boundary line
$y = m_2x + b_2$

θ θ θ

x_{01}, y_{01} x_{0p}, y_{0p} x_{02}, y_{02} x_3, y_3

GROA boundary line segment

Figure 5 — Distances from GROA Line Segment to Site Boundary Line Segments with an Inflection Point

For the north or south GROA boundary line segment R_p is:

$$R_p = \frac{y_2 - y_0}{\cos\theta}$$ **Equation 17**

For the east or west GROA boundary line segment R_p is:

$$R_p = \frac{x_2 - x_0}{\sin\theta} \quad \textbf{Equation 18}$$

The minimum distance from the GROA boundary line segment to the site boundary at an angle θ, is the minimum of R_1 R_2, and R_p.

4.3.4 Sector Minimum Distance

Per Regulatory Guide 1.145 (Reference 2.2.22 [DIRS 103651]) Section 1.2, for each of the 16 meteorological sectors, the distance to the boundary from a release point is the nearest point to the boundary within a 45 degree sector centered on the compass direction of interest.

4.4 ANNUAL AVERAGE χ/Q MODEL (REGULATORY GUIDE 1.111 MODEL)

The annual average atmospheric dispersion is calculated using the Constant Mean Wind Direction Model. This model assumes that a constant mean wind transports and diffuses effluents, within the entire region of interest, in the direction of airflow at the release point. A commonly used version of this model is the Gaussian straight-line trajectory model. In this model, the windspeed and atmospheric stability at the release point are assumed to determine the atmospheric dispersion characteristics in the direction of the mean wind at all distances. This model is implemented in Regulatory Guide 1.111 (Reference 2.2.21 [DIRS 103765]) using the following equation:

$$\left(\frac{\overline{\chi}}{Q}\right)_D = 2.032 \sum_{ij} \frac{n_{ij} \cdot e^{\left[-h_e^2 / 2\sigma_{zj}^2(x)\right]}}{N \cdot x \cdot \overline{u}_i \Sigma_{zj}(x)}$$

Equation 19

where:

- h_e is the effective release height in meters;
- n_{ij} is the length of time (hours of valid data) weather conditions are observed to be at a given wind direction, windspeed class, *i*, and atmospheric stability class, *j*;
- N is the total hours of valid data;
- $\overline{u}_i$ is the midpoint of windspeed class, *i*, at a height representative of release in m/sec;
- x is the distance downwind of the source in meters;
- $\sigma_{zj}(x)$ is the vertical plume spread without volumetric correction at distance, *x*, for stability class, *j*, in meters;
- $\Sigma_{zj}(x)$ is the vertical plume spread with a volumetric correction for a release within the building wake cavity, at distance, *x*, for stability class, *j*, in meters; otherwise $\Sigma_{zj}(x) = \sigma_{zj}(x)$
- $\left(\frac{\overline{\chi}}{Q}\right)_D$ is the average effluent concentration, χ, normalized by source strength, *Q*, at distance, *x*, in a given downwind direction, *D* in sec/m^3; and
- 2.032 is $(2/\pi)^{1/2}$ divided by the width in radians of a 22.5° sector.

Because this calculation uses the meteorological data directly, and not pre-processed into windspeed categories, Equation 19 is modified to calculate a χ/Q for each hour as follows:

$$\left(\frac{\chi}{Q}\right)_h = \frac{2.032 \cdot e^{\left[-h_e^2/2\sigma_{zj}^2(x)\right]}}{x \cdot u_h \Sigma_{zj}(x)}$$ **Equation 20**

where:

u_h is the windspeed for hour *h* in m/sec, and

$\left(\frac{\chi}{Q}\right)_h$ is the atmospheric dispersion for hour *h* in sec/m^3.

The annual average χ/Q for a given meteorological sector is calculated by summing all of the $(\chi/Q)_{h,s}$ over n_s hours in that sector and then dividing by the total hours, N_T, of valid meteorological data:

$$\left(\frac{\overline{\chi}}{Q}\right)_s = \left[\frac{\sum\left(\frac{\chi}{Q}\right)_{h,s}}{n_s}\right]\frac{n_s}{N_T}$$ **Equation 21**

Per assumption 3.2.2, the releases are assumed to be at ground level; therefore, the effective release height, h_e, is set to zero.

Building Wake Correction

For ground-level releases only (h_e = 0), an adjustment may be made in Equation 19 or in Equation 20 that takes into consideration initial mixing of the effluent plume within the building wake. This adjustment is in the form of (Regulatory Guide 1.111, Reference 2.2.21 [DIRS 103765]):

$$\Sigma_{zj}(x) = \sqrt{\sigma_{zj}^2(x) + \frac{0.5D_z^2}{\pi}} \le \sqrt{3}\sigma_{zj}(x)$$ **Equation 22**

Where D_z is the maximum adjacent building height either up or downwind from the release point.

4.5 HOURLY χ/Q MODEL (REGULATORY GUIDE 1.145 MODEL)

This calculation follows the methodology of Regulatory Guide 1.145 (Reference 2.2.22 [DIRS 103651]) to determine the short-term (accident) hourly χ/Q values. For releases from building vents or other building vents that are at release points effectively lower than two and one-half times the height of adjacent solid structures, a ground level release model is used (assumption 3.2.2).

From Regulatory Guide 1.145, χ/Q values for ground level releases are determined based on two sets of meteorological conditions as follows:

a. During neutral (D) or stable (E, F, or G) atmospheric stability conditions when the wind speed at the 10-meter level is less than 6 meters per second, horizontal plume meander may be considered. χ/Q values may be determined through selective use of the following set of equations for ground-level relative concentrations at the plume centerline:

$$\left(\frac{\chi}{Q}\right)_1 = \frac{1}{u_{10}(\pi\sigma_y\sigma_z + A/2)}$$ **Equation 23**

$$\left(\frac{\chi}{Q}\right)_2 = \frac{1}{u_{10}(3\pi\sigma_y\sigma_z)}$$ **Equation 24**

$$\left(\frac{\chi}{Q}\right)_3 = \frac{1}{u_{10}\pi\Sigma_y\sigma_z}$$ **Equation 25**

where:

u_{10} is the wind speed at 10 meters above plant grade in meter/sec

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

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

Σ_y is the lateral plume spread with meander and building wake effects, a function of atmospheric stability, wind speed u_{10}, and distance, in meters.

- For distances equal or less than 800 meters, $\Sigma_y = M\sigma_y$
- For distances greater than 800 meters, $\Sigma_y = (M-1)\sigma_{y_{800m}} + \sigma_y$

M is the plume meander correction factor.

A is the vertical-plane cross-sectional area of the release building orthogonal to the wind direction in m^2.

χ/Q values are calculated using Equation 23 through Equation 25. The final value is selected by taking the higher χ/Q value calculated using Equation 23 and Equation 24 and then comparing with that calculated using Equation 25. The lower value becomes the final χ/Q.

b. During all other meteorological conditions, plume meander is not considered. The appropriate χ/Q value for these conditions is the higher value calculated from either Equation 23 or Equation 24.

The plume meander correction factor, M, is calculated using Regulatory Guide 1.145 (Reference 2.2.22 [DIRS 103651]) Figure 3. Figure 3 has four log-log figures and the general equation is:

$$M = e^{(m \cdot \ln(u_{10}) + b)} \quad , u_{10} > 2\ m/\sec \qquad \textbf{Equation 26}$$

Where u_{10} is the wind speed (m/sec) measured 10 meters above the surface.

Using Regulatory Guide 1.145 Figure 3, the constants m and b in the above equation were calculated as follows:

$$m = \frac{ln(M_2/M_1)}{ln(u_2/u_1)} \qquad \textbf{Equation 27}$$

From Equation 26:

$$\ln(M) = m \cdot \ln(u) + b \quad thus \quad b = \ln(M) - m \cdot \ln(u) \qquad \textbf{Equation 28}$$

Using $M_1 = 1$; $u_1 = 6$ m/sec, the resultant m and b values for stability classes D through G are shown on Table 2

Table 2 — Plume Meander Correction Parameters

Stability Class	M_2	u_2	m	b
D	2	2	-0.63093	1.130474
E	3	2	-1.0	1.791759
F	4	2	-1.26186	2.260949
G	6	2	-1.63093	2.922234

For $u_{10} \leq 2$ m/sec, $M = M_2$.

4.6 DEPOSITION AND DEPLETION

Deposition is included in the calculation of atmospheric dispersion factors because the deposited material contributes to dose through ground shine and the ingestion pathway and deposition of material reduces the concentration of material in the air. As discussed in assumption 3.2.8, only dry deposition is considered.

4.6.1 Dry Deposition

The flux of material to the ground resulting from dry deposition is assumed to be proportional to the material's concentration in the air near the ground. Deposition velocity is the term given to the constant of proportionality. The dry deposition rate is calculated using Equation 5.88 of the *GENII Version 2 Software Design Document* (Reference 2.2.17 [DIRS 179908]):

$$\omega_{ij}(t) = v_{dd}\chi(1,t)$$ **Equation 29**

where:

$\omega_{ij}(t)$ is the dry deposition rate at position i, j at time t in m^{-2}

vdd is the dry deposition velocity in m/s

$\chi(1,t)$ is the concentration at a height of 1 m at position i, j at time t in Bq/m^3

The dry deposition velocity is modeled in the *GENII Version 2 Software Design Document* (Reference 2.2.17 [DIRS 179908] section 5.3.5.1) using an analogy to electrical resistance. Resistances are associated with atmospheric conditions, physical and chemical characteristics of the material, and the physical, chemical and biological properties of the surface.

As discussed in assumption 3.2.9, only small particles (1 μm diameter or less) will be considered for deposition. Using Equation 5.89 of the *GENII Version 2 Software Design Document* (Reference 2.2.17 [DIRS 179908]):

$$v_{dd} = (r_a + r_s + r_t)^{-1}$$ **Equation 30**

where:

r_a is the aerodynamic resistance (s/m)

r_s is the surface resistance (s/m)

r_t is the transfer resistance (s/m)

The aerodynamic resistance is calculated directly from the wind speed and a parameter that is characteristic of the turbulence in the lowest layer of the atmosphere. Using Equation 5.90 of the *GENII Version 2 Software Design Document* (Reference 2.2.17 [DIRS 179908]):

$$r_a = \frac{U(z)}{u_*^2}$$ **Equation 31**

where:

z is the height at which the concentration is estimated

u_* is the characteristic turbulence velocity, called the friction velocity (m/s)

$U(z)$ is the wind speed at height z (m/s)

Per the *GENII Version 2 Software Design Document* (Reference 2.2.17 [DIRS 179908]) the surface resistance is only a function of the friction velocity. It is given by:

$$r_s = \frac{2.6}{0.4u_*} \qquad \textbf{Equation 32}$$

Where 2.6 is a dimensionless empirical constant and 0.4 is von Karman's constant.

Per design input 6.1.4, a transfer resistance of 100 s/m for particulates is used.

4.6.2 Depletion

Depletion is calculated using the methodology described in section 5.3.7 of the *GENII Version 2 Software Design Document* (Reference 2.2.17 [DIRS 179908]). The depletion of the source is calculated between each distance x_1 to x_2 using Equation 5.119 of the *GENII Version 2 Software Design Document*:

$$Q'(x_2) = Q'(x_1)\exp\left(-\frac{1}{2}\sqrt{\frac{2}{\pi}}\frac{v_{dd}}{U}\int_{x_1}^{x_2}\frac{G(z)}{\sigma_z}dx\right) \qquad \textbf{Equation 33}$$

The term G(z), which is the vertical dispersion factor which includes plume reflection off the ground and the mixing layer is implicitly considered to be 2 in the Regulatory Guide 1.111 (Equation 19) and 1.145 models (Equation 23 to Equation 25). Therefore, Equation 33 becomes:

$$Q'(x_2) = Q'(x_1)\exp\left(-\sqrt{\frac{2}{\pi}}\frac{v_{dd}}{U}\int_{x_1}^{x_2}\frac{1}{\sigma_z}dx\right) \qquad \textbf{Equation 34}$$

The integral in Equation 34 cannot be solved explicitly. Therefore, using the guidance from section 5.3.7 of the *GENII Version 2 Software Design Document*, the integral is approximated numerically using a trapezoidal rule. The integral is calculated at each direction beginning at 100 meters. The distance is doubled until the minimum receptor distance in any meteorological sector is reached. From that point, the integral is calculated for the distance to the site boundary for each meteorological sector in increasing distance. Intermediate values for the integral are determined at all distances for each stability class.

4.7 DISPERSION COEFFICIENTS

The lateral (σ_y) and horizontal (σ_z) dispersion coefficients are implementations of the Pasquill-Gifford curves used in the NRC computer codes PAVAN (Reference 2.2.3 [DIRS 175685], section 4.16) and XOQDOQ (Reference 2.2.24 [DIRS 175686], section 4.21), ARCON96 (Reference 2.2.18 [DIRS 164547], section A.7). The basic equation at a downwind distance x is:

$$\sigma_j = A_j x^{B_j} + C_j \qquad \textbf{Equation 35}$$

For j = y, B_y = 0.9031 and C_y = 0. The other constants are given in Table 3.

Table 3 — Constants for the Pasquill-Gifford Diffusion Formulas

		Stability Class						
	Distance	**A**	**B**	**C**	**D**	**E**	**F**	**G**
A_y	All	0.3658	0.2751	0.2089	0.1471	0.1046	0.0722	0.0481
A_z	< 100 m	0.192	0.156	0.116	0.079	0.063	0.053	0.032
	100 to 1,000 m	0.00066	0.0382	0.113	0.222	0.211	0.086	0.052
	> 1,000 m	0.00024	0.055	0.113	1.26	6.73	18.05	10.83
B_z	< 100 m	0.936	0.922	0.905	0.881	0.871	0.814	0.814
	100 to 1,000 m	1.941	1.149	0.911	0.725	0.678	0.74	0.74
	> 1,000 m	2.094	1.098	0.911	0.516	0.305	0.18	0.18
C_z	< 100 m	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	100 to 1,000 m	9.27	3.3	0.0	-1.7	-1.3	-0.35	-0.21
	> 1,000 m	-9.6	2.0	0.0	-13.0	-34.0	-48.6	-29.2

Constants obtained from Reference 2.2.18 [DIRS 164547] section A.7 (p. 92).

Following the methodology of PAVAN (Bander 1982, section 4.16, Reference 2.2.3 [DIRS 175685]) and XOQDOQ (Sagendorf et. al. 1982, section 4.21, Reference 2.2.24 [DIRS 175686]), both the lateral (σ_y) and vertical (σ_z) dispersion coefficients are limited to a maximum value of 1,000 meters, a conservative mixing limit.

4.8 ATMOSPHERIC STABILITY CLASSIFICATION

Atmospheric stability is entered as a number from 1 through 7. A stability class of 1 represents extremely unstable conditions, and a stability class of 7 represents extremely stable conditions. Atmospheric stability classes are determined from the ΔT given in the meteorological data using the following classification scheme from Table 2 of Regulatory Guide 1.23 (Reference 2.2.20 [DIRS 103640]):

Table 4 — Classification of Atmospheric Stability

Stability Classification	**Pasquill Category**	**Stability Class**	**Temperature Change with Height**	
			(°C/100m)	**(°C/50m)**
Extremely Unstable	A	1	ΔT/Δz <= -1.9	ΔT/Δz <= -0.95
Moderately Unstable	B	2	-1.9 < ΔT/Δz <= -1.7	-0.95 < ΔT/Δz <= -0.85
Slightly Unstable	C	3	-1.7 < ΔT/Δz <= -1.5	-0.85 < ΔT/Δz <= -0.75
Neutral	D	4	-1.5 < ΔT/Δz <= -0.5	-0.75 < ΔT/Δz <= -0.25
Slightly Stable	E	5	-0.5< ΔT/Δz <= 1.5	-0.25< ΔT/Δz <= 0.75
Moderately Stable	F	6	1.5 < ΔT/Δz <= 4.0	0.75 < ΔT/Δz <= 2.0
Extremely Stable	G	7	4.0 < ΔT/Δz	2.0 < ΔT/Δz

Because the meteorological data from design input 6.1.2 provides ΔT between 10 and 60 meters, the classification from Regulatory Guide in °C/100 m is converted to °C/50 m by dividing the definition temperature differences by two.

4.9 MIXING HEIGHT

The mixing height is described as follows. In the layer of the atmosphere next to the earth's surface, friction caused by surface roughness and heating of the surface combine to generate turbulence that efficiently mixes material released at or near the surface through the layer. This layer is referred to as the mixing layer. The top of the mixing layer is marked by a decrease in turbulence brought about by stable atmospheric conditions above. The depth of the mixing layer, also referred to as the thickness of the mixing layer, changes with atmospheric conditions. The mixing layer is generally thickest during the day and during periods with high wind speeds, and it is thinnest at night during the periods with low wind speeds. In either case, the mixing layer depth tends to increase with surface roughness.

Per Section A.2.4 of the *GENII Version 2 Users' Guide* (Reference 2.2.16 [DIRS 179907]), the mixing height for stable atmospheric conditions is:

$$H = k\sqrt{\frac{u_* L}{f}}$$ **Equation 36**

Where:

- H is the mixing layer height (m)
- k is von Karman constant (dimensionless, 0.4)
- u_* is the friction velocity (m/s)
- L is the Monin-Obukhov Length (m)
- f is the Coriolis parameter $= 1.46 \times 10^{-5} \sin\varphi$, where φ is the latitude (s^{-1})

For neutral and unstable conditions, the mixing layer height is estimated using:

$$H = \beta \frac{u_*}{f}$$ **Equation 37**

Where β is a constant with a value of 0.2

Per Section A.2.4 of the *GENII Version 2 Users' Guide*, the mixing layer height is not allowed to exceed 2,000 meters or fall under 10 meters.

4.9.1 Friction Velocity

The friction velocity, u_* used in Equation 31, Equation 32, Equation 36, and Equation 37 is calculated using the diabatic wind profile from Equation 5.51 of the *GENII Version 2 Software Design Document* (Reference 2.2.17 [DIRS 179908]):

$$U(z) = \frac{u_*}{k}\left[\ln\left(\frac{z}{z_0}\right) - \psi\left(\frac{z}{L}\right)\right]$$

rearranging,

$$u_* = \frac{k \cdot U(z)}{\left[\ln\left(\frac{z}{z_0}\right) - \psi\left(\frac{z}{L}\right)\right]}$$ **Equation 38**

Where:

U(z)	is the wind speed at height z (m/s)
z_0	is the measure of surface roughness (roughness length) (m)
z	is the height (m)
ψ	is the stability correction factor

All other parameters defined previously.

4.9.2 Stability Correction Factor

As discussed in Section 5.3.2 of the *GENII Version 2 Software Design Document* (Reference 2.2.17 [DIRS 179908]), the term ψ accounts for the effects of stability of the wind profile. In stable atmospheric conditions it takes a form of:

$$\psi\left(\frac{z}{L}\right) = -\alpha\frac{z}{L}$$ **Equation 39**

Per Section 5.3.2 of the *GENII Version 2 Software Design Document* (Reference 2.2.17 [DIRS 179908]), a value of 5 is used for α.

In neutral conditions ψ is zero.

For unstable conditions, the stability correction factor takes the form of Equation 5.52 of the *GENII Version 2 Software Design Document* (Reference 2.2.17 [DIRS 179908]):

$$\psi\left(\frac{z}{L}\right) = \ln\left(\left[\frac{1+x^2}{2}\right]\left[\frac{1+x}{2}\right]^2\right) - 2\tan^{-1}x + \frac{\pi}{2}$$ **Equation 40**

Where x is:

$$x = \left(1 - 16\frac{z}{L}\right)^{0.25}$$ **Equation 41**

4.9.3 Monin-Obukhov Length

The Monin-Obukhov length is a measure of atmospheric stability. It varies from small negative values (a few meters) in extremely unstable atmospheric conditions to negative infinity as the atmospheric stability approaches neutral from unstable. In extremely stable conditions, the Monin-Obukhov length is small and positive. As neutral conditions are approached from stable conditions, the Monin-Obukhov length approaches infinity. In the above expressions, the inverse Monin-Obukhov length is used (1/L). Therefore, as the Monin-Obukhov length approaches infinity, 1/L approaches zero.

Figure 6, a reproduction of Figure 5.1 of the *GENII Version 2 Software Design Document* (Reference 2.2.17 [DIRS 179908]) shows the range for 1/L as a function of stability classes and surface roughness. Mid-range values for 1/L from this figure are used to estimate 1/L. An implementation of this methodology can be found in subroutine INVMOL2 of the ARCON96 code (Reference 2.2.18 [DIRS 164547], pp 86 and 87). This methodology is employed in this

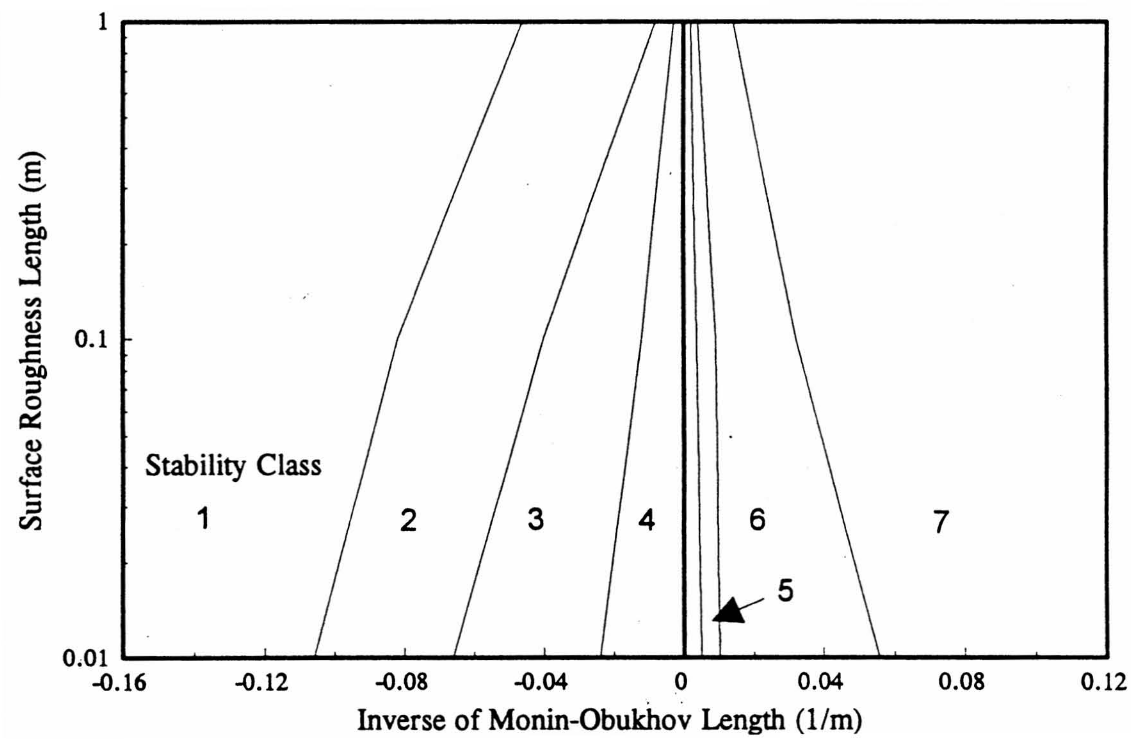

Figure 6 — Relationship between Stability Class and Monin-Obukhov Length as a Function of Surface Roughness Length

4.10 ABSOLUTE HUMIDITY

The average absolute humidity is determined from the Yucca Mountain site meteorological data cited in Section 6.1.2. The meteorological data collected for years 2001 to 2005 includes hourly relative humidity data.

The absolute humidity can be derived from a combination of the air temperature, relative humidity, or dew point temperature. The dew point is the temperature to which a given air volume must be cooled to reach saturation at constant pressure and constant water vapor content.

The saturation vapor pressure is a measure of the amount of water vapor content that the atmosphere can hold for a given temperature. The saturation vapor temperature can be calculated using the following expression (Allen et al. 1998, Reference 2.2.1 [DIRS 157311], equations 11 and 12, p. 36):

$$e_s(T) = 0.6108 \exp\left[\frac{17.27T}{T + 237.3}\right]$$ **Equation 42**

Where:

$e_s(T)$ saturation vapor pressure at temperature T (kPa),
T air temperature (ºC)
0.6108 relationship constant (kPa)

Define $e(T)$ as the vapor pressure at temperature T (kPa). Then, using the ideal gas law and the definition of the water vapor pressure,

$$eV = n_w R(T + 273.15)$$ **Equation 43**

Where:

V volume of air (m^3)
n_w number of moles of water vapor
R gas constant, 8.3143 x 10^{-3} kPa-m^3/mole-ºK (ASME 1993, Reference 2.2.2 [DIRS 108050], p. 86)

The molar concentration (moles/m^3) of water vapor is then:

$$\frac{n_w}{V} = \frac{e}{R(T + 273.15)}$$ **Equation 44**

The absolute humidity AH, expressed in g/m^3 is calculated by multiplying both sides of Equation 44 by the molecular weight of water, MW_w =18.015 g/mole (ASME 1993, Reference 2.2.2 [DIRS 108050], p. 86):

$$AH = \frac{n_w \cdot MW_w}{V} = \frac{e \cdot MW_e}{R(T + 273.15)}$$ **Equation 45**

The vapor pressure at temperature T, given a relative humidity RH (%) is then:

$$e(T) = \frac{RH \cdot e_s(T)}{100}$$ **Equation 46**

Combining Equation 44, Equation 45, and Equation 46 yields:

$$AH = \frac{RH \cdot MW_w}{100R(T+273.15)} 0.6108 \exp\left[\frac{17.27T}{T+237.3}\right]$$ **Equation 47**

4.11 TIME DEPENDENT ATMOSPHERIC DISPERSION FACTORS

Regulatory Guide 1.145 (Reference 2.2.22 [DIRS 103651]) section 1.3 states that calculations based on meteorological data representing a 1-hour average should be assumed to apply for the entire 2-hour period immediately following an accident. Regulatory Guide 1.145 section 2.1.1 states that using the hourly χ/Q values for each of the 16 meteorological sectors, the value for each of the sectors that is exceeded 0.5 percent of the total number of hours in the data set should be selected as the 2-hour χ/Q value for that sector. In addition, in Regulatory Guide 1.145 section 3 the overall site χ/Q value that is exceeded 5 percent of the time should be selected to represent the 2-hour 5 percentile site χ/Q value. The maximum of the site 2-hour χ/Q value and the sector 2-hour χ/Q value should then be selected.

For accident scenarios with a release duration between 2 to 8,760 hr (1 year), Regulatory Guide 1.145 recommends that a logarithmic interpolation be used between the acute bounding integrated χ/Q value with plume meander and the chronic annual average χ/Q value. In general, the χ/Q for a release duration, Trel, between 2 hr and 1 year is computed using the following formula:

$$\frac{\chi}{Q}_{Trel} = \frac{\chi}{Q}_{2hr} \times \left(\frac{Trel}{2hr}\right)^{slope}$$ **Equation 48**

where Trel = release duration in hours. The slope is computed using Trel = 8,760 hr:

$$slope = \ln\left(\frac{\frac{\chi}{Q}_{Trel}}{\frac{\chi}{Q}_{2hr}}\right) \div \ln\left(\frac{8{,}760\,hr}{2\,hr}\right)$$ **Equation 49**

4.12 ARCON96 METHODOLOGY

4.12.1 General Methodology

ARCON96 was developed by Pacific Northwest National Laboratory for the NRC to calculate χ/Q values in plumes for nuclear power plants at control room air intakes in the vicinity of the release point (Reference 2.2.18 [DIRS 164547]). ARCON96 implements a straight-line Gaussian dispersion model with dispersion coefficients that are modified to account for low wind meander and building wake effects. The code calculates normalized concentrations (χ/Q) using hourly meteorological data. These hourly values are averaged to form χ/Qs for various time periods ranging from 2 hours to a much longer duration. The calculated values for each period are then used to form cumulative frequency distributions (CFDs).

The ARCON96 code accounts for variations in the location of release points and plume dispersion due to building wakes and plume meander under low wind speed conditions. For each receptor of interest, a CFD of χ/Q is constructed by the code for various release time periods (e.g., 2 hours, 4 hours, 8 hours, 12 hours, etc., or longer time periods). The 8,760-hour probabilistic χ/Q distribution is used to determine the annual mean and median (50^{th} percentile) χ/Q values for the receptor of interest. The 95^{th} percentile χ/Q values may be used to conservatively assess the potential consequences of event sequences.

4.12.2 Calculation of 50^{th} Percentile Annual Average χ/Q

ARCON96 is a directionally-dependent code; it computes χ/Qs only when the wind direction is within a (default) 90º window centered on the intake-to-source direction. ARCON96 determines 95^{th} percentile χ/Q values but not 50^{th} percentile χ/Q values. Thus, 50^{th} percentile χ/Qs must be determined outside the code. The following discussion describes the development of the methodology that is used to calculate 50^{th} percentile χ/Qs.

One of the output files generated by the ARCON96 code is a cumulative frequency distribution (CFD). The CFD lists the number of hours that a certain χ/Q value has been exceeded for each of the averaging periods. The lower limit of hourly χ/Q values determined by ARCON96 in the CFD output is 1.00×10^{-7} sec/m^3. The lower limit used by ARCON96 for a particular case is given in the primary output (LOG) file.

ARCON96 uses the CFD data to determine the 95^{th} percentile χ/Q values. As stated in section 3.8 of the ARCON96 manual (Reference 2.2.18 [DIRS 164547]):

> "Relative atmospheric concentrations (χ/Qs') that are exceeded no more than 5% of the time during a year are determined from complementary cumulative frequency distributions of the averages from each averaging period. The basis for determining these values is the possible number of averages for the period minus the number of averages not available due to missing data. For example, assuming data for one year are being processed, there are 8760 possible hourly χ/Q' values. The 95^{th} percentile is that concentration exceeded by 438 values. However, if 10% of the data were missing, the 95^{th} percentile relative concentration would be that concentration that is exceeded by 394 values."

As noted above, ARCON96 determines the χ/Qs based on the total number of hours of valid meteorological data, regardless of the averaging period. However, for the 50^{th} percentile χ/Qs especially at shorter averaging time periods, it may not be possible to directly utilize the ARCON96 results, because the accumulated hours for which valid χ/Q data exist may be less than 50% of the total valid hours.

Therefore, the 50^{th} percentile χ/Qs for each averaging period will be calculated from the ARCON96 CFD data using the following methodology. The median χ/Q for the averaging period is first calculated from the ARCON96 CFD output based on the accumulated number of hours for which valid χ/Q data exist in each averaging period. Thus, for example, the median χ/Q for a 1 hour averaging period in a sector is that χ/Q that is not exceeded for 14,080 hours out of an accumulated 28,160 valid hours. The median χ/Q value, which is determined by linear interpolation between the two nearest values in the CFD data that bound the number of hours exceeded, i.e. 14,080 hours, as shown below.

$$\frac{\tilde{\chi}}{Q} = \frac{\chi}{Q}_{lower} + \frac{\frac{\chi}{Q}_{lower} - \frac{\chi}{Q}_{upper}}{Hours_{lower} - Hours_{upper}} \times (Hours_{median} - Hours_{lower})$$

Equation 50

where:

$Hours_{median}$ is the hours exceeded corresponding to the 50th percentile χ/Q
$Hours_{lower}$ is the nearest hours exceeded less than $Hours_{median}$
$Hours_{upper}$ is the nearest hours exceeded greater than $Hours_{median}$
$\frac{\tilde{\chi}}{Q}_{lower}$ is the χ/Q value for $Hours_{lower}$
$\frac{\tilde{\chi}}{Q}_{upper}$ is the χ/Q value for $Hours_{upper}$
$\frac{\tilde{\chi}}{Q}$ is the median χ/Q for the averaging period

The χ/Q for the remaining portion of the valid hours is taken to be 1.00 x 10^{-7} sec/m^3, the lower limit reported by ARCON96. The 50th percentile χ/Q is then time-average calculated as:

$$\frac{\chi}{Q}_{50} = \frac{\left(AH \times \frac{\tilde{\chi}}{Q} + (TH - AH) \times 1.00x10^{-7} \right)}{TH}$$

Equation 51

where:

$\frac{\tilde{\chi}}{Q}_{50}$ is the 50th percentile χ /Q for the averaging period
AH is the number of accumulated hours in the averaging period
TH is the total number of valid hours in the CFD output.

5. LIST OF ATTACHMENTS

Attachment I: Listing of Computer Files Contained in Attachment III (8 pages).

Attachment II: E-Mail from GIS Requests (Audrey Rager) to Jorge Schulz (Reference 2.2.15) (2 pages).

Attachment III: Three Compact Disks (CD) containing the EXCEL spreadsheets and ARCON96 files used in the calculation process.

6. BODY OF CALCULATION

6.1 DESIGN INPUTS

6.1.1 Meteorological Tower Location

The location of the meteorological tower at Site 1 is selected to represent the area of repository surface facilities. Per Reference 2.2.33, DTN: SN0612GEOCOORD.001, Geographic Coordinates and Elevation for Yucca Mountain Meteorological Sites 1, 2, 3, 6, 8, and 9 shows that the tower at Site 1 is located at coordinates 761,795 feet North and 569,126 feet East in the Nevada State Plane Coordinates. The locations of the meteorological towers given in DTN: SN0612GEOCOORD.001 were qualified within a tolerance of 27 meters in ANL-MGR-MD-000015 REV00 (Reference 2.2.34). This tolerance is acceptable for the intended purposes of this calculation. Reference 2.2.33 also shows that Site 1 is located at latitude 36º 50’ 34” north and longitude 116º 25’ 50” west. This DTNs is listed in the information exchange document (IED), 100-IED-WHS0-00201-000-00B (Reference 2.2.32). This information is corroborated by Reference 2.2.35, which shows that this tower is located at coordinates 761,796.168 feet North and 569,127.073 feet East in the Nevada State Plane Coordinates. The latitude of the location is used to determine the coriolis force as described in section 4.9.

Suitability for Use: The Site 1 is located approximately 1-km south-south-west of the North Portal. Releases during normal operations and from event sequences can be from surface facilities processing waste forms and from the subsurface exhaust shafts. For surface facility releases, Site 1 is the closest meteorological site to the surface facilities and therefore most appropriate for use in calculating atmospheric dispersion factors for the surface facilities. For subsurface releases, Site 2 is closer to the subsurface exhaust shafts. However, the meteorological conditions at Site 2 result in consistently higher wind speeds due to a high elevation, 4,850ft at Site 2 vs 3,750 ft at Site 1. As atmospheric dispersion factors are inversely proportional to wind speed, this results in greater atmospheric dispersion using data from Site 2 as compared to Site 1. Greater atmospheric dispersion results in lower dose consequences, therefore, it is conservative to use Site 1 data to evaluate release from the subsurface exhaust shafts. The selected meteorological tower is located in the area of repository surface facilities; it is the best available location to link the meteorological information with the potential radionuclide source releases for the preclosure safety analysis.

The difference in the coordinates between references 2.2.35 and 2.2.33, based on different surveys is only 1 foot in the east and north direction; therefore, they are in good agreement, and the latitude and longitude given in reference 2.2.33 is suitable for the intended use in section 4.9.

6.1.2 Meteorological Data

Meteorology data set from the Yucca Mountain site is available for the 5-year period of 2001 through 2005. The meteorological data used for χ/Q value, absolute humidity, and average rainfall calculations are based on site-specific measurements made at air quality and meteorology monitoring Site 1, which is a 60-m tower located approximately 1-km south–southwest of the North Portal. The temperature difference (ΔT) is provided between 10 and 60 m.

The meteorological data included in the relevant DTNs listed below are used as direct inputs to this calculation. These DTNs are listed in the information exchange document (IED), 100-IED-WHS0-00201-000-00B (Reference 2.2.32). The data set consists of hourly measured data collected under quality assurance procedures that are submitted to the Technical Data Management System under the following data tracking numbers (DTNs):

DTN: MO0305SEP01MET.002 (Reference 2.2.25 [DIRS 166164]) Meteorological Monitoring Data for 2001. Submittal date: 05/21/2003.

DTN: MO0305SEP02MET.002 (Reference 2.2.26 [DIRS 166163]) Meteorological Monitoring Data for 2002. Submittal date: 05/21/2003.

DTN: MO0503SEPMMD03.001 (Reference 2.2.27 [DIRS 176097]) Meteorological Monitoring Data for 2003. Submittal date: 03/03/2005.

DTN: MO0607SEPMMD04.001 (Reference 2.2.28 [DIRS 178311]) Meteorological Monitoring Data for 2004. Submittal date: 07/18/2006.

DTN: MO0610METMND05.000 (Reference 2.2.29 [DIRS 178328]) Meteorological Monitoring Data for 2005. Submittal date: 09/18/2006.

The meteorological data was formatted into the ARCON96 format in file *ymp.met* as discussed in section 6.9.1 and into the GENII format in file *ymp01-05.met* as discussed in section 6.10.4.

Rationale: The qualified data cited provides the appropriate meteorological information for the repository. This data is consistent with the regulatory positions of Regulatory Guide 1.23 (Reference 2.2.20 [DIRS 103640]) that is cited in Regulatory Guide 1.145 (Reference 2.2.22 [DIRS 103651]).

6.1.3 Surface Roughness Length

Per Regulatory Guide 1.194 Table A-2 (Reference 2.2.23 [DIRS 165736]), reasonable values for the surface roughness length are 0.1 m for sites with low surface vegetation to 0.5 m for forest-covered sites. Since the Yucca Mountain site is a desert site with low surface vegetation, a value of 0.1 m is used for the surface roughness length.

Suitability for Use: This is appropriate regulatory guidance for this parameter. It is used for meteorological database generation, which is documented in section 6.10.4

6.1.4 Transfer Resistance

Transfer resistances are usually associated with the characteristics of the depositing material and surface type (Reference 2.2.19 [DIRS 177811], p.570). The transfer resistance is used as a mathematical device to establish an upper limit on the deposition velocity. The user can enter transfer resistance, but as a default, 10 and 100 s/m are assumed for gas (iodine) and particles, respectively (Reference 2.2.17 [DIRS 179908], Section 5.3.5.1). For the purposes of this calculation the transfer resistance for particles (100 s/m) is used for both particles and iodines.

This is conservative because the higher transfer resistance results in lower deposition velocities and higher depleted χ/Q values.

Suitability for Use: As the parameter is an empirical value to fit the mathematical model for the dry deposition velocity and this model is provided as an option in GENIIv2, the default parameter values are appropriate to use.

6.1.5 Repository Exhaust Shaft Coordinates

As shown in drawing 800-P00-TUN0-00701-000-00A (Reference 2.2.6 [DIRS 165314]), there are three exhaust shafts and two exhaust raises for the subsurface facilities. Drawing 800-P00-TUN0-00701-000-00A (Reference 2.2.6 [DIRS 165314]) presents the coordinates for each of the exhaust shafts and raises. These coordinates are shown in Table 5.

Table 5 — Subsurface Facilities Exhaust Shaft Coordinates

	East (ft)	North (ft)
Exhaust Shaft 1	559,368	770,604
Exhaust Shaft 2	563,658	775,360
Exhaust Shaft 3	559,937	757,357
Exhaust Raise 1	560,005	767,748
Exhaust Raise 2	563,942	769,618

Rationale: The cited reference provides the coordinates of the exhaust shafts and raises for the subsurface facility.

6.1.6 Nearest Resident

The closest residents to the repository are located in the Amargosa Valley at the intersection of U.S. Highway 95 and Nevada State Route 373 as discussed in the Biosphere Model Report (Reference 2.2.8 [DIRS 169460] Section 6.1.1.3 and Table 1 and Figure 1 of Reference 2.2.7 [DIRS 168723].

Rationale: The cited references provide the location of the nearest resident. This is the best available data.

6.1.7 Initial Handling Facility Building Dimensions

As discussed in assumption 3.2.5, the IHF is used to determine the building wake effect. A review of the preliminary layout drawings 51A-P0K-IH00-10101-000-00B (Reference 2.2.11), 51A-P0K-IH00-10103-000-00B (Reference 2.2.12), and 51A-P0K-IH00-10104-000-00B (Reference 2.2.13), shows that the building cross-sectional area between columns 5 and 10 results in the smallest area. This conservatively excludes the area between columns 1 and 5. Relevant building dimensions are obtained from the above drawings are presented in Table 6.

Table 6 — IHF Building Parameters

Parameter	Value	Reference
Building height	105 ft	51A-P0K-IH00-10103-000-00B
Distance from 5 to 6	25 ft	51A-P0K-IH00-10103-000-00B
Distance from 6 to 7	25 ft	51A-P0K-IH00-10103-000-00B
Distance from 7 to 8	25 ft	51A-P0K-IH00-10103-000-00B
Distance from 8 to 9	25 ft	51A-P0K-IH00-10103-000-00B
Distance from 9 to 10	23 ft	51A-P0K-IH00-10103-000-00B

Note: 5, 6, 7, 8, 9, and 10 refer to column lines on the referenced drawing

Rationale: The cited references provide the dimensions for the initial handling facility.

6.1.8 ARCON96 Default Values

The default averaging times of 1, 2, 4, 8, 12, 24, 96, 168, 360, and 720 suggested in ARCON96 (Reference 2.2.18 [DIRS 164547], Figure 13) are used to calculate the 95th percentile χ/Q values. To evaluate annual average and median χ/Q values, the last two averaging times (360 and 720) are replaced by 720 and 8,760 hours, respectively.

The default averaging sector width constant is 4.3 per Regulatory Guide 1.194 (Reference 2.2.23 [DIRS 165736])**,** Table A-2.

All other default values parameters use the defaults of ARCON96 (Reference 2.2.18 [DIRS 164547], Figure 13). They are:

Surface roughness length (m) = 0.1

Wind direction window (degrees) = 90

Minimum wind speed (m/s) = 0.5

Minimum number of hours = 1, 2, 4, 8, 11, 22, 87, 152, 324, and 648, except for the annual average the last two values are 648 and 7884.

The default initial diffusion coefficients are conservatively set to zero:

Initial lateral diffusion coefficient (m) = 0.0

Initial vertical diffusion coefficient (m) = 0.0

Rationale: The cited references provide appropriately conservative values for the ARCON96 default values.

6.2 BUILDING WAKE PARAMETERS

As discussed in assumption 3.2.5, the IHF is used to determine the building wake parameters. The building height for use in Equation 22 is 105 feet (design input 6.1.7). This is equivalent to 32.00 meters.

The IHF cross-sectional area used in Equation 23 is calculated as follows:

From design input 6.1.7 the cross-sectional area consists of the width between columns 5 and 10 multiplied by the height.

The width between columns 5 and 10 is 25 ft x 4 +23 ft = 123 ft, or 37.49 meters.

The cross-sectional area is then 32.00 m x 37.49 m = 1,200 m^2.

6.3 DISTANCES TO THE SITE BOUNDARY

The distances from the GROA or from the subsurface exhaust shafts are calculated in an Excel spreasheet, *Site Coordinates – GROA.xls*. This spreadsheet contains four worksheets. Two are used to calculate distances from the subsurface exhaust shafts and two are used to calculate distances from the GROA. These worksheets are described in the following subsections. Sample hand calculations are provided to validate the methodology of the worksheets.

6.3.1 Distances from the Subsurface Exhaust Shafts and Raises

The distances from the subsurface exhaust shafts to the site boundary are calculated in four worksheets of the Excel spreadsheet *Site Coordinates – GROA.xls.* These are *Exhaust Shaft, Exhaust Shaft Distances, Exhaust Raise,* and *Exhaust Raise Distances*. The *Exhaust Shaft* and *Exhaust Raise* are similar, therefore only the *Exhaust Shaft* worksheet will be discussed. The *Exhaust Shaft Distances* and *Exhaust Raise Distances* are similar, therefore only the *Exhaust Shaft Distances* worksheet will be discussed.

6.3.1.1 Exhaust Shaft worksheet

Cells B1 through D5 show the exhaust shaft coordinates from design input 6.1.5 in feet.

Cells B9 through D21 show the site boundary coordinates from assumption 3.1.1 in feet.

Cells C25 through C37 perform the calculation of the slope *m* for each of the site boundary line segments using Equation 2. As an example, the slope of the segment between lines 6 and 7 is calculated.

From assumption 3.1.1 the coordinates for points 6 and 7 are:

Point	East (ft)	North (ft)
6	598,635.8125	699,918.7500
7	579,349.5625	699,037.0625

Using Equation 2, the slope *m* is:

$$m = \frac{y_1 - y_2}{x_1 - x_2} = \frac{699{,}918.75 - 699{,}037.0625}{598{,}635.8125 - 579{,}349.5625} = \frac{881.6875}{19{,}286.25} = 0.04572$$

This value is in excellent agreement with the value presented in cell C30 of the worksheet.

Cells D25 through D37 perform the calculation of the intercept b for each of the site boundary line segments using Equation 3. As an example, the intercept of the segment between lines 6 and 7 is calculated.

$$b = y_1 - mx_1 = 699{,}918.75 - 0.04572 \times 598{,}635.8125 = 672{,}549 \; \textit{feet}$$

This value is in excellent agreement with the value presented in cell D30 of the worksheet.

Cells G3 through R15 are used to calculate the distance and the angle between each exhaust shaft and each point of the site boundary. The distance is calculated using Equation 9 and the angle is calculated using Equation 11. As an example, the distance and angle between exhaust shaft 2 and site boundary point 6 is calculated below.

From design input 6.1.5 the coordinates for exhaust shaft 2 are:

	East (ft)	**North (ft)**
Exhaust Shaft 2	563,658	775,360

Using Equation 9, the distance between the exhaust shaft and point 6 is:

$$R_1 = \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2}$$

$$= \sqrt{(598{,}635.8125 - 563{,}658)^2 + (699{,}918.75 - 775{,}360)^2}$$

$$= 83{,}155.45 \; \textit{feet}$$

This value is in excellent agreement with the value shown in cell K8 of the worksheet.

Using Equation 11 the angle between the exhaust shaft and point 6 is:

$$\theta' = \sin^{-1}\left(\frac{x_1 - x_0}{\sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2}}\right)$$

$$= \sin^{-1}\left(\frac{598{,}635.8125 - 563{,}658}{83{,}155.45}\right) = 24.87$$

This value is in excellent agreement with the value shown in cell L8 of the worksheet.

The angle calculated above using the Excel function *asin* returns values in the range –90 to 90, instead of 0 to 360 as needed to calculate distances for the meteorological sectors. Therefore, a check is performed to determine in which quadrant the vector from the exhaust shaft to the site boundary point is located. The check is as follows:

1. If $x_1 - x_0 \geq 0$ and $y_1 - y_0 \geq 0$, the vector is in the first quadrant (0 – 90 degrees). Therefore, $\theta = \theta'$
2. If $x_1 - x_0 \geq 0$ and $y_1 - y_0 < 0$, the vector is in the second quadrant (90 – 180 degrees). Therefore, $\theta = 180 - \theta'$
3. If $x_1 - x_0 < 0$ and $y_1 - y_0 < 0$, the vector is in the third quadrant (180 – 270 degrees). Therefore, $\theta = 180 - \theta'$
4. If none of the above conditions are met, the vector is in the fourth quadrant (270 – 360 degrees). Therefore, $\theta = 360 + \theta'$

Between exhaust shaft 2 and point 6 on the site boundary $x_1 - x_0 \geq 0$ and $y_1 - y_0 < 0$, therefore the vector is in the second quadrant, as shown in cell M8 of the worksheet. Therefore, the angle is 180 – 24.87 = 155.13, as shown in cell N8 of the worksheet.

6.3.1.2 Exhaust Shaft Distances worksheet

Cells F3 through G16; O3 through P16, and X3 through Y16 build look-up tables for the beginning angle for each site boundary coordinate for each of the three exhaust shafts. The beginning angles for each site boundary segment in columns F, P, and X are obtained from the *Exhaust Shaft* worksheet. These are placed in ascending angle order clockwise from 0º in the north direction; therefore, the beginning of segment 1 (from point 1 to 2) is shown at the bottom of the list (row 16).

Cells A23 through A54 present the angles for the mid-point and boundaries for each of the 16 meteorological sectors beginning from the north. Cells B23 through B54 convert the angles from degrees to radians using the Excel built-in function *radians*. Cells C23 through D54 calculate the cosine and the sine of the angles using the Excel built-in functions *cos* and *sin*, respectively.

The distances from the exhaust shafts to the site boundary at angle increments of 11.25 degrees are calculated in cells E23 through M54 for exhaust shaft 1; cells N23 through V54 for exhaust shaft 2, and cells W23 through AE54 for exhaust shaft 3. The methodology is described in the following paragraphs.

Values in columns E, N, and W are lookups of the meteorological angles in column A to the beginning angles for each of the site boundary segments determining the beginning point of the segment. For example, the center point of the ENE sector is 67.5 degrees. A lookup of this angle for exhaust shaft 1 in cells F3 through G16 indicates that this angle is greater than the starting angle for segment 3, therefore a value of 3 is returned in cell E29.

Values in columns F, O, and X are lookups of the beginning point of the site boundary segment previously determined for the slope of the line calculated in cells C25 through C37 of the *Exhaust Shaft* worksheet. For example, for the centerpoint of the ENE sector, the site boundary line begins at point 3. From cell C27 of the *Exhaust Shaft* worksheet, the slope of the line is -2.300×10^2, which is the value shown in cell F29 of the *Exhaust Shaft Distances* worksheet.

Values in columns G, P, and Y are lookups of the beginning point of the site boundary segment previously determined for the intercept of the line calculated in cells D25 through D37 of the *Exhaust Shaft* worksheet. For example, for the centerpoint of the ENE sector, the site boundary line begins at point 3. From cell D27 of the *Exhaust Shaft* worksheet, the intercept of the line is 1.381×10^8, which is the value shown in cell G29 of the *Exhaust Shaft Distances* worksheet.

Values in columns H, Q, and Z are calculations of the distances from the exhaust shafts to the site boundary at angle θ using Equation 7. For example, using Equation 7 to calculate the distance from exhaust shaft 2 to the site boundary at the centerpoint of ENE sector at 67.5 degrees is:

$$R = \frac{mx_0 + b - y_0}{\cos\theta - m\sin\theta}$$

$$= \frac{-2.30\times10^2 \times 563{,}658 + 1.381\times10^8 - 775{,}360}{0.383 + 2.30\times10^2 \times 0.924}$$

$$= 36{,}088\ \textit{feet}$$

This value is in good agreement with the value of 35,988 feet presented in cell Q29. The differences are due to the number of significant digits used in the calculation. Excel uses the full 15 significant digits, while the hand calculation uses the displayed significant digits.

Values in columns I, R, and AA are the distances converted to meters.

In addition to calculating the distances to the site boundary for each angle in increments of 11.5 degrees, the distances to the inflection points (points where two site boundary line segments meet) need to be calculated and accounted for when determining the minimum distance. This calculation is performed in cells J23 through M54 for exhaust shaft 1, cells S23 through V54 for exhaust shaft 2, and cells AB23 through AE54 for exhaust shaft 3. In columns J, S, and AB a check is performed to determine if an inflection point is included between the previous angle and the current angle. This check is performed by comparing the segment number values in successive rows of columns E, N, and W, respectively. If the segment numbers are not equal, then there is at least one inflection point. A second check is performed to determine if a second inflection point is included. This check is performed in columns L, U, and AD by comparing the first inflection point value to the segment number. If they are not equal, then there is a second inflection point.

For example, for exhaust shaft 2 at an angle of 67.5 degrees the intercepted site boundary line segment is 3 as shown in cell N29. The previous angle, of 56.25 degrees, the intercepted site boundary line segment is 1 as shown in cell N28. Therefore, because the segment numbers are not equal, there must be at least one inflection point between 56.25 and 67.5 degrees. The first of these inflection points is determined in cell S29. The second inflection point is determined in cell U29. For cases where there is only one inflection point, such as between angles 146.25 and 157.5, cells in column U are left blank.

The inflection points are the same as the site boundary coordinate points. The distances from each exhaust shaft to the site boundary coordinate points have been calculated in worksheet *Exhaust Shaft*. The distances are shown in cells G3 through G15 for exhaust shaft 1, K3 through K15 for exhaust shaft 2, and O3 through O15 for exhaust shaft 3. These values are used as lookup tables for columns K, M, T, V, AC, and AE of worksheet *Exhaust Shaft Distances*. For example, from cell K4 of worksheet *Exhaust Shaft,* the distance from exhaust shaft 2 to site boundary coordinate point 2 is 38,008 feet. Converting to meters, the distance is 11,585 m, which agrees very well with the value presented in cell T29 of worksheet *Exhaust Shaft Distances*.

Cells H3 through I18; Q3 through R18, and Z3 through AA18 present the minimum distances from each of the exhaust shafts to the site boundary for each of the 16 meteorological sectors. Per Reference 2.2.21, the minimum distance is the nearest point on the boundary within a 45-degree sector centered on the direction of interest. Therefore, the minimum distance is defined as the minimum of the distances within the range of two 11.25 degree intervals on either direction of the sector midpoint angle. In addition, the distances to any inflection points within the range are also considered. For example, the minimum distance in the ENE sector with a midpoint angle of 67.5º for exhaust shaft 2 is the minimum of the distances presented in cells R27 through R31, which are distances for angles of 45º, 56.25º, 67.5º, 78.75º, and 90°. The inflection point distances presented in cells T27 through T31 and cells V27 through V31 are also considered in the minimum distance calculation. The minimum distance is 8,474 meters, which is for the distance for an angle of 45º shown in cell R27. This distance is correctly selected and presented in cell R6.

The minimum distance from the exhaust raises is presented in cells AD3 through AD18. These values are obtained from worksheet *Exhaust Raise Distances* cells C3 through C18

The minimum distance for all three exhaust shafts and two exhaust raises to the site boundary for each of the 16 meteorological sectors is presented in cells C3 through C18. This is the minimum of cells I3 through I18, R3 through R18, AA3 through AA18, and AF3 through AF18. For example, the minimum distance in the ENE sector is for exhaust shaft 2, which is 8,474 meters. This value is correctly selected and presented in cell C6. The resultant minimum distances are presented in Table 7.

Table 7 — Minimum Distances from Subsurface Exhaust Shafts to Site Boundary

Sector	Wind From	Distance (m)
N	S	6,027
NNE	SSW	6,027
NE	SW	6,508
ENE	WSW	8,474
E	W	10,073
ESE	WNW	10,073
SE	NW	10,369
SSE	NNW	14,974
S	N	17,755
SSW	NNE	12,081
SW	NE	9,261
WSW	ENE	7,835
W	E	7,835
WNW	ESE	7,835
NW	SE	6,539
NNW	SSE	6,027

Per assumption 3.2.6, the member of the public in the general environment can only be located to the west or south of the repository. The wind direction sectors that would affect those members of the public in the general environment from releases from the surface or subsurface facilities are determined. Section 6.3.3.2 determined that the winds from the NNW through the SE sectors impact receptors in the general environment from the exhaust shafts or exhaust raises. Cells J10 through K17; S10 through T17, and AB10 through AC17 present the minimum distances from each of the exhaust shafts to the general environment for each of the affected meteorological sectors. Per Reference 2.2.21, the minimum distance is the nearest point on the boundary within a 45-degree sector centered on the direction of interest. With the exception of the SSE and NW sectors, the distances are the same as the distances to the site boundary. Therefore, the distances from the exhaust shafts to the general environment for the S sector through the WNW sector are duplicated from the distances to the site boundary.

As shown in Figure 2, the general environment extends northward from the west boundary of the YMP withdrawal area and eastward from the south boundary. Therefore, the minimum distance for the NW sector would be for locations south of point 1 shown in Figure 1, and for the SSE sector for locations west of point 6. For example, the distance from exhaust shaft 1 to the general environment in the SSE sector is determined by taking the minimum distance in cells I37 through I39, since these locations are within a 45-degree sector centered on the SSE direction and west of point 6. In addition the distances to inflection points 6 and 7 are also considered in the determination of the minimum distance. The minimum distance is 21,793 meters, which is the distance for an angle of 180º shown in cell I39. This distance is correctly selected and presented in cell K10.

The minimum distance from the exhaust raises is presented in cells AH10 through AH17. These values are obtained from worksheet *Exhaust Raise Distances* cells D10 through D17

The minimum distance for all three exhaust shafts and two exhaust raises to the general environment for each of the affected meteorological sectors is presented in cells D10 through D17. This is the minimum of cells K10 through K17, T10 through T17, AC10 through AC17, and AH10 through AH17. For example, the minimum distance in the NW sector is for exhaust shaft 1, which is 8,512 meters. This value is correctly selected and presented in cell D17. The resultant minimum distances are presented in Table 8.

Table 8 — Minimum Distances from Subsurface Exhaust Shafts to the General Environment

Sector	Wind From	Distance (m)
SSE	NNW	17,755
S	N	17,755
SSW	NNE	12,081
SW	NE	9,261
WSW	ENE	7,835
W	E	7,835
WNW	ESE	7,835
NW	SE	8,512

6.3.2 Distances from the GROA

The distances from the GROA to the site boundary are calculated in two worksheets of the Excel spreadsheet *Site Coordinates – GROA.xls.* These are *GROA* and *GROA Distances*. Each of these worksheets is described below.

6.3.2.1 GROA worksheet

Cells B1 through D5 show the GROA boundary coordinates from assumption 3.2.1 in feet.

Cells B9 through D21 show the site boundary coordinates from assumption 3.1.1 in feet.

Cells C25 through C37 perform the calculation of the slope *m* for each of the site boundary line segments using Equation 2. This is the same method used to calculate the slope for the exhaust shafts as discussed in section 6.3.1.1; therefore, no further verification is required.

Cells D25 through D37 perform the calculation of the intercept b for each of the site boundary line segments using Equation 3. This is the same method used to calculate the intercept for the exhaust shafts as discussed in section 6.3.1.1; therefore, no further verification is required.

Cells F11 through N23 and cells F27 through N39 are used to calculate the distance and the angle between each corner point of the GROA boundary and each point of the site boundary shown in Table 1. The distance is calculated using Equation 9 and the angle is calculated using Equation 11. This is the same method used to calculate the distance and angle for the exhaust shafts as discussed in section 6.3.1.1; therefore, no further verification is required.

6.3.2.2 GROA Distances worksheet

Cells I4 through J17; K4 through L17; M4 through N17, and O4 through P17 build a look-up table for the beginning angle for each site boundary coordinate for each of the four corners of the GROA boundary. The beginning angles for each site boundary segment in columns I, K, M, and O are obtained from the *GROA* worksheet. These are placed in ascending angle order; therefore, the beginning of segment 1 (from point 1 to 2) is shown at the bottom of the list (row 17).

Cells A24 through A55 present the angles for the mid-point and boundaries for each of the 16 meteorological sectors beginning from the north. Cells B24 through B55 convert the angles from degrees to radians using the Excel built-in function *radians*. Cells C24 through D55 calculate the cosine and the sine of the angles using the Excel built-in functions *cos* and *sin*, respectively. These are duplicated in cells A60 through D91, A96 through D127, and A132 through D163.

The distances from the corners of the GROA boundary to the site boundary are calculated in cells E24 through AC55 for the north GROA boundary; cells E60 through AC91 for the south GROA boundary; cells E96 through AC127 for the east GROA boundary, and cells E132 through AC163 for the west GROA boundary. The methodology is described in the following paragraphs.

Values in column E are lookups of the meteorological angles in column A to angles at each site boundary coordinate that determines the intercepted site boundary line segment for the start of the GROA boundary line. For example, for the north GROA boundary this is a lookup for the northwest corner of the GROA boundary. Values in column J are lookups of the meteorological angles in column A for the northeast corner of the GROA boundary. If the values in columns E and J are the same, then rays at angle θ from each corner intercepts the same site boundary line segment and the methodology presented in section 4.3.2 is used. If these values are different, then there must be at least one inflection point and the methodology of section 4.3.3 is used.

Two examples are used to illustrate and validate the methodology. The first is for the north GROA boundary at an angle of 67.5º (row 30), and a second for the east GROA boundary at an angle of 101.25º (row 105).

<u>North GROA boundary</u>

The beginning of the north GROA boundary is the northwest corner, therefore the lookup in cells E24 through E55 is made in cells I4 through J17. The angle of 67.5º is greater than the starting angle for segment 3 but less than the starting angle for segment 4, therefore a value of 3 is returned in cell E30. The end of the north GROA boundary is the northeast corner, therefore the lookup in cells J24 through J55 is made in cells K4 through L17. The angle of 67.5º is greater than the starting angle for segment 3 but less than the starting angle for segment 4, therefore a value of 3 is returned in cell J30.

<u>East GROA boundary</u>

The beginning of the east GROA boundary is the northeast corner, therefore the lookup is made in cells K4 through L17. The angle of 101.25º is greater than the starting angle for segment 3 but less than the starting angle for segment 4, therefore a value of 3 is returned in cell E105. The end of the east GROA boundary is the southeast corner, therefore the lookup is made in cells M4 through N17. The angle of 101.25º is greater than the starting angle for segment 5 but less than the starting angle for segment 6, therefore a value of 5 is returned in cell J105.

Values in columns F and K are lookups of the beginning point of the site boundary segment previously determined for the slope of the line calculated in cells C25 through C37 of the *GROA* worksheet. This is the same method used to determine the slope for the exhaust shafts as discussed in section 6.3.1.2; therefore no further verification is required.

Values in columns G and L are lookups of the beginning point of the site boundary segment previously determined for the intercept of the line calculated in cells D25 through D37 of the *GROA* worksheet. This is the same method used to determine the intercept for the exhaust shafts as discussed in section 6.3.1.2; therefore no further verification is required.

Values in column H are calculations of the distances from the beginning point of the GROA boundary line to the site boundary using either Equation 13 or Equation 15. Values in column M are calculations of the distances from the end point of the GROA boundary line to the site boundary using either Equation 14 or Equation 16. The previously defined examples are used to illustrate and validate the methodology.

North GROA boundary

As shown above, intercepts of the northwest and northeast corners of the north GROA boundary for an angle of 67.5º are within segment 3 of the site boundary. Therefore, Equation 13 is used to calculate the distance from the northwest corner, and Equation 14 is used to calculate the distance from the northeast corner.

$$R_1 = \frac{mx_{01} + b - y_{01}}{\cos\theta - m\sin\theta}$$

$$= \frac{-2.30\times10^2 \times 570{,}000 + 1.381\times10^8 - 767{,}500}{0.383 + 2.30\times10^2 \times 0.924}$$

$$= 29{,}274 \ \textit{feet}$$

This value is in good agreement with the value of 29,173 presented in cell H30. The differences are due to the number of significant digits used in the calculation. Excel uses the full 15 significant digits, while the hand calculation uses the displayed significant digits.

$$R_2 = \frac{mx_{02} + b - y_{02}}{\cos\theta - m\sin\theta}$$

$$= \frac{-2.30\times10^2 \times 575{,}000 + 1.381\times10^8 - 767{,}500}{0.383 + 2.30\times10^2 \times 0.924}$$

$$= 23{,}872 \textit{ feet}$$

This value is in good agreement with the value of 23,770 presented in cell M30. The differences are due to the number of significant digits used in the calculation. Excel uses the full 15 significant digits, while the hand calculation uses the displayed significant digits.

East GROA boundary

As shown above, for an angle of 101.25º the intercept of the northeast point is within segment 3 of the site boundary, and the intercept of the southeast point is within segment 5 of the site boundary. Therefore, Equation 15 is used to calculate the distance from the northeast point and Equation 16 is used to calculate the distance from the southeast point.

$$R_1 = \frac{m_1 x_{01} + b_2 - y_{01}}{\cos\theta - m_1 \sin\theta}$$

$$= \frac{-2.30\times10^2 \times 575{,}000 + 1.381\times10^8 - 767{,}500}{-0.195 + 2.30\times10^2 \times 0.981}$$

$$= 22{,}545 \textit{ feet}$$

This value is in good agreement with the value of 22,451 presented in cell H105. The differences are due to the number of significant digits used in the calculation. Excel uses the full 15 significant digits, while the hand calculation uses the displayed significant digits.

$$R_2 = \frac{m_2 x_{02} + b_2 - y_{02}}{\cos\theta - m_2 \sin\theta}$$

$$= \frac{-2.30\times10^2 \times 575{,}000 + 1.381\times10^8 - 760{,}000}{-0.195 + 2.30\times10^2 \times 0.981}$$

$$= 22{,}579 \textit{ feet}$$

This value is in good agreement with the value of 22,484 presented in cell M105. The differences are due to the number of significant digits used in the calculation. Excel uses the full 15 significant digits, while the hand calculation uses the displayed significant digits.

Values in columns I and N are the distances converted to meters.

For the cases where the beginning and the end points of a GROA boundary line intercept two different site boundary segments for a given angle, columns O and T are used to define the points where the segments meet (inflection points). The absolute order of the difference between the intercepted segments determines the number of inflection points. The first inflection point is determined in column O as the maximum of the two intercepted segment numbers. In these cases there are two inflection points, the second inflection point is determined in column T as the minimum of the two intercepted segment numbers plus 1. Columns P and Q are lookup values for the x (East) and y (North) coordinates for the first inflection point. Columns U and V are lookup values for the x (East) and y (North) coordinates for the second inflection point. Columns R and W are the distances from the GROA boundary to the inflection points using either Equation 17 for the north and south GROA boundary lines or Equation 18 for the east and west GROA boundary lines. Columns S and X convert the distances from feet to meters.

The previously defined examples are used to illustrate and validate the methodology.

<u>North GROA boundary</u>

As shown above, intercepts of the northwest and northeast corners of the north GROA boundary for an angle of 67.5º are within segment 3 of the site boundary. Therefore, there are no inflection points. The entries in cells O30 through X30 are blank.

<u>East GROA boundary</u>

As shown above, for an angle of 101.25º the intercept of the northeast corner is within segment 3 of the site boundary, and the intercept of the southeast corner is within segment 5 of the site boundary. Therefore there are two inflection points, which are points 4 and 5 of the site boundary. These are shown in cells O105 and T105.

The lookup in cells P105, Q105, U105, and V105 correctly extracts the site boundary coordinates for points 4 and 5 from the data presented in cells B9 through D21 of the *GROA* worksheet.

As discussed in section 4.3.3, Equation 18 should be used to calculate the distance for the east GROA boundary to the inflection point. Therefore, the distance from the GROA boundary line to the inflection points is:

$$R_{p4} = \frac{x_2 - x_0}{\sin\theta} = \frac{597{,}026 - 575{,}000}{0.981} = 22{,}453\ feet$$

This value is in good agreement with the value of 24,457 presented in cell W105. The differences are due to the number of significant digits used in the calculation. Excel uses the full 15 significant digits, while the hand calculation uses the displayed significant digits.

$$R_{p5} = \frac{x_2 - x_0}{\sin\theta} = \frac{598{,}714 - 575{,}000}{0.981} = 24{,}173\ \textit{feet}$$

This value is in good agreement with the value of 24,179 presented in cell R105. The differences are due to the number of significant digits used in the calculation. Excel uses the full 15 significant digits, while the hand calculation uses the displayed significant digits.

Column Y presents the minimum distances from each GROA boundary at angle θ to the site boundary. This is the minimum of the distance to the two corners (columns I and N) and the distances to the inflection points (Columns S and X).

Cells C4 through G19 present the minimum distances from each of the GROA boundary lines to the site boundary for each of the 16 meteorological sectors. Per Reference 2.2.21, the minimum distance is the nearest point on the boundary within a 45-degree sector centered on the direction of interest. Therefore, the minimum distance is defined as the minimum of the distances within the range of two 11.25 degree intervals on either direction of the sector midpoint angle. For example, the minimum distance in the N sector for the west GROA boundary is the minimum of the distances presented in cells Y132 through Y134, Y162 and Y163, which are distances for angles of 0º, 11.25º, 22.5°, 337.5°, and 348.75º. The minimum distance is 8,411 meters, which is for the midpoint of the sector shown in cell Y132. This distance is correctly selected and presented in cell F4.

The minimum distance for all four GROA boundary lines to the site boundary for each of the 16 meteorological sectors is presented in cells G4 through G19. This is the minimum of cells C4 through F19. The resultant minimum distances are presented in Table 9.

Table 9 — Minimum Distances from the GROA Boundary to Site Boundary

Sector	Wind From	Distance (m)
N	S	8,403
NNE	SSW	8,403
NE	SW	7,245
ENE	WSW	6,706
E	W	6,706
ESE	WNW	6,706
SE	NW	7,819
SSE	NNW	10,208
S	N	18,572
SSW	NNE	16,638
SW	NE	12,755
WSW	ENE	11,064
W	E	11,064
WNW	ESE	11,064
NW	SE	9,117
NNW	SSE	8,403

Per assumption 3.2.6, the member of the public in the general environment can only be located to the west or south of the repository. The wind direction sectors that would affect those members of the public in the general environment from releases from the surface or subsurface facilities are determined. Section 6.3.3.1 determined that the winds from the NNW through the SE sectors impact receptors in the general environment from the exhaust shafts or exhaust raises.

Cells S4 through V11 present the minimum distances from each of the GROA boundary lines to the general environment for each of the affected meteorological sectors. Per Reference 2.2.21, the minimum distance is the nearest point on the boundary within a 45-degree sector centered on the direction of interest. With the exception of the SSE and NW sectors, the distances are the same as the distances to the site boundary. Therefore, the distances from the GROA to the general environment for the S sector through the WNW sector are duplicated from the distances to the site boundary.

As shown in Figure 2, the general environment extends northward from the west boundary of the YMP withdrawal area and eastward from the south boundary. Therefore, the minimum distance for the NW sector would be for locations south of point 1 shown in Figure 1, and for the SSE sector for locations west of point 6. For example, the minimum distance in the NW sector for the north GROA boundary is the minimum of the distances presented in cells Y50 and Y51, since these locations are within a 45-degree sector centered on the NW direction and south of point 1. The minimum distance is 12,024 meters, which is for a direction of 292.5 º. This distance is correctly selected and presented in cell S11.

The minimum distance for all four GROA boundary lines to the general environment for each of the affected meteorological sectors is presented in cells W4 through W11. This is the minimum of cells S4 through V11. The resultant minimum distances are presented in Table 10.

Table 10 — Minimum Distances from the GROA Boundary to the General Environment

Sector	Wind From	Distance (m)
SSE	NNW	18,572
S	N	18,572
SSW	NNE	16,638
SW	NE	12,755
WSW	ENE	11,064
W	E	11,064
WNW	ESE	11,064
NW	SE	12,000

6.3.3 Wind Direction Sectors to a Member of the Public in the General Environment

Per assumption 3.2.6, the member of the public in the general environment can only be located to the west or south of the repository. The wind direction sectors that would affect those members of the public in the general environment from releases from the surface or subsurface facilities are determined.

6.3.3.1 Surface Facilities Releases (GROA)

Figure 7 shows the wind (from) direction sectors from a release inside the GROA boundary defined in assumption 3.2.1 to the site boundary. As can be seen in this figure, wind from the NNW through the SE sectors impact the west and south site boundary. Therefore, only winds from these directions can affect a member of the public in the general environment.

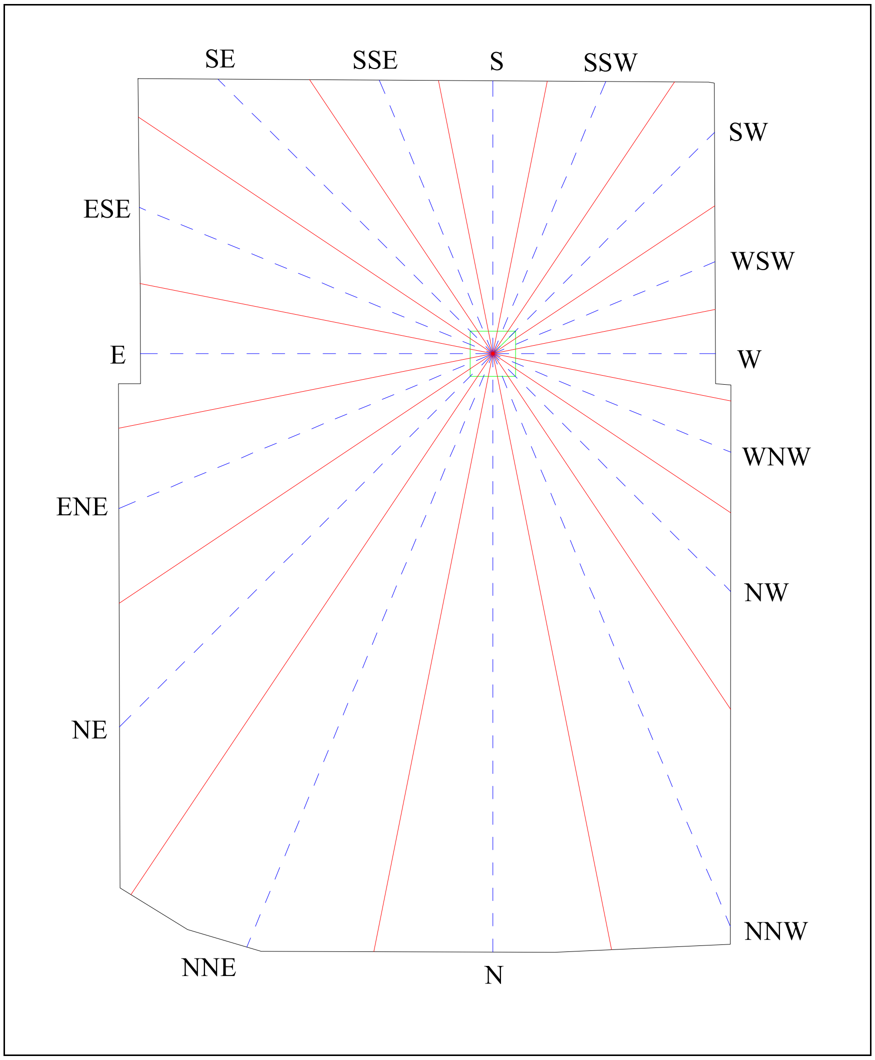

Figure 7 — Wind (from) Direction Sectors from GROA to Site Boundary

The dashed lines in Figure 7 represent the sector centerlines. The solid lines represent the sector boundary lines.

6.3.3.2 Subsurface Facilities Releases (Exhaust Shafts)

Figure 8 through Figure 12 show the wind (from) direction sectors from a release from exhaust shafts 1 through 3 and exhaust raises 1 and 2 to the site boundary. As can be seen in these figures, wind from the NNW through the SE sectors impact the west and south site boundary. Therefore, only winds from these directions can affect a member of the public in the general environment.

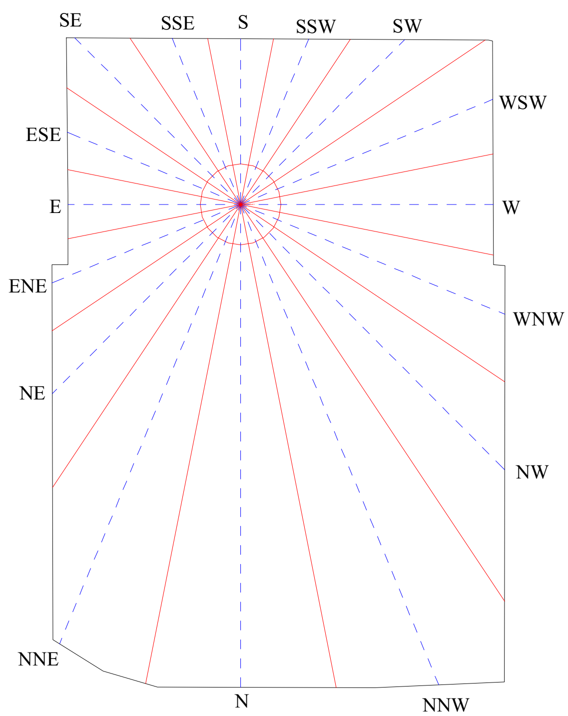

Figure 8 — Wind (from) Direction Sectors from Exhaust Shaft 1 to Site Boundary

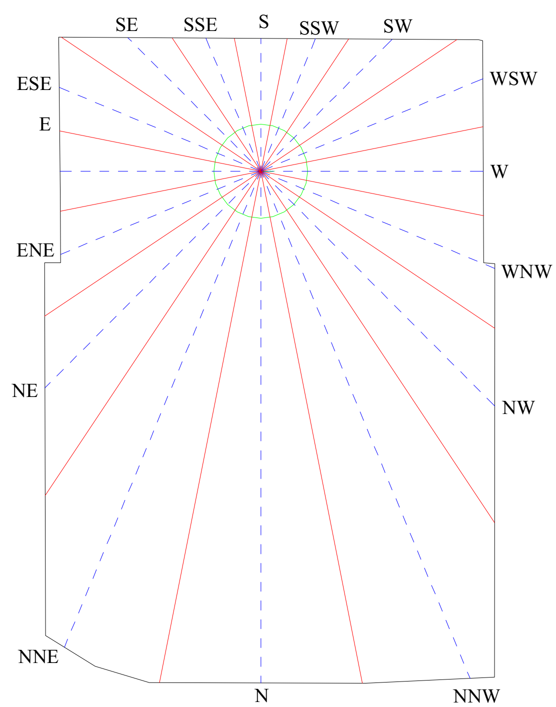

Figure 9 — Wind (from) Direction Sectors from Exhaust Shaft 2 to Site Boundary

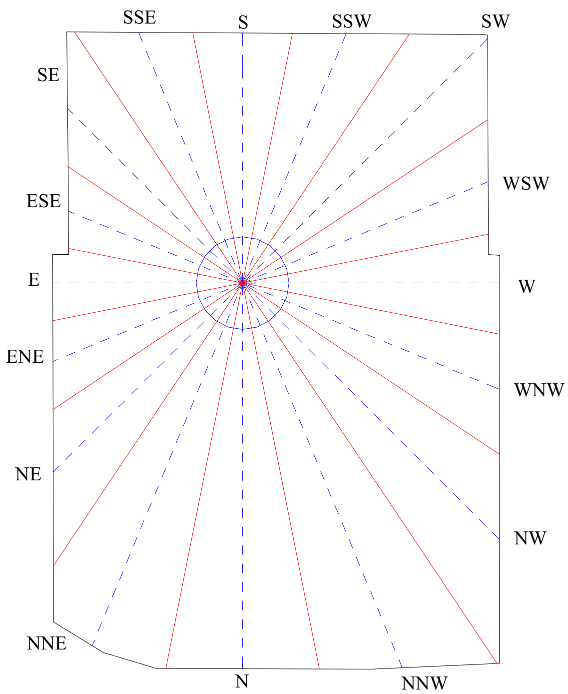

Figure 10 — Wind (from) Direction Sectors from Exhaust Shaft 3 to Site Boundary

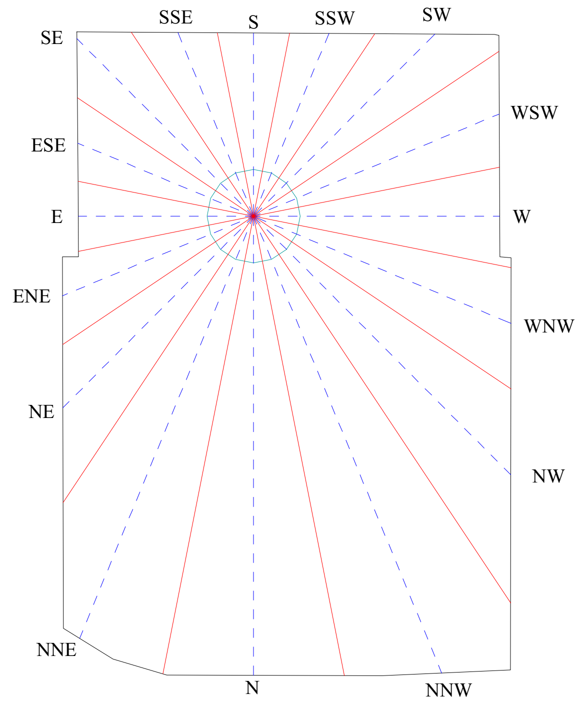

Figure 11 — Wind (from) Direction Sectors from Exhaust Raise 1 to Site Boundary

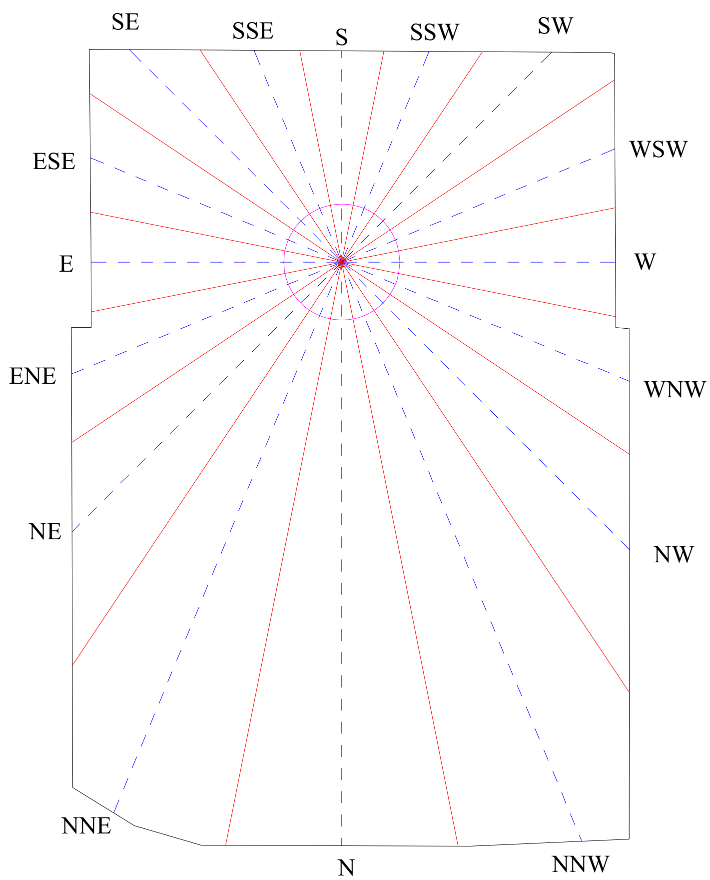

Figure 12 — Wind (from) Direction Sectors from Exhaust Raise 2 to Site Boundary

The dashed lines in Figure 8 through Figure 12 represent the sector centerlines. The solid lines represent the sector boundary lines.

6.4 DISTANCES BETWEEN THE GROA AND THE SUBSURFACE EXHAUST SHAFTS

Effluents from the GROA surface facilities could contribute to doses to on-site members of the public located near the subsurface exhaust shafts, and effluents from the subsurface exhaust shafts could contribute to doses to on-site members of the public located near the surface facilities. In this section the distances between these effluent sources and on-site locations is determined along with the wind direction sectors that could impact the receptors. Per assumption 3.2.3, no credit is taken for the elevation difference between the GROA and subsurface exhaust shafts.

6.4.1 Calculation of Distances

Distance between the GROA and Exhaust Shaft 1

As shown in Figure 13 and Figure 18, the shortest horizontal distance between the GROA and the subsurface exhaust shaft 1 is to the northwest corner of the GROA boundary. Using the northwest coordinates for the GROA from assumption 3.2.1 and the coordinates of the subsurface exhaust shaft 1 from design input 6.1.5, the distance between these points is calculated as follows:

$$\begin{aligned} R_{G1} &= \sqrt{(559{,}368 - 570{,}000)^2 + (770{,}604 - 767{,}500)^2} \\ &= 11{,}076\ ft \\ &= 3{,}376\ m \end{aligned}$$

Since a receptor is assumed to be 100 m away from either the exhaust shaft or the GROA facilities per assumption 3.2.7, the distance is reduced by 100 m, thus R_{G1} = 3,276 m.

Distance between the GROA and Exhaust Shaft 2

As shown in Figure 14 and Figure 19, the shortest horizontal distance between the GROA and the subsurface exhaust shaft 2 is to the northwest corner of the GROA boundary. Using the northwest coordinates for the GROA from assumption 3.2.1 and the coordinates of the subsurface exhaust shaft 2 from design input 6.1.5, the distance between these points is calculated as follows:

$$\begin{aligned} R_{G2} &= \sqrt{(563{,}658 - 570{,}000)^2 + (775{,}360 - 767{,}500)^2} \\ &= 10{,}100\ ft \\ &= 3{,}078\ m \end{aligned}$$

Since a receptor is assumed to be 100 m away from either the exhaust shaft or the GROA facilities per assumption 3.2.7, the distance is reduced by 100 m, thus R_{G2} = 2,978 m.

Distance between the GROA and Exhaust Shaft 3

As shown in Figure 15 and Figure 20, the shortest horizontal distance between the GROA and the subsurface exhaust shaft 3 is to the southwest corner of the GROA. Using the southwest coordinates for the GROA from assumption 3.2.1 and the coordinates of the subsurface exhaust shaft 3 from design input 6.1.5, the distance between these points is calculated as follows:

$$\begin{aligned} R_{G3} &= \sqrt{(559{,}937 - 570{,}000)^2 + (757{,}357 - 760{,}000)^2} \\ &= 10{,}404\ ft \\ &= 3{,}171\ m \end{aligned}$$

Since a receptor is assumed to be 100 m away from either the exhaust shaft or the GROA facilities per assumption 3.2.7, the distance is reduced by 100 m, thus R_{G3} = 3,071 m.

Distance between the GROA and Exhaust Raise 1

As shown in Figure 16 and Figure 21, the shortest horizontal distance between the GROA and the subsurface exhaust raise 1 is to the northwest corner of the GROA boundary. Using the northwest coordinates for the GROA from assumption 3.2.1 and the coordinates of the subsurface exhaust raise 1 from design input 6.1.5, the distance between these points is calculated as follows:

$$\begin{aligned} R_{GR1} &= \sqrt{(560{,}005 - 570{,}000)^2 + (767{,}748 - 767{,}500)^2} \\ &= 9{,}998\, ft \\ &= 3{,}047\, m \end{aligned}$$

Since a receptor is assumed to be 100 m away from either the exhaust raise or the GROA facilities per assumption 3.2.7, the distance is reduced by 100 m, thus R_{GR1} = 2,947 m.

Distance between the GROA and Exhaust Raise 2

As shown in Figure 17 and Figure 22, the shortest horizontal distance between the GROA and the subsurface exhaust raise 2 is to the northwest corner of the GROA boundary. Using the northwest coordinates for the GROA from assumption 3.2.1 and the coordinates of the subsurface exhaust raise 1 from design input 6.1.5, the distance between these points is calculated as follows:

$$\begin{aligned} R_{GR2} &= \sqrt{(563{,}942 - 570{,}000)^2 + (769{,}618 - 767{,}500)^2} \\ &= 6{,}418\, ft \\ &= 1{,}956\, m \end{aligned}$$

Since a receptor is assumed to be 100 m away from either the exhaust raise or the GROA facilities per assumption 3.2.7, the distance is reduced by 100 m, thus R_{GR2} = 1,856 m.

6.4.2 Wind Direction Sectors from the GROA to the Exhaust Shafts and Raises

To determine the wind sectors that may affect each of the subsurface exhaust shafts due to releases from the GROA, the following procedure is used. Per assumption 3.2.7, a member of the public on site may be a distance of 100 m from the exhaust shaft. Therefore, a circle with a radius of 100 m is drawn around the exhaust shaft. To determine which wind sectors are affected, two lines are drawn from the GROA boundary tangent to this circle (these lines are shown as dashed lines in Figure 13 through Figure 17). Winds within the cone bounded by these two lines could transport releases from the GROA to a member of the public 100 m away from the exhaust shaft.

Wind direction sectors from the GROA to exhaust shaft 1

Figure 13 shows the location of the subsurface exhaust shaft 1 to the GROA in a horizontal plane. As shown on Figure 13, winds from the east through the southeast sector would affect exhaust shaft 1.

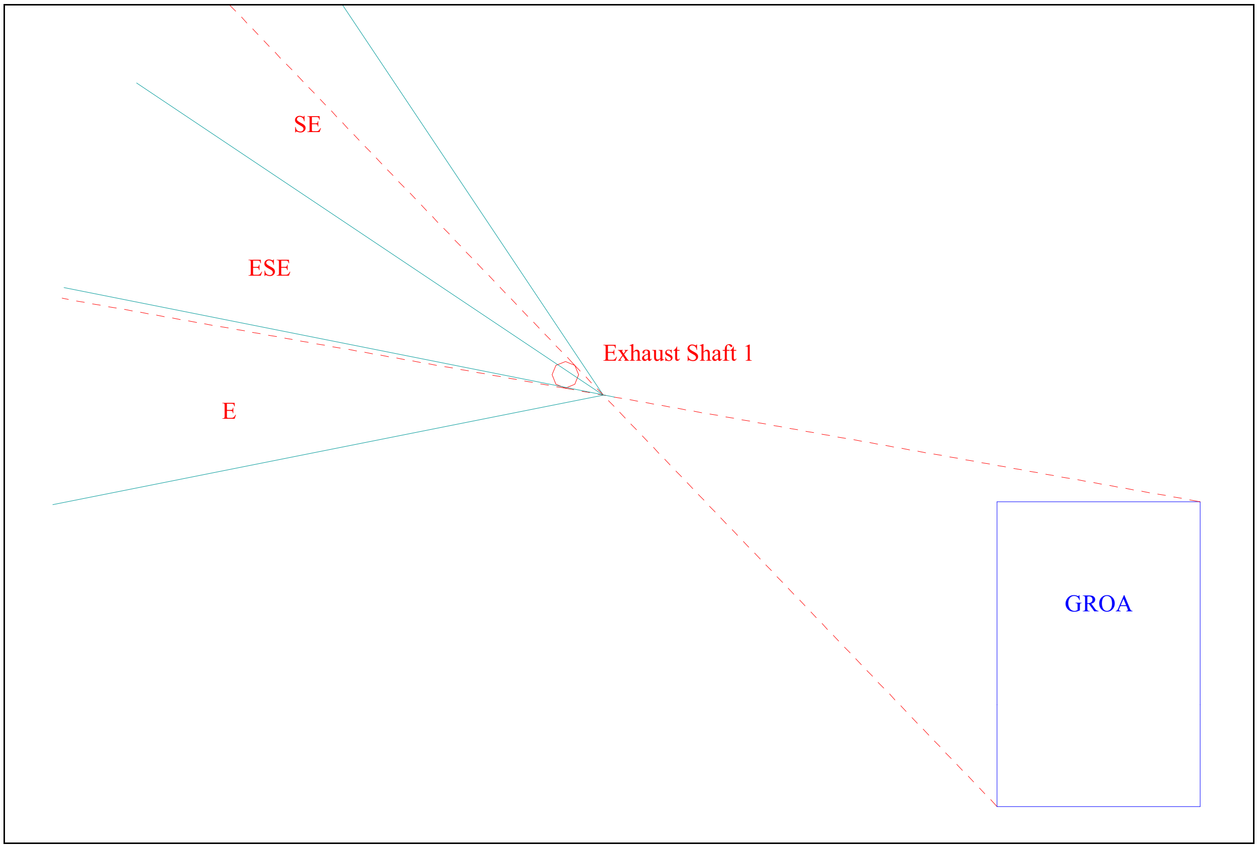

Figure 13 — Wind (from) Direction Sectors from the GROA to Exhaust Shaft 1

Wind direction sectors from the GROA to exhaust shaft 2

Figure 14 shows the location of the subsurface exhaust shaft 2 to the GROA in a horizontal plane. As shown on Figure 14, winds from the east-southeast through the south-southeast sector would affect exhaust shaft 2.

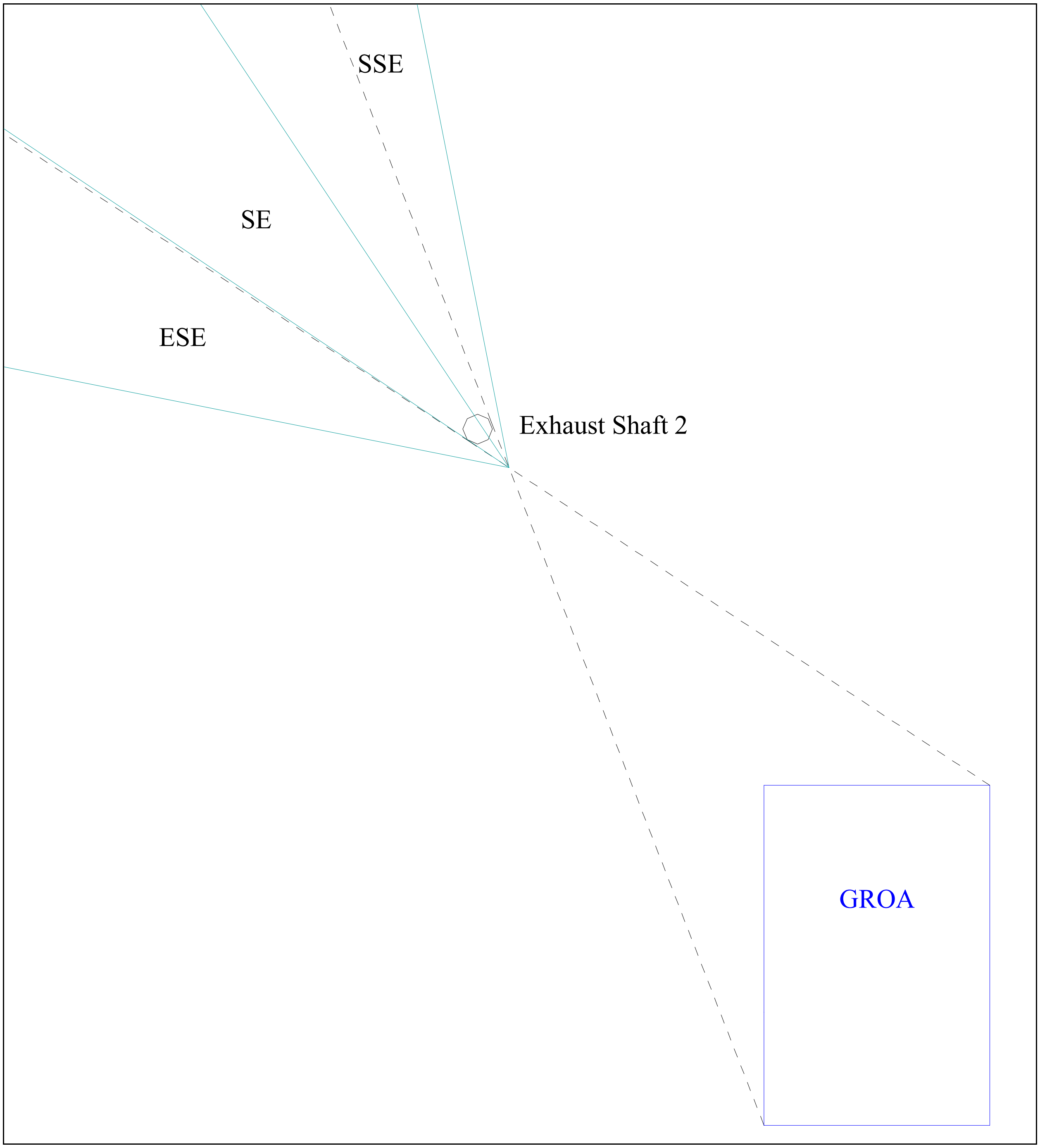

Figure 14 — Wind (from) Direction Sectors from the GROA to Exhaust Shaft 2

Wind direction sectors from the GROA to exhaust shaft 3

Figure 15 shows the location of the subsurface exhaust shaft 3 to the GROA in a horizontal plane. As shown on Figure 15, winds from the east through the northeast sector would affect exhaust shaft 3.

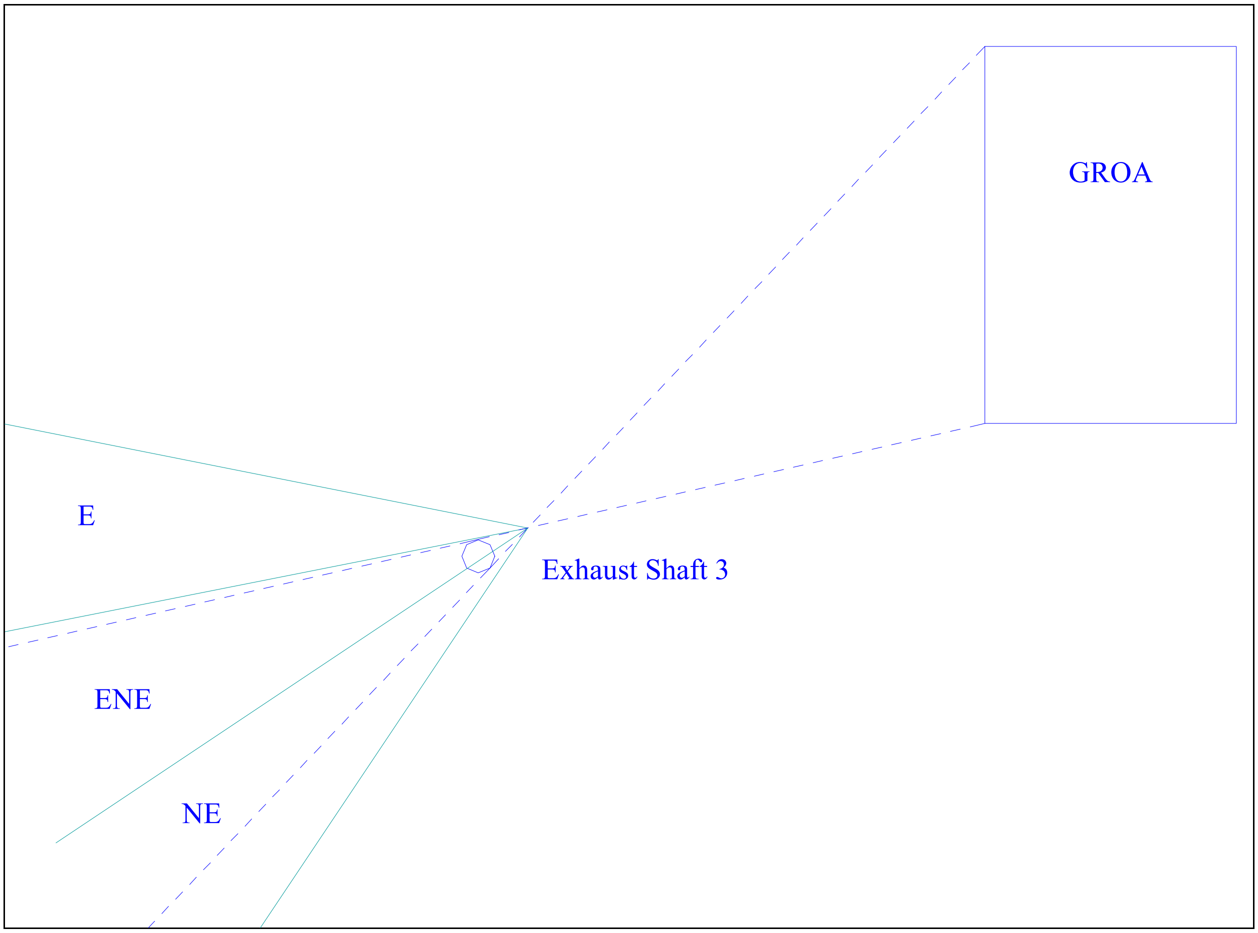

Figure 15 — Wind (from) Direction Sectors from the GROA to Exhaust Shaft 3

Wind direction sectors from the GROA to exhaust raise 1

Figure 16 shows the location of the subsurface exhaust shaft 3 to the GROA in a horizontal plane. As shown on Figure 16, winds from the east through the southeast sector would affect exhaust raise 1.

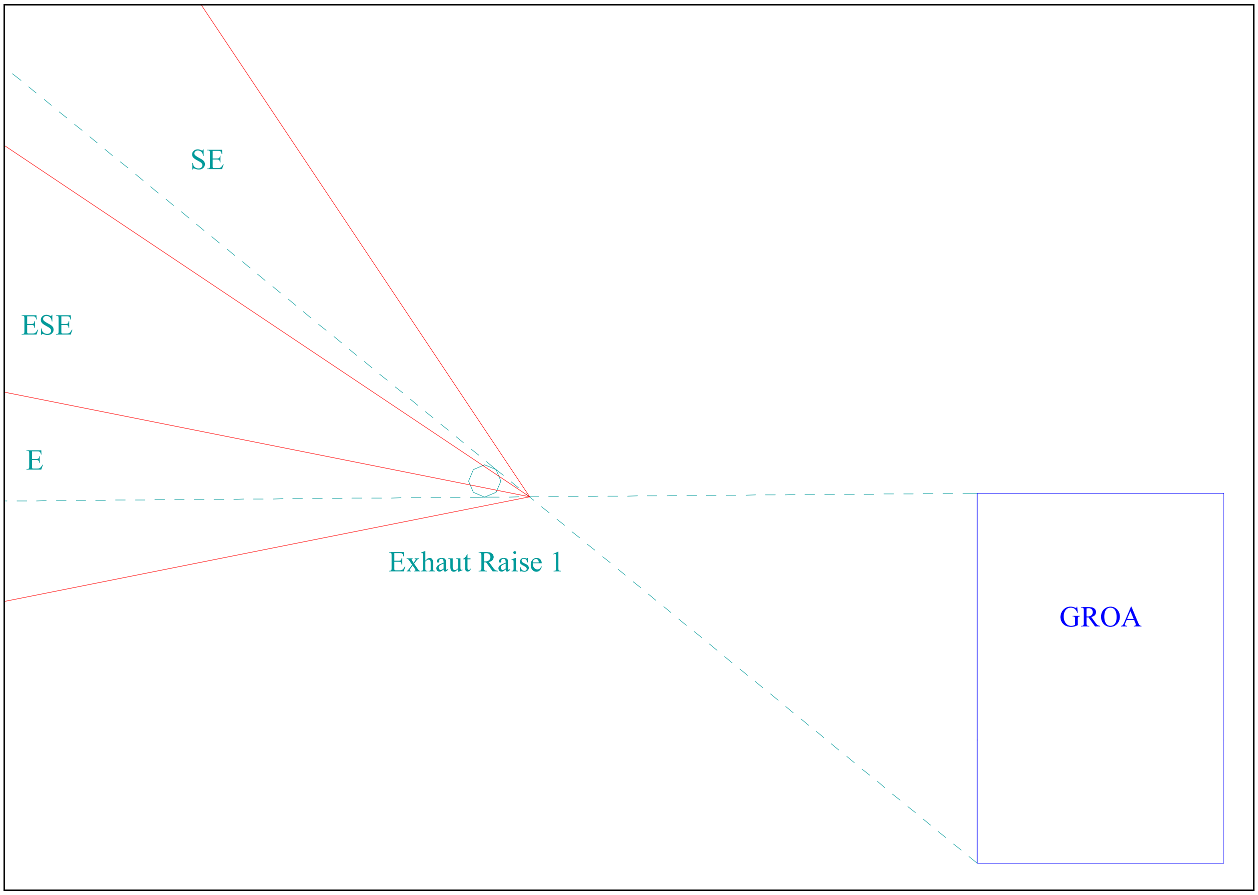

Figure 16 — Wind (from) Direction Sectors from the GROA to Exhaust Raise 1

Wind direction sectors from the GROA to exhaust raise 2

Figure 17 shows the location of the subsurface exhaust shaft 3 to the GROA in a horizontal plane. As shown on Figure 17, winds from the east through the south-southeast sector would affect exhaust raise 2.

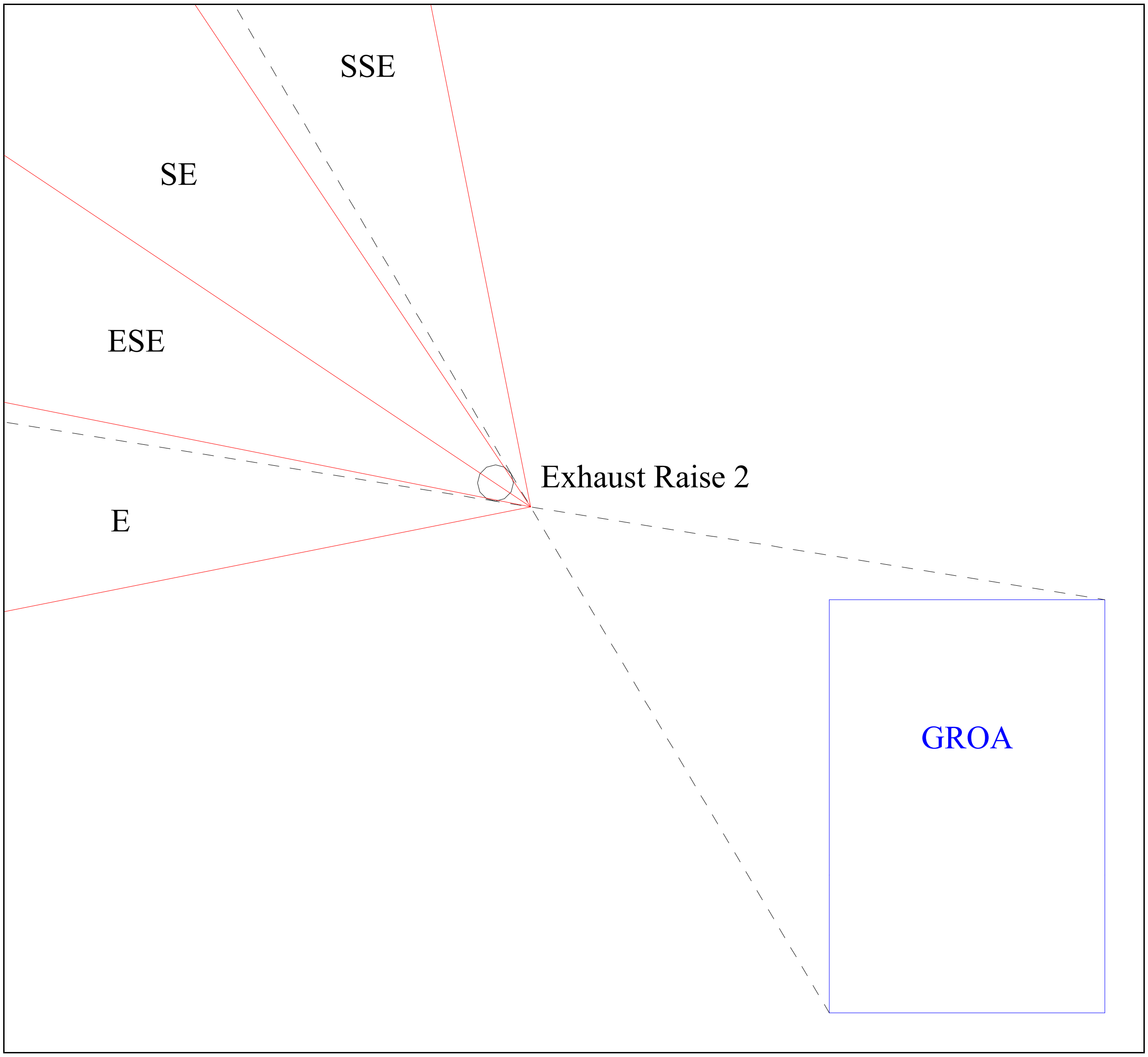

Figure 17 — Wind (from) Direction Sectors from the GROA to Exhaust Raise 2

6.4.3 Wind Direction Sectors from the Exhaust Shafts and Raises to the GROA

To determine the wind sectors that may affect the GROA due to releases from each of the subsurface exhaust shafts and raises, the following procedure is used. Per assumption 3.2.7, a member of the public on site may be a distance of 100 m from the GROA surface facilities. Therefore, an external boundary line is drawn exactly 100 m from any point of the GROA boundary. To determine which wind sectors are affected, two lines are drawn from the center of the exhaust shaft to the extended GROA boundary (these lines are shown as dashed lines in

Figure 18 through Figure 22). Winds within the cone bounded by these two lines could transport releases from the exhaust shafts to a member of the public 100 m away from the GROA.

Wind direction sectors from the exhaust shaft 1 to the GROA

As shown in Figure 18, winds from the northwest through the west sectors would affect the GROA due to releases from exhaust shaft 1.

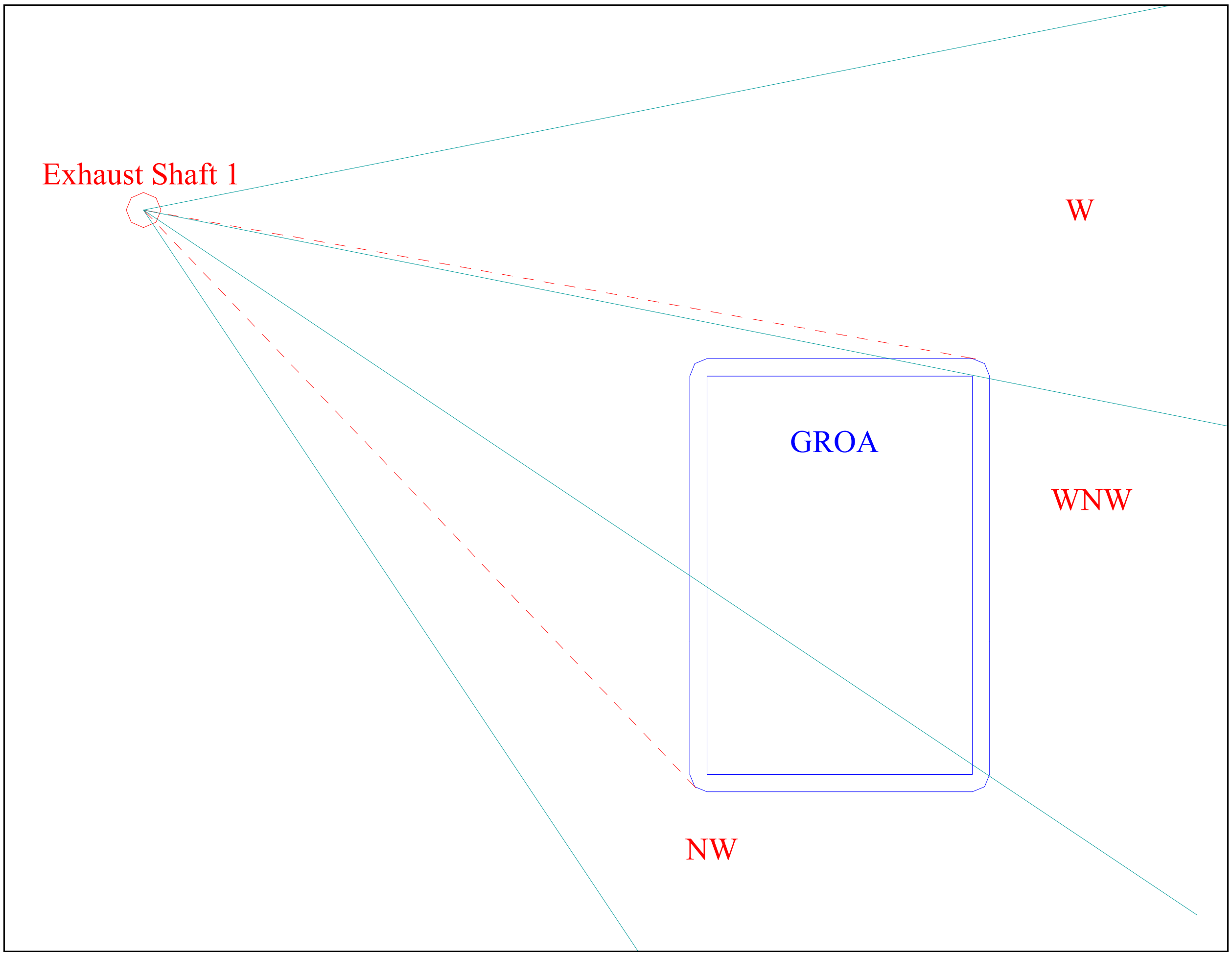

Figure 18 — Wind (from) Direction Sectors from Exhaust Shaft 1 to the GROA

Wind direction sectors from the exhaust shaft 2 to the GROA

As shown in Figure 19, winds from the north-northwest through the west-northwest sectors would affect the GROA due to releases from exhaust shaft 2.

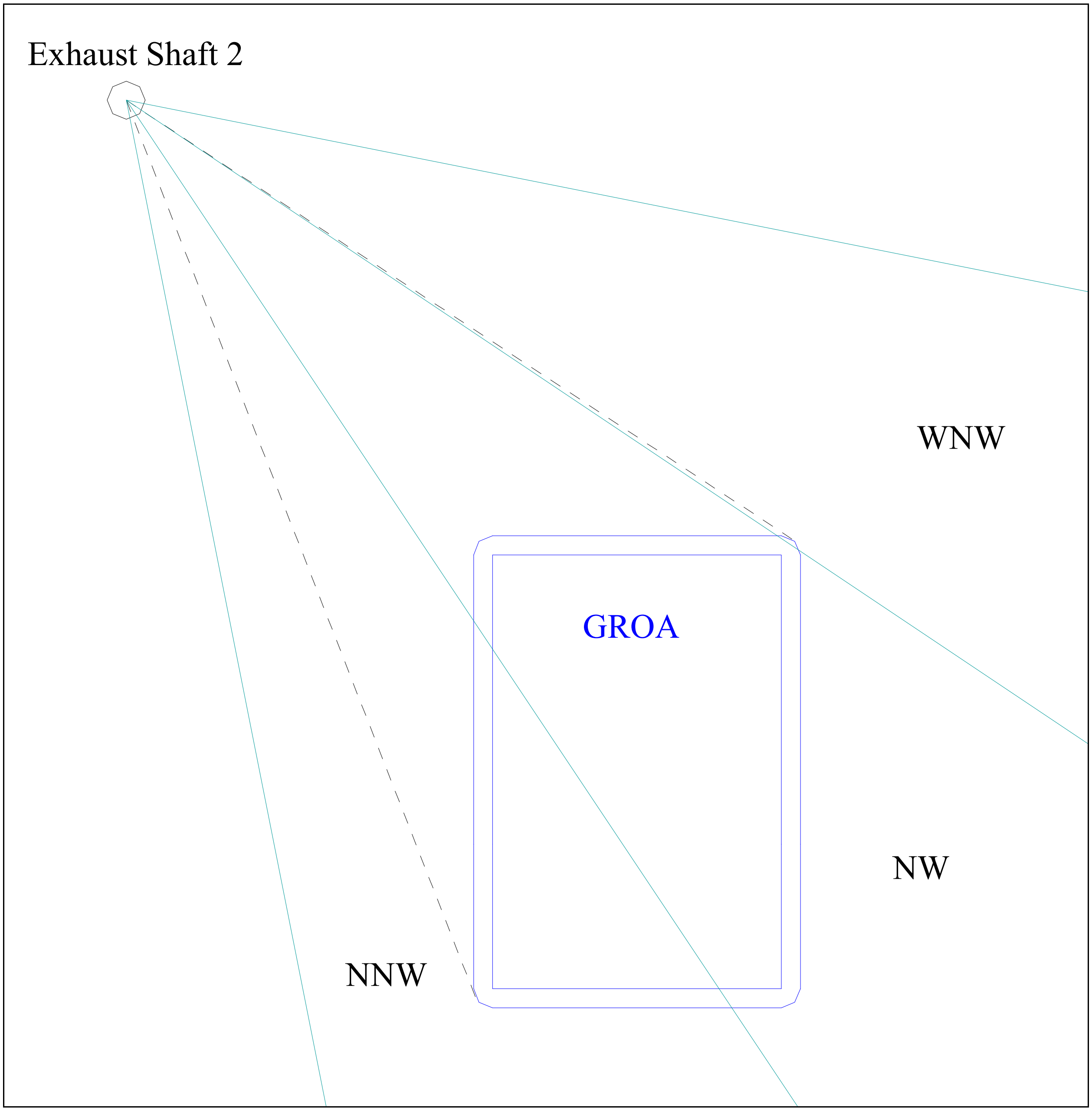

Figure 19 — Wind (from) Direction Sectors from Exhaust Shaft 2 to the GROA

Wind direction sectors from the exhaust shaft 3 to the GROA

As shown in Figure 20, winds from the west through the southwest sectors would affect the GROA due to releases from exhaust shaft 3.

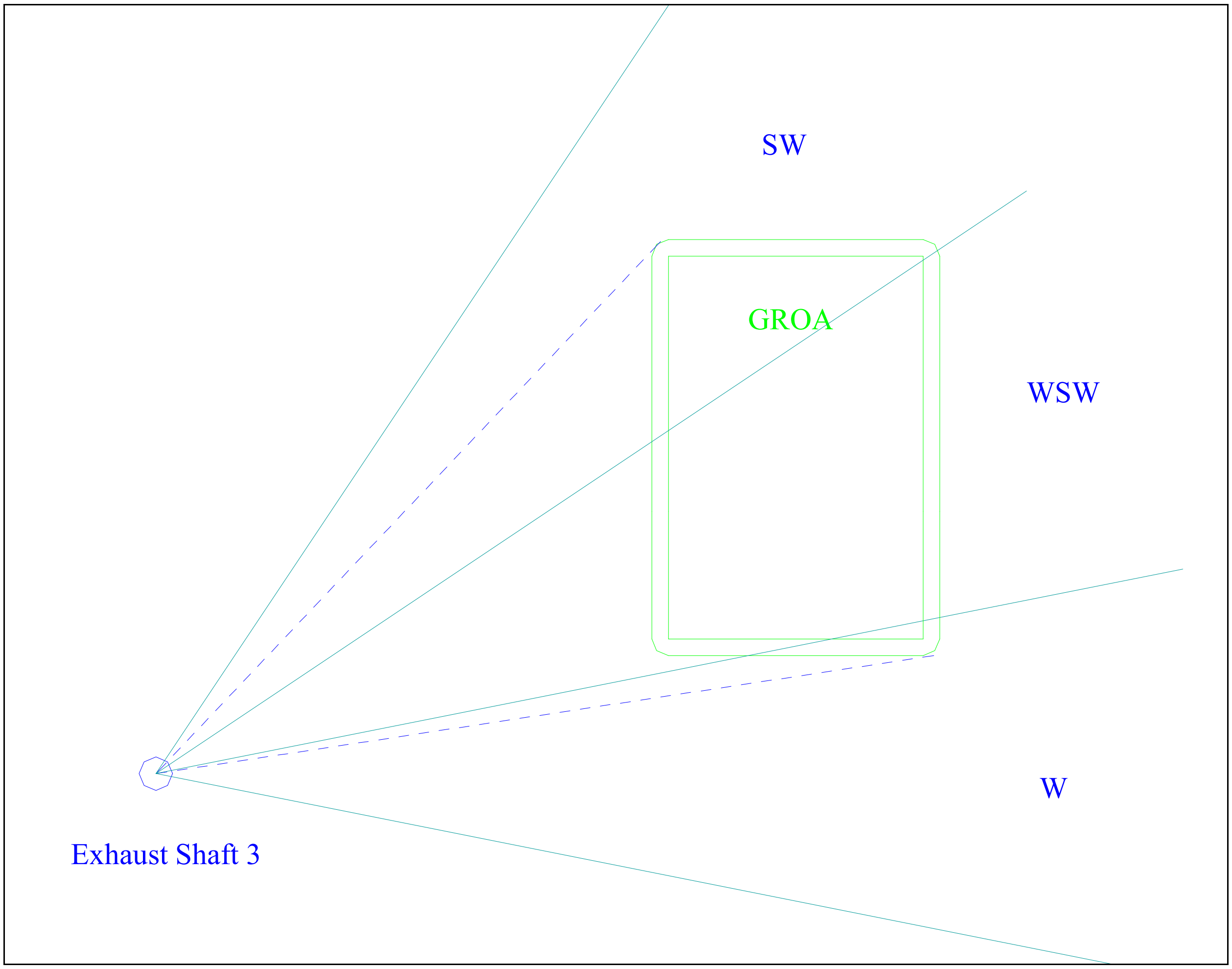

Figure 20 — Wind (from) Direction Sectors from Exhaust Shaft 3 to the GROA

Wind direction sectors from the exhaust raise 1 to the GROA

As shown in Figure 21, winds from the northwest through the west sectors would affect the GROA due to releases from exhaust raise 1.

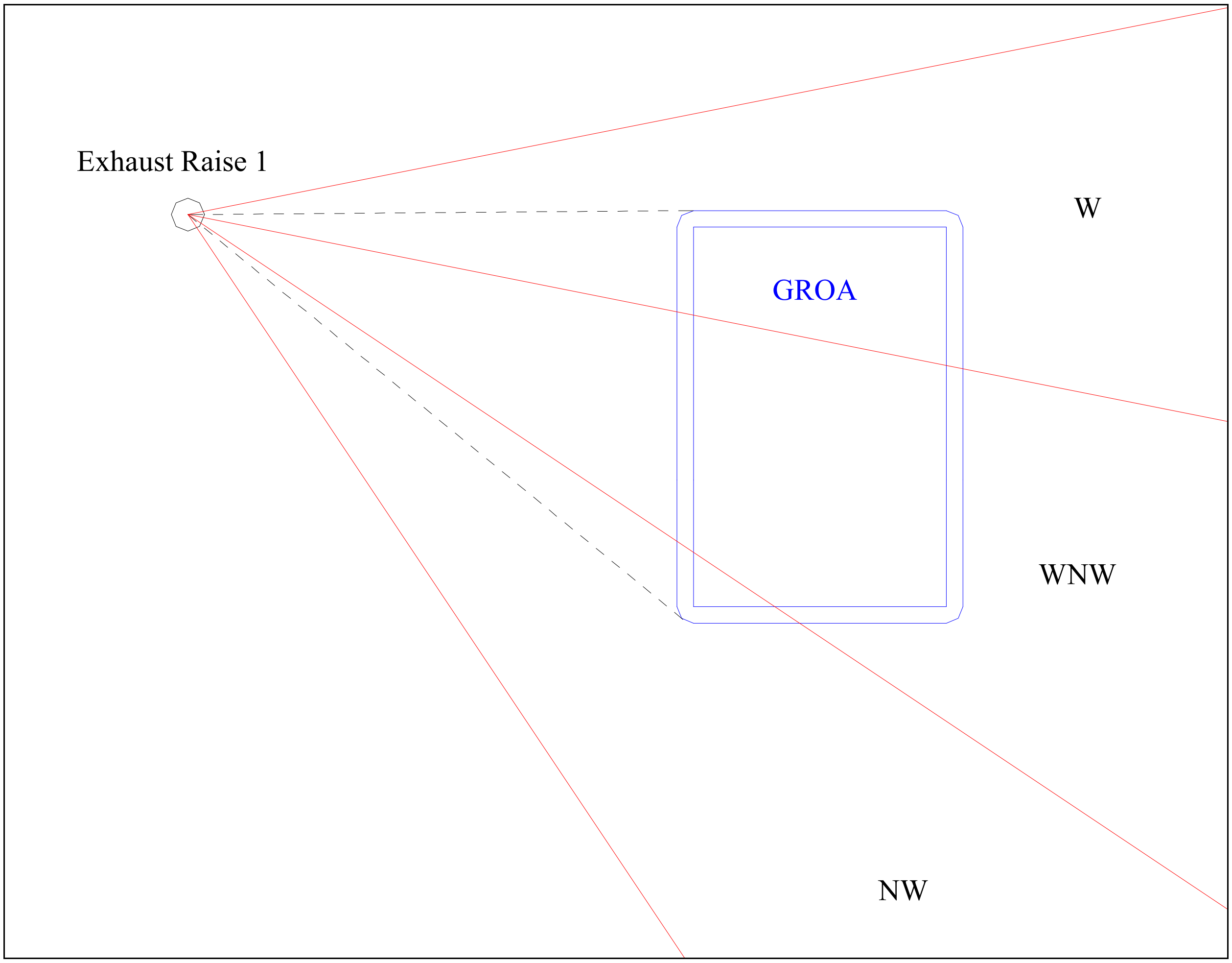

Figure 21 — Wind (from) Direction Sectors from Exhaust Raise 1 to the GROA

Wind direction sectors from the exhaust raise 2 to the GROA

As shown in Figure 22, winds from the north-northwest through the west sectors would affect the GROA due to releases from exhaust raise 2.

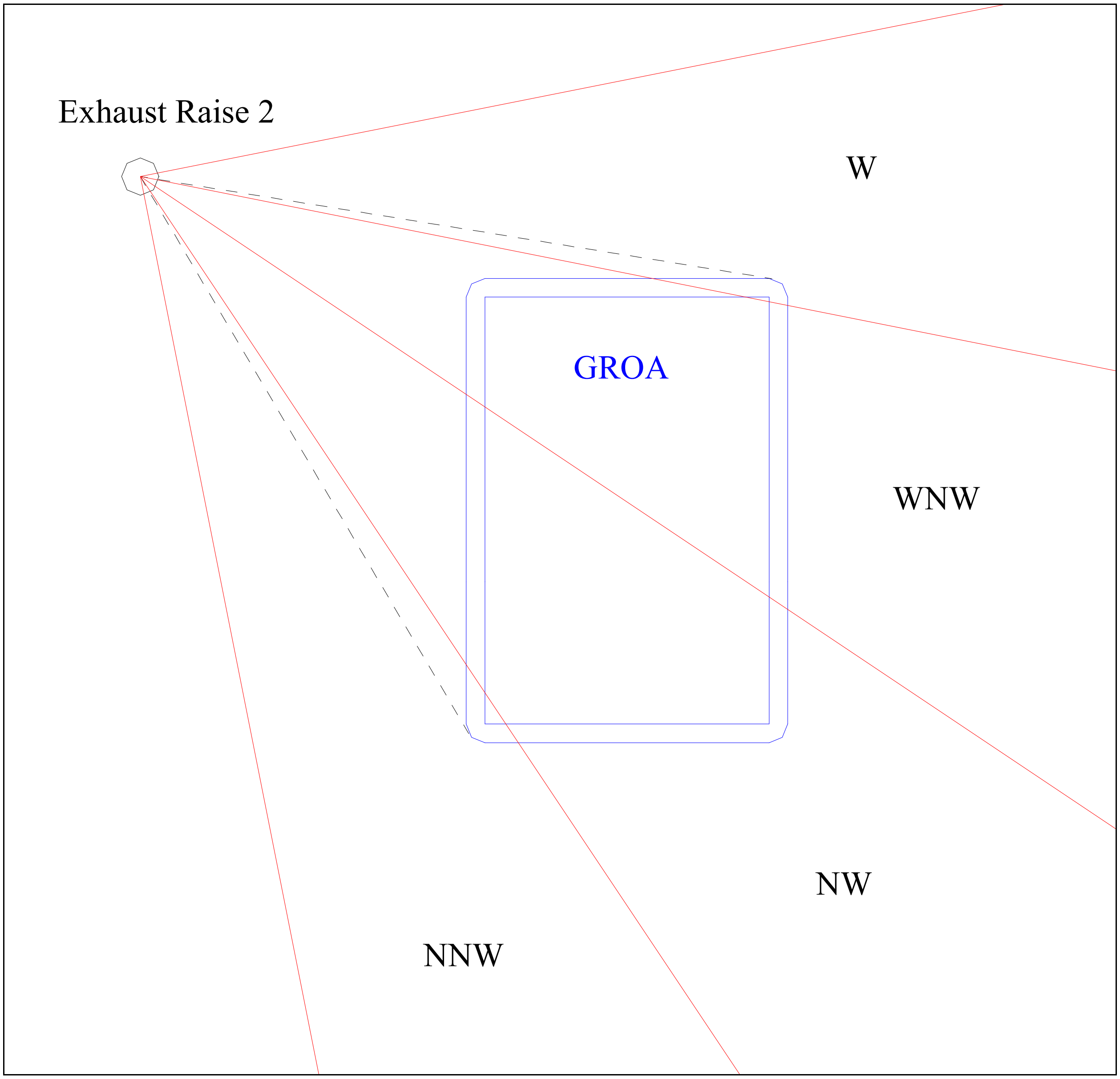

Figure 22 — Wind (from) Direction Sectors from Exhaust Raise 2 to the GROA

6.5 DISTANCE TO NEAREST RESIDENT

As discussed in design input 6.1.6, the nearest resident to the repository is located in Amargosa Valley at the intersection of U.S. Route 95 and Nevada State Route 373. In this section the distances from the GROA and the subsurface facility exhaust shafts to this intersection are calculated.

6.5.1 Distance and Direction from the GROA to Nearest Resident

The distance from the GROA to the nearest resident is calculated for each of the four points defining the boundary of the GROA from assumption 3.2.1 using Equation 9. From assumption 3.1.2 the coordinates of the nearest resident are:

578,368.58 ft East
689,421.97 ft North

Distance from the northwest corner of the GROA to the nearest resident is:

$$\begin{aligned} R_{NW} &= \sqrt{(578{,}368.58 - 570{,}000)^2 + (689{,}421.97 - 767{,}500)^2} \\ &= 78{,}525\ ft \\ &= 23{,}934\ m \end{aligned}$$

Distance from the northeast corner of the GROA to the nearest resident is:

$$\begin{aligned} R_{NE} &= \sqrt{(578{,}368.58 - 575{,}000)^2 + (689{,}421.97 - 767{,}500)^2} \\ &= 78{,}151\ ft \\ &= 23{,}820\ m \end{aligned}$$

Distance from the southwest corner of the GROA to the nearest resident is:

$$\begin{aligned} R_{SW} &= \sqrt{(578{,}368.58 - 570{,}000)^2 + (689{,}421.97 - 762{,}500)^2} \\ &= 73{,}556\ ft \\ &= 22{,}420\ m \end{aligned}$$

Distance from the southeast corner of the GROA to the nearest resident is:

$$\begin{aligned} R_{SE} &= \sqrt{(578{,}368.58 - 575{,}000)^2 + (689{,}421.97 - 762{,}500)^2} \\ &= 73{,}156\ ft \\ &= 22{,}298\ m \end{aligned}$$

The direction from each of the points defining the boundary of the GROA from assumption 3.2.1 is calculated using a modified version of Equation 11:

$$\theta_A = \sin^{-1}\left(\frac{x_A - x_0}{R_A}\right)$$

The direction from the northwest corner of the GROA to the nearest resident is:

$$\begin{aligned}\theta_{NW} &= \sin^{-1}\left(\frac{x_{NW} - x_0}{R_{NW}}\right) \\ &= \sin^{-1}\left(\frac{570{,}000 - 578{,}368.58}{78{,}525}\right) \\ &= -6.12\end{aligned}$$

This direction is 6.12 degrees east of due south; therefore, it is in the north wind direction sector.

The direction from the northeast corner of the GROA to the nearest resident is:

$$\begin{aligned}\theta_{NE} &= \sin^{-1}\left(\frac{x_{NE} - x_0}{R_{NE}}\right) \\ &= \sin^{-1}\left(\frac{575{,}000 - 578{,}368.58}{78{,}151}\right) \\ &= -2.47\end{aligned}$$

This direction is 2.47 degrees east of due south; therefore, it is in the north wind direction sector.

The direction from the southwest corner of the GROA to the nearest resident is:

$$\begin{aligned}\theta_{SW} &= \sin^{-1}\left(\frac{x_{SW} - x_0}{R_{SW}}\right) \\ &= \sin^{-1}\left(\frac{570{,}000 - 578{,}368.58}{73{,}556}\right) \\ &= -6.53\end{aligned}$$

This direction is 6.53 degrees east of due south; therefore, it is in the north wind direction sector.

The direction from the southeast corner of the GROA to the nearest resident is:

$$\begin{aligned}\theta_{SE} &= \sin^{-1}\left(\frac{x_{SE} - x_0}{R_{SE}}\right) \\ &= \sin^{-1}\left(\frac{575{,}000 - 578{,}368.58}{73{,}156}\right) \\ &= -2.64\end{aligned}$$

This direction is 2.64 degrees east of due south; therefore, it is in the north wind direction sector.

The minimum distance from the GROA to the nearest resident is 22,298 m from the southeast corner of the GROA.

6.5.2 Distance and Direction from the Exhaust Shafts and Raises to Nearest Resident

The distance from the exhaust shafts to the nearest resident is calculated for each exhaust shaft coordinates from input 6.1.5 using Equation 9. From assumption 3.1.2 the coordinates of the nearest resident are:

578,368.58 ft East
689,421.97 ft North

From input 6.1.5, the exhaust shaft and exhaust raise coordinates are:

	East (ft)	North (ft)
Exhaust Shaft 1	559,368	770,604
Exhaust Shaft 2	563,658	775,360
Exhaust Shaft 3	559,937	757,357
Exhaust Raise 1	560,005	767,748
Exhaust Raise 2	563,942	769,618

Distance from exhaust shaft 1 to the nearest resident is:

$$
\begin{aligned}
R_{ES1} &= \sqrt{(578{,}368.58 - 559{,}368)^2 + (689{,}421.97 - 770{,}604)^2} \\
&= 83{,}376\ ft \\
&= 25{,}413\ m
\end{aligned}
$$

Distance from exhaust shaft 2 to the nearest resident is:

$$
\begin{aligned}
R_{ES2} &= \sqrt{(578{,}368.58 - 563{,}658)^2 + (689{,}421.97 - 775{,}360)^2} \\
&= 87{,}188\ ft \\
&= 26{,}575\ m
\end{aligned}
$$

Distance from exhaust shaft 3 to the nearest resident is:

$$
\begin{aligned}
R_{ES3} &= \sqrt{(578{,}368.58 - 559{,}937)^2 + (689{,}421.97 - 757{,}357)^2} \\
&= 70{,}391\ ft \\
&= 21{,}455\ m
\end{aligned}
$$

Distance from exhaust raise 1 to the nearest resident is:

$$R_{ER1} = \sqrt{(578{,}368.58 - 560{,}005)^2 + (689{,}421.97 - 767{,}748)^2}$$
$$= 80{,}450\ ft$$
$$= 24{,}521\,m$$

Distance from exhaust raise 2 to the nearest resident is:

$$R_{ER2} = \sqrt{(578{,}368.58 - 563{,}942)^2 + (689{,}421.97 - 769{,}618)^2}$$
$$= 81{,}483\ ft$$
$$= 24{,}836\,m$$

The direction from exhaust shaft 1 to the nearest resident is:

$$\theta_{ES1} = \sin^{-1}\left(\frac{x_{ES1} - x_0}{R_{ES1}}\right)$$
$$= \sin^{-1}\left(\frac{559{,}368 - 578{,}368.58}{83{,}376}\right)$$
$$= -13.17$$

This direction is 13.17 degrees east of due south; therefore, it is in the north-northwest wind direction sector.

The direction from exhaust shaft 2 to the nearest resident is:

$$\theta_{ES2} = \sin^{-1}\left(\frac{x_{ES2} - x_0}{R_{ES2}}\right)$$
$$= \sin^{-1}\left(\frac{563{,}658 - 578{,}368.58}{87{,}188}\right)$$
$$= -9.71$$

This direction is 9.71 degrees east of due south; therefore, it is in the north wind direction sector.

The direction from exhaust shaft 3 to the nearest resident is:

$$\theta_{ES3} = \sin^{-1}\left(\frac{x_{ES3} - x_0}{R_{ES3}}\right)$$
$$= \sin^{-1}\left(\frac{559{,}937 - 578{,}368.58}{70{,}391}\right)$$
$$= -15.18$$

This direction is 15.18 degrees east of due south; therefore, it is in the north-northwest wind direction sector.

The direction from exhaust raise 1 to the nearest resident is:

$$
\begin{aligned}
\theta_{ER1} &= \sin^{-1}\left(\frac{x_{ER1} - x_0}{R_{ER1}}\right) \\
&= \sin^{-1}\left(\frac{560{,}005 - 578{,}368.58}{80{,}450}\right) \\
&= -13.19
\end{aligned}
$$

This direction is 13.19 degrees east of due south; therefore, it is in the north-northwest wind direction sector.

The direction from exhaust raise 2 to the nearest resident is:

$$
\begin{aligned}
\theta_{ER2} &= \sin^{-1}\left(\frac{x_{ER2} - x_0}{R_{ER2}}\right) \\
&= \sin^{-1}\left(\frac{563{,}942 - 578{,}368.58}{81{,}483}\right) \\
&= -10.20
\end{aligned}
$$

This direction is 10.20 degrees east of due south; therefore, it is in the north wind direction sector.

The direction from exhaust shafts 1 and 3 and exhaust raise 1 are from the north-northwest sector; therefore, the shortest distance will be used. The shortest distance is from exhaust shaft 3, or 21,455 m. The direction from exhaust shaft 2 and exhaust raise 2 are from the north sector; therefore, the shortest distance will be used. The shortest distance is from exhaust raise 2 or 24,836 m.

6.6 ATMOSPHERIC DISPERSION FACTORS – SITE BOUNDARY

The atmospheric dispersion factors (χ/Qs) at the site boundary and at 100 m from the subsurface exhaust shafts are calculated in 17 spreadsheets:

Spreadsheet	Description
GROA to Withdrawal-1.xls	Calculation of χ/Qs for the N – SE sectors
GROA to Withdrawal-2.xls	Calculation of χ/Qs for the SSE and S sectors
GROA to Withdrawal-3.xls	Calculation of χ/Qs for the SSW – WNW sectors
GROA to Withdrawal-4.xls	Calculation of χ/Qs for the NW sector
GROA to Withdrawal-5.xls	Calculation of χ/Qs for the NNW sector
GROA to General Environment-1.xls	Calculation of χ/Qs at the general environment for the N – SE sectors
GROA to General Environment-5.xls	Calculation of χ/Qs at the general environment for the NNW sector
GROA to Withdrawal Summary Rev 1.xls	Summary spreadsheet for releases from the GROA
Exhaust Shafts to Withdrawal-1.xls	Calculation of χ/Qs for the N – SE sectors
Exhaust Shafts to Withdrawal-2.xls	Calculation of χ/Qs for the SSE and S sectors
Exhaust Shafts to Withdrawal-3.xls	Calculation of χ/Qs for the SSW – WNW sectors
Exhaust Shafts to Withdrawal-4.xls	Calculation of χ/Qs for the NW sector
Exhaust Shafts to Withdrawal-5.xls	Calculation of χ/Qs for the NNW sector
Exhaust Shafts to General Environment-1.xls	Calculation of χ/Qs at the general environment for the N – SE sectors
Exhaust Shafts to General Environment-5.xls	Calculation of χ/Qs at the general environment for the NNW sector
Exhaust Shafts to Withdrawal Summary Rev 1.xls	Summary spreadsheet for releases from the exhaust shafts
XQ Calculation - 100 m Exhaust Shafts.xls	Calculation of χ/Qs at 100 meters from the exhaust shafts.

The structure of the 7 GROA and 7 Exhaust Shaft spreadsheets is the same, the only difference is the wind direction sectors considered. The *XQ Calculation – 100 m Exhaust Shafts.xls* spreadsheets is similar, but it determines maximum χ/Qs for all 16 sectors per assumption 3.2.7. Therefore, for the purposes of validating and describing the spreadsheets, the following discussion applies to all these spreadsheets. Examples used are from the *GROA to Withdrawal-1.xls* spreadsheet. The two summary spreadsheets are similar; therefore, for the purpose of validating and describing these spreadsheets the *GROA to Withdrawal Summary Rev 1.xls* spreadsheet is used.

6.6.1 Site Boundary Distances Worksheet

This worksheet links to the *Site Coordinates – GROA.x*ls spreadsheet to obtain the distances to the site boundary calculated in section 6.3 and shown in Table 9. The links are in cells C3 through C18. Since the meteorological data provides the wind direction as the angle from the north that the wind blows from, the distances for the meteorological sectors determined in the *Site Coordinates – GROA.x*ls spreadsheet are rotated by 180º as shown in Table 9. For example, for a wind blowing from the north, the site boundary distance for the south sector is used. The values in cells C3 through C18 are then conservatively rounded down to the nearest 100 meters as shown in cells D3 through D18.

Cells E3 through F18 provide the angular direction for the lower and upper boundaries for each of the 16 meteorological sectors that are 22.5° wide. These values are used in conjunction with the sector number in column G in the *Hourly Met Data* worksheet.

Cell E20 presents the adjacent building height calculated in section 6.1. Cell E21 presents the building orthogonal area calculated in section 6.1. These values are used in the *Hourly Met Data* worksheet.

6.6.2 Hourly Met Data Worksheet

6.6.2.1 Meteorological Data

Columns A through F and column H present the hourly meteorological data from January 1, 2001 through December 31, 2005 obtained from design input 6.1.2.

6.6.2.2 Meteorological Sector

Column G determines the meteorological sector for the from wind direction presented in column F. This column uses a lookup table from the *Site Boundary Distances* worksheet cells E4 through G18.

The meteorological data was sorted by ascending meteorological sector.

6.6.2.3 Atmospheric Stability Classification

Column I determines the stability class based on the temperature difference presented in column H. The stability class is determined using the methodology presented in section 4.8. Stability classes go from 1 (A) to 7 (G). For example, in cell H2, the ΔT is 1.25º; therefore, per Table 4 this corresponds to stability class F, or 6, which is the value shown in cell I2. As a second example, in cell H9, the ΔT is 0.71º; therefore, per Table 4 this corresponds to stability class E, or 5, which is the value shown in cell I9.

6.6.2.4 Site Boundary Distance

Column K is a lookup to find the appropriate minimum distance to the site boundary for the meteorological sector in column G. This lookup uses the values in column G to find the distance presented in the *Site Boundary Distance* worksheet cells B3 through D18. For example, for sector 1 a value of 18,500 meters is shown, which is the distance for the north sector as shown in the *Site Boundary Distance* worksheet cell D3. As a second example, for sector 5 a value of 11,000 meters is shown, which is the distance for the east sector as shown in the *Site Boundary Distance* worksheet cell D7.

6.6.2.5 Dispersion Coefficient Calculation

Lateral σ_y Dispersion Coefficient

Column L calculates the lateral dispersion coefficient, σ_y using Equation 35. As shown in section 4.6, $B_y = 0.9031$ and $C_y = 0$. The constant Ay is obtained as a lookup based on column I stability class from the *Sigmas* worksheet cells A3 through B9. As an example, the σ_y for stability class 5 (E) at a distance of 18,500 meters is calculated. From Table 3, $A_y = 0.1046$; therefore,

$$\sigma_y = A_y x^{B_y} + C_y$$

$$= 0.1046 \times 18{,}500^{0.9031} + 0$$

$$= 746.82\, meters$$

The above value is in excellent agreement with the results shown in Cell L9.

As a second example, the σ_y for stability class 1 (A) at a distance of 18,500 meters is calculated. From Table 3, $A_y = 0.3658$; therefore,

$$\sigma_y = A_y x^{B_y} + C_y$$

$$= 0.3658 \times 18{,}500^{0.9031} + 0$$

$$= 2{,}611.72\, meters$$

The above value is in excellent agreement with the results shown in Cell L47.

Per section 4.6, values for σ_y are limited to a maximum of 1,000 meters. This limit is implemented in column M.

Horizontal σ_z Dispersion Coefficient

As shown in Table 3, the calculation of σ_z using Equation 35 is performed for three distance ranges, less than 100 meters, between 100 and 1,000 meters, and greater than 1,000 meters. To implement this methodology, the distance range is determined in column N. If the distance is less than 100 meters, a value of 1 is entered; if the distance is between 100 and 1,000 meters, a value of 2 is entered; if the distance is greater than 1,000 meters, a value of 3 is entered. The distance range values in column N and the stability class in column I are then used to look up the constants A_z, B_z, and C_z from cells D4 through M10 of the *Sigmas* Worksheet to calculate the "raw σ_z" in column O.

For example, the σ_z for stability class 5 (E) at a distance of 18,500 meters is calculated. From Table 3, $A_z = 6.73$, $B_z = 0.305$, $C_z = -34.0$; therefore,

$$\sigma_z = A_z x^{B_z} + C_z$$

$$= 6.73 \times 18{,}500^{0.305} - 34.0$$

$$= 100.74\, meters$$

The above value is in excellent agreement with the results shown in Cell O9.

As a second example, the σ_z for stability class 1 (A) at a distance of 18,500 meters is calculated. From Table 3, $A_z = 0.00024$, $B_z = 2.094$, $C_z = -9.6$; therefore,

$$\sigma_z = A_z x^{B_z} + C_z$$

$$= 0.00024 \times 18{,}500^{2.094} - 9.6$$

$$= 206{,}846.74\, meters$$

The above value is in excellent agreement with the results shown in Cell O47.

Per section 4.6, values for σ_z are limited to a maximum of 1,000 meters. This limit is implemented in column O.

6.6.2.6 Annual Average χ/Q Calculation

The annual average χ/Q for each hour of meteorological data is calculated using the methodology described in section 4.4. First, the building wake correction factor for ground releases is calculated using Equation 22 in column Q. This calculation uses the adjacent building height determined in section 6.1 and presented in cell E20 of the *Site Boundary Distance* worksheet. For example, the adjusted Σ_z at a distance of 18,500 meters is calculated.

$$\Sigma_{zj}(x) = \sqrt{\sigma_{zj}^2(x) + \frac{0.5D_z^2}{\pi}}$$

$$= \sqrt{100.74^2 + \frac{0.5 \times 32.00^2}{\pi}}$$

$$= 101.55\, meters$$

$$\sqrt{3}\sigma_{zj}(x) = \sqrt{3} \times 100.74 = 174.49\, meters$$

The inequality condition of Equation 22 is met with Σ_z = 101.55 meters, which is the value presented in cell Q9.

The annual average χ/Q for each hour of meteorological data is calculated using Equation 20 in column R. For example, the adjusted χ/Q at a distance of 18,500 meters is calculated. Since ground level releases are considered, $h_e = 0$; therefore, the exponential term is 1.

$$\left(\frac{\chi}{Q}\right)_h = \frac{2.032 \cdot e^{\left[-h_e^2/2\sigma_{zj}^2(x)\right]}}{x \cdot u_h \Sigma_{zj}(x)}$$

$$= \frac{2.032}{18{,}500 \times 2.56 \times 101.55}$$

$$= 4.23 \times 10^{-7} \frac{s}{m^3}$$

This value is in excellent agreement with the value presented in cell R9.

6.6.2.7 Short-term (Accident) χ/Q Calculation

The short term χ/Q for each hour of meteorological data is calculated using the methodology described in section 4.5. In column S the σ_y at 800 meters is calculated. This is calculated using the same methodology described in section 6.6.2.5, but for a distance of 800 meters. Then the plume meander correction factor parameters are calculated. Column T determines the meander correction factor M. If the stability class is A, B, or C (1 to 3) or if the wind speed is greater than

6 m/s, M is set to 1. If the wind speed is less than 2 m/s, then M is set to the appropriate M_2 value from Table 2. For example, the row 26 wind speed is 1.85 m/s and the stability class is 5. From Table 2, the appropriate M_2 value is 3, which is shown in cell T26. And for example, as shown in row 48, the wind speed is 9.56 m/s; therefore cell T48 is set to 1. For other conditions, Equation 26 is used to determine M.

For example, row 4 has a wind speed of 3.29 m/s and stability class 5. From Table 2, m = -1, b = 1.791759. Using Equation 26:

$$M = e^{(m \cdot \ln(u_{10}) + b)} = \exp\left(-1 \times \ln(3.29) + 1.791759\right) = 1.82$$

This value is in excellent agreement with the value presented in cell T4.

As discussed in section 4.5, the lateral plume spread Σ_y is $M\sigma_y$ for distances less than 800 m and is calculated as follows for distances greater than 800 meters:

$$\Sigma_y = (M-1)\sigma_{y_{800m}} + \sigma_y$$

Thus, for the row 4 meteorological data, Σ_y is then:

$$\Sigma_y = (1.82 - 1) \times 43.78 + 746.82$$

$$= 782.88\, meters$$

This value is in good agreement with the value presented in cell U4.

Following the methodology discussed in section 4.5, three χ/Q values for each hour of meteorological data are determined. In column V Equation 23 is used; in column W Equation 24 is used, and in column X Equation 25 is used.

Using the meteorological data of row 4, the building cross-sectional area A =1,200 m^3 calculated in section 6.1, and using Equation 23,

$$\left(\frac{\chi}{Q}\right)_1 = \frac{1}{u_{10}(\pi\sigma_y\sigma_z + A/2)}$$

$$= \frac{1}{3.29 \cdot \left(\pi \cdot 746.82 \cdot 100.74 + 1{,}200/2\right)}$$

$$= 1.28 \times 10^{-6}\, \frac{s}{m^3}$$

Using Equation 24,

$$\left(\frac{\chi}{Q}\right)_2 = \frac{1}{u_{10}(3\pi\sigma_y\sigma_z)}$$

$$= \frac{1}{3.29\cdot(3\cdot\pi\cdot 746.82\cdot 100.74)}$$

$$= 4.29\times 10^{-7}\frac{s}{m^3}$$

Using Equation 25,

$$\left(\frac{\chi}{Q}\right)_3 = \frac{1}{u_{10}\pi\Sigma_y\sigma_z}$$

$$= \frac{1}{3.29\cdot\pi\cdot 782.93\cdot 100.74}$$

$$= 1.23\times 10^{-6}\frac{s}{m^3}$$

The above values are in excellent agreement with the values presented in cells V4 through X4.

Column Y presents the selected χ/Q value using the selection criteria described in section 4.5. For example, for the meteorological data of row 4, first the higher value using Equation 23 and Equation 24 is selected. From above the higher value is calculated using Equation 23. This value is then compared to the value calculated using Equation 25, and the lower value is selected. From above, the lower value is calculated using Equation 25. This value is shown in cell Y4.

For stability classes A through C and wind speeds greater than 6 m/s, the higher value using Equation 23 and Equation 24 is selected. For example, for the meteorological data shown in row 74, the higher value is calculated using Equation 23, which is the value shown in cell Y74.

6.6.3 Deposition Velocity Worksheet

This worksheet uses the meteorological data from the *Hourly Met Data* worksheet to calculate the dry deposition velocity. The first three columns, A through C present the year, Julian day and hour from the *Hourly Met Data* worksheet.

6.6.3.1 Calculate Monin-Obukhov Length

Columns D through F are used to calculate the inverse Monin-Obukhov length using the methodology of ARCON96 described in section 4.9.3. The data from subroutine INVMOL2 of the ARCON96 code (Reference 2.2.18 [DIRS 164547], pp 86) is presented in Table 11. This data is shown in worksheet *Monin-Obukhov Data*.

Table 11 — Monin-Obukhov Length Parameters

Stability Class	Bnd1L	Bnd1U	Bnd2LA	Bnd2LB	Bnd2UA	Bnd2UB	Bnd3LA	Bnd3LB	Bnd3UA	Bnd3UB	Bnd4L	Bnd4U
1	-0.16	-0.106	-0.16	0	-0.058	0.024	-0.16	0	-0.046	0.036	-0.16	-0.046
2	-0.106	-0.066	-0.058	0.024	-0.014	0.026	-0.046	0.036	-0.008	0.032	-0.046	-0.008
3	-0.066	-0.024	-0.014	0.026	0	0.012	-0.008	0.032	-0.003	0.009	-0.008	-0.003
4	-0.024	0.005	0	0.012	0.002	-0.0015	-0.003	0.009	0.002	-0.0015	-0.003	0.002
5	0.005	0.01	0.002	-0.0015	0.008	-0.001	0.002	-0.0015	0.004	-0.005	0.002	0.004
6	0.01	0.056	0.008	-0.001	0.008	-0.024	0.004	-0.005	0.014	-0.018	0.004	0.014
7	0.056	0.12	0.008	-0.024	0.12	0	0.014	-0.018	0.12	0	0.014	0.12

Per design input 6.1.3, the surface roughness length, z_0, is 0.1 m. Therefore, the inverse Monin-Obukhov length (1/L) is calculated using the following expressions from subroutine INVMOL2 for stability class (Stab):

LoBnd = Bnd2LA(Stab) + Bnd2LB(Stab) x alog10(z0)
UpBnd = Bnd2UA(Stab) + Bnd2UB(Stab) x alog10(z0)
INVMOL2 = LoBnd + 0.5 x (UpBnd – LoBnd)

The first expression, for LoBnd is coded in column D of the *Deposition Velocity* worksheet. This is accomplished using the Excel VLOOKUP function for each row n.

From Table 11, values for Bnd2LA are given in column 4, and values for Bnd2LB are given in column 5. For example, for stability class 6 shown in cell I2 of the *Hourly Met Data* worksheet and Table 11, the LoBnd parameter in cell D2 is calculated as:

$$LoBnd = 0.008 - 0.001 \times alog10(0.1) = 9.00 \times 10^{-3}$$

This value is in exact agreement with the value shown in cell D2.

The second expression, for UpBnd is coded in column E of the *Deposition Velocity* worksheet. This is accomplished using the Excel VLOOKUP function for each row n.

From Table 11, values for Bnd2UA are given in column 6, and values for Bnd2UB are given in column 7. For example, for stability class 6 shown in cell I2 of the *Hourly Met Data* worksheet and Table 11, the UPBnd parameter in cell E2 is calculated as:

$$UpBnd = 0.008 - 0.024 \times alog10(0.1) = 3.20 \times 10^{-2}$$

This value is in exact agreement with the value shown in cell E2.

The third expression calculates the resultant inverse Monin-Obukhov length (1/L) and is coded in column F for each row n.

Continuing the previous example:

$$INVMOL2 = 9.00 \times 10^{-3} + 0.5 \times (3.20 \times 10^{-2} - 9.00 \times 10^{-3}) = 2.05 \times 10^{-2}$$

This value is in exact agreement with the value shown in cell F2.

6.6.3.2 Calculate Stability Correction Factor

In column G, the parameter x is calculated using Equation 41 for each row n. This parameter is only required for unstable conditions, that is, stability classes A, B, and C (1 through 3), for other stability classes this parameter is blank.

For example, for stability class 3 (row 34):

$$
\begin{aligned}
x &= \left(1 - 16\frac{z}{L}\right)^{0.25} \\
&= \left(1 - 16 \cdot 10 \cdot \left[-2.60 \times 10^{-2}\right]\right)^{0.25} \\
&= 1.51
\end{aligned}
$$

This value is in exact agreement with the results presented in cell G34.

The stability correction factor is then determined in column H using the methodology discussed in Section 4.9.2 for each row n. Equation 39 is used for stable conditions (stability classes 5, 6, and 7). Equation 40 is used for unstable conditions (stability classes 1, 2, and 3). For neutral conditions (stability class 4), the stability correction factor is zero.

Three examples are considered, stable, unstable, and neutral stability conditions.

<u>Stable condition</u>

The stability class for row 2 of the *Hourly Met Data* worksheet is 6, or very stable. Therefore, Equation 39 is used:

$$
\begin{aligned}
\psi\left(\frac{z}{L}\right) &= -\alpha \frac{z}{L} \\
&= -5 \frac{10}{1/2.05 \times 10^{-2}} \\
&= -1.03
\end{aligned}
$$

This value is in exact agreement with the result shown in cell H2.

<u>Unstable condition</u>

The stability class for row 34 of the *Hourly Met Data* worksheet is 3, or slightly unstable. Therefore, Equation 40 is used:

$$
\begin{aligned}
\psi\left(\frac{z}{L}\right) &= \ln\left(\left[\frac{1+x^2}{2}\right]\left[\frac{1+x}{2}\right]^2\right) - 2\tan^{-1} x + \frac{\pi}{2} \\
&= \ln\left(\left[\frac{1+1.51^2}{2}\right]\left[\frac{1+1.51}{2}\right]^2\right) - 2\tan^{-1} 1.51 + \frac{\pi}{2} \\
&= 5.48 \times 10^{-1}
\end{aligned}
$$

This value is in good agreement with the result shown in cell H34.

Neutral condition

The stability class for row 21 of the *Hourly Met Data* worksheet is 4, or stable; therefore, $\psi = 0$. A value of zero is shown in cell H21.

6.6.3.3 Calculate Friction Velocity

The friction velocity is determined in column I using the methodology discussed in section 4.9.1 for each row n. Equation 38 is used and solved for the friction velocity.

Using the parameters for row 2 of the *Hourly Met Data* worksheet, the friction velocity is calculated as:

$$u_* = \frac{k \cdot U(z)}{\left[\ln\left(\frac{z}{z_0}\right) - \psi\left(\frac{z}{L}\right)\right]}$$

$$= \frac{0.4 \cdot 2.81}{\left[\ln\left(\frac{10}{0.1}\right) + 1.03\right]}$$

$$= 0.199$$

This value is in exact agreement with the result shown in cell I2.

6.6.3.4 Calculate Dry Deposition Velocity

Columns J through L of the *Deposition Velocity* worksheet determine the dry deposition velocity. Column J determines the aerodynamic resistance, r_a, using Equation 31. For example, for the data of row 2, the aerodynamic resistance is:

$$r_a = \frac{U(z)}{u_*^2} = \frac{2.81}{0.200^2} = 7.03 \times 10^1$$

This value is in good agreement with the result shown in cell J2.

The surface resistance, r_s, is calculated using Equation 32 in column K. For example, for the data of row 2, the surface resistance is:

$$r_s = \frac{2.6}{0.4 u_*} = \frac{2.6}{0.4 \times 0.200} = 3.25 \times 10^1$$

This value is in excellent agreement with the result shown in cell K2.

The dry deposition velocity is calculated in column L using Equation 30. The transfer resistance, r_t, is 100 s/m per design input 6.1.4 for particulates. Therefore, using the data for column 2, the resultant dry deposition velocity is:

$$\begin{aligned} v_{dd} &= \left(r_a + r_s + r_t\right)^{-1} \\ &= \left(70.5 + 32.5 + 100\right)^{-1} \\ &= 4.93 \times 10^{-3} \end{aligned}$$

This value is in excellent agreement with the result shown in cell L2.

6.6.4 Sigmaz Integration Worksheet

This worksheet determines the horizontal dispersion coefficient, σ_z, and the integral portion of Equation 34 as a function of distance and stability class. This information is then used in the *Depletion* worksheet as a look-up table.

Since the integration is a trapezoidal numerical approximation, the distances were chosen to minimize the error in the estimation of the integral. As described in section 5.3.7 of the *GENII Version 2 Software Design Document* (Reference 2.2.17 [DIRS 179908]) depletion does not occur for distances less than 100 meters; therefore, 100 meters was chosen as the start of the distance range. Intermediate distances are chosen by doubling the previous distance until the closest site boundary distance is reached. Each site boundary distance as calculated in the *Site Boundary Distance* worksheet is used.

6.6.4.1 Horizontal σ_z Dispersion Coefficient

As shown in Table 3, the calculation of σ_z using Equation 35 is performed for three distance ranges, less than 100 meters, between 100 and 1,000 meters, and greater than 1,000 meters. To implement this methodology, the distance range is determined in row 3. If the distance is less than 100 meters, a value of 1 is entered; if the distance is between 100 and 1,000 meters, a value of 2 is entered; if the distance is greater than 1,000 meters, a value of 3 is entered. The distance range values in row 3 and the stability class in column A are then used to look up the constants A_z, B_z, and C_z from cells D4 through M10 of the *Sigmas* Worksheet to calculate the σ_z in cells B4 through R10.

For example, the σ_z for stability class 5 (E) at a distance of 800 meters is calculated. From Table 3, $A_z = 0.211$, $B_z = 0.678$, $C_z = -1.3$; therefore,

$$\begin{aligned} \sigma_z &= A_z x^{B_z} + C_z \\ &= 0.211 \times 800^{0.678} - 1.3 \\ &= 18.31\, meters \end{aligned}$$

The above value is in excellent agreement with the results shown in Cell E8.

As a second example, the σ_Z for stability class 1 (A) at a distance of 1,600 meters is calculated. From Table 3, $A_Z = 0.00024$, $B_Z = 2.094$, $C_Z = -9.6$; therefore,

$$\sigma_z = A_z x^{B_z} + C_z$$

$$= 0.00024 \times 1{,}600^{2.094} - 9.6$$

$$= 1{,}219.65\, meters$$

The above value is greater than 1,000 meters. Per section 4.6, values for σ_Z are limited to a maximum of 1,000 meters, which is the value shown in cell F4.

6.6.4.2 Horizontal σ_z Dispersion Coefficient Integration

The integral portion of Equation 34 is calculated using a trapezoidal numerical integration in cells C14 through R20. The form of the semi-log trapezoidal integration is:

$$\int_{x_1}^{x_2} \frac{1}{\sigma_z} dx = \sqrt{\frac{1}{\sigma_z(x_1)} \times \frac{1}{\sigma_z(x_2)}} \times (x_2 - x_1)$$

For example, the integral for stability class 3 (C) between 800 and 1,600 meters is:

$$\int_{x_1}^{x_2} \frac{1}{\sigma_z} dx = \sqrt{\frac{1}{49.86} \times \frac{1}{93.76}} \times (1{,}600 - 800)$$

$$= 11.70$$

This value is in excellent agreement with the result presented in cell F16.

6.6.5 Depletion Worksheet

This worksheet determines the source depletion using Equation 34, the depleted χ/Q, and the dry deposition rate using Equation 29. The source depletion calculation uses a unit initial source; therefore, the depleted χ/Q is then the Q'(x) calculated using Equation 29 multiplied by the undepleted χ/Q determined in worksheet *Hourly Met Data*.

The first three columns, A through C present the year, julian day and hour from the *Hourly Met Data* worksheet. Column D presents the depletion at 100 meters. Since no depletion occurs at distances less than 100 meters, a value of 1 is entered in this column. Columns E through T calculate the cumulative depletion as a function of distance. Cells E2 through T2 repeat the distances from worksheet *Sigmaz Integration*. Cells E3 through T3 are column numbers used by the VLOOKUP function to determine the appropriate σ_Z integral from the *Sigmaz Integration* worksheet.

As an example, the information for year 2001, julian day 1, 2300 hours (row 3 of the *Hourly Met Data* worksheet) is used. From the *Deposition Velocity* worksheet, vdd = 5.29 x 10^{-3} m/s, from the *Hourly Met Data* worksheet the 10 m wind speed is 3.25 m/s, and the stability class is 6. To calculate the depletion at a distance of 1,600 meters, the depletion from the previous distance is needed. Q'(800m) = 0.860 (Cell G5). From the *Sigmaz Integration* worksheet, for a distance of 1,600 meters and stability class 6 the integral portion of Equation 34 is 52.8. Therefore:

$$Q'(x_2) = Q'(x_1)\exp\left(-\sqrt{\frac{2}{\pi}}\frac{v_{dd}}{U}\int_{x_1}^{x_2}\frac{1}{\sigma_z}dx\right)$$

$$= 0.860 \times \exp\left(-\sqrt{\frac{2}{\pi}}\frac{5.29\times10^{-3}}{3.25}\times 52.8\right)$$

$$= 0.803$$

This value is in excellent agreement with the result presented in cell H5.

The short-term depleted χ/Q is calculated in column U. Continuing on the previous example, the short term χ/Q from the *Hourly Met Data* worksheet is 3.11 x 10^{-6} s/m^3, the total source depletion at the site boundary distance of 18,500 meters is 0.470; therefore, the depleted χ/Q is:

$\chi/Q^d = 3.11 \text{ x } 10^{-6} \text{ x } 0.470 = 1.46 \text{ x } 10^{-6} \text{ s/m}^3$

This value is in excellent agreement with the result shown in cell U5.

The deposition rate, calculated using Equation 29 is shown in column V. Continuing on the previous example, the deposition rate is:

$$\omega_{ij}(t) = v_{dd}\chi(1,t)$$
$$= 5.29\times10^{-3}\times1.46\times10^{-6}$$
$$= 7.73\times10^{-9}\ m^{-2}$$

This value is in excellent agreement with the results shown in cell V5.

The annual average depleted χ/Q is calculated in column W. Continuing on the previous example, the annual average χ/Q from the *Hourly Met Data* worksheet is 5.76 x 10^{-7} s/m^3, the total source depletion at the site boundary distance of 18,500 meters is 0.470; therefore, the depleted χ/Q is:

$\chi/Q^d = 5.76 \text{ x } 10^{-7} \text{ x } 0.470 = 2.71 \text{ x } 10^{-7} \text{ s/m}^3$

This value is in excellent agreement with the result shown in cell W5.

The deposition rate, calculated using Equation 29 is shown in column X. Continuing on the previous example, the deposition rate is:

$$\begin{aligned}\omega_{ij}(t) &= v_{dd}\chi(1,t) \\ &= 5.29\times10^{-3}\times2.71\times10^{-7} \\ &= 1.43\times10^{-9}\ m^{-2}\end{aligned}$$

This value is in excellent agreement with the results shown in cell X5.

6.6.6 Sigmas Worksheet

This worksheet contains the data to calculate the lateral (σ_y) and horizontal (σ_z) dispersion coefficients.

Cells B3 through B9 present the constant A_y as a function of stability class from Table 3 used to calculate σ_y using Equation 35.

Cells E4 through M10 present the constants A_z, B_z, and C_z as a function of stability class from Table 3 used to calculate σ_z using Equation 35.

Cells E13 through H16 present the plume meander correction parameters for stability classes D through G (4 to 7) from Table 2 used in Equation 28.

6.6.7 Time Averaged XQs Worksheet

This worksheet summarizes the χ/Q values calculated in the *Hourly Met Data* and the *Depletion* worksheets. In addition, the time dependent χ/Q values for release periods of 2 – 8 hours, 8 – 24 hours, 24 – 96 hours, and 96 – 720 hours are calculated for each sector using Equation 48 and Equation 49. Only the information for the sectors considered in the spreadsheet is presented. All other sectors are blanked out. In the *GROA to Withdrawal-1.xls* spreadsheet only the N to SE sectors are considered, therefore the other sectors are blank.

This worksheet is divided into three sections. Rows 1 through 21 present the undepleted χ/Q results, rows 23 through 43 present the depleted χ/Q results, and rows 45 through 65 present the deposition rate results. Since the methodology for each of the three sections is the same, only the methodology for the undepleted χ/Qs in the first section is described below.

Values in cells B4 through B19, B26 through B41, and B48 through C63 repeat the minimum site boundary distances for each sector from the *Site Boundary Distances* worksheet.

Values in cells C4 through C19, C26 through C41, and C48 through C63 present the number of hours of occurrences for each sector using the Excel function COUNTA.

Values in cells D4 through D19 present the mean χ/Q values for each sector calculated in row R of the *Hourly Met Data* worksheet using the Excel function AVERAGE.

Values in cells E4 through E19 present the median χ/Q values for each sector calculated in row R of the *Hourly Met Data* worksheet using the Excel function MEDIAN.

Values in cells F4 through F19 present the annual average χ/Q values for each sector. These values are calculated by multiplying the mean χ/Q values presented in cells D3 through D18 by the number of occurrences for a particular sector and divided by the total number of occurrences. For example, for the north sector there are 3,095 occurrences. The total number of occurrences, shown in Cell C70 is 42,861. The mean χ/Q is 4.42 x 10^{-7} s/m^3. Therefore, the annual average χ/Q is:

$$\text{Annual average } \chi/Q = 4.42 \times 10^{-7} \times 3{,}095 \div 42{,}861 = 3.19 \times 10^{-8} \text{ s/m}^3$$

This value is in excellent agreement with the result shown in cell F4.

To determine the χ/Q value that is exceeded 0.5% of the total number of hours in the data set (99.5 percentile), the number of hours in the complete data set exceeding the 99.5 percentile χ/Q value is first calculated in cell C69. The total number of hours in the data set is the sum of valid hours in each of the 16 sectors is 42,861 as shown in cell C70; therefore, the number of hours that the 99.5 percentile χ/Q is exceeded is 0.005 x 42,861 = 214 hours. For each meteorological sector, the percentile value within that sector that 214 hours corresponds to is determined as follows:

$$Percentiles = 1 - \frac{214}{n_s}$$

Where n_s is the number of hours of χ/Q values in the sector presented in column C.

For example, there are 1,392 hours of χ/Q values in sector NNE, therefore the percentile value that corresponds to the 99.5 percentile for the total number of hours in the data set is:

$$Percentiles = 1 - \frac{214}{1{,}392} = 84.63\%$$

This value is then used as the argument for the *PERCENTILE* Excel function along with the χ/Q value range.

Values in cells G4 through G19 present the 99.5th percentile χ/Q values for each sector calculated using the PERCENTILE Excel function for the short-term χ/Q values from the *Hourly Met Data* worksheet column Y.

The slope is calculated using Equation 49 and presented in cells L4 through L19 for each sector with Trel equal to 8,760 hours. For example, the slope for the SE sector is calculated:

$$slope = \ln\left(\frac{\frac{\chi}{Q}_{Trel}}{\frac{\chi}{Q}_{2hr}}\right) \div \ln\left(\frac{8{,}760\,hr}{2\,hr}\right)$$

$$= \ln\left(\frac{1.95\times10^{-8}}{3.02\times10^{-6}}\right) \div \ln\left(\frac{8{,}760\,hr}{2\,hr}\right)$$

$$= -0.601$$

This value is in excellent agreement with the value presented in cell L10.

The χ/Q values for the different release periods for each sector are calculated in cells H4 through K19 using Equation 48. For example, the χ/Q value for the 8 – 24 hour period for the East sector is:

$$\frac{\chi}{Q}_{Trel} = \frac{\chi}{Q}_{2hr} \times \left(\frac{Trel}{2\,hr}\right)^{slope}$$

$$= 2.18\times10^{-6} \times \left(\frac{16}{2}\right)^{-0.626}$$

$$= 5.93\times10^{-7}\,\frac{s}{m^3}$$

This value is in good agreement with the value presented in cell I8.

Cells D20 through K20 present the maximum χ/Q values for all sectors. Cells D21 through K21 in the *Time Averaged XQs* worksheet of the *GROA to Withdrawal-n.xls* and *Exhaust Shafts to Withdrawal-n.xls* Excel files present the maximum public in the general environment χ/Q values based only on the sectors identified in Section 6.3.3. The file *XQ Calculation – 100 m Exhaust Shafts.xls* does not have this summary since per assumption 3.2.7, a member of the public located 100 meters from the release point may be in any of the 16 meteorological sectors.

6.6.8 Summary Spreadsheet

The two summary spreadsheets, *GROA to Withdrawal Summary Rev 1.xls* and *Exhaust Shafts to Withdrawal Summary Rev 1.xls* summarize the results from the other spreadsheets. The *GROA to Withdrawal Summary Rev 1.xls* summarizes the *GROA to Withdrawal-n.xls* and *GROA to General Environment-n.xls* Excel spreadsheets. The *Exhaust Shafts to Withdrawal Summary Rev*

1.xls summarizes the *Exhaust Shafts to Withdrawal-n.xls* and *Exhaust Shafts to General Environment-n.xls*,Excel files. These spreadsheets have three worksheets, *Hourly XQ Results, Withdrawal Summary and General Environment Summary.*

6.6.8.1 Hourly XQ Results Worksheet

This worksheet links the resultant χ/Q values from each *GROA to Withdrawal-n.xls* spreadsheet. Column A presents the undepleted annual average χ/Q values obtained from column R of the *Hourly Met Data* worksheet. Column B presents the undepleted 1-hour χ/Q values from column Y of the *Hourly Met Data* worksheet. Columns C through F link to columns U through X of the *Depletion* worksheet to obtain the resultant 1-hour depleted χ/Q values, the 1-hour deposition rates, the annual average depleted χ/Q values, and the annual average deposition rates. These values are used in the Summary worksheet to determine the site 95%ile and 50%ile χ/Qs.

6.6.8.2 Withdrawal Summary Worksheet

This worksheet has the same structure as the *Time Averaged XQs* worksheet described in section 6.6.7. The values in columns D, E, and F are obtained from the *Time Averaged XQs* worksheet of each *GROA to Withdrawal-n.xls* spreadsheet. The calculation of the χ/Q value that is exceeded 0.5% of the time is performed using the same methodology presented in the *Time Averaged XQs* worksheet described in section 6.6.7. Per section 4.11, for the 2-hour χ/Q, the maximum is selected from the maximum of the site 2-hour χ/Q 95 percentile and the sector 2-hour 99.5 percentile values. The site 2-hour χ/Q 95 percentile is calculated in cell G20 for the undepleted χ/Q, G43 for the depleted χ/Q, and cell G66 for the deposition rate using the Excel function PERCENTILE.

In addition a calculation of the site 50%ile χ/Q values is performed. This is shown in row 22 for the undepleted χ/Q, row 45 for the depleted χ/Q, and row 68 for the deposition rate. For example, the mean undepleted χ/Q is calculated using the Excel function AVERAGE with the values presented in column A of the *Hourly XQ Results* worksheet. The median is calculated using the Excel function MEDIAN with the values presented in column A of the *Hourly XQ Results* worksheet. The 2-hour 50%ile χ/Q is determined using the Excel function PERCENTILE with the values presented in column B of the *Hourly XQ Results* worksheet.

6.6.8.3 General Environment Summary Worksheet

This worksheet is similar to the *Withdrawal Summary Worksheet* described in the previous section. The values in columns D, E, and F are obtained from the *Time Averaged XQs* worksheet of each *GROA to General Environment-n.xls* spreadsheet. The calculation of the χ/Q value that is exceeded 0.5% of the time is performed using the same methodology presented in the *Time Averaged XQs* worksheet described in section 6.6.7. The maximum value is then selected and presented in row 12 for the undepleted χ/Qs, row 25 for the depleted χ/Qs, and row 38 for the deposition rates.

6.7 ATMOSPHERIC DISPERSION FACTORS – GROA TO/FROM EXHAUST SHAFTS AND RAISES

The atmospheric dispersion factors (χ/Qs) at the GROA from releases from the subsurface exhaust shafts and at the exhaust shafts from releases from the GROA are calculated in ten spreadsheets:

Spreadsheet	Receptor Location	Release Source
ES-1 to GROA.xls	GROA	Exhaust shaft 1
ES-2 to GROA.xls	GROA	Exhaust shaft 2
ES-3 to GROA.xls	GROA	Exhaust shaft 3
ER-1 to GROA.xls	GROA	Exhaust raise 1
ER-2 to GROA.xls	GROA	Exhaust raise 2
GROA to ES-1.xls	Exhaust shaft 1	GROA
GROA to ES-2.xls	Exhaust shaft 2	GROA
GROA to ES-3.xls	Exhaust shaft 3	GROA
GROA to ER-1.xls	Exhaust raise 1	GROA
GROA to ER-2.xls	Exhaust raise 2	GROA

The structure of these spreadsheets is the same; therefore, for the purposes of validating and describing the spreadsheets, the following discussion applies to all ten spreadsheets. In general, these spreadsheets use the same structure as the spreadsheets described in section 6.5. The differences are described in the following subsections. Examples used are from the *GROA to ES-1.xls* spreadsheet.

6.7.1 Distances Worksheet

This worksheet is similar to the Site Boundary Distances worksheet described in section 6.6.1 with the following exceptions. This worksheet links to the *Site Coordinates – GROA.x*ls spreadsheet to obtain the distances between the GROA and the exhaust shafts calculated in section 6.4.1. The links are in cells C3 through C18 for the wind directions determined in sections 6.4.2 and 6.4.3. For other wind directions, the distance is given a zero value and blanked out.

6.7.2 Hourly Met Data Worksheet

This worksheet is similar to the *Hourly Met Data* worksheet described in section 6.6.2 with the following exceptions. The calculations of annual average χ/Qs in column R and the calculation of short-term χ/Qs in columns V through X were modified to include a check to see if the distance for the wind direction during that hour was zero. If the distance is zero, then a blank is returned in these cells, otherwise, the χ/Qs are calculated as described in section 6.6.2. For example, the distance shown in cell K2 for the north sector is zero, therefore the values in cells R2, V2, W2, and X2 are blank. The distance shown in cell K6149, for the east sector is 3,200 m;

therefore, the values in cells R6149, V6149, W6149, and X6149 are calculated as described in section 6.6.2.

6.7.3 Sigmas Worksheet

This worksheet is identical to the Sigmas worksheet described in section 6.6.6.

6.7.4 Time Averaged XQs Worksheet

This worksheet is similar to the *Time Averaged XQs* Worksheet described in section 6.6.7 with the following exceptions. The mean values in column D and the median values in column E are set to blank if the distance in column b is zero. The calculations in columns F through L have been modified to check if the values in column D are blank. If blank, then a blank is returned, otherwise the calculation proceeds as described in section 6.6.7.

6.8 ATMOSPHERIC DISPERSION FACTORS – NEAREST RESIDENT

The atmospheric dispersion factors (χ/Qs) at the location of the nearest resident is calculated in two spreadsheets, *ES to Amargosa.xls* for releases from the repository exhaust shafts and *GROA to Amargosa.xls* for releases from the GROA. These spreadsheets are identical in structure to the spreadsheets described in section 6.6.

6.9 ARCON 96 CALCULATION

The ARCON96 methodology discussed in section 4.12 is used to determine annual average and 95^{th} percentile χ/Qs for releases from surface facilities to an on-site general public location at 200 feet. This methodology accounts for low wind meander and building wake effects associated with building releases. Because the subsurface releases are at ground level and without a building wake effect, ARCON96 is not used for subsurface releases.

6.9.1 Meteorological Data Conversion

The meteorological data from design input 6.1.2 is not in the ARCON96 format as described in section 4.4.2 of the ARCON96 manual (Reference 2.2.18 [DIRS 164547]). The conversion is performed in the Excel spreadsheet *Arcon96 Data Conversion.xls*, described in this section.

The Excel spreadsheet *Arcon96 Data Conversion.xls* has two worksheets, *Hourly Met Data* and *ARCON96 Met Data*. Columns A through I present the hourly meteorological data from January 1, 2001 through December 31, 2005 obtained from design input 6.1.2. The data is sorted by increasing date and time.

Column J determines the stability class based on the temperature difference presented in column H. The stability class is determined using the methodology presented in section 4.8. Stability classes go from 1 (A) to 7 (G). For example, in cell I2, the ΔT is 2.67^{o}; therefore, per Table 4 this corresponds to stability class G, or 7, which is the value shown in cell J2. As a second example, in cell I11, the ΔT is -0.38^{o}; therefore, per Table 4 this corresponds to stability class D, or 4, which is the value shown in cell J11.

The conversion of the meteorological data to the ARCON96 format is performed in the *ARCON96 Met Data* worksheet. Column A is the site identifier, "YMP." Column B is the year, obtained from column B or the *Hourly Met Data* worksheet. Column C is the Julian day from column C of the *Hourly Met Data* worksheet converted to text format. Column D is the hour, obtained by dividing column D of the *Hourly Met Data* worksheet by 100 and converting it to text format. Column E is the lower wind direction, obtained by rounding to the nearest integer the 10 meter wind direction data from column F of the *Hourly Met Data* worksheet. Column F is the 10 meter wind speed data from column E of the *Hourly Met Data* worksheet multiplied by 10. Column G converts the wind speed from column F rounded to the nearest integer into text format. Column H is the stability class from column H of the *Hourly Met Data* worksheet converted to text format. Column I is the upper wind direction, obtained by rounding to the nearest integer the 60 meter wind direction data from column H of the *Hourly Met Data* worksheet. Column J is the 60 meter wind speed data from column G of the *Hourly Met Data* worksheet multiplied by 10. Column K converts the wind speed from column J rounded to the nearest integer into text format. The information in columns A, B, C, D, E, G, H, I, and K is concatenated in column L in the ARCON96 format. This column was then exported into file *ymp01-05.met*.

6.9.2 ARCON96 95th percentile χ/Q values at 100 meters from Surface Facilities

There are 16 different ARCON96 runs, one for each meteorological sector. These files are listed in Appendix I and included in the CD-ROM of Appendix II. The major input parameters used in the input files are shown in Table 12.

Table 12 — Summary of Major Input Parameters for the ARCON96 Runs

Input Parameter	Value	Source
Number of meteorological data files	1	Design input 6.1.2
Name of meteorological data file	ymp.met	Design input 6.1.2
Lower measurement height (m)	10	Design input 6.1.2
Upper measurement height (m)	60	Design input 6.1.2
Release type	Ground level	Assumption 3.2.2
Release height (m)	Ground level (0 m)	Assumption 3.2.2
Building area (m^2)	1,200	Section 6.1
Exit vertical velocity (m/s)	0	Assumption 3.2.4
Effluent flow (m^3/s)	0	Assumption 3.2.4
Distance to receptor (m)	61	Assumption 3.2.7
Intake height (m)	0	Assumption 3.2.3
Direction to source	Incremented in 22.5° sections beginning at 0° for 16 sectors	Assumptions 3.2.1 and 3.2.7
Surface roughness (m)	0.1	Design Input 6.1.8
Minimum wind speed (m/s)	0.5	Design Input 6.1.8
Averaging sector width constant	4.3	Design Input 6.1.8
Initial lateral diffusion coefficient (m)	0	Design Input 6.1.8
Initial vertical diffusion coefficient (m)	0	Design Input 6.1.8

6.9.3 ARCON96 50th percentile χ/Q values at 100 meters from Surface Facilities

As noted in section 4.12.2, ARCON96 determines χ/Qs based on the total number of hours of valid meteorological data, regardless of the averaging period. However, for 50th percentile χ/Qs especially at shorter averaging time periods, it may not be possible to directly utilize the ARCON96 results, because the accumulated hours for which valid χ/Q data exist may be less than 50% of the total valid hours as discussed in section 4.12.2. For example, the primary output file for a wind blowing from the north (*a0000.log*; see Attachment III) shows that 43,824 hours of valid meteorological data exist for the 1 hour averaging period:

Total number of hours of data processed	43,824
Hours of missing data	858
Total valid hours	42,966

Fifty percent of this total number of valid hours is about 21,483 hours. During the 1 hour averaging period, only 17,360 accumulated hours exist for which both the wind direction is within the 90º window centered on the intake-to-source direction and the χ/Q values exceed the lower limit of 1.00 x 10^{-6} sec/m^3. Since 50 percent of the total number of valid hours exceeds the number of accumulated hours, the 50^{th} percentile χ/Q for the 1 hour averaging period using the ARCON96 method would be below the range of interest (i.e., < 1.00 x 10^{-6}, or essentially zero).

For example, if the 50^{th} percentile χ/Qs are determined using the ARCON96 method for determining the 95^{th} percentile χ/Qs, the following results are obtained:

Averaging Period	1	2	4	8	12	24	96	168	360	720
Accum. Hours	17,543	21,094	25,207	31,532	30,952	36,361	40,837	41,897	41,754	41,437
50% χ/Q	<1E-6	<1E-6	~3.6E-4	~4.5E-04	~4.4E-04	~4.0E-04	~3.6E-04	~3.5E-04	~3.4E-04	~3.4E-04

This approach is unrealistic especially when applied to the shorter time periods. The 50^{th} percentile χ/Qs for the 1 and 2-hour averaging periods cannot be determined using this method.

Therefore, the 50^{th} percentile χ/Qs for each averaging period is calculated from the CFD data using the methodology described in section 4.12.2. This methodology is implemented in the Excel spreadsheet *ARCON 96 XQ Calculation - 200 ft.xls*. This spreadsheet has a worksheet for each meteorological sector. The appropriate sector CFD file has been imported into these worksheets into cells A4 through K103. Each of the 16 worksheets are identical to each other; therefore, the following description of the *NNW* worksheet applies to all 16 worksheets.

Cell B105 contains the total number of valid hours of data, which is 42,966 hours (42,966 processed hours minus 858 hours of missing data). The number of hours corresponding to the median χ/Q is calculated in row 106 for each averaging period. For example, the total number of hours for the 8,760 hour averaging period is 35,905. Therefore, the median number of hours corresponding to the median χ/Q is 0.5 x 35,905 = 17,953 hours, which is shown in cell K106.

To determine the median χ/Q for the averaging period, the upper and lower hours bounding the median number of hours is first determined. The Excel function *MATCH* is used to find the lower bound. *MATCH* returns the location in the array for the number of hours that is less than or equal to the median. For example, for the 8,760 hour averaging period in cell K107 a value of 34 is returned. The upper bound location is simply the lower bound location plus one as shown in row 108. The number of hours corresponding to the 34^{th} and 35^{th} locations of the array are shown in cells K37 and K38. These hours bound the median number of hours.

In rows 109 and 110 the Excel function *INDEX* is used to return the number of hours corresponding to the locations presented in rows 107 and 108. For example, for the 8,760 hour averaging period cell K109 shows a value of 0 hours and cell K110 a value of 18,171 hours, which bound the value of 17,953 hours. The corresponding χ/Q values from column A are then selected in rows 111 and 112 using the Excel function *INDEX*.

The median χ/Q values are calculated in row 113 using the Excel function *FORECAST*, which implements Equation 50. For example, for the 8,760 hour averaging period:

$$\frac{\tilde{\chi}}{Q} = \frac{\chi}{Q}_{lower} + \frac{\frac{\chi}{Q}_{lower} - \frac{\chi}{Q}_{upper}}{Hours_{lower} - Hours_{upper}} \times (Hours_{median} - Hours_{lower})$$
$$= 3.98\times10^{-4} + \frac{3.98\times10^{-4} - 4.37\times10^{-4}}{18{,}171 - 0}\times(17{,}953 - 18{,}171)$$
$$= 3.99\times10^{-4}$$

This value is in excellent agreement with the value shown in cell K113.

The χ/Q for the remaining portion of the valid hours is taken to be 1.00 x 10^{-6} sec/m^3, the lower limit reported by ARCON96. The 50^{th} percentile χ/Q is then time-average calculated using Equation 51 as:

$$\frac{\chi}{Q}_{50} = \frac{\left(AH\times\frac{\tilde{\chi}}{Q} + (TH - AH)\times1.00\times10^{-6}\right)}{TH}$$
$$= \frac{35{,}905\times3.99\times10^{-4} + (42{,}966 - 35{,}905)\times1.00\times10^{-6}}{42{,}966}$$
$$= 3.34\times10^{-4}$$

This value is in good agreement with the value shown in cell K114.

The 8,760 hour averaging values presented in cell K114 of each of the 16 sector worksheets is summarized in the Time Averaged XQs worksheet Annual Average column D.

6.10 GENII METEOROLOGICAL DATA

Using the meteorological data presented in design input 6.1.2, other calculated parameters are developed in this section for use with the GENII Version 2 code.

6.10.1 Absolute Humidity

Absolute humidity is used to calculate tritium concentration in food pathways. The parameter is developed using site-specific meteorological data provided in design input 6.1.2. The calculation is performed in an Excel file: *Absolute_Humidity.xls*, which is discussed in details below.

The average absolute humidity is calculated in the worksheet *MetData*. The worksheet range $A$2 to $J$43825 contains the 5 years of meteorological data from design input 6.1.2.

The absolute humidity is calculated using the relative humidity with standard Excel functions, including EXP from Equation 47. Cells $K$2 to $K$43825 contain the formula:

IF(OR(En=9999,Jn=9999),"",MWw*es_constant*Jn/(100*Gas_Constant*(En+273.15))*EXP(17.27*En/(En+237.3)))

Where "n" is the row number from 2 to 43825. The columns E and J contain the air temperatures in ^{o}C and the relative humidity (%), respectively. The "OR" condition compares values in those columns to a value of "9999" in order to identify any hours with missing data. A value of "9999" is used in the hourly meteorological data files to identify missing data. The constants "MWw", "es_constant", and "Gas_Constant" are range names that cross-reference to values in cells in the worksheet, *Parameters* as shown in Table 13.

Table 13 — Parameters Used to Calculate Absolute Humidity

"*Parameters*" Cell Reference	Range Name	Value	Units
C3	Gas_Constant	8.3143 E-03	kPa-m^3/mole-K
C4	Molecular Weight of Water (MWw)	18.015	g/mole
C5	es_constant	0.6108	kPa

The following is a sample calculation using Equation 47 to validate the cell formulas in Column K. For January 1, 2001 at 12:00, where the relative humidity in Cell J13 is given as 15.3 and the air temperature in Cell E13 is given as 14.89 ^{o}C:

$$\begin{aligned} AH &= \frac{RH \cdot MW_w}{100R(T+273.15)} 0.6108 \exp\left[\frac{17.27T}{T+237.3}\right] \\ &= \frac{15.3 \cdot 18.015}{100 \cdot 8.3143\times10^{-3}(14.89+273.15)} 0.6108 \exp\left[\frac{17.27\cdot 14.89}{14.89+237.3}\right] \\ &= 1.95\left(gm/m^3\right) \end{aligned}$$

That value 1.95 gm/m^3 is in exact agreement with the results in Cell K13.

6.10.1.1 Average Absolute Humidity and Its Distribution

The average absolute humidity, *AH*, is calculated with the following expression:

$$AH\left(gm/m^3\right) = \frac{\sum_{i=1}^{Na} AH_i\left(gm/m^3\right)}{Na\,(hrs)} \qquad \textbf{Equation 52}$$

where *Na* is the total number of hours with a calculated absolute humidity value.

The standard Excel function, AVERAGE and STDEV, are used to calculate the average and standard deviation of the hourly absolute humidity values in Cells $K$2 to $K$43825. The results are in the cells K43832 and K43833. To calculate geometric mean and geometric standard deviation, Column L takes the natural logarithm of Column K, and results are in cells M43832 and M43833.

The arithmetic mean of the hourly absolute humidity values is 4.08 g/m^3 and standard deviation is 2.09 g/m^3. A lognormal distribution is recommended with GM of 3.63 g/m^3, GSD of 1.63, lower bound of 0.39 g/m^3 and upper bound of 16.4 g/m^3, as calculated in cells K43832:N43836.

6.10.2 Average Daily Rain Rate

The average daily rain rate is determined from the Yucca Mountain site meteorological data in design input 6.1.2, which includes the precipitation amount, *p*, in mm for each hour. The average daily rain rate is calculated by (1) summing the hourly precipitation for each calendar day, and (2) averaging calculated daily rain rate for the entire period.

The calculation is performed in the Excel file *Absolute_Humidity.xls*, which contains two worksheets. *MetData* worksheet contains all raw data and average calculation, and *Parameters* worksheet provides some inputs and summary of average calculation done in *MetData*.

MetData worksheet contains the 5 years of meteorological data in range $A$2 to $J$43825 from the DTNs listed in design input 6.1.2. Column H “Precip. (mm)” contains the amount of precipitation in any hour including no precipitation as value of zero. Column M “Daily Precip (mm/day)” contains the daily precipitation calculated by summing the hourly precipitation for each calendar day. The standard Excel function DAVERAGE is used to calculate the daily precipitation amounts with the condition that the daily precipitation rate is larger and equal to 0, but lower than 9998, which is to eliminate those cells containing no precipitation data Cell H43832 calculates the mean of daily rain rate using the formula:

DAVERAGE($M$1:$M$43825,"Daily Precip (mm/day)",$F$43832:$G$43833)

Cell H43833 calculates the standard deviation of daily rain rate using the formula:

DSTDEV($M$1:$M$43825,"Daily Precip (mm/day)",$F$43832:$G$43833)

Cell H43841 calculates the number of hours with measurable precipitation using the formula:

DCOUNTA($H$1:$H$43825,"Precip. (mm/day)",$F$43841:$G$43842)

Cell H43842 calculates the number of hours with valid data using the formula:

DCOUNTA($H$1:$H$43825,"Precip. (mm/day)",$F$43838:$G$43839)

The calculated average daily rain rate is 0.49 mm/day and standard deviation is 2.88 mm/day for those days with precipitation. There are 699 hours of precipitation out of a total of 43,751 hours of valid data (1.6%).

6.10.3 Wind Speed and Ambient Air Temperature

The straight-line Gaussian plume model is defined under the assumption of a non-zero wind speeds, because of infinite concentration and no direction defined (Reference 2.2.17 [DIRS 179908], Section 5.1.6). The GENIIv2 provides a method to solve the problem by introducing a minimum wind speed for calm winds. Based on the wind speed measurements during the five years period, the mean wind speed is 3.64 m/s and its SD is 2.02 m/s with the minimum wind speed of 0.45 m/s, and the maximum wind speed of 17.8 m/s. The calculation is performed in the worksheet *MetData* of Excel file *Met Data 2001-2005.xls*. With minimum wind speed of 0.45 m/s, the calm wind situation may not occur at the Yucca Mountain.

The other parameter measured in the Yucca Mountain and calculated in the worksheet *MetData* of Excel file *Met Data 2001-2005.xls* is ambient air temperature. The mean temperature is 17.04°C and SD of 10.13°C with the minimum of –7.5°C and the maximum of 42.31°C.

6.10.4 Meteorological Data File Generation

A meteorological data file for the Yucca Mountain site is generated and documented in this section, which is consistent with the (GENIIv2) input data format. The file, *ymp01-05.met* contains date, time, stability class, wind direction, wind speed, temperature, mixing height, precipitation code, precipitation rate, and weight in the GENIIv2 format, which are converted from the meteorological data files provided in Section 6.1.1 (Reference 2.2.16 [DIRS 179907] Appendix B, pages 140 and 141).

Calculation of the required additional parameters and the meteorological data conversion into the GENIIv2 format is performed in the Excel spreadsheet *Met Data 2001-2005.xls* as described in this section. The Excel spreadsheet *Met Data 2001-2005.xls* has several worksheets, of which, three: *Parameter*s, *Monin-Obukhov Data*, and *MetData* are used in the meteorological data conversion.

6.10.4.1 Meteorological Data Conversion

Columns A through K in the *MetData* worksheet present the hourly meteorological data from January 1, 2001 through December 31, 2005 obtained directly from the meteorological data files identified in Section 6.1.2. The data is sorted by increasing date and time.

Precipitation Code

Per Section A.2.6 of the *GENII Version 2 Users' Guide* (Reference 2.2.16 [DIRS 179907]), the precipitation is coded within a range of 0 to 6. A zero is used when there is no precipitation. Precipitation codes 1, 2, and 3 indicate light, moderate, and heavy liquid precipitation, respectively. Liquid precipitation includes rain, drizzle, freezing rain, and freezing drizzle. All drizzle intensities are coded as 1. Codes 4, 5, 6 indicate light, moderate, and heavy frozen precipitation, respectively. Frozen precipitation includes snow, snow grains, snow pellets, ice pellets, ice crystals, and hail. If a mixture of liquid and frozen precipitation is occurring (e.g., rain and snow reported at the same time), liquid precipitation is assumed unless the intensity of the frozen precipitation is greater than the liquid precipitation. For example, if both moderate rain and moderate snow where reported for the hour, the precipitation code would be 2. If moderate rain and heavy snow were reported for the hour, the precipitation code would be 6.

For the purposes of this calculation, all precipitation is assumed to consist of liquid precipitation as discussed in Assumption 3.2.10.

The default precipitation rates based on the precipitation code from Table A.4 of the *GENII Version 2 Users' Guide* (Reference 2.2.16 [DIRS 179907]) was used to determine a range for each precipitation code. This range was then used to determine the precipitation code from the precipitation rates provided by the meteorological data of Section 6.1.2.

Table 14 — Precipitation Codes and Precipitation Rates

Precipitation Code	Description	Default Precipitation Rate (mm/hr)	Precipitation Range (mm/hr)
0	No precipitation	0	0
1	Light liquid precipitation	1	0 < rate ≤ 3
2	Moderate liquid precipitation	5	3 < rate ≤ 7.5
3	Heavy liquid precipitation	10	7.5 < rate

Column L determines the precipitation code using the methodology discussed above using the Excel IF function for each row n.

IF(Kn>1000,9,IF(Kn=0,0,IF(AND(Kn>0,Kn<=3),1,IF(AND(Kn>3,Kn<=7.5),2,3))))

For example, the precipitation shown in cell K185 is 0.51 mm/h. From Table 14, this precipitation rate corresponds to precipitation code 1, which is correctly calculated and presented in cell L185. As a second example, the precipitation shown in cell K242 is 4.06 mm/h. From Table 14, this precipitation rate corresponds to precipitation code 2, which is correctly calculated and presented in cell L242.

<u>Wind Direction</u>

Per Attachment B of the *GENII User's Guide* (Reference 2.2.16 [DIRS 179907]), the wind direction (flow vector) is defined as the direction that the wind is blowing <u>towards</u> (in degrees). The meteorological data from Section 6.1.2 provides the direction as the wind is blowing <u>from</u>. Therefore, the data presented in column F is rotated by 180º and presented in column M using the Excel IF function for each row n.

IF(Fn>360,999,IF(Fn>180,Fn-180,180+Fn))

For example, the wind direction in cell F2 is 345.00º degrees. Subtracting 180º results in a direction of 165.00º, as presented in cell M2. As a second example, the wind direction in cell F11 is 170.80º. Adding 180º results in a direction of 350.80º, as presented in cell M11.

Stability Class

Column N determines the stability class based on the temperature difference presented in column J. Stability classes go from 1 (A) to 7 (G). The stability class is determined using the methodology presented in Section 4.8 and the Excel IF function for each row n.

IF(Jn<=-0.95,1,IF(Jn<=-0.85,2,IF(Jn<=-0.75,3,IF(Jn<=-0.25,4,IF(Jn<=0.75,5,IF(Jn<=2,6,7))))))

For example, in cell J2, the ΔT is 2.67º; therefore, per Table 4 this corresponds to stability class G, or 7, which is the value shown in cell N2. As a second example, in cell J14, the ΔT is -0.90º; therefore, per Table 4 this corresponds to stability class B, or 2, which is the value shown in cell N14.

Meteorological Sector

The meteorological sector is presented in column O, with North = 1, NNW = 16. This is determined using the wind "from" direction presented in column F. This column uses a lookup table from the *Parameters* worksheet cells H25 through J39.

Monin-Obukhov Length

Columns P through R are used to calculate the inverse Monin-Obukhov length using the methodology of ARCON96 described in Section 4.9.3, which is implemented as described in section 6.6.3.1.

Stability Correction Factor

Columns S and T determine the stability correction factor using the methodology implemented in section 6.6.3.2.

Friction Velocity

The friction velocity is calculated in column U using the methodology described in section 4.9.1 as implemented in section 6.6.3.3.

Mixing Height

The mixing height is calculated in column V using Equation 36 for stable atmospheric conditions (stability classes E through G) or Equation 37 for neutral and unstable atmospheric conditions (stability classes A through D) for each row n.

IF(Nn<5,Un*beta/coriolis,k*SQRT(Un/Rn/coriolis))

Two examples are considered, one for stable atmospheric conditions, and a second for neutral and unstable atmospheric conditions. Both equations use a coriolis parameter that is dependent on the latitude of the measured meteorological data. Per Section 6.1.1, the latitude of the meteorological tower is 36º 50' 34" north, which is equivalent to 0.643 radians. The coriolis parameter from Equation 36 is then:

$$f = 1.46 \times 10^{-5} \sin(0.643)$$
$$= 8.75 \times 10^{-6} s^{-1}$$

Stable atmospheric conditions

The stability class for row 10 of the *MetData* worksheet is 6, or very stable. Therefore, Equation 36 is used:

$$H = k\sqrt{\frac{u_* L}{f}}$$
$$= 0.4\sqrt{\frac{0.0705}{2.05 \times 10^{-2} \times 8.75 \times 10^{-6}}}$$
$$= 251 m$$

This value is in exact agreement with the result presented in cell V10.

Neutral and unstable atmospheric conditions

The stability class for row 15 of the *MetData* worksheet is 3, or slightly unstable. Therefore, Equation 37 is used:

$$H = \beta \frac{u_*}{f}$$
$$= 0.2 \frac{0.199}{8.75 \times 10^{-6}}$$
$$= 4.55 \times 10^{3} m$$

This value is in excellent agreement with the result presented in cell V15.

As discussed in Section A.2.4 of the *GENII Version 2 Users' Guide* (Reference 2.2.16 [DIRS 179907]), the mixing height is not allowed to exceed 2,000 meters. The adjusted mixing height is presented in column W of the *MetData* worksheet for each row n.

IF(OR(Un=9999,N2=9),9999,IF(Vn<10,10,IF(Vn>2000,2000,Vn)))

For example, in cell V15 the mixing height is 4.55 x 10^3 meters. This height is adjusted to 2,000 meters, as shown in cell W15.

Column X converts the 2 m temperature from degrees C to degrees K for each row n using the Excel CONVERT function.

6.10.4.2 GENII Meteorological Data Generation

GENIIv2 requires that the date be provided in a year, month, date, hour format. The meteorological data from Section 6.1.1 provides the date in year, Julian day, and hour. Julian day is a sequential number from 1 to 365 for standard years and 1 to 366 for leap years. To covert the date format to conform to the GENIIv2 format, the following procedure is used.

1. In cells Z2 through Z6 the date for the day prior to the yearly meteorological data set is entered. For example, the day prior to the 2001 meteorological data is 12/31/2000. This date is entered in cell Z2.

2. In column AA a check is performed to determine which of the five dates in cells Z2 through Z6 precedes the current yearly data set for each row n.

3. In column AB the value in column AA is added to the Julian day in column C.

4. Column AC repeats the year provided in column B

5. Column AD uses the Excel function MONTH to determine the month of the year for the date presented in column AB.

6. Column AE uses the Excel function DAY to determine the day of the month for the date presented in column AB.

7. Column AF converts the time into hours from the value presented in column D by dividing it by 100.

The information in columns AC, AD, AE, AF, N, M, E, X, W, L, and K is concatenated in column AH into the GENIIv2 format. This column was then exported into file *ymp01-05.met*.

6.11 JOINT FREQUENCY TABLES

GENII and other programs such as CAP88 can use meteorological data in the form of joint frequency data. As discussed in Section 4.4.5.2 of the *GENII Version 2 Users' Guide* (Reference 2.2.16 [DIRS 179907]), a common format for the joint frequency data is the ISC3 format or STAR format. This is constructed using the 16 wind direction sectors, six wind speed classes and six stability classes. Wind speed classes are usually grouped as 0–3, 4–6, 7–10, 11–16, 17–21, and greater than 21 knots. Stability classes are based on the Pasquill stability categories. For the purposes of this calculation a 7^{th} stability class (G, extremely stable) is included.

The joint frequency data is determined in worksheets *PG Stability A* through *PG Stability G* and summarized in worksheet *Joint Frequency Tables* of the *Met Data 2001-2005.xls* spreadsheet. Since worksheets *PG Stability A* through *PG Stability G* have the same structure, the description for the *PG Stability A* worksheet applies to all seven worksheets.

Cells B3 through G18 of the *PG Stability A* worksheet provide the hours of data for each wind speed class and wind "from" direction. These hours are determined using the Excel function DCOUNTA. This function counts the nonblank cells in a database that match conditions set by the user. This function has three arguments:

1. The first argument is the database. This argument is cells E1 through O43825 of the *MetData* worksheet.

2. The second argument is the field that will be counted. This is the "10 m Wind Speed (m/s)" column in the *MetData* worksheet.

3. The third argument is the criteria used to determine which cells are to be counted. This argument varies for each wind speed class and wind direction. The criteria consists of four parameters, the lower bound for the wind speed, the upper bound for the wind speed, the stability class, and the wind direction sector. These are presented in columns J through M, O through R, T through W, and Y through AB.

   For example, for "from" sector 16, and wind speed class 10–16 knots the criteria is presented in cells J7 through M8. The lower wind speed of 10.5 knots is converted to m/s using a conversion factor of 0.5144444 m/s per knot in cell J8, the upper wind speed is converted to m/s in cell K8.

The resultant hours for each wind speed class and wind direction from cells B3 through G18 of worksheets *PG Stability A* through *PG Stability G* are summarized in worksheet *Joint Frequency Tables* columns B through H. Rows 4 through 19 are from *PG Stability A*, rows 25 through 40 are from *PG Stability B*, and so on. Finally, the totals for all stability classes are presented in cells B151 through G166. The total hours counted, 42,791, is presented in cell H167.

Columns K through P determine the frequency of occurrence for each stability class, wind "from" direction, and wind speed class. The corresponding number of hours from columns B through G is divided by the total number of hours presented in cell H167. For example, there were 1,418 hours of occurrence for stability class A in the South sector for wind speed class 10 – 16 knots as shown in cell E12. The frequency is then 1,418/42,791 = 3.31%, as shown in cell N12.

The frequency data is then concatenated with the wind "from" direction sector designator and the stability class in column U in the STAR format. This data is then extracted into file *ymp01-05.str*.

7. RESULTS AND CONCLUSIONS

7.1 RELEASES FROM THE GROA

7.1.1 Site Boundary χ/Qs

The following tables (Table 15 through Table 17) summarize the atmospheric dispersion coefficient calculations from the GROA to the site boundary from the Excel spreadsheets *GROA to Withdrawal-n.xls* (where n is 1 – 5) as presented in spreadsheet *GROA to Withdrawal Summary Rev 1.xls*. The χ/Q values are based on the minimum distances to the site boundary from any point within the GROA boundary as shown in Table 9 and are therefore suitable for releases from any facility within the GROA boundary.

Table 15 — Site Boundary χ/Qs (s/m^3) from the GROA

					Averaging Time (hrs):	**6**	**16**	**72**	**624**
From Sector	**Distance (m)**	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	18,500	4.42E-07	2.97E-07	3.19E-08	6.41E-06	3.20E-06	1.72E-06	6.65E-07	1.70E-07
NNE	16,600	4.02E-07	2.38E-07	1.31E-08	2.96E-06	1.46E-06	7.72E-07	2.92E-07	7.21E-08
NE	12,700	7.45E-07	3.87E-07	1.61E-08	3.69E-06	1.81E-06	9.59E-07	3.62E-07	8.93E-08
ENE	11,000	9.60E-07	6.93E-07	1.64E-08	3.06E-06	1.54E-06	8.36E-07	3.27E-07	8.52E-08
E	11,000	8.14E-07	5.68E-07	1.15E-08	2.18E-06	1.10E-06	5.94E-07	2.32E-07	5.99E-08
ESE	11,000	6.13E-07	2.32E-07	1.21E-08	2.09E-06	1.07E-06	5.84E-07	2.32E-07	6.14E-08
SE	9,100	6.08E-07	1.92E-07	1.95E-08	3.02E-06	1.56E-06	8.66E-07	3.50E-07	9.56E-08
SSE	8,400	3.62E-07	8.34E-08	3.16E-08	3.58E-06	1.92E-06	1.11E-06	4.74E-07	1.40E-07
S	8,400	2.96E-07	6.67E-08	5.37E-08	4.19E-06	2.37E-06	1.42E-06	6.51E-07	2.12E-07
SSW	8,400	7.86E-07	6.42E-07	4.49E-08	6.78E-06	3.51E-06	1.95E-06	7.94E-07	2.18E-07
SW	7,200	1.33E-06	1.10E-06	4.74E-08	9.62E-06	4.80E-06	2.58E-06	9.93E-07	2.53E-07
WSW	6,700	2.12E-06	1.83E-06	6.05E-08	1.27E-05	6.30E-06	3.37E-06	1.29E-06	3.26E-07
W	6,700	2.81E-06	2.79E-06	7.18E-08	1.62E-05	7.98E-06	4.23E-06	1.60E-06	3.96E-07
WNW	6,700	3.21E-06	3.05E-06	1.34E-07	2.50E-05	1.26E-05	6.84E-06	2.68E-06	6.96E-07
NW	7,800	2.54E-06	2.37E-06	4.36E-07	2.76E-05	1.60E-05	9.86E-06	4.69E-06	1.61E-06
NNW	10,200	1.68E-06	1.65E-06	2.71E-07	2.25E-05	1.26E-05	7.51E-06	3.40E-06	1.09E-06
Site 95%ile 2 hour		N/A	N/A	N/A	2.14E-05	N/A	N/A	N/A	N/A
Maximum all Sectors[(a)]		3.21E-06	3.05E-06	4.36E-07	2.76E-05	1.60E-05	9.86E-06	4.69E-06	1.61E-06
Site 50%ile[(b)]		1.27E-06	7.57E-07	1.27E-06	2.35E-06	2.17E-06	2.02E-06	1.81E-06	1.54E-06

Notes:

(a) Applicable to all Category 2 event sequences and normal operations and Category 1 event sequences other than for purposes of note (b).

(b) Site 50%ile denotes the results for the total site meteorology for use in Beyond Category 2 event consequence calculations.

Table 16 — Site Boundary Depleted χ/Qs (s/m^3) from the GROA

					Averaging Time (hrs):	6	16	72	624
From Sector	**Distance (m)**	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	18,500	2.13E-07	1.84E-07	1.54E-08	2.21E-06	1.15E-06	6.44E-07	2.64E-07	7.35E-08
NNE	16,600	2.04E-07	1.67E-07	6.63E-09	1.49E-06	7.32E-07	3.88E-07	1.47E-07	3.65E-08
NE	12,700	3.83E-07	2.80E-07	8.29E-09	2.04E-06	9.92E-07	5.21E-07	1.94E-07	4.70E-08
ENE	11,000	5.29E-07	4.81E-07	9.04E-09	1.92E-06	9.50E-07	5.07E-07	1.94E-07	4.89E-08
E	11,000	4.71E-07	4.04E-07	6.63E-09	1.45E-06	7.14E-07	3.80E-07	1.45E-07	3.62E-08
ESE	11,000	3.70E-07	1.90E-07	7.31E-09	1.40E-06	7.03E-07	3.80E-07	1.48E-07	3.83E-08
SE	9,100	4.02E-07	1.67E-07	1.29E-08	2.05E-06	1.06E-06	5.84E-07	2.35E-07	6.37E-08
SSE	8,400	2.58E-07	7.90E-08	2.25E-08	2.48E-06	1.34E-06	7.73E-07	3.32E-07	9.89E-08
S	8,400	2.21E-07	6.42E-08	4.01E-08	2.80E-06	1.61E-06	9.77E-07	4.56E-07	1.53E-07
SSW	8,400	5.19E-07	4.98E-07	2.97E-08	4.21E-06	2.20E-06	1.23E-06	5.07E-07	1.41E-07
SW	7,200	8.54E-07	8.25E-07	3.04E-08	5.98E-06	3.00E-06	1.61E-06	6.26E-07	1.61E-07
WSW	6,700	1.32E-06	1.28E-06	3.78E-08	7.51E-06	3.75E-06	2.02E-06	7.82E-07	2.00E-07
W	6,700	1.69E-06	1.73E-06	4.31E-08	8.99E-06	4.47E-06	2.39E-06	9.18E-07	2.32E-07
WNW	6,700	1.90E-06	1.85E-06	7.91E-08	1.47E-05	7.43E-06	4.03E-06	1.58E-06	4.11E-07
NW	7,800	1.47E-06	1.40E-06	2.52E-07	1.44E-05	8.49E-06	5.29E-06	2.56E-06	9.03E-07
NNW	10,200	8.85E-07	8.99E-07	1.43E-07	1.06E-05	6.04E-06	3.65E-06	1.68E-06	5.56E-07
Site 95%ile 2 hour		N/A	N/A	N/A	1.19E-05	N/A	N/A	N/A	N/A
Maximum all Sectors[(a)]		1.90E-06	1.85E-06	2.52E-07	1.47E-05	8.49E-06	5.29E-06	2.56E-06	9.03E-07
Site 50%ile[(b)]		7.44E-07	5.18E-07	7.44E-07	1.59E-06	1.44E-06	1.32E-06	1.15E-06	9.45E-07

Notes:

(a) Applicable to all Category 2 event sequences and normal operations and Category 1 event sequences other than for purposes of note (b).

(b) Site 50%ile denotes the results for the total site meteorology for use in Beyond Category 2 event consequence calculations.

Table 17 — Site Boundary Deposition Rates (m^{-2}) from the GROA

					Averaging Time (hrs):	6	16	72	624
From Sector	**Distance (m)**	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	18,500	1.03E-09	1.11E-09	7.47E-11	7.73E-09	4.21E-09	2.45E-09	1.06E-09	3.22E-10
NNE	16,600	9.60E-10	1.09E-09	3.12E-11	5.70E-09	2.88E-09	1.57E-09	6.15E-10	1.61E-10
NE	12,700	1.45E-09	1.62E-09	3.14E-11	8.36E-09	4.02E-09	2.09E-09	7.68E-10	1.82E-10
ENE	11,000	1.99E-09	2.33E-09	3.40E-11	9.45E-09	4.52E-09	2.34E-09	8.53E-10	2.00E-10
E	11,000	1.88E-09	2.22E-09	2.65E-11	6.01E-09	2.95E-09	1.56E-09	5.91E-10	1.46E-10
ESE	11,000	1.53E-09	8.94E-10	3.03E-11	5.90E-09	2.96E-09	1.60E-09	6.20E-10	1.60E-10
SE	9,100	1.80E-09	9.99E-10	5.77E-11	8.15E-09	4.26E-09	2.39E-09	9.82E-10	2.74E-10
SSE	8,400	1.34E-09	5.45E-10	1.17E-10	1.34E-08	7.22E-09	4.14E-09	1.77E-09	5.21E-10
S	8,400	1.35E-09	4.74E-10	2.44E-10	1.44E-08	8.46E-09	5.25E-09	2.53E-09	8.83E-10
SSW	8,400	2.66E-09	3.17E-09	1.52E-10	1.58E-08	8.61E-09	5.00E-09	2.17E-09	6.57E-10
SW	7,200	3.95E-09	4.94E-09	1.41E-10	2.07E-08	1.08E-08	6.01E-09	2.46E-09	6.79E-10
WSW	6,700	5.72E-09	6.57E-09	1.63E-10	3.34E-08	1.67E-08	8.94E-09	3.44E-09	8.74E-10
W	6,700	6.63E-09	7.69E-09	1.69E-10	3.44E-08	1.72E-08	9.21E-09	3.55E-09	9.03E-10
WNW	6,700	7.33E-09	7.99E-09	3.06E-10	4.13E-08	2.17E-08	1.22E-08	5.07E-09	1.43E-09
NW	7,800	5.83E-09	6.06E-09	1.00E-09	4.48E-08	2.72E-08	1.74E-08	8.82E-09	3.32E-09
NNW	10,200	3.36E-09	3.92E-09	5.42E-10	2.94E-08	1.74E-08	1.09E-08	5.34E-09	1.91E-09
Site 95%ile 2 hour		N/A	N/A	N/A	3.89E-08	N/A	N/A	N/A	N/A
Maximum all Sectors[(a)]		7.33E-09	7.99E-09	1.00E-09	4.48E-08	2.72E-08	1.74E-08	8.82E-09	3.32E-09
Site 50%ile[(b)]		3.12E-09	2.90E-09	3.12E-09	8.35E-09	7.34E-09	6.54E-09	5.48E-09	4.26E-09

Notes:

(a) Applicable to all Category 2 event sequences and normal operations and Category 1 event sequences other than for purposes of note (b).

(b) Site 50%ile denotes the results for the total site meteorology for use in Beyond Category 2 event consequence calculations.

7.1.2 General Environment χ/Qs

The following tables (Table 18 through Table 20) summarize the atmospheric dispersion coefficient calculations from the GROA to the general environment from the Excel spreadsheets *GROA to General Environment-n.xls* (where n is 1 or 5) as presented in spreadsheet *GROA to Withdrawal Summary Rev 1.xls*. The χ/Q values are based on the minimum distances to the general environment from any point within the GROA boundary as shown in Table 10. These χ/Q values are applicable to normal operations, Category 1, and Category 2 event sequences for evaluation of compliance with general environment dose standards.

Table 18 — General Environment χ/Qs (s/m^3) from the GROA

					Averaging Time (hrs):	6	16	72	624
From Sector	**Distance (m)**	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	18,500	4.42E-07	2.97E-07	3.19E-08	6.41E-06	3.20E-06	1.72E-06	6.65E-07	1.70E-07
NNE	16,600	4.02E-07	2.38E-07	1.31E-08	2.96E-06	1.46E-06	7.72E-07	2.92E-07	7.21E-08
NE	12,700	7.45E-07	3.87E-07	1.61E-08	3.69E-06	1.81E-06	9.59E-07	3.62E-07	8.93E-08
ENE	11,000	9.60E-07	6.93E-07	1.64E-08	3.06E-06	1.54E-06	8.36E-07	3.27E-07	8.52E-08
E	11,000	8.14E-07	5.68E-07	1.15E-08	2.18E-06	1.10E-06	5.94E-07	2.32E-07	5.99E-08
ESE	11,000	6.13E-07	2.32E-07	1.21E-08	2.09E-06	1.07E-06	5.84E-07	2.32E-07	6.14E-08
SE	11,900	4.10E-07	1.16E-07	1.32E-08	2.09E-06	1.08E-06	5.95E-07	2.40E-07	6.50E-08
NNW	18,500	7.62E-07	7.42E-07	1.23E-07	1.24E-05	6.76E-06	3.94E-06	1.73E-06	5.26E-07
Maximum Public in General Environment		9.60E-07	7.42E-07	1.23E-07	1.24E-05	6.76E-06	3.94E-06	1.73E-06	5.26E-07

Table 19 — General Environment Depleted χ/Qs (s/m^3) from the GROA

					Averaging Time (hrs):	6	16	72	624
From Sector	**Distance (m)**	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	18,500	2.13E-07	1.84E-07	1.54E-08	2.21E-06	1.15E-06	6.44E-07	2.64E-07	7.35E-08
NNE	16,600	2.04E-07	1.67E-07	6.63E-09	1.49E-06	7.32E-07	3.88E-07	1.47E-07	3.65E-08
NE	12,700	3.83E-07	2.80E-07	8.29E-09	2.04E-06	9.92E-07	5.21E-07	1.94E-07	4.70E-08
ENE	11,000	5.29E-07	4.81E-07	9.04E-09	1.92E-06	9.50E-07	5.07E-07	1.94E-07	4.89E-08
E	11,000	4.71E-07	4.04E-07	6.63E-09	1.45E-06	7.14E-07	3.80E-07	1.45E-07	3.62E-08
ESE	11,000	3.70E-07	1.90E-07	7.31E-09	1.40E-06	7.03E-07	3.80E-07	1.48E-07	3.83E-08
SE	11,900	2.61E-07	1.00E-07	8.38E-09	1.37E-06	7.02E-07	3.87E-07	1.55E-07	4.17E-08
NNW	18,500	3.17E-07	3.23E-07	5.12E-08	4.40E-06	2.46E-06	1.46E-06	6.56E-07	2.08E-07
Maximum Public in General Environment		5.29E-07	4.81E-07	5.12E-08	4.40E-06	2.46E-06	1.46E-06	6.56E-07	2.08E-07

Table 20 — General Environment Deposition Rates (m^{-2}) from the GROA

					Averaging Time (hrs):	6	16	72	624
From Sector	**Distance (m)**	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	18,500	1.03E-09	1.11E-09	7.47E-11	7.73E-09	4.21E-09	2.45E-09	1.06E-09	3.22E-10
NNE	16,600	9.60E-10	1.09E-09	3.12E-11	5.70E-09	2.88E-09	1.57E-09	6.15E-10	1.61E-10
NE	12,700	1.45E-09	1.62E-09	3.14E-11	8.36E-09	4.02E-09	2.09E-09	7.68E-10	1.82E-10
ENE	11,000	1.99E-09	2.33E-09	3.40E-11	9.45E-09	4.52E-09	2.34E-09	8.53E-10	2.00E-10
E	11,000	1.88E-09	2.22E-09	2.65E-11	6.01E-09	2.95E-09	1.56E-09	5.91E-10	1.46E-10
ESE	11,000	1.53E-09	8.94E-10	3.03E-11	5.90E-09	2.96E-09	1.60E-09	6.20E-10	1.60E-10
SE	11,900	1.17E-09	5.96E-10	3.77E-11	5.43E-09	2.83E-09	1.58E-09	6.49E-10	1.80E-10
NNW	18,500	1.21E-09	1.42E-09	1.96E-10	1.17E-08	6.85E-09	4.24E-09	2.04E-09	7.11E-10
Maximum Public in General Environment		1.99E-09	2.33E-09	1.96E-10	1.17E-08	6.85E-09	4.24E-09	2.04E-09	7.11E-10

7.2 RELEASES FROM THE SUBSURFACE FACILITY EXHAUST SHAFTS

7.2.1 Site Boundary χ/Qs

The following tables (Table 21 through Table 23) summarize the atmospheric dispersion coefficient calculations from the Excel spreadsheet *Exhaust Shafts to Withdrawal-n.xls* (where n is 1 – 5) as presented in spreadsheet *Exhaust Shafts to Withdrawal Summary Rev 1.xls*. The χ/Q values are based on the minimum distances to the site boundary from any exhaust shaft as shown in Table 7 and are therefore suitable for releases from any exhaust shaft.

Table 21 — Site Boundary χ/Qs (s/m^3) from Exhaust Shafts

					Averaging Time (hrs):	**6**	**16**	**72**	**624**
From Sector	**Distance (m)**	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	17,700	4.70E-07	3.16E-07	3.39E-08	6.75E-06	3.37E-06	1.82E-06	7.03E-07	1.80E-07
NNE	12,000	6.31E-07	3.82E-07	2.05E-08	4.38E-06	2.17E-06	1.16E-06	4.42E-07	1.11E-07
NE	9,200	1.17E-06	6.40E-07	2.53E-08	5.44E-06	2.69E-06	1.44E-06	5.48E-07	1.37E-07
ENE	7,800	1.58E-06	1.19E-06	2.69E-08	4.68E-06	2.38E-06	1.30E-06	5.16E-07	1.37E-07
E	7,800	1.35E-06	9.57E-07	1.90E-08	3.50E-06	1.77E-06	9.60E-07	3.77E-07	9.82E-08
ESE	7,800	1.02E-06	4.36E-07	2.01E-08	3.33E-06	1.71E-06	9.39E-07	3.75E-07	1.01E-07
SE	6,500	1.01E-06	3.64E-07	3.23E-08	4.78E-06	2.48E-06	1.38E-06	5.65E-07	1.56E-07
SSE	6,000	5.98E-07	1.27E-07	5.22E-08	5.55E-06	3.01E-06	1.74E-06	7.55E-07	2.27E-07
S	6,000	4.85E-07	9.88E-08	8.80E-08	6.37E-06	3.64E-06	2.20E-06	1.02E-06	3.39E-07
SSW	6,000	1.27E-06	1.06E-06	7.29E-08	1.02E-05	5.35E-06	3.00E-06	1.24E-06	3.46E-07
SW	6,500	1.54E-06	1.28E-06	5.48E-08	1.08E-05	5.42E-06	2.92E-06	1.13E-06	2.90E-07
WSW	8,400	1.54E-06	1.32E-06	4.41E-08	9.95E-06	4.89E-06	2.60E-06	9.82E-07	2.43E-07
W	10,000	1.62E-06	1.59E-06	4.14E-08	1.06E-05	5.13E-06	2.68E-06	9.91E-07	2.38E-07
WNW	10,000	1.86E-06	1.76E-06	7.77E-08	1.62E-05	8.04E-06	4.31E-06	1.65E-06	4.18E-07
NW	10,300	1.75E-06	1.63E-06	3.01E-07	2.11E-05	1.21E-05	7.36E-06	3.43E-06	1.15E-06
NNW	14,900	1.01E-06	9.90E-07	1.64E-07	1.54E-05	8.51E-06	5.00E-06	2.21E-06	6.86E-07
Site 95%ile 2 hour		N/A	N/A	N/A	1.60E-05	N/A	N/A	N/A	N/A
Maximum all Sectors[(a)]		1.86E-06	1.76E-06	3.01E-07	2.11E-05	1.21E-05	7.36E-06	3.43E-06	1.15E-06
Site 50%ile[(b)]		1.07E-06	8.47E-07	1.07E-06	2.88E-06	2.53E-06	2.25E-06	1.89E-06	1.46E-06

Notes:

(a) Applicable to all Category 2 event sequences and normal operations and Category 1 event sequences other than for purposes of note (b).

(b) Site 50%ile denotes the results for the total site meteorology for use in Beyond Category 2 event consequence calculations.

Table 22 — Site Boundary Depleted χ/Qs (s/m³) from Exhaust Shafts

					Averaging Time (hrs):	6	16	72	624
From Sector	**Distance (m)**	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	17,700	2.35E-07	2.01E-07	1.70E-08	2.47E-06	1.28E-06	7.17E-07	2.94E-07	8.15E-08
NNE	12,000	3.63E-07	2.85E-07	1.18E-08	2.51E-06	1.24E-06	6.65E-07	2.54E-07	6.39E-08
NE	9,200	6.66E-07	4.84E-07	1.44E-08	3.29E-06	1.62E-06	8.56E-07	3.23E-07	7.98E-08
ENE	7,800	9.52E-07	8.65E-07	1.63E-08	3.15E-06	1.58E-06	8.55E-07	3.32E-07	8.56E-08
E	7,800	8.47E-07	7.21E-07	1.19E-08	2.46E-06	1.22E-06	6.56E-07	2.52E-07	6.40E-08
ESE	7,800	6.61E-07	3.64E-07	1.31E-08	2.38E-06	1.20E-06	6.54E-07	2.57E-07	6.73E-08
SE	6,500	7.08E-07	3.20E-07	2.27E-08	3.43E-06	1.78E-06	9.89E-07	4.02E-07	1.10E-07
SSE	6,000	4.79E-07	1.23E-07	4.18E-08	4.39E-06	2.39E-06	1.38E-06	6.01E-07	1.81E-07
S	6,000	4.01E-07	9.61E-08	7.27E-08	4.93E-06	2.84E-06	1.73E-06	8.13E-07	2.75E-07
SSW	6,000	9.80E-07	8.98E-07	5.60E-08	7.55E-06	3.97E-06	2.24E-06	9.29E-07	2.63E-07
SW	6,500	1.01E-06	9.73E-07	3.60E-08	6.93E-06	3.48E-06	1.88E-06	7.32E-07	1.89E-07
WSW	8,400	9.11E-07	8.87E-07	2.60E-08	5.53E-06	2.74E-06	1.46E-06	5.60E-07	1.41E-07
W	10,000	8.95E-07	9.24E-07	2.29E-08	5.33E-06	2.61E-06	1.38E-06	5.18E-07	1.27E-07
WNW	10,000	1.01E-06	9.86E-07	4.20E-08	8.65E-06	4.30E-06	2.31E-06	8.88E-07	2.25E-07
NW	10,300	9.34E-07	8.95E-07	1.60E-07	1.01E-05	5.84E-06	3.60E-06	1.72E-06	5.91E-07
NNW	14,900	4.95E-07	5.02E-07	8.00E-08	6.65E-06	3.73E-06	2.22E-06	1.01E-06	3.22E-07
Site 95%ile 2 hour		N/A	N/A	N/A	8.37E-06	N/A	N/A	N/A	N/A
Maximum all Sectors[(a)]		1.01E-06	9.86E-07	1.60E-07	1.01E-05	5.84E-06	3.60E-06	1.72E-06	5.91E-07
Site 50%ile[(b)]		6.45E-07	5.27E-07	6.45E-07	1.96E-06	1.70E-06	1.49E-06	1.22E-06	9.16E-07

Notes:

(a) Applicable to all Category 2 event sequences and normal operations and Category 1 event sequences other than for purposes of note (b).

(b) Site 50%ile denotes the results for the total site meteorology for use in Beyond Category 2 event consequence calculations.

Table 23 — Site Boundary Deposition Rates (m^{-2}) from Exhaust Shafts

				Averaging Time (hrs):		6	16	72	624
From Sector	**Distance (m)**	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	17,700	1.14E-09	1.21E-09	8.21E-11	8.50E-09	4.63E-09	2.69E-09	1.17E-09	3.54E-10
NNE	12,000	1.68E-09	1.88E-09	5.45E-11	9.73E-09	4.93E-09	2.69E-09	1.06E-09	2.79E-10
NE	9,200	2.50E-09	2.78E-09	5.40E-11	1.35E-08	6.53E-09	3.42E-09	1.27E-09	3.07E-10
ENE	7,800	3.55E-09	4.20E-09	6.08E-11	1.55E-08	7.52E-09	3.93E-09	1.45E-09	3.49E-10
E	7,800	3.36E-09	3.96E-09	4.73E-11	1.02E-08	5.06E-09	2.70E-09	1.03E-09	2.57E-10
ESE	7,800	2.72E-09	1.75E-09	5.38E-11	1.00E-08	5.05E-09	2.74E-09	1.07E-09	2.79E-10
SE	6,500	3.14E-09	1.93E-09	1.01E-10	1.37E-08	7.19E-09	4.05E-09	1.68E-09	4.74E-10
SSE	6,000	2.44E-09	8.39E-10	2.12E-10	2.34E-08	1.26E-08	7.28E-09	3.13E-09	9.34E-10
S	6,000	2.40E-09	7.08E-10	4.35E-10	2.52E-08	1.48E-08	9.22E-09	4.45E-09	1.56E-09
SSW	6,000	4.96E-09	5.82E-09	2.84E-10	2.85E-08	1.56E-08	9.09E-09	3.97E-09	1.21E-09
SW	6,500	4.68E-09	5.83E-09	1.67E-10	2.41E-08	1.25E-08	7.01E-09	2.87E-09	7.99E-10
WSW	8,400	3.95E-09	4.56E-09	1.13E-10	2.45E-08	1.21E-08	6.46E-09	2.46E-09	6.16E-10
W	10,000	3.52E-09	4.09E-09	8.99E-11	2.01E-08	9.90E-09	5.26E-09	1.99E-09	4.94E-10
WNW	10,000	3.90E-09	4.29E-09	1.63E-10	2.55E-08	1.32E-08	7.29E-09	2.94E-09	8.00E-10
NW	10,300	3.71E-09	3.87E-09	6.38E-10	2.98E-08	1.80E-08	1.15E-08	5.76E-09	2.14E-09
NNW	14,900	1.88E-09	2.21E-09	3.04E-10	1.76E-08	1.03E-08	6.42E-09	3.10E-09	1.09E-09
Site 95%ile 2 hour		N/A	N/A	N/A	2.81E-08	N/A	N/A	N/A	N/A
Maximum all Sectors[(a)]		4.96E-09	5.83E-09	6.38E-10	2.98E-08	1.80E-08	1.15E-08	5.76E-09	2.14E-09
Site 50%ile[(b)]		2.86E-09	2.28E-09	2.86E-09	1.06E-08	8.93E-09	7.66E-09	6.06E-09	4.32E-09

Notes:

(a) Applicable to all Category 2 event sequences and normal operations and Category 1 event sequences other than for purposes of note (b).

(b) Site 50%ile denotes the results for the total site meteorology for use in Beyond Category 2 event consequence calculations.

7.2.2 General Environment χ/Qs

The following tables (Table 24 through Table 26) summarize the atmospheric dispersion coefficient calculations from the Excel spreadsheet *Exhaust Shafts to General Environment-n.xls* (where n is 1 or 5) as presented in spreadsheet *Exhaust Shafts to Withdrawal Summary Rev 1.xls*. The χ/Q values are based on the minimum distances to the general environment from any exhaust shaft as shown in Table 8 and are therefore suitable for releases from any exhaust shaft. These χ/Q values are applicable to normal operations, Category 1, and Category 2 event sequences for evaluation of compliance with general environment dose standards.

Table 24 — General Environment χ/Qs (s/m^3) from Exhaust Shafts

					Averaging Time (hrs):	**6**	**16**	**72**	**624**
From Sector	**Distance (m)**	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	17,700	4.70E-07	3.16E-07	3.39E-08	6.75E-06	3.37E-06	1.82E-06	7.03E-07	1.80E-07
NNE	12,000	6.31E-07	3.82E-07	2.05E-08	4.38E-06	2.17E-06	1.16E-06	4.42E-07	1.11E-07
NE	9,200	1.17E-06	6.40E-07	2.53E-08	5.44E-06	2.69E-06	1.44E-06	5.48E-07	1.37E-07
ENE	7,800	1.58E-06	1.19E-06	2.69E-08	4.68E-06	2.38E-06	1.30E-06	5.16E-07	1.37E-07
E	7,800	1.35E-06	9.57E-07	1.90E-08	3.50E-06	1.77E-06	9.60E-07	3.77E-07	9.82E-08
ESE	7,800	1.02E-06	4.36E-07	2.01E-08	3.33E-06	1.71E-06	9.39E-07	3.75E-07	1.01E-07
SE	8,500	6.73E-07	2.19E-07	2.16E-08	3.32E-06	1.72E-06	9.53E-07	3.86E-07	1.06E-07
NNW	17,700	8.08E-07	7.87E-07	1.30E-07	1.30E-05	7.09E-06	4.14E-06	1.82E-06	5.56E-07
Maximum Public in General Environment		1.58E-06	1.19E-06	1.30E-07	1.30E-05	7.09E-06	4.14E-06	1.82E-06	5.56E-07

Table 25 — General Environment Depleted χ/Qs (s/m^3) from Exhaust Shafts

					Averaging Time (hrs):	**6**	**16**	**72**	**624**
From Sector	**Distance (m)**	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	17,700	2.35E-07	2.01E-07	1.70E-08	2.47E-06	1.28E-06	7.17E-07	2.94E-07	8.15E-08
NNE	12,000	3.63E-07	2.85E-07	1.18E-08	2.51E-06	1.24E-06	6.65E-07	2.54E-07	6.39E-08
NE	9,200	6.66E-07	4.84E-07	1.44E-08	3.29E-06	1.62E-06	8.56E-07	3.23E-07	7.98E-08
ENE	7,800	9.52E-07	8.65E-07	1.63E-08	3.15E-06	1.58E-06	8.55E-07	3.32E-07	8.56E-08
E	7,800	8.47E-07	7.21E-07	1.19E-08	2.46E-06	1.22E-06	6.56E-07	2.52E-07	6.40E-08
ESE	7,800	6.61E-07	3.64E-07	1.31E-08	2.38E-06	1.20E-06	6.54E-07	2.57E-07	6.73E-08
SE	8,500	4.51E-07	1.91E-07	1.45E-08	2.29E-06	1.18E-06	6.52E-07	2.63E-07	7.14E-08
NNW	17,700	3.53E-07	3.59E-07	5.71E-08	4.89E-06	2.73E-06	1.62E-06	7.30E-07	2.32E-07
Maximum Public in General Environment		9.52E-07	8.65E-07	5.71E-08	4.89E-06	2.73E-06	1.62E-06	7.30E-07	2.32E-07

Table 26 — General Environment Deposition Rates (m^{-2}) from Exhaust Shafts

				Averaging Time (hrs):		6	16	72	624
From Sector	**Distance (m)**	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	17,700	1.14E-09	1.21E-09	8.21E-11	8.50E-09	4.63E-09	2.69E-09	1.17E-09	3.54E-10
NNE	12,000	1.68E-09	1.88E-09	5.45E-11	9.73E-09	4.93E-09	2.69E-09	1.06E-09	2.79E-10
NE	9,200	2.50E-09	2.78E-09	5.40E-11	1.35E-08	6.53E-09	3.42E-09	1.27E-09	3.07E-10
ENE	7,800	3.55E-09	4.20E-09	6.08E-11	1.55E-08	7.52E-09	3.93E-09	1.45E-09	3.49E-10
E	7,800	3.36E-09	3.96E-09	4.73E-11	1.02E-08	5.06E-09	2.70E-09	1.03E-09	2.57E-10
ESE	7,800	2.72E-09	1.75E-09	5.38E-11	1.00E-08	5.05E-09	2.74E-09	1.07E-09	2.79E-10
SE	8,500	2.01E-09	1.14E-09	6.46E-11	9.08E-09	4.75E-09	2.66E-09	1.10E-09	3.07E-10
NNW	17,700	1.35E-09	1.58E-09	2.18E-10	1.29E-08	7.57E-09	4.70E-09	2.26E-09	7.89E-10
Maximum Public in General Environment		3.55E-09	4.20E-09	2.18E-10	1.55E-08	7.57E-09	4.70E-09	2.26E-09	7.89E-10

7.3 ONSITE PUBLIC X/QS AT THE RESTRICTED AREA BOUNDARY FROM A SURFACE FACILITY

Table 27 summarizes the atmospheric dispersion coefficient calculations from the Excel spreadsheet *ARCON96 XQ Calculation – 200 ft.xls*. Per assumption 3.2.7, a member of the public on site maybe located in any direction from a release, therefore all 16 sectors are considered. The χ/Q values are based on a 200 ft distance from a release. The use of these χ/Q values for summing results is conservative and would presume that the same individual is located at 200 ft from each release event.

Table 27 — Onsite Public χ/Qs (s/m^3) at the Restricted Area Boundary from Surface Facilities

	Averaging Time (hrs):		6	16	72	624
Sector	**Annual Average**	**2 – hour 0.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	2.91E-04	2.02E-03	1.51E-03	3.94E-04	5.32E-04	4.57E-04
NNE	1.19E-04	1.64E-03	8.64E-04	4.01E-04	2.87E-04	2.17E-04
NE	5.96E-05	1.17E-03	3.76E-04	2.28E-04	1.67E-04	1.13E-04
ENE	3.61E-05	8.18E-04	1.97E-04	8.36E-05	8.52E-05	6.41E-05
E	3.56E-05	8.07E-04	1.77E-04	5.57E-05	6.89E-05	6.12E-05
ESE	4.68E-05	9.51E-04	2.47E-04	8.50E-05	9.91E-05	8.45E-05
SE	9.61E-05	1.17E-03	4.87E-04	1.71E-04	1.73E-04	1.42E-04
SSE	1.34E-04	1.43E-03	6.73E-04	2.56E-04	2.41E-04	1.92E-04
S	1.45E-04	1.50E-03	7.05E-04	2.75E-04	2.61E-04	2.09E-04
SSW	1.45E-04	1.55E-03	6.96E-04	2.75E-04	2.62E-04	2.15E-04
SW	1.06E-04	1.56E-03	5.33E-04	1.66E-04	1.92E-04	1.63E-04
WSW	7.97E-05	1.48E-03	3.90E-04	1.20E-04	1.45E-04	1.23E-04
W	1.14E-04	1.66E-03	5.72E-04	1.71E-04	1.94E-04	1.70E-04
WNW	2.74E-04	2.02E-03	1.56E-03	2.91E-04	4.70E-04	4.19E-04
NW	3.19E-04	2.03E-03	1.64E-03	3.46E-04	5.42E-04	4.96E-04
NNW	3.33E-04	2.03E-03	1.64E-03	3.71E-04	5.63E-04	5.14E-04
Maximum all Sectors	3.33E-04	2.03E-03	1.64E-03	4.01E-04	5.63E-04	5.14E-04

7.4 ONSITE PUBLIC X/QS AT 100 METERS FROM A SUBSURFACE EXHAUST SHAFT

Table 28 summarizes the atmospheric dispersion coefficient calculations from the Excel spreadsheet *XQ Calculation – 100 m Exhaust Shafts.xls*. Per assumption 3.2.7, a member of the public on site maybe located in any direction from a release, therefore all 16 sectors are considered. The χ/Q values are based on a 100 m distance from a subsurface exhaust shaft. The use of these χ/Q values for summing results is conservative and would presume that the same individual is located at 100 m from each release event.

Table 28 — Onsite Public χ/Qs (s/m^3) at 100 Meters from a Subsurface Exhaust Shaft

				Averaging Time (hrs):	6	16	72	624
From Sector	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
N	2.32E-03	1.61E-03	1.68E-04	5.48E-03	3.47E-03	2.31E-03	1.24E-03	5.03E-04
NNE	1.97E-03	1.23E-03	6.40E-05	3.90E-03	2.28E-03	1.41E-03	6.73E-04	2.34E-04
NE	2.57E-03	1.59E-03	5.57E-05	3.11E-03	1.84E-03	1.15E-03	5.57E-04	1.98E-04
ENE	2.84E-03	2.29E-03	4.85E-05	2.80E-03	1.65E-03	1.03E-03	4.95E-04	1.74E-04
E	2.55E-03	1.93E-03	3.59E-05	2.30E-03	1.33E-03	8.19E-04	3.88E-04	1.33E-04
ESE	2.07E-03	1.41E-03	4.08E-05	2.30E-03	1.35E-03	8.45E-04	4.10E-04	1.45E-04
SE	1.65E-03	1.07E-03	5.32E-05	2.41E-03	1.46E-03	9.35E-04	4.72E-04	1.77E-04
SSE	9.61E-04	5.21E-04	8.38E-05	2.29E-03	1.49E-03	1.01E-03	5.57E-04	2.38E-04
S	7.22E-04	4.01E-04	1.31E-04	2.27E-03	1.56E-03	1.12E-03	6.71E-04	3.22E-04
SSW	1.54E-03	1.26E-03	8.81E-05	3.57E-03	2.20E-03	1.43E-03	7.34E-04	2.83E-04
SW	2.01E-03	1.61E-03	7.15E-05	3.91E-03	2.31E-03	1.45E-03	7.07E-04	2.52E-04
WSW	2.77E-03	2.36E-03	7.91E-05	4.20E-03	2.50E-03	1.57E-03	7.69E-04	2.77E-04
W	3.63E-03	3.52E-03	9.27E-05	4.72E-03	2.82E-03	1.78E-03	8.80E-04	3.20E-04
WNW	4.09E-03	3.82E-03	1.71E-04	6.85E-03	4.22E-03	2.74E-03	1.41E-03	5.47E-04
NW	4.01E-03	3.70E-03	6.89E-04	1.01E-02	7.11E-03	5.19E-03	3.21E-03	1.61E-03
NNW	3.82E-03	3.67E-03	6.18E-04	9.23E-03	6.48E-03	4.72E-03	2.91E-03	1.45E-03
Maximum all Sectors	4.09E-03	3.82E-03	6.89E-04	1.01E-02	7.11E-03	5.19E-03	3.21E-03	1.61E-03

7.5 DISPERSION FACTORS FROM THE GROA TO THE SUBSURFACE EXHAUST SHAFTS

Table 29 summarizes the dispersion coefficient calculations from the Excel spreadsheets *GROA to ES-1.xls*, *GROA to ES-2.xls,* and *GROA to ES-3.xls.*

Table 29 — Atmospheric Dispersion Factors (sec/m^3) from the GROA to the Subsurface Exhaust Shafts

Exhaust Shaft or Raise	From Sector	Distance (m)	Mean	Median	Annual Average	2 hour 99.5%ile	2–8 hour	8–24 hour	1–4 days	4–30 days
ES-1	**ENE**	3,200	5.17E-06	3.89E-06	7.28E-08	1.16E-05	5.96E-06	3.29E-06	1.33E-06	3.60E-07
ES-1	**E**	3,200	3.97E-06	2.12E-06	7.84E-08	1.09E-05	5.73E-06	3.21E-06	1.33E-06	3.72E-07
ES-1	**ESE**	3,200	3.02E-06	1.41E-06	9.69E-08	1.22E-05	6.46E-06	3.67E-06	1.54E-06	4.44E-07
ES-2	**E**	2,900	4.63E-06	2.50E-06	9.15E-08	1.24E-05	6.54E-06	3.68E-06	1.52E-06	4.30E-07
ES-2	**ESE**	2,900	3.52E-06	1.70E-06	1.13E-07	1.38E-05	7.37E-06	4.20E-06	1.77E-06	5.14E-07
ES-2	**SE**	2,900	1.84E-06	3.20E-07	1.60E-07	1.41E-05	7.83E-06	4.64E-06	2.08E-06	6.56E-07
ES-3	**NNE**	3,000	5.89E-06	3.56E-06	1.27E-07	2.00E-05	1.03E-05	5.71E-06	2.31E-06	6.27E-07
ES-3	**NE**	3,000	6.50E-06	5.34E-06	1.11E-07	1.59E-05	8.29E-06	4.64E-06	1.91E-06	5.31E-07
ES-3	**ENE**	3,000	5.71E-06	4.31E-06	8.05E-08	1.26E-05	6.50E-06	3.60E-06	1.45E-06	3.95E-07
ER-1	**ENE**	2,900	6.02E-06	4.55E-06	8.48E-08	1.32E-05	6.80E-06	3.77E-06	1.52E-06	4.16E-07
ER-1	**E**	2,900	4.63E-06	2.50E-06	9.15E-08	1.24E-05	6.54E-06	3.68E-06	1.52E-06	4.30E-07
ER-1	**ESE**	2,900	3.52E-06	1.70E-06	1.13E-07	1.38E-05	7.37E-06	4.20E-06	1.77E-06	5.14E-07
ER-2	**ENE**	1,800	1.27E-05	9.79E-06	1.79E-07	2.41E-05	1.27E-05	7.14E-06	2.96E-06	8.37E-07
ER-2	**E**	1,800	9.84E-06	6.02E-06	1.95E-07	2.30E-05	1.23E-05	7.04E-06	2.99E-06	8.75E-07
ER-2	**ESE**	1,800	7.54E-06	4.20E-06	2.42E-07	2.53E-05	1.38E-05	7.99E-06	3.47E-06	1.05E-06
ER-2	**SE**	1,800	3.93E-06	6.14E-07	3.42E-07	2.52E-05	1.43E-05	8.67E-06	4.01E-06	1.33E-06
Maximum to all Exhausts			1.27E-05	9.79E-06	3.42E-07	2.53E-05	1.43E-05	8.67E-06	4.01E-06	1.33E-06

7.6 DISPERSION FACTORS FROM SUBSURFACE EXHAUST SHAFTS TO THE GROA

Table 30 summarizes the dispersion coefficient calculations from the Excel spreadsheets *ES-1 to GROA.xls*, *ES-2 to GROA.xls,* and *ES-3 to GROA.xls.*

Table 30 — Atmospheric Dispersion Factors (sec/m^3) from Subsurface Exhaust Shafts to the GROA

Exhaust Shaft or Raise	From Sector	Distance (m)	Mean	Median	Annual Average	2 hour 99.5%ile	2–8 hour	8–24 hour	1–4 days	4–30 days
ES-1	WSW	3,200	7.93E-06	7.91E-06	2.02E-07	3.41E-05	1.74E-05	9.57E-06	3.81E-06	1.02E-06
ES-1	W	3,200	8.95E-06	8.62E-06	3.74E-07	5.47E-05	2.85E-05	1.59E-05	6.50E-06	1.80E-06
ES-1	WNW	3,200	8.52E-06	7.97E-06	1.46E-06	6.12E-05	3.75E-05	2.43E-05	1.24E-05	4.75E-06
ES-2	W	2,900	1.03E-05	9.92E-06	4.29E-07	6.02E-05	3.15E-05	1.77E-05	7.28E-06	2.04E-06
ES-2	WNW	2,900	9.75E-06	9.14E-06	1.68E-06	6.66E-05	4.11E-05	2.67E-05	1.38E-05	5.35E-06
ES-2	NW	2,900	9.20E-06	9.29E-06	1.49E-06	7.06E-05	4.26E-05	2.71E-05	1.36E-05	5.02E-06
ES-3	SSW	3,000	4.73E-06	4.05E-06	1.68E-07	2.66E-05	1.37E-05	7.57E-06	3.05E-06	8.29E-07
ES-3	SW	3,000	6.66E-06	6.00E-06	1.90E-07	2.94E-05	1.52E-05	8.43E-06	3.41E-06	9.32E-07
ES-3	WSW	3,000	8.69E-06	8.67E-06	2.22E-07	3.63E-05	1.86E-05	1.03E-05	4.11E-06	1.11E-06
ER-1	WSW	2,900	9.12E-06	9.11E-06	2.33E-07	3.75E-05	1.93E-05	1.06E-05	4.28E-06	1.16E-06
ER-1	W	2,900	1.03E-05	9.92E-06	4.29E-07	6.02E-05	3.15E-05	1.77E-05	7.28E-06	2.04E-06
ER-1	WNW	2,900	9.75E-06	9.14E-06	1.68E-06	6.66E-05	4.11E-05	2.67E-05	1.38E-05	5.35E-06
ER-2	WSW	1,800	1.81E-05	1.81E-05	4.63E-07	6.02E-05	3.18E-05	1.80E-05	7.52E-06	2.15E-06
ER-2	W	1,800	2.03E-05	1.96E-05	8.46E-07	9.32E-05	5.03E-05	2.90E-05	1.25E-05	3.72E-06
ER-2	WNW	1,800	1.89E-05	1.77E-05	3.24E-06	1.05E-04	6.63E-05	4.42E-05	2.37E-05	9.68E-06
ER-2	NW	1,800	1.78E-05	1.82E-05	2.87E-06	1.06E-04	6.63E-05	4.34E-05	2.27E-05	8.96E-06
Maximum from all Exhausts			2.03E-05	1.96E-05	3.24E-06	1.06E-04	6.63E-05	4.42E-05	2.37E-05	9.68E-06

7.7 DISPERSION FACTORS TO THE NEAREST RESIDENT

The following tables (Table 31 through Table 33) summarize the dispersion coefficient calculations from the Excel spreadsheets *GROA to Amargosa.xls* and *ES to Amargosa.xls.*

Table 31 — Nearest Resident χ/Qs (s/m^3) from the GROA or a Subsurface Exhaust Shaft or Raise

					Averaging Time (hrs):	6	16	72	624
From Sector	**Distance (m)**	**Mean**	**Median**	**Annual Average**	**2 hour 99.5%ile**	**2–8 hour**	**8–24 hour**	**1–4 days**	**4–30 days**
Releases from the GROA									
N	22,200	3.54E-07	2.31E-07	2.55E-08	5.24E-06	2.61E-06	1.40E-06	5.38E-07	1.37E-07
Releases from subsurface exhaust shafts or raises									
N	24,800	3.04E-07	1.97E-07	2.20E-08	4.63E-06	2.30E-06	1.23E-06	4.71E-07	1.19E-07
NNW	21,400	6.56E-07	6.28E-07	1.06E-07	1.06E-05	5.82E-06	3.39E-06	1.48E-06	4.53E-07
Maximum from Exhaust Shafts		6.56E-07	6.28E-07	1.06E-07	1.06E-05	5.82E-06	3.39E-06	1.48E-06	4.53E-07

Table 32 — Nearest Resident Depleted χ/Qs (s/m^3) from the GROA or a Subsurface Exhaust Shaft or Raise

				Averaging Time (hrs):		6	16	72	624
From Sector	Distance (m)	Mean	Median	Annual Average	2 hour 99.5%ile	2–8 hour	8–24 hour	1–4 days	4–30 days
Releases from the GROA									
N	22,200	1.69E-07	1.43E-07	1.22E-08	1.80E-06	9.37E-07	5.23E-07	2.13E-07	5.90E-08
Releases from subsurface exhaust shafts or raises									
N	24,800	1.46E-07	1.23E-07	1.05E-08	1.59E-06	8.26E-07	4.59E-07	1.86E-07	5.11E-08
NNW	21,400	2.72E-07	2.72E-07	4.40E-08	3.78E-06	2.11E-06	1.25E-06	5.64E-07	1.79E-07
Maximum from Exhaust Shafts		2.72E-07	2.72E-07	4.40E-08	3.78E-06	2.11E-06	1.25E-06	5.64E-07	1.79E-07

Table 33 — Nearest Resident Deposition Rates (m^{-2}) from the GROA or a Subsurface Exhaust Shaft or Raise

				Averaging Time (hrs):		6	16	72	624
From Sector	Distance (m)	Mean	Median	Annual Average	2 hour 99.5%ile	2–8 hour	8–24 hour	1–4 days	4–30 days
Releases from the GROA									
N	22,200	8.17E-10	8.67E-10	5.90E-11	6.23E-09	3.38E-09	1.96E-09	8.51E-10	2.56E-10
Releases from subsurface exhaust shafts or raises									
N	24,800	7.02E-10	7.43E-10	5.07E-11	5.47E-09	2.96E-09	1.71E-09	7.40E-10	2.22E-10
NNW	21,400	1.04E-09	1.23E-09	1.67E-10	9.87E-09	5.78E-09	3.59E-09	1.73E-09	6.04E-10
Maximum from Exhaust Shafts		1.04E-09	1.23E-09	1.67E-10	9.87E-09	5.78E-09	3.59E-09	1.73E-09	6.04E-10

7.8 RECOMMENDED ATMOSPHERIC DISPERSION VALUES

The χ/Q values presented in Table 15 through Table 33 are summarized in Table 34. The annual average χ/Q values are recommended for use in calculating consequences from normal releases. The 0 – 2 hour χ/Q values are recommended for use in calculating consequences from short duration (less than 2 hours) Category 1 and Category 2 events. For longer duration Category 1 and Category 2 events the appropriate combination of time averaged χ/Q values should be used. For example, for a one day release, the 0 – 2 hour value should be used for the first 2 hours, the 2 – 8 hour value for the next 6 hours, and the 8 – 24 hour value for the next 16 hours.

Table 34 — Recommended Atmospheric Dispersion Values

Offsite Public At the Site Boundary – Releases from:						
	GROA			Exhaust Shafts		
Time Period	**χ/Q (sec/m^3)**	**Depleted χ/Q (sec/m^3)**	**Deposition Rate (m^{-2})**	**χ/Q (sec/m^3)**	**Depleted χ/Q (sec/m^3)**	**Deposition Rate (m^{-2})**
Annual Average	4.36×10^{-7}	2.52×10^{-7}	1.00×10^{-9}	3.01×10^{-7}	1.60×10^{-7}	6.38×10^{-10}
0 – 2 hours	2.76×10^{-5}	1.47×10^{-5}	4.48×10^{-8}	2.11×10^{-5}	1.01×10^{-5}	2.98×10^{-8}
2 – 8 hours	1.60×10^{-5}	8.49×10^{-6}	2.72×10^{-8}	1.21×10^{-5}	5.84×10^{-6}	1.80×10^{-8}
8 – 24 hours	9.86×10^{-6}	5.29×10^{-6}	1.74×10^{-8}	7.36×10^{-6}	3.60×10^{-6}	1.15×10^{-8}
1 – 4 days	4.69×10^{-6}	2.56×10^{-6}	8.82×10^{-9}	3.43×10^{-6}	1.72×10^{-6}	5.76×10^{-9}
4 – 30 days	1.61×10^{-6}	9.03×10^{-7}	3.32×10^{-9}	1.15×10^{-6}	5.91×10^{-7}	2.14×10^{-9}
Source:	Table 15	Table 16	Table 17	Table 21	Table 22	Table 23
Offsite Public in the General Environment – Releases from:						
	GROA			Exhaust Shafts		
Time Period	**χ/Q (sec/m^3)**	**Depleted χ/Q (sec/m^3)**	**Deposition Rate (m^{-2})**	**χ/Q (sec/m^3)**	**Depleted χ/Q (sec/m^3)**	**Deposition Rate (m^{-2})**
Annual Average	1.23×10^{-7}	5.12×10^{-8}	1.96×10^{-10}	1.30×10^{-7}	5.71×10^{-8}	2.18×10^{-10}
0 – 2 hours	1.24×10^{-5}	4.40×10^{-6}	1.17×10^{-8}	1.30×10^{-5}	4.89×10^{-6}	1.55×10^{-8}
2 – 8 hours	6.76×10^{-6}	2.46×10^{-6}	6.85×10^{-9}	7.09×10^{-6}	2.73×10^{-6}	7.57×10^{-9}
8 – 24 hours	3.94×10^{-6}	1.46×10^{-6}	4.24×10^{-9}	4.14×10^{-6}	1.62×10^{-6}	4.70×10^{-9}
1 – 4 days	1.73×10^{-6}	6.56×10^{-7}	2.04×10^{-9}	1.82×10^{-6}	7.30×10^{-7}	2.26×10^{-9}
4 – 30 days	5.26×10^{-7}	2.08×10^{-7}	7.11×10^{-10}	5.56×10^{-7}	2.32×10^{-7}	7.89×10^{-10}
Source:	Table 18	Table 19	Table 20	Table 24	Table 25	Table 26

Table 34 — Recommended Atmospheric Dispersion Values

Nearest Resident – Releases from:						
	GROA			Exhaust Shafts		
Time Period	**χ/Q (sec/m^3)**	**Depleted χ/Q (sec/m^3)**	**Deposition Rate (m^{-2})**	**χ/Q (sec/m^3)**	**Depleted χ/Q (sec/m^3)**	**Deposition Rate (m^{-2})**
Annual Average	2.55×10^{-8}	1.22×10^{-8}	5.90×10^{-11}	1.06×10^{-7}	4.40×10^{-8}	1.67×10^{-10}
0 – 2 hours	5.24×10^{-6}	1.80×10^{-6}	6.23×10^{-9}	1.06×10^{-5}	3.78×10^{-6}	9.87×10^{-9}
2 – 8 hours	2.61×10^{-6}	9.37×10^{-7}	3.38×10^{-9}	5.82×10^{-6}	2.11×10^{-6}	5.78×10^{-9}
8 – 24 hours	1.40×10^{-6}	5.23×10^{-7}	1.96×10^{-9}	3.39×10^{-6}	1.25×10^{-6}	3.59×10^{-9}
1 – 4 days	5.38×10^{-7}	2.13×10^{-7}	8.51×10^{-10}	1.48×10^{-6}	5.64×10^{-7}	1.73×10^{-9}
4 – 30 days	1.37×10^{-7}	5.90×10^{-8}	2.56×10^{-10}	4.53×10^{-7}	1.79×10^{-7}	6.04×10^{-10}
Source:	Table 31	Table 32	Table 33	Table 31	Table 32	Table 33

Onsite Public at 200 ft from GROA – Releases from:		
Time Period	**GROA χ/Q (sec/m^3)**	**Exhaust Shafts χ/Q (sec/m^3)**
Annual Average	3.33×10^{-4}	3.24×10^{-6}
0 – 2 hours	2.03×10^{-3}	1.06×10^{-4}
2 – 8 hours	1.64×10^{-3}	6.63×10^{-5}
8 – 24 hours	4.01×10^{-4}	4.42×10^{-5}
1 – 4 days	5.63×10^{-4}	2.37×10^{-5}
4 – 30 days	5.14×10^{-4}	9.68×10^{-6}
Source:	Table 27	Table 30

Onsite Public at 100 m from Exhaust Shafts – Releases from:		
Time Period	**GROA χ/Q (sec/m^3)**	**Exhaust Shafts χ/Q (sec/m^3)**
Annual Average	3.42×10^{-7}	6.89×10^{-4}
0 – 2 hours	2.53×10^{-5}	1.01×10^{-2}
2 – 8 hours	1.43×10^{-5}	7.11×10^{-3}
8 – 24 hours	8.67×10^{-6}	5.19×10^{-3}
1 – 4 days	4.01×10^{-6}	3.21×10^{-3}
4 – 30 days	1.33×10^{-6}	1.61×10^{-3}
Source:	Table 29	Table 28

7.9 COMPARISON TO PREVIOUS VALUES

In this section, the atmospheric dispersion factors determined in this calculation are compared to the values used in *Preclosure Consequence Analyses for License Application,* calculation 000-00C-MGR0-00900-000-00C (Reference 2.2.9). The χ/Q values used in Reference 2.2.9 are calculated by the MACCS2 program. The comparison is presented in Table 35.

Table 35 — Comparison to Previous Values

		Calculation 000-00C-MGR0-00900-000-00C		This Calculation
Type	**Location**	**MACCS2 Output File**	**χ/Q (sec/m^3)**	**χ/Q (sec/m^3)**
Annual Average	100 m – Surface Facilities	lasur01i.out	5.62×10^{-5}	3.33×10^{-4} (200 ft)
	100 m – Exhaust Shafts	lasub01i.out	4.66×10^{-3}	6.89×10^{-4}
	Site Boundary – Surface Facilities	lasur01i.out	2.69×10^{-6}	4.36×10^{-7}
	Site Boundary – Exhaust Shafts	lasub01i.out	5.26×10^{-6}	3.01×10^{-7}
2-hour Accident	100 m – Surface Facilities	lapwr01i.out	1.12×10^{-3}	2.03×10^{-3} (200 ft)
	100 m – Exhaust Shafts	lasub01i.out	1.34×10^{-2}	1.01×10^{-2}
	Site Boundary – Surface Facilities	lapwr01i.out	9.68×10^{-6}	2.76×10^{-5}
	Site Boundary – Exhaust Shafts	lasub01i.out	1.59×10^{-5}	2.11×10^{-5}

As shown in Table 35, the χ/Q values calculated by MACCS2 and this calculation are within a factor of approximately 2. The differences between the χ/Q values generated by MACCS2 and this calculation are due to the different methodologies used. MACCS2 treats building wake effects by modifying the initial dispersion coefficients, which is comparable to the methodology employed by ARCON96 for short distances where building wake effects are significant. For longer distances building wake effects are less significant, and the methodology described in sections 4.4 for annual average and section 4.5 for accident conditions is more appropriate. For the subsurface exhaust shafts, where no building wake correction is considered, the results between this calculation and MACCS2 are comparable.

MACCS2 does not calculate an annual average χ/Q, but a χ/Q for the duration of the release. The maximum duration of release that can be used in MACCS2 is 24 hours. This was used to determine the annual average doses in BSC 2005 (Reference 2.2.9). A 24 hour duration release results in higher χ/Q values than a one year release, which is shown in Table 35 for the subsurface exhaust shafts and the surface facilities at the site boundary. At 100 m from the surface facilities MACCS2 calculates a lower χ/Q value because MACCS2 treats the release as an elevated release instead of a ground level release as performed in this calculation.

ATTACHMENT I. LISTING OF COMPUTER FILES CONTAINED IN ATTACHMENT III

This attachment contains a listing of the Excel spreadsheet and ARCON96 files contained on the attachment CDs of this calculation (Attachment III). The files on the CDs are given following the tables. The Excel spreadsheets contain all calculations performed for this document.

Files on CD 1 of 3				
File Name	File Size (bytes)	File Date	File Time	Description
ARCON96 Installation Comparison Files				
compcfd.txt	1,254	11/8/2006	10:47:08	Comparison file between the installation test runs and the code package CFD files
complog.txt	5,307	11/8/2006	10:47:07	Comparison file between the installation test runs and the code package LOG files
ARCON96 Input and Output Files				
a100m.bat	1,037	1/26/2006	8:44:44	Batch file to run ARCON96 for the short-term χ/Qs.
n100m.bat	976	1/26/2006	8:45:04	Batch file to run ARCON96 for the annual average χ/Qs.
ymp.met	1,621,488	3/5/2007	13:48:06	Hourly meteorological data in ARCON96 format.
a0000.cfd	11,168	11/9/2006	9:30:11	Short-term χ/Q CFD output file for the north sector.
a0000.log	4,837	11/9/2006	9:30:11	Short-term χ/Q Log output file for the north sector.
a0000.rsf	362	10/31/2006	9:56:40	Short-term χ/Q Input file for the north sector.
a0225.cfd	11,168	11/9/2006	9:30:11	Short-term χ/Q CFD output file for the north-northeast sector.
a0225.log	4,837	11/9/2006	9:30:11	Short-term χ/Q Log output file for the north-northeast sector.
a0225.rsf	362	10/31/2006	10:00:29	Short-term χ/Q Input file for the north-northeast sector.
a0450.cfd	11,168	11/9/2006	9:30:11	Short-term χ/Q CFD output file for the northeast sector.
a0450.log	4,837	11/9/2006	9:30:11	Short-term χ/Q Log output file for the northeast sector.
a0450.rsf	362	10/31/2006	10:00:38	Short-term χ/Q Input file for the northeast sector.
a0675.cfd	11,168	11/9/2006	9:30:12	Short-term χ/Q CFD output file for the east-northeast sector.
a0675.log	4,837	11/9/2006	9:30:12	Short-term χ/Q Log output file for the east-northeast sector.
a0675.rsf	362	10/31/2006	10:00:50	Short-term χ/Q Input file for the east-northeast sector.
a0900.cfd	11,168	11/9/2006	9:30:12	Short-term χ/Q CFD output file for the east sector.
a0900.log	4,837	11/9/2006	9:30:12	Short-term χ/Q Log output file for the east sector.
a0900.rsf	362	10/31/2006	10:00:59	Short-term χ/Q Input file for the east sector.
a1125.cfd	11,168	11/9/2006	9:30:12	Short-term χ/Q CFD output file for the east-southeast sector.
a1125.log	4,837	11/9/2006	9:30:12	Short-term χ/Q Log output file for the east-southeast sector.

Files on CD 1 of 3				
File Name	File Size (bytes)	File Date	File Time	Description
a1125.rsf	362	10/31/2006	10:01:10	Short-term χ/Q Input file for the east-southeast sector.
a1350.cfd	11,168	11/9/2006	9:30:13	Short-term χ/Q CFD output file for the southeast sector.
a1350.log	4,837	11/9/2006	9:30:13	Short-term χ/Q Log output file for the southeast sector.
a1350.rsf	362	10/31/2006	10:01:23	Short-term χ/Q Input file for the southeast sector.
a1575.cfd	11,168	11/9/2006	9:30:13	Short-term χ/Q CFD output file for the south-southeast sector.
a1575.log	4,837	11/9/2006	9:30:13	Short-term χ/Q Log output file for the south-southeast sector.
a1575.rsf	362	10/31/2006	10:01:35	Short-term χ/Q Input file for the south-southeast sector.
a1800.cfd	11,168	11/9/2006	9:30:13	Short-term χ/Q CFD output file for the south sector.
a1800.log	4,837	11/9/2006	9:30:13	Short-term χ/Q Log output file for the south sector.
a1800.rsf	362	10/31/2006	10:01:47	Short-term χ/Q Input file for the south sector.
a2025.cfd	11,168	11/9/2006	9:30:14	Short-term χ/Q CFD output file for the south-southwest sector.
a2025.log	4,837	11/9/2006	9:30:14	Short-term χ/Q Log output file for the south-southwest sector.
a2025.rsf	362	10/31/2006	10:02:03	Short-term χ/Q Input file for the south-southwest sector.
a2250.cfd	11,168	11/9/2006	9:30:14	Short-term χ/Q CFD output file for the southwest sector.
a2250.log	4,837	11/9/2006	9:30:14	Short-term χ/Q Log output file for the southwest sector.
a2250.rsf	362	10/31/2006	10:02:11	Short-term χ/Q Input file for the southwest sector.
a2475.cfd	11,168	11/9/2006	9:30:15	Short-term χ/Q CFD output file for the west-southwest sector.
a2475.log	4,837	11/9/2006	9:30:15	Short-term χ/Q Log output file for the west-southwest sector.
a2475.rsf	362	10/31/2006	10:04:02	Short-term χ/Q Input file for the west-southwest sector.
a2700.cfd	11,168	11/9/2006	9:30:15	Short-term χ/Q CFD output file for the west sector.
a2700.log	4,837	11/9/2006	9:30:15	Short-term χ/Q Log output file for the west sector.
a2700.rsf	362	10/31/2006	10:01:53	Short-term χ/Q Input file for the west sector.
a2925.cfd	11,168	11/9/2006	9:30:16	Short-term χ/Q CFD output file for the west-northwest sector.
a2925.log	4,837	11/9/2006	9:30:16	Short-term χ/Q Log output file for the west-northwest sector.
a2925.rsf	362	10/31/2006	10:03:57	Short-term χ/Q Input file for the west-northwest sector.
a3150.cfd	11,168	11/9/2006	9:30:16	Short-term χ/Q CFD output file for the northwest sector.
a3150.log	4,837	11/9/2006	9:30:16	Short-term χ/Q Log output file for the northwest sector.

Files on CD 1 of 3				
File Name	File Size (bytes)	File Date	File Time	Description
a3150.rsf	362	10/31/2006	10:03:50	Short-term χ/Q Input file for the northwest sector.
a3375.cfd	11,168	11/9/2006	9:30:16	Short-term χ/Q CFD output file for the north-northwest sector.
a3375.log	4,837	11/9/2006	9:30:16	Short-term χ/Q Log output file for the north-northwest sector.
a3375.rsf	362	10/31/2006	10:03:45	Short-term χ/Q Input file for the north-northwest sector.
n0000.cfd	11,168	11/9/2006	9:31:06	Annual average χ/Q CFD output file for the north sector.
n0000.log	4,802	11/9/2006	9:31:06	Annual average χ/Q Log output file for the north sector.
n0000.rsf	362	10/31/2006	10:03:39	Annual average χ/Q Input file for the north sector.
n0225.cfd	11,168	11/9/2006	9:31:06	Annual average χ/Q CFD output file for the north-northeast sector.
n0225.log	4,802	11/9/2006	9:31:06	Annual average χ/Q Log output file for the north-northeast sector.
n0225.rsf	362	10/31/2006	10:03:34	Annual average χ/Q Input file for the north-northeast sector.
n0450.cfd	11,168	11/9/2006	9:31:07	Annual average χ/Q CFD output file for the northeast sector.
n0450.log	4,802	11/9/2006	9:31:07	Annual average χ/Q Log output file for the northeast sector.
n0450.rsf	362	10/31/2006	10:03:28	Annual average χ/Q Input file for the northeast sector.
n0675.cfd	11,168	11/9/2006	9:31:07	Annual average χ/Q CFD output file for the east-northeast sector.
n0675.log	4,802	11/9/2006	9:31:07	Annual average χ/Q Log output file for the east-northeast sector.
n0675.rsf	362	10/31/2006	10:03:22	Annual average χ/Q Input file for the east-northeast sector.
n0900.cfd	11,168	11/9/2006	9:31:08	Annual average χ/Q CFD output file for the east sector.
n0900.log	4,802	11/9/2006	9:31:08	Annual average χ/Q Log output file for the east sector.
n0900.rsf	362	10/31/2006	10:03:18	Annual average χ/Q Input file for the east sector.
n1125.cfd	11,168	11/9/2006	9:31:08	Annual average χ/Q CFD output file for the east-southeast sector.
n1125.log	4,802	11/9/2006	9:31:08	Annual average χ/Q Log output file for the east-southeast sector.
n1125.rsf	362	10/31/2006	10:03:12	Annual average χ/Q Input file for the east-southeast sector.
n1350.cfd	11,168	11/9/2006	9:31:09	Annual average χ/Q CFD output file for the southeast sector.
n1350.log	4,802	11/9/2006	9:31:09	Annual average χ/Q Log output file for the southeast sector.
n1350.rsf	362	10/31/2006	10:03:08	Annual average χ/Q Input file for the southeast sector.
n1575.cfd	11,168	11/9/2006	9:31:09	Annual average χ/Q CFD output file for the south-southeast sector.
n1575.log	4,802	11/9/2006	9:31:09	Annual average χ/Q Log output file for the south-southeast sector.

Files on CD 1 of 3				
File Name	File Size (bytes)	File Date	File Time	Description
n1575.rsf	362	10/31/2006	10:03:03	Annual average χ/Q Input file for the south-southeast sector.
n1800.cfd	11,168	11/9/2006	9:31:10	Annual average χ/Q CFD output file for the south sector.
n1800.log	4,802	11/9/2006	9:31:10	Annual average χ/Q Log output file for the south sector.
n1800.rsf	362	10/31/2006	10:02:57	Annual average χ/Q Input file for the south sector.
n2025.cfd	11,168	11/9/2006	9:31:10	Annual average χ/Q CFD output file for the south-southwest sector.
n2025.log	4,802	11/9/2006	9:31:10	Annual average χ/Q Log output file for the south-southwest sector.
n2025.rsf	362	10/31/2006	10:02:50	Annual average χ/Q Input file for the south-southwest sector.
n2250.cfd	11,168	11/9/2006	9:31:11	Annual average χ/Q CFD output file for the southwest sector.
n2250.log	4,802	11/9/2006	9:31:11	Annual average χ/Q Log output file for the southwest sector.
n2250.rsf	362	10/31/2006	10:02:45	Annual average χ/Q Input file for the southwest sector.
n2475.cfd	11,168	11/9/2006	9:31:12	Annual average χ/Q CFD output file for the west-southwest sector.
n2475.log	4,802	11/9/2006	9:31:12	Annual average χ/Q Log output file for the west-southwest sector.
n2475.rsf	362	10/31/2006	10:02:39	Annual average χ/Q Input file for the west-southwest sector.
n2700.cfd	11,168	11/9/2006	9:31:12	Annual average χ/Q CFD output file for the west sector.
n2700.log	4,802	11/9/2006	9:31:12	Annual average χ/Q Log output file for the west sector.
n2700.rsf	362	10/31/2006	10:02:33	Annual average χ/Q Input file for the west sector.
n2925.cfd	11,168	11/9/2006	9:31:12	Annual average χ/Q CFD output file for the west-northwest sector.
n2925.log	4,802	11/9/2006	9:31:12	Annual average χ/Q Log output file for the west-northwest sector.
n2925.rsf	362	10/31/2006	10:02:27	Annual average χ/Q Input file for the west-northwest sector.
n3150.cfd	11,168	11/9/2006	9:31:13	Annual average χ/Q CFD output file for the northwest sector.
n3150.log	4,802	11/9/2006	9:31:13	Annual average χ/Q Log output file for the northwest sector.
n3150.rsf	362	10/31/2006	10:02:22	Annual average χ/Q Input file for the northwest sector.
n3375.cfd	11,168	11/9/2006	9:31:13	Annual average χ/Q CFD output file for the north-northwest sector.
n3375.log	4,802	11/9/2006	9:31:13	Annual average χ/Q Log output file for the north-northwest sector.
n3375.rsf	362	10/31/2006	10:02:17	Annual average χ/Q Input file for the north-northwest sector.
Meteorological Data Files				
ymp01-05.met	2,629,451	1/16/2007	14:26:40	Hourly meteorological data in GENII format.
ymp01-05.str	5,600	1/04/2007	12:47:44	Joint-Frequency Data in STAR format.

Files on CD 1 of 3				
File Name	File Size (bytes)	File Date	File Time	Description
Excel Spreadsheets				
Absolute_Humidity.xls	10,677,760	1/04/2007	8:58:01	Calculation of absolute humidity and average precipitation
Arcon96 Data Conversion.xls	39,791,616	3/5/2007	13:47:12	Excel spreadsheet containing the methodology used to format the meteorological data into the ARCON96 format.
ARCON96 XQ Calculation - 200 ft.xls	344,064	11/30/2006	8:06:49	Excel spreadsheet containing the results of the ARCON96 χ/Q calculation.
ER-1 to GROA.xls	54,503,424	11/30/2006	16:03:45	Excel spreadsheet containing the calculation of χ/Qs for releases from the subsurface facility exhaust raise 1 to the GROA.
ER-2 to GROA.xls	54,503,424	11/30/2006	16:05:05	Excel spreadsheet containing the calculation of χ/Qs for releases from the subsurface facility exhaust raise 2 to the GROA.
ES-1 to GROA.xls	54,503,424	11/30/2006	16:06:32	Excel spreadsheet containing the calculation of χ/Qs for releases from the subsurface facility exhaust shaft 1 to the GROA.
ES-2 to GROA.xls	54,503,424	11/30/2006	16:07:44	Excel spreadsheet containing the calculation of χ/Qs for releases from the subsurface facility exhaust shaft 2 to the GROA.
ES-3 to GROA.xls	54,503,424	11/30/2006	16:09:33	Excel spreadsheet containing the calculation of χ/Qs for releases from the subsurface facility exhaust shaft 3 to the GROA.
ES to Amargosa.xls	44,781,056	11/29/2006	10:18:50	Excel spreadsheet containing the calculation of χ/Qs for releases from the GROA to the nearest resident.
Exhaust Shafts - GROA Summary.xls	36,352	11/30/2006	16:20:40	Excel spreadsheet summarizing the results of the previous six spreadsheet.
Exhaust Shafts to Withdrawal-1.xls	39,569,920	11/29/2006	9:40:52	Excel spreadsheet containing the calculation of χ/Qs for releases from the subsurface facility exhaust shafts to the site boundary for the N - SE sectors.
Exhaust Shafts to Withdrawal-2.xls	51,380,736	11/29/2006	9:42:08	Excel spreadsheet containing the calculation of χ/Qs for releases from the subsurface facility exhaust shafts to the site boundary for the SSE and S sectors
Exhaust Shafts to Withdrawal-3.xls	36,142,080	11/29/2006	9:43:24	Excel spreadsheet containing the calculation of χ/Qs for releases from the subsurface facility exhaust shafts to the site boundary for the SSW - WNW sectors.
Exhaust Shafts to Withdrawal-4.xls	32,938,496	11/29/2006	9:45:49	Excel spreadsheet containing the calculation of χ/Qs for releases from the subsurface facility exhaust shafts to the site boundary for the NW sector.
Exhaust Shafts to Withdrawal-5.xls	30,989,312	11/29/2006	9:47:07	Excel spreadsheet containing the calculation of χ/Qs for releases from the subsurface facility exhaust shafts to the site boundary for the NNW Sector.

Files on CD 2 of 3				
File Name	**File Size (bytes)**	**File Date**	**File Time**	**Description**
Excel Spreadsheets				
GROA to Withdrawal-1.xls	39,345,664	11/30/2006	13:51:24	Excel spreadsheet containing the calculation of χ/Qs for releases from the GROA to the site boundary for the N - SE sectors
GROA to Withdrawal-2.xls	51,380,736	11/30/2006	14:12:10	Excel spreadsheet containing the calculation of χ/Qs for releases from the GROA to the site boundary for the SSE and S sectors.
GROA to Withdrawal-3.xls	36,142,080	11/30/2006	14:16:25	Excel spreadsheet containing the calculation of χ/Qs for releases from the GROA to the site boundary for the SSW - WNW sectors.
GROA to Withdrawal-4.xls	32,669,696	11/30/2006	14:17:54	Excel spreadsheet containing the calculation of χ/Qs for releases from the GROA to the site boundary for the NW sector.
GROA to Withdrawal-5.xls	30,987,776	11/30/2006	14:19:37	Excel spreadsheet containing the calculation of χ/Qs for releases from the GROA to the site boundary for the NNW sector.
GROA to Amargosa.xls	13,735,936	11/29/2006	10:08:09	Excel spreadsheet containing the calculation of χ/Qs for releases from the subsurface facility exhaust shafts or raises to the nearest resident.
GROA to ER-1.xls	54,503,424	11/30/2006	15:53:45	Excel spreadsheet containing the calculation of χ/Qs for releases from the GROA to the subsurface facility exhaust raise 1.
GROA to ER-2.xls	54,503,424	11/30/2006	15:55:23	Excel spreadsheet containing the calculation of χ/Qs for releases from the GROA to the subsurface facility exhaust raise 2.
GROA to ES-1.xls	54,503,424	11/30/2006	15:57:15	Excel spreadsheet containing the calculation of χ/Qs for releases from the GROA to the subsurface facility exhaust shaft 1.
GROA to ES-2.xls	54,503,424	11/30/2006	15:58:47	Excel spreadsheet containing the calculation of χ/Qs for releases from the GROA to the subsurface facility exhaust shaft 2.
GROA to ES-3.xls	54,503,424	11/30/2006	16:00:17	Excel spreadsheet containing the calculation of χ/Qs for releases from the GROA to the subsurface facility exhaust shaft 3.
Met Data 2001-2005.xls	54,498,304	1/16/2007	14:34:30	Development of meteorological data for use by GENII
XQ Calculation - 100 m Exhaust Shafts.xls	55,538,176	11/9/2006	8:49:26	Excel spreadsheet containing the calculation of χ/Qs for a distance of 100 meters from subsurface exhaust shafts.

Files on CD 3 of 3				
File Name	**File Size (bytes)**	**File Date**	**File Time**	**Description**
Excel Spreadsheets				
GROA to Withdrawal Summary Rev 1.xls	12,535,808	8/2/2007	10:16:58	Excel spreadsheet containing the summary results of spreadsheets GROA to Withdrawal-1 through 5 and GROA to General Environment-1 and 5.
GROA to General Environment-1.xls	40,103,424	8/2/2007	10:08:58	Excel spreadsheet containing the calculation of χ/Qs for releases from the GROA to the general environment for the N - SE sectors
GROA to General Environment-5.xls	30,980,096	8/2/2007	10:10:11	Excel spreadsheet containing the calculation of χ/Qs for releases from the GROA to the general environment for the NNW sector.
Exhaust Shafts to Withdrawal Summary Rev 1.xls	12,536,832	8/2/2007	10:15:02	Excel spreadsheet containing the summary results of spreadsheets Exhaust Shafts to Withdrawal-1 through 5 and Exhaust Shafts to General Environment-1 and 5.
Exhaust Shafts to General Environment-1.xls	39,560,192	8/2/2007	10:11:13	Excel spreadsheet containing the calculation of χ/Qs for releases from the subsurface facility exhaust shafts to the general environment for the N - SE sectors.
Exhaust Shafts to General Environment-5.xls	30,558,208	8/2/2007	10:12:09	Excel spreadsheet containing the calculation of χ/Qs for releases from the subsurface facility exhaust shafts to the general environment for the NNW Sector.
Site Coordinates - GROA.xls	427,520	6/28/2007	07:19:10	Excel spreadsheet containing the calculation of distances from the GROA and the exhaust shafts to the site boundary

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ATTACHMENT II. E-MAIL FROM GIS REQUEST (AUDREY RAGER) TO JORGE SCHULZ (REFERENCE 2.2.15)

GIS Requests
08/08/2006 13:00

Sent by: Audrey Rager

To: Jorge Schulz/YM/RWDOE@CRWMS
cc:
Subject: Re: Convert Coordinates

LSN: Not Relevant - Not Privileged
User Filed as: Excl/AdminMgmt-14-4/QA:N/A

E578234.7613ft. N688128.2655ft.

The geographic coordinates 36o 38' 25" N116o 24' 0" were converted to State Plane, Datum NAD27, Units feet, Zone 4626 using the ArcInfo project command on ArcInfo 7.2.1 (10033-7.2.1-00) on an SGI computer with IRIX 6.5 operating system.

However, I think more accurate coordinates for this point are:
E578368.58ft, N689421.97ft
This point was obtained by determining the xy coordinate at the intersection of the two highways in question using a 1:24 000 -scale roads coverage (DTN: MO9908COV97558.000) and ArcGIS software (ArcGIS Desktop, V.9.1, PC, Windows XP, 11205-9.1-00).

Please see the attached map showing the point derived from the Lat Long coordinates you submitted plotted agains the roads coverage.

The discrepancy between the two sets of points probably results from three factors. First, the lat/long coordinates were estimated from a map. Second, the scale of the map from which you estimated the coordinates, Third, units of latitude and longitude do not have the same ground measurement across the globe. Longitude is more precise than latitude the at higher latitudes. That is why the coordinate you gave me is more accurate east-west than north-south.

-Audrey

ymp-06-049_0.pdf

Jorge Schulz

Jorge Schulz
08/08/2006 09:41 AM

To: GIS Requests@CRWMS
cc:
Subject: Convert Coordinates

LSN: Not Relevant - Not Privileged
User Filed as: Excl/AdminMgmt-14-4/QA:N/A

Please convert the following coordinates (for the intersection if US 95 and Nevada 373) to the Nevada Coordinate System.

36o 38' 25" north
116o 24' 0" west

Thanks

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