

Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms

J.M. Grigsby

Washington River Protection Solutions LLC.

Richland, WA 99352

U.S. Department of Energy Contract DE-AC27-08RV14800

EDT/ECN: ECN-10-001420 UC:

Cost Center: 2KD00 Charge Code: 200741

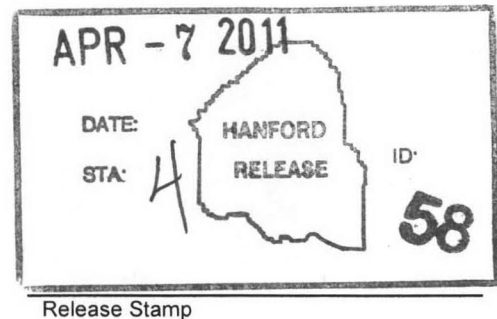
B&R Code: Total Pages:

Key Words: Atmospheric dispersion, dose calculation, GXQ, X/Q, radiological, toxicological

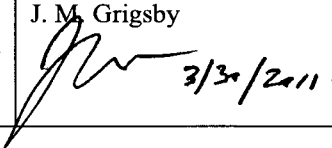
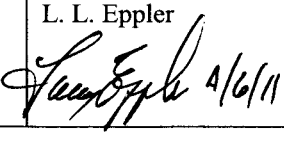
Abstract: This report presents the atmospheric dispersion coefficients used in Tank Farms safety analysis. The basis equations for calculating radiological and toxicological exposures are also included. In this revision, the time averaging for toxicological consequence evaluations is clarified based on a review of DOE complex guidance and a review of tank farm chemicals.

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

M. Washington
M. Washington 4/7/2011
Release Approval Date



Approved For Public Release

Tank Farm Contractor (TFC)		(1) Document Number:	
RECORD OF REVISION		RPP-13482	
(2) Title:			
Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms			
Change Control Record			
(3) Revision	(4) Description of Change – Replace, Add, and Delete Pages	Authorized for Release	
		(5) Resp. Engr. (print/sign/date)	(6) Resp. Mgr. (print/sign/date)
0	EDT 636616, Original Issuance.	W. L. Cowley 07/29/03	R. J. Stevens 07/29/03
1	Incorporate comments from DOE review.	W. L. Cowley 07/29/03	R. J. Stevens 07/29/03
2	Incorporate comments from DOE review.	W. L. Cowley 09/24/03	R. J. Stevens 10/08/03
3	Incorporate section on Building Wake and calculate X/Qs for 222-S and 242-A per ECN 722760, Rev 0.	W. L. Cowley 02/01/05	R. J. Stevens 02/01/05
4	Incorporate X/Qs calculated for use in safety analysis for the Demonstration Bulk Vitrification System per ECN 722760, Rev 1.	K. R. Sandgren 03/02/05	J. M. Grigsby 03/02/05
5	Incorporate Appendix N for X/Q's calculated for use in safety analysis for the Contract-Handled Transuranic/Mixed Waste Facility, per ECN 722760, Rev 4.	S. D. Kozlowski 09/22/05	J. M. Grigsby 09/22/05
6	Revision to clarify the use and basis of X/Qs and to include new X/Qs that were derived for use in DBVS and Tank Farms accident scenarios. A few editorial corrections were also made. ECN 722760, Rev 5.	K. R. Sandgren 11/16/06	S. J. Eberlein 11/16/06
6-A	Revision adds a more detailed basis for receptor breathing rates. This basis used to be included RPP-5924 (e.g., Rev 4) ECN-724755-Rev 0. L. F. 05/30/07	J. M. Grigsby 05/29/07	S. J. Eberlein 05/30/07
6-B	Revision clarifies the chemical concentration averaging time used in toxicological exposure calculations to be consistent with USDOE guidance in DOE G 151.1-1 (7-11-07). (ECN 725724)	J. M. Grigsby 07/21/08	L. L. Eppler 07/22/08
7 RS	Revision clarifies the chemical concentration averaging time used in toxicological exposure calculations based on a review of DOE complex guidance and a review of tank farm chemicals	J. M. Grigsby  3/30/2011	L. L. Eppler  4/6/11

CONTENTS

1.0	INTRODUCTION	1-1
2.0	GXQ CALCULATIONS OF TANK FARM DISPERSION COEFFICIENTS.....	2-1
2.1	ATMOSPHERIC DISPERSION	2-1
2.2	BASIC DISPERSION CALCULATIONS.....	2-3
2.2.1	Acute Release Dispersion	2-3
2.2.2	Annual Average Meteorology.....	2-5
2.2.3	50 th Percentile Meteorology.....	2-5
2.2.4	Plume Meander	2-5
2.2.5	Puff Release Dispersion Coefficient.....	2-7
2.2.6	Results of Basic Dispersion Calculations	2-8
2.3	MODIFIED DISPERSION CALCULATIONS	2-9
2.3.1	Plume Depletion.....	2-9
2.3.2	Releases From Short Stacks with Momentum/Thermal Rise	2-14
2.3.3	Large Source Effects.....	2-20
2.3.4	Pool Entrainment	2-22
2.3.5	Building Wake Effects.....	2-24
2.3.6	Ground-Level Fires.....	2-25
2.4	SELECTION OF APPROPRIATE DISPERSION COEFFICIENTS.....	2-43
2.4.1	Short (< 1 hr) or Variable Rate Releases	2-43
2.4.2	Release Durations From One to Two Hours.....	2-43
2.4.3	Release Durations Greater Than Two Hours	2-44
2.4.4	Puff Releases.....	2-44
3.0	VERIFICATION OF GXQ VERSION 4.0F CALCULATIONS.....	3-1
3.1	BASIC DISPERSION COEFFICIENTS.....	3-1
3.2	DISPERSION COEFFICIENTS WITH PLUME DEPLETION.....	3-23
3.3	DISPERSION COEFFICIENTS WITH PLUME RISE	3-25
3.4	DISPERSION COEFFICIENTS FOR AREA SOURCES.....	3-27
3.5	AIR TRANSPORT FACTORS FOR POOL SOURCES	3-28
3.6	BUILDING WAKE	3-29
3.6.1	Formulas for NRC Regulatory Guide 1.145 Building Wake and Plume Meander	3-29
3.6.2	Verification Testing of the GXQ Building Wake and Plume Meander Model.....	3-31
3.7	GXQ VERSION 4.0F SOURCE CODE LISTING	3-36
4.0	RADIOLOGICAL DOSE CALCULATIONS	4-1
4.1	EXPOSURE PATHWAYS.....	4-1
4.2	SOURCE TERM DEVELOPMENT	4-2
4.3	RADIOLOGICAL DOSE CALCULATIONS	4-3
5.0	TOXICOLOGICAL EXPOSURE CALCULATIONS.....	5-1
5.1	STEADY-STATE MODEL.....	5-2

5.2	PUFF RELEASE MODEL	5-3
5.3	TOXIC CHEMICAL MIXES	5-4
6.0	REFERENCES	6-1

APPENDICES

A	PROGRAM LISTING OF THE GXQ CODE VERSION 4.0F	A-i
B	SAMPLE INPUT FILE AND RUN FILES FOR BASIC DISPERSION COEFFICIENT CALCULATIONS IN SECTION 2.2	B-i
C	SAMPLE RUN FILES FOR MODIFICATIONS TO THE BASIC DISPERSION COEFFICIENTS.....	C-i
D	GXQ CDF OUTPUT FOR THE BASE CASE CENTERLINE PLUME	D-i
E	GXQ CDF OUTPUT FOR THE CENTERLINE PLUME WITH MEANDER	E-i
F	GXQ CDF OUTPUT FOR PUFF RELEASE	F-i
G	SPECIAL χ/Q 'S FOR THERMALLY LOFTED RELEASES AND DISPLACED VOLUMES.....	G-i
H	SPECIAL χ/Q 'S AND χ/Q 'S FOR PUFF RELEASES DUE TO RAPID VENTING OF UNDERGROUND TANK	H-i
I	SPECIAL GROUND LEVEL RELEASE χ/Q 'S WITH PLUME DEPLETION	I-i
J	SPECIAL χ/Q 'S FOR GASOLINE POOL FIRES	J-i
K	SPECIAL χ/Q 'S FOR RELEASES FROM THE 242-A EVAPORATOR.....	K-i
L	SPECIAL χ/Q 'S FOR RELEASES FROM THE 222-S LABORATORY	L-i
M	SPECIAL χ/Q 'S FOR POOL FIRES AT THE DEMONSTRATION BULK VITRIFICATION SYSTEM	M-i
N	SPECIAL χ/Q 'S FOR POOL FIRES AT THE CONTACT-HANDLED TRANSURANIC MIXED WASTE PACKAGING UNIT	N-i
O	SPECIAL χ/Q ' FOR A 155-FOOT STACK.....	O-i
P	CHEMICAL EXPOSURE TIMES FOR ACCIDENT ANALYSIS	P-i
Q	PEER REVIEW CHECKLISTS	Q-i

LIST OF FIGURES

Figure 2-1. Deposition Velocities.....	2-12
Figure 2-2. Effect of Plume Rise from 9.5-ft Stacks on Onsite χ/Q' Values.....	2-18
Figure 2-3. Onsite χ/Q' as a Function of Heat Output from the Fire.....	2-30
Figure 2-4. Hanford Site Boundary χ/Q' as a Function of Heat Output from the Fire.....	2-31
Figure 2-5. Onsite χ/Q' as a Function of Fire Diameter.....	2-32
Figure 2-6. Hanford Site Boundary χ/Q' as a Function of Fire Diameter.....	2-33
Figure 2-7. Fire Sizes Where the Alternate Model is Recommended.....	2-39

LIST OF TABLES

Table 2-1. Wind Speed Classifications.....	2-2
Table 2-2. Atmospheric Stability Classifications.....	2-2
Table 2-3. Site Boundary Distances.....	2-4
Table 2-4. Dispersion Coefficients for 200 Area Tank Farms to Onsite Receptor at 100 m.....	2-8
Table 2-5. Dispersion Coefficients for 200 Area Tank Farms to Site Boundary Receptor.....	2-9
Table 2-6. Effects of Plume Depletion with 0.15 cm/s Deposition Velocity – Onsite Receptor at 100 m.....	2-10
Table 2-7. Effects of Plume Depletion with 0.15 cm/s Deposition Velocity – Site Boundary Receptor.....	2-10
Table 2-8. Terminal Fall Velocities and Deposition Velocities.....	2-13
Table 2-9. All-Sector 95 th Percentile, 1-hr χ/Q 's for the Onsite Receptor at 100 m.....	2-13
Table 2-10. All-Sector 95 th Percentile, 1-hr χ/Q 's for the Site Boundary Receptor.....	2-13
Table 2-11. All-Sector 95 th Percentile Puff Release χ/Q s for the Onsite Receptor at 100 m.....	2-14
Table 2-12. All-Sector 95 th Percentile Puff Release χ/Q s for the Site Boundary Receptor.....	2-14

Table 2-13. All-Sector 95 th Percentile, 1-hr χ/Q' for the Onsite Receptor for Various Source Conditions.	2-17
Table 2-14. All-Sector 95 th Percentile, 1-hr χ/Q' for the Hanford Site Boundary Receptor for Various Source Conditions	2-19
Table 2-15. All-Sector 95 th Percentile, 1-hr χ/Q' s for the Onsite Receptor at 100 m for Various Source Widths.....	2-21
Table 2-16. All-Sector 95 th Percentile, 1-hr χ/Q' s for the Hanford Site Boundary Receptor for Various Source Widths.....	2-21
Table 2-17. Entrainment Coefficients for Onsite Receptor.	2-23
Table 2-18. Entrainment Coefficients for Offsite Receptor.....	2-24
Table 2-19. Example Onsite and Site Boundary χ/Q' s with Building Wake Correction.	2-25
Table 2-20. Heat Flux (MW/m ²) for Each Fire Evaluated with GXQ.....	2-27
Table 2-21. All-Sector 95 th Percentile, 1-hr χ/Q' (s/m ³) for the Onsite Receptor from Each Fire Evaluated with GXQ.....	2-28
Table 2-22. All-Sector 95 th Percentile, 1-hr χ/Q' (s/m ³) for the Hanford Site Boundary Receptor from Each Fire Evaluated with GXQ.....	2-29
Table 2-23. Comparison of χ/Q' from RPP-13482 and Table Interpolation.....	2-36
Table 2-24. Comparison of Recalculated χ/Q' from GXQ and Table Interpolation.....	2-37
Table 2-25. All-Sector 95 th Percentile, 1-hr Onsite χ/Q' from GXQ.....	2-40
Table 2-26. All-Sector 95 th Percentile, 1-hr Onsite χ/Q' from the Alternate Model for a Building Height of 15 m.....	2-41
Table 2-27. Ratios of 1-hr Onsite χ/Q' -- GXQ Divided by Alternate Model	2-42
Table 3-1. Horizontal and Vertical Standard Deviations for Each Distance.	3-2
Table 3-2. Plume Reflection Parameter Values.....	3-3
Table 3-3. Cumulative Probability Distribution for the Worker at 100 m, All Sectors, Centerline Values	3-4
Table 3-4. Cumulative Probability Distribution for the Hanford Site Boundary, All Sectors, Centerline Values	3-6
Table 3-5. Cumulative Probability Distribution for the Site Boundary, North Sector, Centerline Values	3-17

Table 3-6. Cumulative Probability Distribution for the Worker at 100 m, North Sector, with Plume Meander.	3-19
Table 3-7. Portion of the GXQ Cumulative Distribution that is Different.	3-20
Table 3-8. Cumulative Distribution When Equal Values are Combined.....	3-21
Table 3-9. Calculation of the Annual Average for the Worker at 100 m, East-Southeast Sector.....	3-21
Table 3-10. Cumulative Probability Distribution for the Worker at 100 m, All Sectors, Short Duration (Puff) Release.	3-23
Table 3-11. Comparison of Plume Depletion Factors for a Ground Deposition Speed of 0.15 cm/s.	3-24
Table 3-12. Comparison of Plume Dispersion Coefficients with Plume Depletion.....	3-24
Table 3-13. Plume Dispersion Coefficients for the 100 ft ³ /min Stack with Downwash and Flow Rate Adjustments.	3-25
Table 3-14. Effective Release Height and Wind Speed for the 1,000 ft ³ /min Stack with ISC2 Plume Rise.	3-26
Table 3-15. Plume Dispersion Coefficients for the 1,000 ft ³ /min Stack with ISC2 Plume Rise.....	3-26
Table 3-16. Comparison of Virtual Source Distances for Two Area Sources.....	3-27
Table 3-17. Comparison of Plume Dispersion Coefficients for the 10-m Wide Source.	3-28
Table 3-18. Scale Factors for Pool Releases.....	3-28
Table 3-19. Plume Air Transport Factors for a 10 m Wide Pool.....	3-29
Table 3-20. Plume Standard Deviations.	3-31
Table 3-21. Building Wake Factors.....	3-32
Table 3-22. Plume Meander Parameters.....	3-32
Table 3-23. Plume Reflection Factors.	3-33
Table 3-24. Computed and Calculated Air Transport Factors.....	3-34

LIST OF TERMS

AED	aerodynamic equivalent diameter
ARF	airborne release fraction
DCF	dose conversion factor
DOE	U.S. Department of Energy
DR	damage ratio
DSA	documented safety analysis
ICRP	International Commission on Radiological Protection
LPF	leakpath factor
MACCS	MELCOR Accident Consequence Code System
MAR	material at risk
MOI	maximum offsite individual
NRC	U.S. Nuclear Regulatory Commission
NQA-1	Nuclear Quality Assurance
χ/Q	puff dispersion coefficient
χ/Q'	atmospheric dispersion coefficient
RF	respirable fraction
SOF	sum of fractions
TWA	time-weighted average
ULD	unit-liter dose
USOF	unit release sum of fractions

1.0 INTRODUCTION

This report presents the general methodology of calculating the atmospheric dispersion coefficients (χ/Q') to be used in the safety basis documents for the tank farm facilities. Values of χ/Q' given in this report were generated using the GXQ code Version 4.0F, which reproduces the statistical treatment of the Hanford Site joint frequency meteorology specified in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.145, *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*. GXQ is documented in WHC-SD-GN-SWD-30002, *GXQ 4.0 Program Users' Guide*, and a listing of the code is shown in Appendix A. Alternate calculations used to verify the GXQ results are contained in the appendices. The alternate calculations are included to demonstrate compliance with Nuclear Quality Assurance (NQA)-1 requirements for software use.

Calculation of the basic dispersion parameters used at the tank farms is discussed in Section 2.2 with results given in Section 2.2.6. Specific assumptions and input used to generate the χ/Q' s at the tank farms are discussed. The logarithmic interpolation procedure used to generate χ/Q' s used for long-duration (> 2 hr) releases is described in detail. A sample input file and a set of run files are listed in Appendix B. Modifications to the basic dispersion coefficients to account for plume depletion, momentum/thermal plume rise, and large source effects are discussed in Section 2.3 with examples calculated. Corresponding sample run files are listed in Appendix C.

The GXQ results were verified using a set of alternate calculations documented in Chapter 3.0. Special GXQ run files used in the independent verification are listed in Appendices D, E, and F.

Chapters 4.0 and 5.0 present detailed discussions of the procedures used to estimate radiological and toxicological exposures using the dispersion coefficients developed in Chapters 2.0 and 3.0. Additional χ/Q' values that were requested to support the documented safety analysis (DSA) are included as Appendices G, H, I, J, K, and L. Future requests for χ/Q' s will be documented as additional appendices to this report.

This page intentionally left blank.

2.0 GXQ CALCULATIONS OF TANK FARM DISPERSION COEFFICIENTS

2.1 ATMOSPHERIC DISPERSION

The χ/Q' is defined to be the air concentration at a receptor location per unit release rate of the material at a release location upwind of the receptor. For material given in terms of C_i , for example, the χ/Q' has units of C_i/m^3 per C_i/s . This is normally condensed to s/m^3 with the units associated with the material (C_i , g, mg, etc.) canceling and, therefore, being completely arbitrary. For toxicological exposures, the exposure level (i.e., the air concentration at the receptor) is proportional to the χ/Q' . However, because radiological exposure is cumulative, the exposure is proportional to the time integrated air concentration over the exposure time of the receptor. If the release rate of the material and the atmospheric dispersion are assumed to be constant, a time-integrated dispersion coefficient equal to $(\chi \times T)/(Q' \times T)$, where T is the release time and the receptor exposure time is applicable. This gives the time-integrated air concentration at the receptor per unit total release of material. Since the T cancels, the time-integrated dispersion coefficient is exactly equal to the χ/Q' if the release rate of the material and the atmospheric dispersion are constant. For this reason, it is convenient to use the instantaneous χ/Q' for both toxicological and radiological exposures, dividing the release into a number of time segments for a radiological exposure if the release rate is varying over time. For toxicological exposures due to very short duration releases, GXQ can calculate puff χ/Q_s that are defined as the maximum instantaneous concentration at the receptor per unit total release (which is assumed to occur in zero time). The puff χ/Q has units of, for example, mg/m^3 per mg released. As before, the material units cancel and the net units are $1/m^3$. This formulation would only be used in special circumstances (e.g., immediately toxic chemical exposures), since acute exposures are averaged over 15 min to obtain a release rate (see Section 5.0). The normal steady-state χ/Q' can then be applied.

The GXQ code normally assumes a straight-line, steady-state Gaussian plume dispersion model. The χ/Q' then depends only on the distance from the release point to the receptor and on atmospheric conditions. For acute releases, the receptor is normally assumed to be on the horizontal plume centerline. The site-specific atmospheric condition information is obtained from a table of joint frequencies of occurrence of wind direction, wind speed, and atmospheric stability. Each box in a table of joint frequencies shows the percentage of the time that conditions were recorded corresponding to the combination of wind direction, wind speed, and atmospheric stability associated with that box. These data have been accumulated over a period of 9 yr (1983 through 1991) at the Hanford Meteorology Station located just east of the 200 West Area. Data tables are available for both surface (10 m) and elevated (61 m and 89 m) conditions. Since there are no tall stacks in any of the tank farm facilities, the elevated data are not used.

Wind directions are sorted into 16 sectors corresponding to the compass points N, NNE, NE, etc. These sectors give the direction the wind is blowing toward (not from, as is the usual practice in meteorology). For each sector, the wind speed is classified into one of eight ranges as shown in

Table 2-1. Data in each wind speed range are associated in the table with the median wind speed for that range.

Table 2-1. Wind Speed Classifications.

Range (m/s)	Median (m/s)
<1.8	0.89
1.8 – 3.6	2.65
3.6 - 5.8	4.7
5.8 – 8.5	7.15
8.5 – 11	9.8
11 – 14	12.7
14 – 17	15.6
>17	19

For each sector and wind speed class, the data are sorted into one of seven atmospheric stability classes, shown in Table 2-2.

Table 2-2. Atmospheric Stability Classifications.

Stability class	Pasquill category
Extremely unstable	A
Moderately unstable	B
Slightly unstable	C
Neutral	D
Slightly stable	E
Moderately stable	F
Extremely stable	G

The atmospheric stability is directly related to the change in air temperature with height above the ground. If a mass of air is raised some distance, it (1) expands due to the decrease in pressure, and (2) expands or contracts due to the change in temperature after it comes to equilibrium with the surrounding air. If the air temperature decreases with height (the usual condition) at just the right rate, then the two effects exactly cancel and the mass of air stays where it is. There is no driving force to move it either up or down. This is referred to as “neutral” stability.

If the air temperature decreases more rapidly with increasing height, then the raised air mass becomes denser than the surrounding air. It then tends to sink back to its original height and

resists any movement up or down. This condition is referred to as "stable." In stable atmospheric conditions, vertical mixing is suppressed and the atmosphere tends to stratify. This condition is associated with low wind speeds and produces low dispersion conditions that result in higher downwind concentrations of released material. If, on the other hand, the air temperature decreases less rapidly with height, the raised air mass becomes less dense than the surrounding air and tends to rise further. Thus, any displacement causes an accelerated movement in the same direction. Such a condition is referred to as "unstable." Unstable atmospheric conditions are characterized by rapid vertical mixing leading to a fairly constant vertical temperature profile. This produces highly dispersive conditions that reduce the downwind concentration of released material.

The extent of vertical mixing is limited to some height above the ground referred to as the mixing layer height. At this height, there is a more rapid decrease of air temperature with height that causes the plume of material to be effectively reflected back downward. At the Hanford Site, this mixing layer height can vary greatly with the day-night cycle and with the seasons, but for purposes of accident analysis has historically been assumed to be 1,000 m. This mixing layer would have a significant effect on the χ/Q' only under unstable atmospheric conditions, or at very great distances where the plume has spread vertically enough to be reflected off the top of the mixing layer. Worst-case meteorology for acute ground-level releases occurs under stable conditions so that the mixing layer depth has little effect over distances considered here. For elevated releases, the mixing layer depth can have a considerable effect since worst-case meteorology is generally in the unstable range (at least close to the release point) because such conditions cause the plume to reach the ground closer to the stack. There are no tall stacks in the tank farms, however, so this is not a concern.

2.2 BASIC DISPERSION CALCULATIONS

Unless otherwise stated, the χ/Q' and χ/Q calculations described in this section and Section 2.3 are performed using the GXQ code, which is the primary software utility used to estimate dispersion coefficients on the Hanford Site. GXQ is an expert program. This means that the code is intended to be used only by highly qualified individuals who are knowledgeable of the limits and applicability of the various models implemented. Although some error checking is provided, it is possible to select a combination of models that may not be compatible with each other, or may not be appropriate for the application. Inappropriate input to the code can result in meaningless results that look reasonable, and that produce no error messages in the code output. It is up to the user to ensure that the models selected are compatible and appropriate to the problem. The user should consult WHC-SD-GN-SWD-30002 and its references, or other similar text, to understand the workings of the code and the model limitations.

2.2.1 Acute Release Dispersion

The GXQ code can use the joint frequency data to calculate a χ/Q' , which is exceeded some specified percentage of the time according to the methods specified in NRC Regulatory Guide 1.145. This can be done based on the data for one sector at a time or based on the combined data over all sectors. Details of the GXQ code input required to calculate the various

types of χ/Q 's described in this section can be found in WHC-SD-GN-SWD-30002. In accordance with NRC Regulatory Guide 1.145, bounding individual sector χ/Q 's are 99.5th percentile (i.e., exceeded 0.5% of the time), while bounding overall (all sectors) χ/Q 's are 95th percentile (i.e., exceeded 5% of the time). These bounding χ/Q 's represent minimum dispersion conditions that result in maximum downwind concentrations (i.e., exceeded only a small fraction of the time) and generally correspond to low wind speeds with stable atmospheric conditions.

χ/Q 's can be evaluated for an individual receptor (such as a nearby facility), at a specific distance (such as 100 m) in all sectors around the release point, or around an irregular boundary where a distance is given for each sector. In the case of the irregular boundary, the distance in each sector is defined to be the minimum distance in a 45° sector centered on the 22.5° direction sector in question in accordance with NRC Regulatory Guide 1.145. For the combined tank farms facilities, the distances to the Hanford Site boundary have been established (in the DSA) and are given in Table 2-3.

Table 2-3. Site Boundary Distances.

Sector	Minimum distance within a 45° sector (m)
S	15,360
SSW	15,360
SW	13,200
WSW	11,100
W	11,100
WNW	11,100
NW	10,800
NNW	8,690
N	8,690
NNE	8,970
NE	10,430
ENE	10,530
E	11,160
ESE	15,190
SE	21,050
SSE	15,360

For simple acute (one-time, short duration) releases lasting less than 1 hr, or for releases with a highly variable rate, the overall (all sectors) 95th percentile χ/Q is normally used to calculate downwind radiological doses or toxicological concentrations at a receptor location in accordance with DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear*

Facility Documented Safety Analyses, Appendix A, "Evaluation Guideline." This χ/Q' is commonly referred to as the "1-hr" χ/Q' .

2.2.2 Annual Average Meteorology

The annual average χ/Q' is calculated for a sector by summing all the frequency-weighted χ/Q' s for all the atmospheric stability classes and wind speed bins for that sector. This value represents the annual average χ/Q' over all conditions having a wind speed in the direction of the sector in question multiplied by the probability of the wind blowing toward that sector. This is normally done assuming the "sector-averaged" plume meander model where the concentration of the material is constant across the width of the sector ($ipm = 3$). This value is suitable for calculating the consequences in a particular sector of a constant-rate release that occurs over a period of at least 1 yr. The annual average χ/Q' can also be used to evaluate the consequences of an acute release in a particular sector under average meteorological conditions if the χ/Q' is divided by the probability of the wind blowing in that sector (i.e., the wind is assumed to be blowing in that sector for the duration of the release). This probability is given as part of the code output, or GXQ can make the correction directly (see WHC-SD-GN-SWD-30002, Section 4.4.1).

2.2.3 50th Percentile Meteorology

For beyond design basis or beyond evaluation basis events, it is permissible to use χ/Q' s based on 50th percentile meteorology (i.e., exceeded 50% of the time). The 50th percentile χ/Q' s can also be used to demonstrate the degree of conservatism in results based on 95th percentile meteorology. If a 50th percentile χ/Q' is evaluated for a particular sector, the joint frequency data for that sector must be normalized, i.e., divided by the frequency of the wind blowing into that sector since this frequency is generally much less than 50%. The GXQ code can be set to do this normalization during the calculation of the χ/Q' ($inorm = T$). The 50th percentile χ/Q' s are also often used to represent "average" conditions for an acute release.

2.2.4 Plume Meander

The correlation parameters used to generate the 1-hr χ/Q' s are based on dispersion data averaged over less than 1 hr (~20 min). Using 1-hr χ/Q' values raises the question of whether they are conservative for near-instantaneous releases. The recommended approach in NRC Regulatory Guide 1.145 is to assume that the 1-hr average dispersion data applies over the 2 hr immediately following the accident. The NRC Regulatory Guide 1.145 concludes this is reasonably conservative considering the small variations of χ/Q' values with averaging time. (The NRC Regulatory Guide 1.145 also states that if the event is estimated to occur over a period of less than 20 min, the applicability of the model should be evaluated. The evaluation described in NRC Regulatory Guide 1.145 is the consideration of fumigation conditions for elevated or stack releases.)

If a release occurs over a longer duration (1 hr or more), it is subjected to more lateral spreading due to random changes in wind direction. This effect is referred to as plume meander. If the release occurs at a reasonably constant rate with a duration of 1 hr or more, a correction may be made for plume meander. For release durations of at least 1 hr, but no more than 2 hr, the GXQ code can generate plume meander corrected χ/Q 's using the model in NRC Regulatory Guide 1.145. Such χ/Q 's are referred to as "2 hr" χ/Q 's.

For releases with durations of more than 2 hr and up to 1 yr (8,760 hr), a hand-calculated logarithmic interpolation procedure can be used to account for the plume meander effect. The interpolation is between the 95th percentile 2-hr χ/Q ' and the annual average χ/Q ', and is done graphically by plotting χ/Q ' versus release duration on log-log paper and drawing a straight line between the two points. This can be done analytically by using the following formula (Equation 2-1). The logs can be either base 10 or natural.

$$\frac{\log\left(\frac{X}{Q'}\right)_{T_{rel}} - \log\left(\frac{X}{Q'}\right)_{2hr}}{\log\left(\frac{X}{Q'}\right)_{1yr} - \log\left(\frac{X}{Q'}\right)_{2hr}} = \frac{\log(T_{rel}) - \log(2 \text{ hr})}{\log(8,760 \text{ hr}) - \log(2 \text{ hr})} \quad (2-1)$$

where:

$$\begin{aligned} T_{rel} &= \text{release duration (hours) between 2 hr and 8,760 hr} \\ (\chi/Q')_{2 \text{ hr}} &= \text{2-hr } \chi/Q' \text{ (s/m}^3\text{)} \\ (\chi/Q')_{1 \text{ yr}} &= \text{annual average } \chi/Q' \text{ (s/m}^3\text{)} \\ (\chi/Q')_{T_{rel}} &= \chi/Q' \text{ for release duration } T_{rel} \text{ (s/m}^3\text{)}. \end{aligned}$$

This formula can be written more directly as Equation 2-2:

$$\left(\frac{X}{Q'}\right)_{T_{rel}} = \left(\frac{X}{Q'}\right)_{2hr} \left(\frac{T_{rel}}{2 \text{ hr}}\right)^{\text{slope}} \quad (2-2)$$

where:

$$\text{slope} = \frac{\log\left(\frac{\left(\frac{X}{Q'}\right)_{1yr}}{\left(\frac{X}{Q'}\right)_{2hr}}\right)}{\log\left(\frac{8760 \text{ hr}}{2 \text{ hr}}\right)}$$

The most commonly encountered logarithmically interpolated χ/Q 's are for 8 hr and 24 hr. It should be carefully noted that this discussion of the effect of release duration on the diffusion

coefficient applies only to radiological dose calculations because the dose is proportional to the time integral of air concentration. Either the 1-hr steady-state χ/Q' or puff χ/Q is always used for toxicological exposures because peak air concentration is the operative parameter.

2.2.5 Puff Release Dispersion Coefficient

Because the peak air concentration of the released material as the plume passes the receptor is of primary concern for toxic releases, the 1-hr χ/Q' can always be used. One of the assumptions inherent in the steady-state χ/Q' , however, is that there is diffusion only in the lateral (y and z) directions. Movement in the windward (x) direction is assumed to be solely due to gross air movement (i.e., wind) with no diffusion. For example, assuming a wind speed of 1 m/s, a release with a duration of 1 sec will produce a plume that is 1 m long. The plume will remain 1 m long no matter how far it travels downwind and will spread only laterally (hence the term "spreading disk model"). In reality, the plume would lengthen due to diffusion in the x-direction as it traveled downwind thereby decreasing the concentration of material in the plume. For extremely short release durations, therefore, the steady-state χ/Q' may be overly conservative and a puff χ/Q ($1/m^3$) that gives peak concentration per unit total release instead of release rate can be used. For longer release durations, the puff χ/Q is overly conservative because it assumes a zero release time. In reality, any release takes some time and therefore stretches out the plume, thereby reducing the concentration.

There is a cross-over point with respect to release time where the puff and steady-state models will give the same number. For release times less than this, the puff model will give a lower concentration, while for longer release times the steady-state model will give lower concentrations. However, both the steady-state and the puff models are always conservative. A trial and error approach can be used where both models are tried and the lower dispersion coefficient used. Alternatively, for any particular receptor, it can be shown theoretically that the cross-over release time is just equal to the ratio of the steady-state χ/Q' to the puff χ/Q . For the onsite receptor at 100 m, the cross-over release time is on the order of a few seconds, while for the Hanford Site boundary receptor, it is a few hundred seconds. Historically, these transition release times have been assumed to be 3.5 sec and 350 sec, respectively. Exact numbers can, however, easily be determined in any given situation. The modeling of the puff χ/Q in the GXQ code assumes a zero release time; however, initial source volume and concentration can be accounted for (see Section 2.3.3). Puff χ/Q 's can be calculated using GXQ by setting $ipuff = 1$ and the release duration equal to zero.

It should be carefully noted that the puff model is only applicable to toxic releases. Radiological doses are proportional to the time-integrated air concentration and therefore do not depend on the release duration.

All of the air transport factors (plume or puff) presented in this document are calculated from wind data that has been averaged over 1-hr intervals and binned into 8 wind speed groups and 7 stability classes for each of 16 wind transport directions.

Ground-level releases under stable conditions are the worst case regardless of release duration. Instantaneous releases have no plume meander, and the worst case is the unmodified straight-line

Gaussian representation. Of particular concern are onsite exposures to short duration releases. These releases are either from ground level or from stacks. For ground level releases, the effect of nearby buildings must be considered.

Puffs from stacks under stable conditions cannot reach onsite receptors within a few hundred meters of the stack. During unstable conditions the puff from a stack could give high concentrations due to looping motion of the air. The high concentrations are of low probability due to the large number of possible puff trajectories. Only a few of the possible trajectories will bring the puff to the onsite receptor.

The extreme cases are generally not useful due to their low probability. The approach taken in NRC Regulatory Guide 1.145 is to avoid worst case conditions in favor of reasonably conservative conditions. Thus, the use of elevated 1-hr χ/Q' values for near-instantaneous releases from stacks is reasonably conservative. The bounding case is to use a ground-level χ/Q' to represent a stack.

The preceding discussion for stacks also applies to releases near large buildings. The plume or puff is trapped in the turbulence near the building. The bounding case is to ignore the building and use the basic dispersion methods described at the end of Section 2.2 for a ground-level release. The reasonably conservative approach acknowledges that the bounding case is low probability and uses χ/Q' modified for building turbulence.

Note that the use of only eight wind speeds to represent Hanford Site wind data means that graphs of χ/Q' versus some parameter (e.g., distance downwind, stack characteristics, or source dimensions) will not be smooth. The χ/Q' will appear to have discontinuities as different wind speeds become more or less important.

2.2.6 Results of Basic Dispersion Calculations

The dispersion coefficients resulting from the basic models discussed above are shown in Tables 2-4 and 2-5 for the onsite receptor at 100 m and the Hanford Site boundary receptor, respectively. The logarithmically interpolated 8-hr χ/Q' 's are shown in Tables 2-4 and 2-5. The corresponding run files are listed in Appendix B.

Table 2-4. Dispersion Coefficients for 200 Area Tank Farms
to Onsite Receptor at 100 m.

Meteorological condition	1-hr χ/Q' (s/m ³)	2-hr χ/Q' (s/m ³)	8-hr χ/Q' (s/m ³)	Maximum puff χ/Q (1/m ³)
95 th Percentile overall	3.28 E-2	9.40 E-3	5.58 E-3	8.88 E-3
Annual average maximum sector	4.03 E-4	--	--	--
50 th Percentile maximum sector	5.33 E-3	2.27 E-3	1.71 E-3	9.48 E-4

Note: The 2-hr and 8-hr χ/Q' 's include the effects of plume meander averaged over 2 hr and 8 hr, respectively.

Table 2-5. Dispersion Coefficients for 200 Area Tank Farms to Site Boundary Receptor.

Meteorological condition	1-hr χ/Q' (s/m ³)	2-hr χ/Q' (s/m ³)	8-hr χ/Q' (s/m ³)	Maximum puff χ/Q (1/m ³)
95 th Percentile overall	2.22 E-5	1.74 E-5	7.90 E-6	5.06 E-8
Annual average maximum sector	1.47 E-7	--	--	--
50 th Percentile maximum sector	4.48 E-6	3.83 E-6	2.23 E-6	1.04 E-8

Note: The 2-hr and 8-hr χ/Q' s include the effects of plume meander averaged over 2 hr and 8 hr, respectively.

2.3 MODIFIED DISPERSION CALCULATIONS

In addition to the basic dispersion plume models already discussed, modifications can be applied to account for other effects such as plume depletion due to particle fallout, plume rise due to thermal buoyancy and/or momentum effects, and source size and volume rate effects. Such corrections to the basic model tend to be scenario specific; however, examples are given here for typical ranges of parameters applicable to tank farms so that the methodology and code run files can be shown in detail for the benefit of analysts. WHC-SD-GN-SWD-30002 and its references should be consulted to obtain a complete understanding of the various models and their applications. As previously mentioned, GXQ is an expert code and these modifications should be implemented only by qualified analysts who understand the limits and applicability of the models used. Sample run files for the various cases shown in this section are listed in Appendix C.

2.3.1 Plume Depletion

The concentration of material in the plume will, in general, decrease not only due to diffusion into the surrounding air, but also due to deposition onto the ground at the plume-ground interface. The operative parameter is the "deposition velocity" defined to be the rate of deposition per unit area per unit concentration of the material just above the ground. This would have units, for example, Ci/s per m² per Ci/m³. The arbitrary units of material quantity (in this case Ci) cancel out, leaving the dimensions of a velocity, i.e., m/s (hence the term deposition "velocity"). The random vorticity in the air outdoors is on the order of 1 cm/s so that particles with gravitational fall velocities less than this value will tend to stay suspended and follow the gross air movements. For small particles less than about 10 μ m having a fall velocity less than roughly 1 cm/s, the deposition velocity represents an interaction coefficient between the material in the plume and the ground (including vegetation), and has very little to do with the fall velocities of the particles in still air. Generally, a gas will exhibit a ground deposition rate due to its chemical activity that will be characterized by a deposition velocity. Larger particles

(> 10 μm) will show a net downward drift equal to their gravitational fall velocity. In this case, the deposition velocity is just equal to the gravitational fall velocity of the particles.

Plume depletion in GXQ is calculated using the Chamberlain model described in TID-24190, *Meteorology and Atomic Energy - 1968*. This model reduces the source strength to match the integrated loss from the plume from the source to the receptor or, equivalently, assumes that the plume is mixed vertically (i.e., ground reflection is assumed to be less than the amount of material lost to deposition at the plume-ground interface). This is strictly valid only for small particles (< 10 μm). In general, the model will give overly conservative results for larger particles with respect to doses at a receptor since it assumes vertical mixing within the plume. In reality, a plume composed of large particles will be tilted downward into the ground with no ground reflection. For this reason, larger particles are commonly assumed to fall to the ground near the source, and to not reach the receptors in significant amounts unless the source is elevated.

An actual release incident in 1985, apparently due to accidental pressurization of a line leading to an open nozzle in a closed diversion box, was analyzed in HNF-SD-WM-CN-096, *Refined Radiological and Toxicological Consequences of Bounding Spray Leak Accidents in the Tank Farm Waste Transfer Pits*. This incident occurred during favorable meteorological conditions immediately after a new layer of snow had fallen, and as such, presented a highly unusual opportunity to gather very accurate background-free surface contamination samples at various distances downwind of the release point. With these measurements, along with air sampler data, it was possible to back out a deposition velocity of 0.15 cm/s using the Chamberlain model. This is very close to the generic value of 0.1 cm/s usually recommended for deposition velocity of respirable particulates (i.e., < 10 μm). The effects of plume depletion with a 0.15 cm/s deposition velocity on the 95th percentile, 1-hr, 2-hr, and annual average χ/Q 's and puff χ/Q s for onsite and offsite receptors are shown in Tables 2-6 and 2-7.

Table 2-6. Effects of Plume Depletion with 0.15 cm/s Deposition Velocity –
Onsite Receptor at 100 m.

χ/Q ' type	χ/Q ' with no depletion (s/m ³)	χ/Q ' with depletion (s/m ³)	Reduction factor
1-hr (no plume meander)	3.28 E-2	2.84 E-2	0.866
2-hr (with plume meander)	9.40 E-3	8.49 E-3	0.903
Annual average	4.03 E-4	3.75 E-4	0.931
Puff	8.88 E-3	8.29 E-3	0.934

Table 2-7. Effects of Plume Depletion with 0.15 cm/s Deposition Velocity – Site Boundary Receptor.

χ/Q' type	χ/Q' with no depletion (s/m ³)	χ/Q' with depletion (s/m ³)	Reduction factor
1-hr (no plume meander)	2.22 E-5	1.14 E-5	0.514
2-hr (with plume meander)	1.74 E-5	8.88 E-6	0.510
Annual average	1.47 E-7	1.01 E-7	0.687
Puff	5.06 E-8	3.42 E-8	0.676

The reduction is larger for the Hanford Site boundary receptor because of the longer transport time and hence more plume depletion, but the effect in both cases is relatively small because of the small particle size range implied by the 0.15 cm/s deposition velocity.

The transition between small particle and large particle behaviors is not sharp, but is spread over the particle size range from about 3 μm to about 35 μm , depending on the particle density and characteristics as shown in Figure 2-1, taken from DOE/TIC-27601, *Atmospheric Science and Power Production*. The $K = V_T$ lines show the theoretical terminal fall velocities for densities of 1, 4, and 11.5 g/cm³. This figure clearly shows the departure of the deposition velocity from the gravitational fall velocity for fall velocities below about 1 cm/s. The major parameter for smaller particles is the roughness height of the surface (including vegetation).

Estimates of both the aerodynamic surface roughness height, z_o , and the air friction velocity, u_* , are needed to predict deposition velocities. The aerodynamic surface roughness is about 0.15 of the vegetation and physical roughness height of the surface. Estimates of aerodynamic surface roughness for different surfaces and wind speeds are given in DOE/TIC-27601, Table 12.6. Based on this information, a value of 10 cm has been assumed at the Hanford Site (grass and low shrubs) for low wind speeds. The air friction velocity was estimated based on the logarithmic description of the wind speed profile above the ground given by DOE/TIC-27601 (Equation 2-3).

$$u = \frac{u_*}{k} \ln \frac{z + z_0}{z_0} \quad (2-3)$$

where:

z = reference wind speed height

k = von Karman's constant which is approximately equal to 1.4.

Based on a low wind speed (1 m/s) at a reference height of 10 m, an air friction velocity of 0.1 m/s has been assumed.

Figure 2-1. Deposition Velocities.

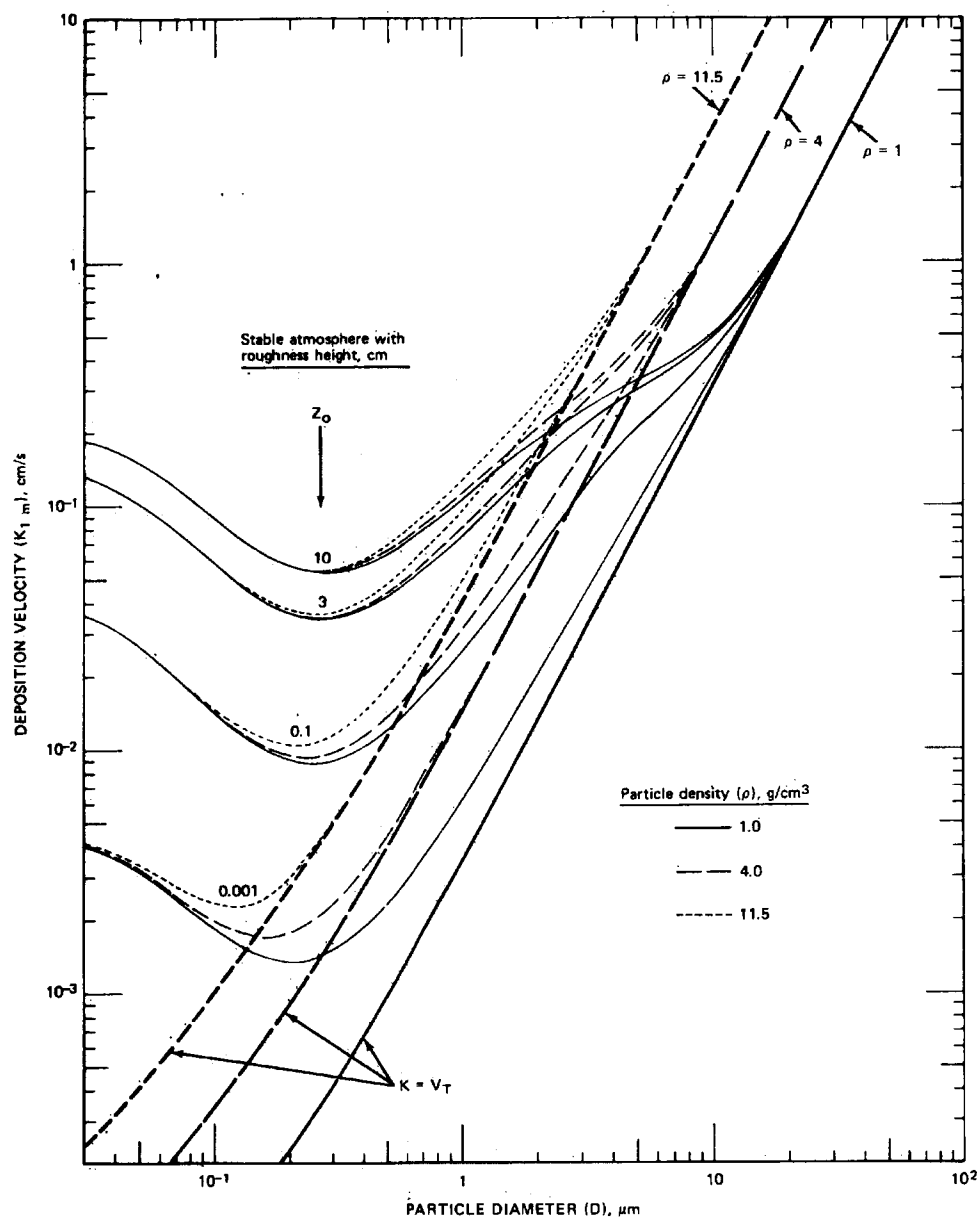


Fig. 12.4 Predicted deposition velocities at 1 m for $u_* = 10$ cm/s and particle densities of 1, 4, and 11.5 g/cm³.

Deposition velocities from Figure 2-1 are shown as a function of size for spherical particles with a density of 1 g/cm³, i.e., in terms of aerodynamic equivalent diameter (AED), in Table 2-8. The theoretical terminal gravitational fall velocities are shown for comparison. Note that the observed deposition velocity begins to depart from the theoretical gravitational fall velocity for particles smaller than about 10 μm.

Table 2-8. Terminal Fall Velocities and Deposition Velocities.

Particle size (AED) (μm)	Terminal fall velocity (cm/s)	Deposition velocity (cm/s)
2	0.01	0.2
10	0.3	0.5
20	1	1
50	7	7

Note:

AED = aerodynamic equivalent diameter.

One-hour χ/Q 's and puff χ/Q s corrected for deposition were calculated using the GXQ code (WHC-SD-GN-SWD-30002) over this transitional particle size range ($\text{idp} = 1$). The release was assumed to be at ground level (release height = 0). Dispersion coefficients with deposition effects were calculated for all sectors (95th percentile overall) at a 100-m radius and at all sectors around the Hanford Site boundary at distances defined in Table 2-3.

The resulting 1-hr χ/Q 's and puff χ/Q s are shown in Tables 2-9 through 2-12 for onsite and site boundary, respectively. The reduction factors relative to the χ/Q 's and puff χ/Q s with no plume depletion are also shown for comparison. These results were extracted from the development of χ/Q 's for a specific accident in the DSA described in more detail in Appendix I.

Table 2-9. All-Sector 95th Percentile, 1-hr χ/Q 's for the Onsite Receptor at 100 m.

Particle size (AED) (μm)	χ/Q ' with no depletion (s/m^3)	χ/Q ' with depletion (s/m^3)	Reduction factor
2	3.28 E-2	2.71 E-2	0.83
10		2.11 E-2	0.64
20		1.38 E-2	0.42
50		1.43 E-3	0.044

Note:

AED = aerodynamic equivalent diameter.

Table 2-10. All-Sector 95th Percentile, 1-hr χ/Q 's for the Site Boundary Receptor.

Particle size (AED) (μm)	χ/Q ' with no depletion (s/m^3)	χ/Q ' with depletion (s/m^3)	Reduction factor
2	2.22 E-5	8.86 E-6	0.40
10		3.62 E-6	0.16
20		1.61 E-6	0.073
50		6.28 E-8	0.0028

Note:

AED = aerodynamic equivalent diameter.

Table 2-11. All-Sector 95th Percentile Puff Release χ/Q s
for the Onsite Receptor at 100 m.

Particle size (AED) (μm)	χ/Q with no depletion ($1/\text{m}^3$)	χ/Q with depletion ($1/\text{m}^3$)	Reduction factor
2	8.88 E-3	7.83 E-3	0.88
10		5.67 E-3	0.64
20		2.75 E-3	0.31
50		6.21 E-4	0.070

Note:

AED = aerodynamic equivalent diameter.

Table 2-12. All-Sector 95th Percentile Puff Release χ/Q s
for the Site Boundary Receptor.

Particle size (AED) (μm)	χ/Q with no depletion ($1/\text{m}^3$)	χ/Q with depletion ($1/\text{m}^3$)	Reduction factor
2	5.06 E-8	3.17 E-8	0.63
10		1.95 E-8	0.39
20		8.35 E-9	0.17
50		2.81 E-10	0.0056

Note:

AED = aerodynamic equivalent diameter.

The effects of deposition can provide a considerable reduction in the χ/Q , particularly for the longer transport distances to the Hanford Site boundary. The Chamberlain model, however, should be considered unrealistic and overly conservative for particle sizes much greater than about 20 μm AED. In addition, each such calculation is performed for only one particle size. An actual release would involve a range of particle sizes with a size distribution that is not usually known. Particle deposition must therefore be applied with care on a case-by-case basis using an effective particle size or some size-grouping scheme. Also, if plume depletion is considered, resuspension may become a factor. Resuspension, however, is usually argued to be negligible compared to the plume inhalation dose unless the receptor is assumed to remain in the contaminated area for a long period of time (i.e., years).

2.3.2 Releases From Short Stacks with Momentum/Thermal Rise

Releases in tank farms can occur from short stacks on ventilation systems with upward momentum and/or thermal buoyancy effects. Normally, credit cannot be taken for a stack unless it is at least 2½ times higher than any nearby buildings. In tank farms, however, many of these ventilation system stacks are far from any buildings and so can be credited with reducing exposures to nearby receptors. Additional plume rise can occur if the release has an initial upward momentum, or if the initial temperature of the effluent is higher than that of the

surrounding air. Source volume rate effects (i.e., an initial source concentration) can also be accounted for by using a virtual source model (iflow = 1). That is, a virtual point source is placed upwind of the actual release point at such a distance as to give the plume the required dimensions as it passes over the actual release point. In GXQ, a virtual source correction is made so that the initial plume at the source is given a non-zero size to account for the initial volume rate and initial concentration of material. The initial lateral plume width is based on the stack diameter. The initial vertical plume spread is based on the exhaust flow rate such that the concentration in the initial plume matches the source concentration coming out of the stack (see WHC-SD-GN-SWD-30002, Section 4.2.4).

Two models are available in GXQ to account for plume rise. The first (MELCOR Accident Consequence Code System [MACCS] buoyant plume rise model, irise = 1) is used only for thermally buoyant plumes (such as those from a fire). The second (ISC2 momentum/buoyancy plume rise model, irise = 2) also includes momentum rise due to an initial upward velocity of the plume (such as fan-driven flow out of a stack). The second model will be of most use in tank farms and is the one demonstrated here. In conjunction with plume rise from a stack, three other models are normally incorporated. First, an entrainment model is turned on to account for the turbulent mixing of the plume with the ambient air at the top of the stack (ientr = 1). This produces an initial dispersion of the plume beyond that required to account only for the initial concentration. Second, a correction is made for the fact that the wind speed normally increases with height due to the planetary boundary layer effect (iwind = 1). This will be a minor correction for the short stacks in tank farms. Third, a down-wash model can be turned on to account for the part of the plume sucked into the wake formed behind the top of the stack (iwash = 1). This should be an insignificant effect for the small stack diameters and the high stack air velocities normally encountered at the tank farms.

In general, elevated releases can produce a maximum χ/Q' at a distance beyond 100 m due to the fact that the plume may not have spread down to the receptor height at that distance. For the relatively low elevated releases from tank farms ventilation stacks, this is not expected to be a problem in these cases. If necessary, the χ/Q' can be evaluated under these conditions at 10-m intervals from about 50 m out to 100 m to ensure that the plume has descended to the receptor height, and that the χ/Q' is decreasing as it passes 100 m. It is also possible to have a few "bumps" in the χ/Q' beyond 100 m due to the discrete binning of the data into stability classes and wind speed intervals. The plume from an elevated release tends to "hit the ground" closest to the release point under unstable atmospheric conditions and low wind speeds. Further out, there is a series of shifts to more stable conditions that can produce a few minor oscillations in the χ/Q' . This is not a real (physical) effect, but is an artifact of the calculational method and is generally not significant.

A set of 95th percentile, 1-hr χ/Q' s were calculated using GXQ to demonstrate the effects of having an elevated source with an initial volume rate, rather than the more usual ground level point source approximation. The point source approximation implies an infinite concentration at zero distance from the source. A model assuming an initial source volume rate will exhibit an initial source concentration at zero distance. Three cases were calculated for a short stack (9.5 ft) release. This is about the shortest stack at tank farms. The receptor height was assumed to be 2 m. The following cases are shown:

1. A point source with infinite concentration at zero distance (the regular DSA χ/Q').
2. A source with an initial volume rate ranging from 2 to 1,000 ft³/min, but with no momentum effects. That is, the source plume is assumed to issue from the top of the stack, but to have no initial upward velocity. The plume centerline will therefore remain level with the top of the stack.
3. A source with an initial volume rate ranging from 2 to 1,000 ft³/min and with an initial upward momentum. That is, the source air is assumed to be exiting from a short stack (9.5 ft or 2.90 m) with a diameter of 10 in. pointing vertically upward. This gives some additional elevation to the plume.

The results are provided in Tables 2-13 and 2-14 for an onsite receptor and a receptor at the Hanford Site boundary. Note that three receptor elevations (0, 1, and 2 m) and numerous distances to the onsite individual were tested to find the combination with the largest χ/Q' . Also note that the ambient temperature and stack gas temperature are both assumed to be 20 °C, so there is no thermal rise. Finally, these are all 95th percentile overall (i.e., all sector) χ/Q' with no plume meander.

Table 2-13. All-Sector 95th Percentile, 1-hr χ/Q' for the Onsite Receptor for Various Source Conditions.

Source volumetric flow rate	Point source at ground level	9.5-ft stack release	
		Volume adjust and downwash only	Including momentum rise
0 ft ³ /min	3.28 E-2 s/m ³	--	--
2 ft ³ /min (0.000944 m ³ /s)	--	1.96 E-2 s/m ³	1.95 E-2 s/m ³
5 ft ³ /min (0.00236 m ³ /s)	--	1.94 E-2 s/m ³	1.93 E-2 s/m ³
10 ft ³ /min (0.00472 m ³ /s)	--	1.92 E-2 s/m ³	1.88 E-2 s/m ³
20 ft ³ /min (0.00944 m ³ /s)	--	1.88 E-2 s/m ³	1.89 E-2 s/m ³
50 ft ³ /min (0.02360 m ³ /s)	--	1.80 E-2 s/m ³	1.65 E-2 s/m ³
80 ft ³ /min (0.03776 m ³ /s)	--	1.72 E-2 s/m ³	1.51 E-2 s/m ³
100 ft ³ /min (0.04719 m ³ /s)	--	1.68 E-2 s/m ³	1.41 E-2 s/m ³
120 ft ³ /min (0.05663 m ³ /s)	--	1.65 E-2 s/m ³	1.30 E-2 s/m ³
140 ft ³ /min (0.06607 m ³ /s)	--	1.61 E-2 s/m ³	1.19 E-2 s/m ³
170 ft ³ /min (0.08023 m ³ /s)	--	1.60 E-2 s/m ³	1.10 E-2 s/m ³
200 ft ³ /min (0.09439 m ³ /s)	--	1.59 E-2 s/m ³	9.64 E-3 s/m ³
250 ft ³ /min (0.1180 m ³ /s)	--	1.57 E-2 s/m ³	7.94 E-3 s/m ³
300 ft ³ /min (0.1416 m ³ /s)	--	1.56 E-2 s/m ³	6.35 E-3 s/m ³
400 ft ³ /min (0.1888 m ³ /s)	--	1.52 E-2 s/m ³	5.10 E-3 s/m ³
500 ft ³ /min (0.2360 m ³ /s)	--	1.50 E-2 s/m ³	3.92 E-3 s/m ³
700 ft ³ /min (0.3304 m ³ /s)	--	1.48 E-2 s/m ³	2.83 E-3 s/m ³
1,000 ft ³ /min (0.4179 m ³ /s)	--	1.47 E-2 s/m ³	2.00 E-3 s/m ³

Note:

The worst-case 95th percentile χ/Q' in every case is for a receptor located 100 m downwind. The exceptions are at 500 ft³/min with momentum rise the distance with the largest χ/Q' is 120 m, and at 1000 ft³/min with momentum rise the distance with the largest χ/Q' is 270 m. Note that for 700 ft³/min case the worst receptor location is 100 m.

A graph of the largest onsite χ/Q' is shown in Figure 2-2. As the flow rate decreases, the effect of momentum rise diminishes. The χ/Q' values that include momentum rise are preferred for use in accident evaluations because they represent the situation more accurately. Note that the stack flow rate may not be guaranteed during an accident, assuming the stack is still standing.

Because the curves are close to being made of straight lines with logarithmic scales for both flow rate and χ/Q' , the recommended method of interpolation (log-log) is shown in the formula below. The formula shows how to calculate χ/Q' at an exhaust flow rate F . The flow rates F_A and F_B are the table values that bracket F .

$$(\chi/Q') = (\chi/Q')_A \left(\frac{F}{F_A} \right)^{\text{slope}} \quad \text{and} \quad \text{slope} = \frac{\ln \left[\frac{(\chi/Q')_B}{(\chi/Q')_A} \right]}{\ln \left(\frac{F_B}{F_A} \right)}$$

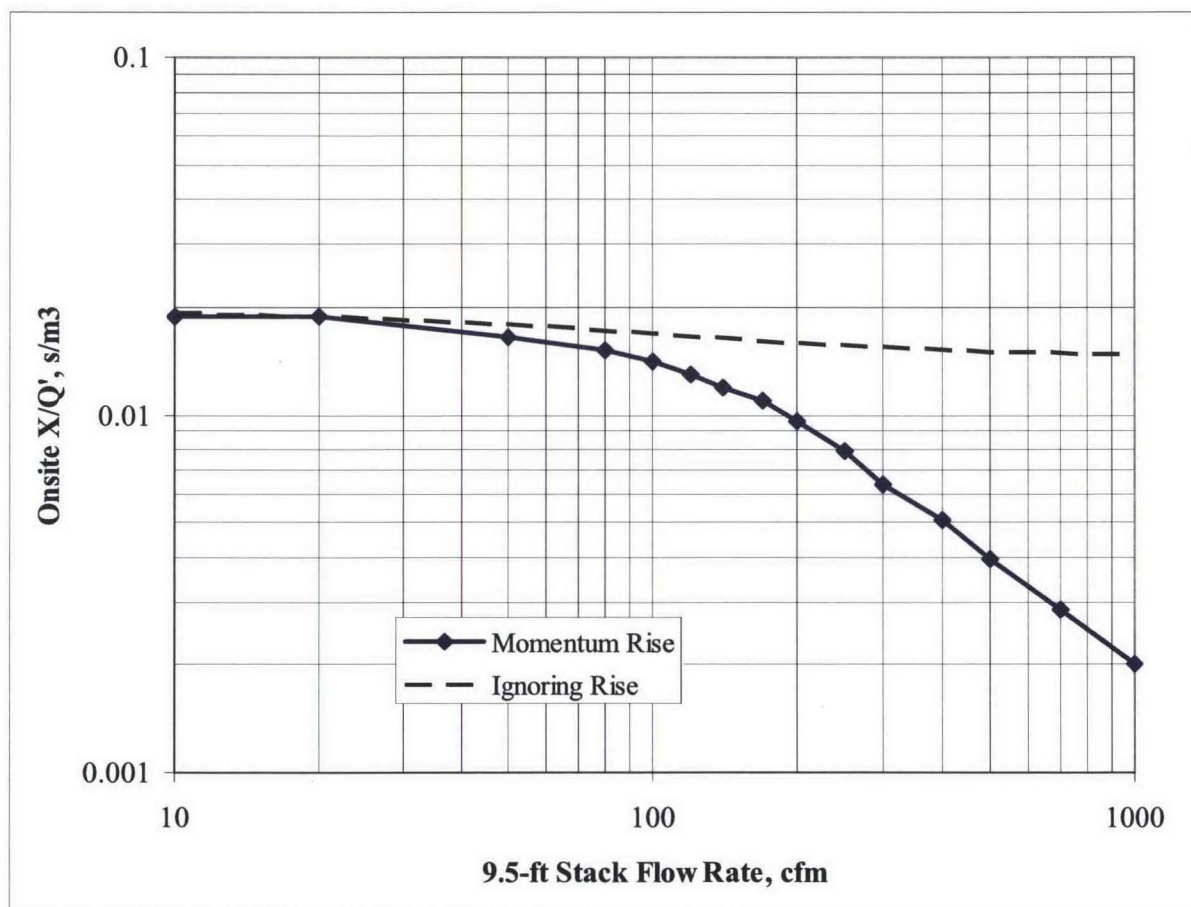
Figure 2-2. Effect of Plume Rise from 9.5-ft Stacks on Onsite χ/Q' Values.

Table 2-14. All-Sector 95th Percentile, 1-hr χ/Q' for the Hanford Site Boundary Receptor for Various Source Conditions

Source volumetric flow rate	Point source at ground level	9.5-ft stack release	
		Volume adjust and downwash only	Including momentum rise
0 ft ³ /min	2.22 E-5 s/m ³	--	--
2 ft ³ /min (0.000944 m ³ /s)	--	2.22 E-5 s/m ³	2.22 E-5 s/m ³
5 ft ³ /min (0.00236 m ³ /s)	--	2.22 E-5 s/m ³	2.22 E-5 s/m ³
10 ft ³ /min (0.00472 m ³ /s)	--	2.22 E-5 s/m ³	2.22 E-5 s/m ³
20 ft ³ /min (0.00944 m ³ /s)	--	2.22 E-5 s/m ³	2.22 E-5 s/m ³
50 ft ³ /min (0.02360 m ³ /s)	--	2.22 E-5 s/m ³	2.22 E-5 s/m ³
80 ft ³ /min (0.03776 m ³ /s)	--	2.22 E-5 s/m ³	2.22 E-5 s/m ³
100 ft ³ /min (0.04719 m ³ /s)	--	2.22 E-5 s/m ³	2.21 E-5 s/m ³
120 ft ³ /min (0.05663 m ³ /s)	--	2.22 E-5 s/m ³	2.21 E-5 s/m ³
140 ft ³ /min (0.06607 m ³ /s)	--	2.22 E-5 s/m ³	2.21 E-5 s/m ³
170 ft ³ /min (0.08023 m ³ /s)	--	2.22 E-5 s/m ³	2.21 E-5 s/m ³
200 ft ³ /min (0.09439 m ³ /s)	--	2.22 E-5 s/m ³	2.21 E-5 s/m ³
250 ft ³ /min (0.1180 m ³ /s)	--	2.22 E-5 s/m ³	2.21 E-5 s/m ³
300 ft ³ /min (0.1416 m ³ /s)	--	2.22 E-5 s/m ³	2.21 E-5 s/m ³
400 ft ³ /min (0.1888 m ³ /s)	--	2.21 E-5 s/m ³	2.20 E-5 s/m ³
500 ft ³ /min (0.2360 m ³ /s)	--	2.21 E-5 s/m ³	2.20 E-5 s/m ³
700 ft ³ /min (0.3304 m ³ /s)	--	2.21 E-5 s/m ³	2.19 E-5 s/m ³
1,000 ft ³ /min (0.4179 m ³ /s)	--	2.21 E-5 s/m ³	2.18 E-5 s/m ³

Note:

The stack diameter is 10 in. Ambient temperature is 20 °C.

The values for the point source model correspond to the 95th percentile overall χ/Q' s with no plume meander in Tables 2-4 and 2-5. This model assumes a zero source volume rate implying an infinite source concentration at zero distance. For this reason, it tends to be overly conservative at very short distances (< 100 m). However, this feature of the standard model has little effect at larger distances such as the Hanford Site boundary because the dilution of the plume in transit dominates any initial dilution at the source. This source is assumed to be at ground level with the receptor at ground level also.

The second case takes account of the initial source volume rate, but takes no credit for initial dilution due to turbulent mixing or plume rise due to the initial velocity of the effluent that is implied by the initial volume rate. The lower volume rate (100 ft³/min) coupled with the plume elevation produces a considerable reduction of the χ/Q' at 100 m, but has little effect at the

Hanford Site boundary because of the large amount of mixing and dilution that occurs in transit. The larger 1,000 ft³/min initial volume rate produces a slightly greater reduction of the 100 m χ/Q' , but still has little effect at the Hanford Site boundary.

The third case has the addition of an initial source velocity and momentum based on the equivalent diameter of the duct or opening through which the source volume rate emanates. In this case, a round opening with a diameter of 10 in. (25.4 cm) was assumed. It was further assumed that the initial source velocity is directed vertically upward giving a momentum plume rise. The temperature of the source plume was assumed to be at the same temperature as ambient so that there is no buoyancy effect due to a temperature difference. Additional effects accounted for include a correction for variation of wind speed with height, and initial air entrainment due to turbulent mixing at the source caused by the upward velocity of the air stream. The 100 ft³/min volume rate produces a slightly larger reduction of the χ/Q' at 100 m, but still has little effect at the Hanford Site boundary because of the large amount of mixing and dilution that occurs in transit. The larger 1,000 ft³/min initial volume rate produces a much greater reduction of the 100 m χ/Q' due to the higher effective plume height, but has little effect at the Hanford Site boundary.

Note that for releases that are elevated at the source due to a short stack, upward momentum, or thermal lofting, the worst-case receptor elevation may not be at ground level. In these cases receptor elevations (z) of 0, 1, and 2 m should be checked as well as downwind distances (x) beyond 100 m to determine which combination of parameters produces the worst case. For a thermally lofted release from or near a large building, the plume may be trapped within the building wake (see WHC-SD-GN-SWD-30002, Section 4.3.1) for wind speeds above a critical value. This test is activated by inserting a non-zero building height in the GXQ input. More discussion about the building wake effect is given in Section 2.3.5.

Appendix O presents additional χ/Q' values for a much taller stack with a height of 155 ft and an inside diameter at the top of 24 in. Calculations at various receptor elevations and distances downwind were used to locate the maximum 95th percentile overall site χ/Q' values. The ambient air temperature is assumed to be 20 °C at the time of the release.

2.3.3 Large Source Effects

The simple Gaussian plume model assumes a point source. However, for some accident scenarios, such as entrainment from a pool, the source may have significant dimensions compared to the distance to the receptor. The initial lateral spread of the source will reduce the concentration at the receptor. To correct for this effect, the MACCS building wake model in GXQ can be used ($i_{wake} = 2$). The width of the source perpendicular to the wind direction is simply entered as the initial plume width in the GXQ input. Note that a plume meander correction should not be applied to a χ/Q' corrected for source width, i.e., a source-width correction should be applied only to the 1-hr χ/Q' .

The effects of an initial source width on 95th percentile χ/Q' s are shown in Tables 2-15 and 2-16. In the case of an effective circular pool, the receptor distance is measured from the center of the pool and the source width corresponds to the pool diameter.

Table 2-15. All-Sector 95th Percentile, 1-hr χ/Q 's for the Onsite Receptor at 100 m for Various Source Widths.

Source width (m)	Point source χ/Q' (s/m ³)	χ/Q' Corrected for source width (s/m ³)	Reduction factor
10	3.28 E-2	2.24 E-2	0.683
20		1.66 E-2	0.506
50		9.21 E-3	0.281
100		5.44 E-3	0.166

Table 2-16. All-Sector 95th Percentile, 1-hr χ/Q 's for the Hanford Site Boundary Receptor for Various Source Widths.

Source width (m)	Point source χ/Q' (s/m ³)	χ/Q' Corrected for source width (s/m ³)	Reduction factor
10	2.22 E-5	2.21 E-5	0.996
20		2.20 E-5	0.991
50		2.16 E-5	0.973
100		2.10 E-5	0.946

A non-zero source size can have a considerable effect on the exposure of the onsite receptor at 100 m, but the effect decreases with increasing distance. Note that a pool can subject the onsite receptor to a direct gamma dose in addition to an inhalation dose from material entrained at the pool surface. The direct dose contribution should be evaluated on a case-by-case basis.

A puff release of toxic material can also be corrected for an initial puff volume by using the MACCS building wake model in GXQ (iwake = 2) with the puff model turned on (ipuff = 1) and the release duration set equal to zero. A special conversion must be made, however, since the MACCS building wake model assumes a Gaussian distribution, whereas the released material concentration is assumed to be uniform over the initial cloud volume. Based on an initial cloud volume, V , derived from ideal gas laws or other considerations, and assuming a hemispherical initial cloud of material with its center at ground level, the initial cloud can be defined in terms of the building height (Hb) and width (Wb) in the MACCS building wake model. Starting with the definitions of the building width and height in terms of the diffusion parameters in the MACCS model shown in WHC-SD-GN-SWD-30002, Section 4.2.2, and the basic definition of the puff χ/Q shown in Section 4.1.2, it can easily be shown that the effective radius of the hemisphere in terms of the MACCS building wake model initial plume dimensions in the GXQ input is given by Equation 2-4:

$$R_{eff} = \frac{2.15}{\sqrt{2\pi}} (2V)^{1/3} = 1.08 V^{1/3} \quad (2-4)$$

The initial plume height (Hb) is then just equal to R_{eff} , while the initial plume width (Wb) is $2 R_{eff}$.

2.3.4 Pool Entrainment

For the special case of wind entrainment from a liquid pool, the release concentration at the receptor is determined not only by the χ/Q' , but also by the rate of entrainment of material from the surface of the pool. The rate of entrainment depends on the size of the pool and is also a sensitive function of the wind speed. Since the χ/Q' is inversely proportional to wind speed and the pool entrainment rate increases with increasing wind speed, these are competing effects and cannot be analyzed separately. The GXQ code contains an option specifically designed to handle pool entrainment cases. When this option is turned on ($isrc = 2$), the χ/Q' is multiplied by a power function of wind speed given by cu^a where u is the wind speed (m/s) and c and a are user-specified constants. The 95th percentile of the parameter $(\chi/Q')(cu^a)$ is found instead of just χ/Q' . It is usual practice to make $c = 1$ and to fold the actual constant multiplier into the source term formulation. It is also usual practice to correct for the width of the pool as discussed in Section 2.3.3.

The appropriate wind speed function was developed in TWR-3958, *Refined Consequence Analysis of Subsurface Leaks from TWRs Facilities that Result in a Surface Pool*, based on data in DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, and is given by Equation 2-5:

$$MRR = 2.14 \times 10^{-15} F_p^3 u^{3.762} \quad (2-5)$$

where:

$$\begin{aligned} MRR &= \text{mass release rate (kg/m}^2\text{s)} \\ F_p &= \text{"fetch," or distance across the pool in the direction of the wind, (m)} \\ u &= \text{wind speed (m/s).} \end{aligned}$$

In order to obtain the total release rate, Q' , the mass release rate must be multiplied by the pool area (m^2). If the release rate in terms of L/s is required, then divide by the liquid density (kg/L, or equivalently g/cm^3). To obtain a total release, Q , for a radiological dose, multiply by the receptor exposure time (s). Since the receptor is normally assumed to be directly downwind of the center of a circular pool, the fetch is normally assumed to be the diameter of the pool. The radiological dose, D , due to entrainment from a liquid pool is then given by Equation 2-6:

$$D = 2.14 \times 10^{-15} \frac{AT F_p}{\rho} \left(\frac{X}{Q'} u^{3.762} \right) (BR)(ULD) \quad (2-6)$$

where:

$$\begin{aligned} A &= \text{pool area (m}^2\text{)} \\ T &= \text{receptor exposure time (s)} \\ \rho &= \text{liquid density} \end{aligned}$$

BR = receptor breathing rate (normally $3.33 \text{ E-4 m}^3/\text{s}$)
 ULD = unit-liter dose (Sv/L or rem/L) for the liquid in the pool.

The $(\chi/Q' u^{3.762})$ is the parameter calculated by GXQ.

The toxic sum of fractions (SOF) for a continuous release is given by Equation 2-7:

$$SOF = 2.14 \times 10^{-15} \frac{AF_p}{\rho} \left(\frac{X}{Q'} u^{3.762} \right) (USOF) \quad (2-7)$$

where:

$USOF$ = unit release rate sum of fractions for continuous releases for the liquid in the pool and the receptor in question.

The 95th percentile parameter $(\chi/Q' u^{3.762})$ for a range of pool sizes (corrected for pool width) is shown in Tables 2-17 and 2-18 for the onsite and Hanford Site boundary receptors, respectively. Note that the distance to the receptor is measured from the center of the pool and the fetch is assumed equal to the pool diameter. The width of the pool was corrected for using the pool diameter as the initial plume width as discussed in Section 2.3.3. A sample GXQ runfile is given in Appendix C. The onsite receptor is normally subject to a direct shine dose from the pool in addition to the inhalation dose from entrained material.

Table 2-17. Entrainment Coefficients for Onsite Receptor.

Pool diameter (m)	Pool area (m ²)	$\chi/Q' u^{3.762}$
10	7.85 E+1	3.32 E+0
20	3.14 E+2	2.35 E+0
30	7.07 E+2	1.83 E+0
40	1.26 E+3	1.47 E+0
50	1.96 E+3	1.28 E+0
60	2.83 E+3	1.09 E+0
70	3.85 E+3	1.00 E+0
80	5.03 E+3	9.27 E-1
90	6.36 E+3	8.61 E-1
100	7.85 E+3	8.04 E-1

Table 2-18. Entrainment Coefficients for Offsite Receptor.

Pool diameter (m)	Pool area (m ²)	$\chi/Q' u^{3.762}$
10	7.85 E+1	2.01 E-3
20	3.14 E+2	2.01 E-3
30	7.07 E+2	2.00 E-3
40	1.26 E+3	2.00 E-3
50	1.96 E+3	1.99 E-3
60	2.83 E+3	1.99 E-3
70	3.85 E+3	1.98 E-3
80	5.03 E+3	1.98 E-3
90	6.36 E+3	1.97 E-3
100	7.85 E+3	1.97 E-3

2.3.5 Building Wake Effects

If a release occurs from a building, the material will become mixed with the building wake within a short distance so that the release plume will initially have some size corresponding to the cross-section of the building perpendicular to the wind direction causing a reduction in the downwind concentration. At Hanford, the NRC Regulatory Guide 1.145 model is used to account for building wake effects. This model can be turned on in GXQ by setting $i_{wake} = 1$ and including the building width and height (m). Note that the Regulatory Guide 1.145 building wake model is coupled with the plume meander correction. If both models are turned on ($i_{wake} = 1$ and $i_{pm} = 1$) with nonzero building dimensions, the larger of the two effects is applied. Note also that the building wake effect is not a time-averaged effect like plume meander. The mixing of the release with the building wake is assumed to occur quickly due to local vorticity around the building and to be complete by the time the plume reaches the onsite receptor at 100 m. The building wake effect can therefore be applied to toxicological as well as radiological consequence calculations.

The building dimensions assumed for the building wake model are the building height (m) and the minimum building width as seen from any direction (m). The operative parameter in the NRC building wake model ($i_{wake} = 1$) is the building cross-sectional area so that a 10 m high by 30 m wide building will have the same effect as a 30 m high by 10 m wide building. Formulation of dimensions of irregularly shaped buildings should be done with this in mind. That is, reasonable dimensions should be assumed that approximate the minimum vertical cross-section of the building when viewed from any direction. Cross-sections for facilities at Hanford are typically around 300 m², but this should be determined on a case-by-case basis. As with elevated plumes, building wake effects tend to decrease with distance as the vertical and lateral extent of the plume increases. Even for a sizable building, therefore, the building wake correction tends to be important only for the onsite receptor. It should also be noted that the maximum building wake correction allowed in the NRC model is a reduction of the χ/Q' by a factor of 3. In addition, NRC Regulatory Guide 1.145 dictates that unless a stack is at least

2.5 times higher than any nearby building, the release must be assumed to mix with the building wake and a stack release model cannot be used.

Sample calculations of χ/Q' 's with building wake corrections are shown in Table 2-19 for minimum building cross-sections from 100 m² to 500 m². The χ/Q' 's for zero building size are just the point release 1-hr χ/Q' 's shown previously in Tables 2-4 and 2-5 and are shown for comparison along with associated reduction factors.

Table 2-19. Example Onsite and Site Boundary χ/Q' 's with Building Wake Correction.

Minimum building cross-section (m ²)	Onsite receptor at 100 m		Site boundary receptor	
	χ/Q' (s/m ³)	Reduction	χ/Q' (s/m ³)	Reduction
0	3.28 E-2	--	2.22 E-5	--
100	1.24 E-2	0.378	2.22 E-5	1.00
200	1.09 E-2	0.333	2.22 E-5	1.00
300	1.09 E-2	0.333	2.21 E-5	0.996
400	1.09 E-2	0.333	2.21 E-5	0.996
500	1.09 E-2	0.333	2.20 E-5	0.991

The modeling of releases with building wake effects is applied to DSA accident analyses in Appendices K and L.

2.3.6 Ground-Level Fires

Fires heat the air nearby causing the combustion products and entrained particulate to have a somewhat lower density than the surrounding air. The emission plume rises due to buoyant effects. Thus, the downwind air concentrations at ground level are lower. This section presents χ/Q' values for a range of possible ground-level fires. The assumed ambient temperature is 20 °C.

Key parameters for input to GXQ are (1) the ambient temperature, (2) the convective heat emission rate of the fire, and (3) the fire diameter. The first parameter, ambient temperature, affects the density of the surrounding air. Higher ambient temperatures lead to less plume rise and higher χ/Q' values. The second parameter, convective heat emission rate, is the amount of energy that goes into heating the gaseous combustion products. Energy lost through radiant emission or absorption/conduction in solid/liquid materials should be subtracted from the total. The third parameter, fire diameter, affects the average heat flux, or heat emission rate per unit area. A fire with a smaller diameter has a larger heat flux. The heat is more concentrated and the buoyant forces larger. Thus a smaller fire diameter leads to more plume rise and a smaller χ/Q' value for a given convective heat emission rate.

Table 2-20 shows the various combinations of fire diameters and heat emission rates that were evaluated. The diameters range from 1 meter to 45 meters, while the heat emission rates range from 10 kW to 0.7 GW. The combinations actually used for GXQ input give heat fluxes ranging

from roughly 0.01 MW/m^2 to 5 MW/m^2 . Fires cooler or hotter than this were deemed unlikely and not evaluated. Table 2-20 shows the heat flux of the fires that were evaluated.

Tables 2-21 and 2-22 show the computed air transport factors for each fire. The χ/Q' values were calculated for three receptor elevations (0, 1, and 2 m) and the largest χ/Q' was selected for the tables. The onsite χ/Q' were also computed at several distances downwind. The distances to the worst-case onsite receptor location is normally 100 m because the higher wind speeds have less plume rise. For fires with total convective powers greater than about 1.5 GW, the 100 m χ/Q' is smaller than the χ/Q' computed for unstable conditions at low wind speed at a distance of about 1400 m. The combination of distance with unstable conditions leads to fumigation-like χ/Q' values that are independent of the initial fire size. Hence, the onsite χ/Q' values are the same. This is judged to be a weakness of the simple models in GXQ, but on the conservative side.

The air transport factors shown in Tables 2-21 and 2-22 are plotted as a function of convective power in Figures 2-3 and 2-4. In these figures the lowest line is for the smallest diameter and the highest line is for the largest diameter. At any given thermal output the larger diameter fire has the larger air transport factor and larger dose. Note that both axes are logarithmic. The preferred method of interpolation to thermal heat rates between table values is therefore a power function.

The air transport factors shown in Tables 2-21 and 2-22 are plotted as a function of fire diameter in Figures 2-5 and 2-6. In these figures the top line is the smallest thermal output and the bottom line has the largest thermal output. At any given fire diameter the lower heat output has the larger air transport factor and larger dose. Note that semi-logarithmic axes are used. The preferred method of interpolation to fire diameters between table values is therefore an exponential function.

Table 2-20. Heat Flux (MW/m²) for Each Fire Evaluated with GXQ.

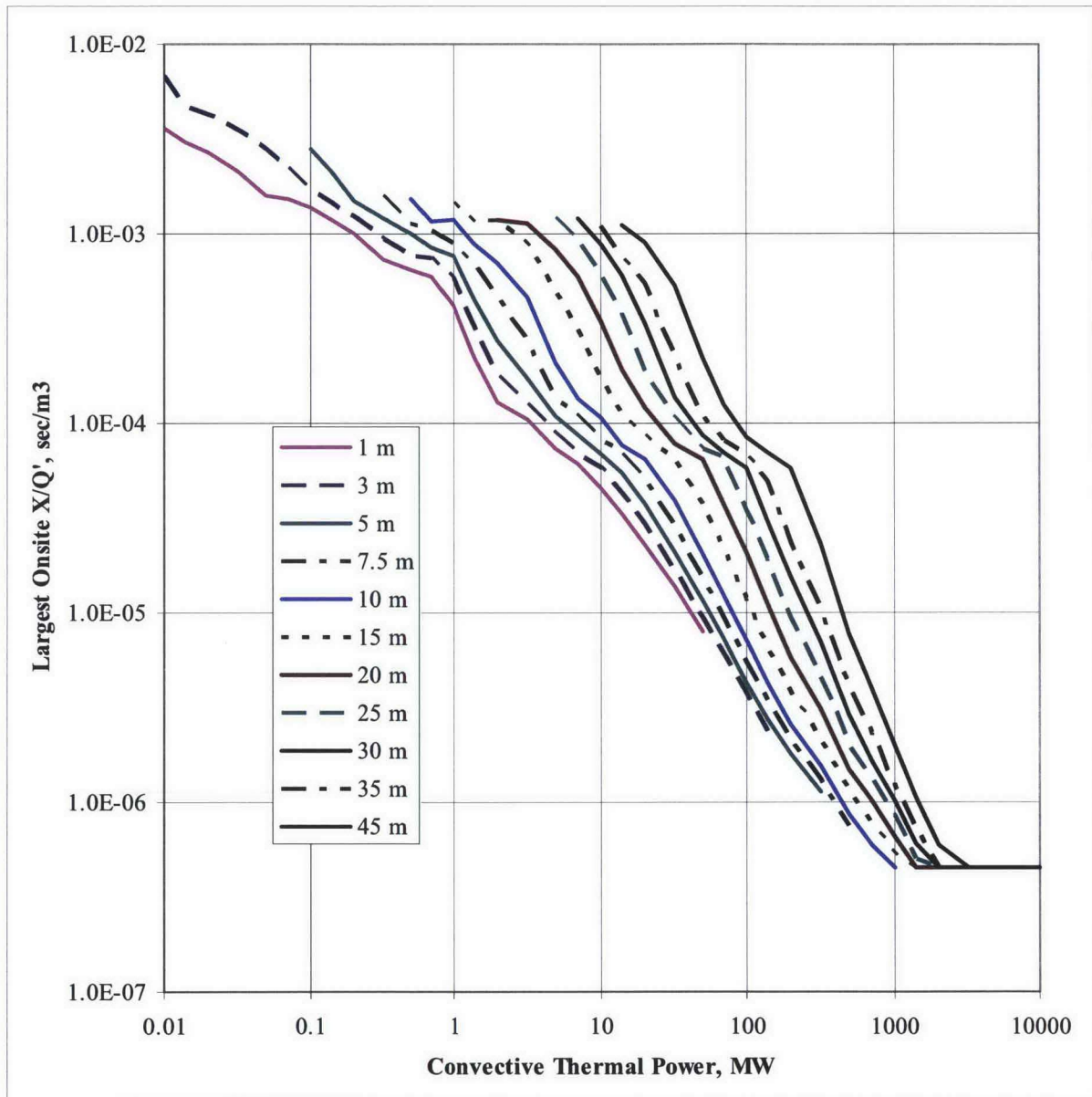
	1 m	3 m	5 m	7.5 m	10 m	15 m	20 m	25 m	30 m	35 m	40 m	45 m
0.01 MW	1.27E-02	1.41E-03	--	--	--	--	--	--	--	--	--	--
0.014 MW	1.78E-02	1.98E-03	--	--	--	--	--	--	--	--	--	--
0.02 MW	2.55E-02	2.83E-03	--	--	--	--	--	--	--	--	--	--
0.032 MW	4.07E-02	4.53E-03	--	--	--	--	--	--	--	--	--	--
0.05 MW	6.37E-02	7.07E-03	--	--	--	--	--	--	--	--	--	--
0.07 MW	8.91E-02	9.90E-03	--	--	--	--	--	--	--	--	--	--
0.1 MW	1.27E-01	1.41E-02	5.09E-03	--	--	--	--	--	--	--	--	--
0.14 MW	1.78E-01	1.98E-02	7.13E-03	--	--	--	--	--	--	--	--	--
0.2 MW	2.55E-01	2.83E-02	1.02E-02	--	--	--	--	--	--	--	--	--
0.32 MW	4.07E-01	4.53E-02	1.63E-02	7.24E-03	--	--	--	--	--	--	--	--
0.5 MW	6.37E-01	7.07E-02	2.55E-02	1.13E-02	6.37E-03	--	--	--	--	--	--	--
0.7 MW	8.91E-01	9.90E-02	3.57E-02	1.58E-02	8.91E-03	--	--	--	--	--	--	--
1 MW	1.27E+00	1.41E-01	5.09E-02	2.26E-02	1.27E-02	5.66E-03	--	--	--	--	--	--
1.4 MW	1.78E+00	1.98E-01	7.13E-02	3.17E-02	1.78E-02	7.92E-03	--	--	--	--	--	--
2 MW	2.55E+00	2.83E-01	1.02E-01	4.53E-02	2.55E-02	1.13E-02	6.37E-03	--	--	--	--	--
3.2 MW	4.07E+00	4.53E-01	1.63E-01	7.24E-02	4.07E-02	1.81E-02	1.02E-02	--	--	--	--	--
5 MW	6.37E+00	7.07E-01	2.55E-01	1.13E-01	6.37E-02	2.83E-02	1.59E-02	1.02E-02	--	--	--	--
7 MW	8.91E+00	9.90E-01	3.57E-01	1.58E-01	8.91E-02	3.96E-02	2.23E-02	1.43E-02	9.90E-03	--	--	--
10 MW	1.27E+01	1.41E+00	5.09E-01	2.26E-01	1.27E-01	5.66E-02	3.18E-02	2.04E-02	1.41E-02	1.04E-02	--	--
14 MW	1.78E+01	1.98E+00	7.13E-01	3.17E-01	1.78E-01	7.92E-02	4.46E-02	2.85E-02	1.98E-02	1.46E-02	1.11E-02	8.80E-03
20 MW	2.55E+01	2.83E+00	1.02E+00	4.53E-01	2.55E-01	1.13E-01	6.37E-02	4.07E-02	2.83E-02	2.08E-02	1.59E-02	1.26E-02
32 MW	4.07E+01	4.53E+00	1.63E+00	7.24E-01	4.07E-01	1.81E-01	1.02E-01	6.52E-02	4.53E-02	3.33E-02	2.55E-02	2.01E-02
50 MW	--	7.07E+00	2.55E+00	1.13E+00	6.37E-01	2.83E-01	1.59E-01	1.02E-01	7.07E-02	5.20E-02	3.98E-02	3.14E-02
70 MW	--	9.90E+00	3.57E+00	1.58E+00	8.91E-01	3.96E-01	2.23E-01	1.43E-01	9.90E-02	7.28E-02	5.57E-02	4.40E-02
100 MW	--	--	5.09E+00	2.26E+00	1.27E+00	5.66E-01	3.18E-01	2.04E-01	1.41E-01	1.04E-01	7.96E-02	6.29E-02
140 MW	--	--	7.13E+00	3.17E+00	1.78E+00	7.92E-01	4.46E-01	2.85E-01	1.98E-01	1.46E-01	1.11E-01	8.80E-02
200 MW	--	--	1.02E+01	4.53E+00	2.55E+00	1.13E+00	6.37E-01	4.07E-01	2.83E-01	2.08E-01	1.59E-01	1.26E-01
320 MW	--	--	--	7.24E+00	4.07E+00	1.81E+00	1.02E+00	6.52E-01	4.53E-01	3.33E-01	2.55E-01	2.01E-01
500 MW	--	--	--	--	6.37E+00	2.83E+00	1.59E+00	1.02E+00	7.07E-01	5.20E-01	3.98E-01	3.14E-01
700 MW	--	--	--	--	8.91E+00	3.96E+00	2.23E+00	1.43E+00	9.90E-01	7.28E-01	5.57E-01	4.40E-01
1,000 MW	--	--	--	--	--	5.66E+00	3.18E+00	2.04E+00	1.41E+00	1.04E+00	7.96E-01	6.29E-01
1,400 MW	--	--	--	--	--	7.92E+00	4.46E+00	2.85E+00	1.98E+00	1.46E+00	1.11E+00	8.80E-01
2,000 MW	--	--	--	--	--	--	6.37E+00	4.07E+00	2.83E+00	2.08E+00	1.59E+00	1.26E+00
3,200 MW	--	--	--	--	--	--	--	6.52E+00	4.53E+00	3.33E+00	2.55E+00	2.01E+00
5,000 MW	--	--	--	--	--	--	--	--	--	5.20E+00	3.98E+00	3.14E+00
7,000 MW	--	--	--	--	--	--	--	--	--	--	5.57E+00	4.40E+00

Table 2-21. All-Sector 95th Percentile, 1-hr χ/Q' (s/m³) for the Onsite Receptor from Each Fire Evaluated with GXQ.

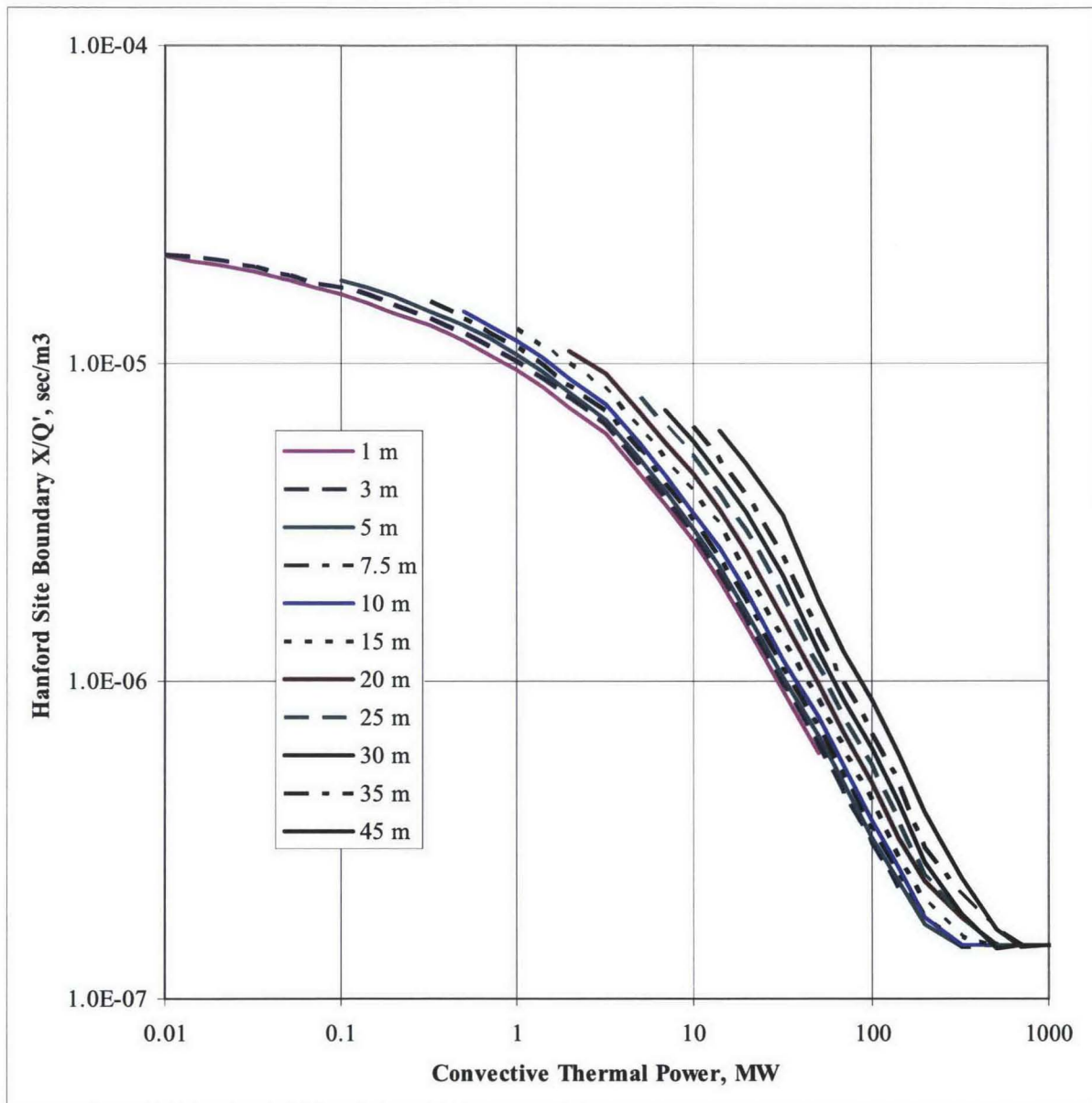
	1 m	3 m	5 m	7.5 m	10 m	15 m	20 m	25 m	30 m	35 m	40 m	45 m
0.01 MW	3.56E-03	6.73E-03	--	--	--	--	--	--	--	--	--	--
0.014 MW	3.06E-03	4.72E-03	--	--	--	--	--	--	--	--	--	--
0.02 MW	2.70E-03	4.24E-03	--	--	--	--	--	--	--	--	--	--
0.032 MW	2.13E-03	3.49E-03	--	--	--	--	--	--	--	--	--	--
0.05 MW	1.60E-03	2.78E-03	--	--	--	--	--	--	--	--	--	--
0.07 MW	1.52E-03	2.22E-03	--	--	--	--	--	--	--	--	--	--
0.1 MW	1.37E-03	1.68E-03	2.77E-03	--	--	--	--	--	--	--	--	--
0.14 MW	1.19E-03	1.45E-03	2.13E-03	--	--	--	--	--	--	--	--	--
0.2 MW	1.01E-03	1.23E-03	1.48E-03	--	--	--	--	--	--	--	--	--
0.32 MW	7.33E-04	9.34E-04	1.20E-03	1.57E-03	--	--	--	--	--	--	--	--
0.5 MW	6.40E-04	7.81E-04	9.94E-04	1.14E-03	1.53E-03	--	--	--	--	--	--	--
0.7 MW	5.95E-04	7.52E-04	8.38E-04	1.05E-03	1.15E-03	--	--	--	--	--	--	--
1 MW	4.11E-04	5.86E-04	7.56E-04	8.80E-04	1.18E-03	1.45E-03	--	--	--	--	--	--
1.4 MW	2.21E-04	3.26E-04	4.55E-04	6.80E-04	8.89E-04	1.15E-03	--	--	--	--	--	--
2 MW	1.28E-04	1.80E-04	2.75E-04	4.71E-04	6.94E-04	1.18E-03	1.17E-03	--	--	--	--	--
3.2 MW	1.05E-04	1.27E-04	1.73E-04	2.72E-04	4.57E-04	8.82E-04	1.14E-03	--	--	--	--	--
5 MW	7.27E-05	8.83E-05	1.08E-04	1.37E-04	2.08E-04	5.05E-04	8.30E-04	1.20E-03	--	--	--	--
7 MW	6.00E-05	6.93E-05	8.69E-05	1.09E-04	1.34E-04	3.09E-04	5.94E-04	8.92E-04	1.21E-03	--	--	--
10 MW	4.55E-05	5.78E-05	6.87E-05	8.30E-05	1.07E-04	1.74E-04	3.46E-04	6.22E-04	8.90E-04	1.09E-03	--	--
14 MW	3.28E-05	4.27E-05	5.45E-05	6.87E-05	7.69E-05	1.09E-04	1.91E-04	3.76E-04	6.07E-04	7.57E-04	1.05E-03	1.10E-03
20 MW	2.24E-05	2.88E-05	3.73E-05	5.01E-05	6.38E-05	8.57E-05	1.22E-04	1.89E-04	3.37E-04	5.41E-04	7.39E-04	8.99E-04
32 MW	1.36E-05	1.65E-05	2.08E-05	2.83E-05	3.91E-05	6.50E-05	7.86E-05	1.06E-04	1.36E-04	2.22E-04	3.70E-04	5.30E-04
50 MW	--	9.39E-06	1.16E-05	1.53E-05	2.04E-05	3.73E-05	6.50E-05	7.26E-05	8.70E-05	1.08E-04	1.47E-04	2.20E-04
70 MW	--	6.08E-06	7.37E-06	9.47E-06	1.23E-05	2.15E-05	3.72E-05	6.55E-05	6.96E-05	8.19E-05	1.04E-04	1.25E-04
100 MW	--	--	4.23E-06	5.47E-06	7.18E-06	1.18E-05	2.10E-05	3.43E-05	5.83E-05	6.87E-05	7.34E-05	8.42E-05
140 MW	--	--	2.76E-06	3.38E-06	4.20E-06	6.62E-06	1.10E-05	1.92E-05	3.01E-05	4.93E-05	6.71E-05	7.00E-05
200 MW	--	--	1.79E-06	2.14E-06	2.59E-06	3.84E-06	5.86E-06	9.40E-06	1.55E-05	2.37E-05	3.58E-05	5.78E-05
320 MW	--	--	--	1.32E-06	1.54E-06	2.15E-06	3.07E-06	4.61E-06	6.98E-06	1.06E-05	1.59E-05	2.31E-05
500 MW	--	--	--	--	8.71E-07	1.14E-06	1.50E-06	2.00E-06	2.88E-06	4.05E-06	5.74E-06	7.82E-06
700 MW	--	--	--	--	5.95E-07	7.72E-07	1.02E-06	1.30E-06	1.67E-06	2.30E-06	3.01E-06	3.96E-06
1,000 MW	--	--	--	--	--	5.34E-07	6.63E-07	8.52E-07	1.02E-06	1.24E-06	1.51E-06	1.98E-06
1,400 MW	--	--	--	--	--	4.54E-07	4.54E-07	5.03E-07	6.06E-07	7.16E-07	8.72E-07	1.07E-06
2,000 MW	--	--	--	--	--	--	4.54E-07	4.54E-07	4.54E-07	4.54E-07	4.95E-07	5.89E-07
3,200 MW	--	--	--	--	--	--	--	4.54E-07	4.54E-07	4.54E-07	4.54E-07	4.54E-07
5,000 MW	--	--	--	--	--	--	--	--	--	4.54E-07	4.54E-07	4.54E-07
7,000 MW	--	--	--	--	--	--	--	--	--	--	4.54E-07	4.54E-07

Table 2-22. All-Sector 95th Percentile, 1-hr χ/Q' (s/m³) for the Hanford Site Boundary Receptor from Each Fire Evaluated with GXQ.

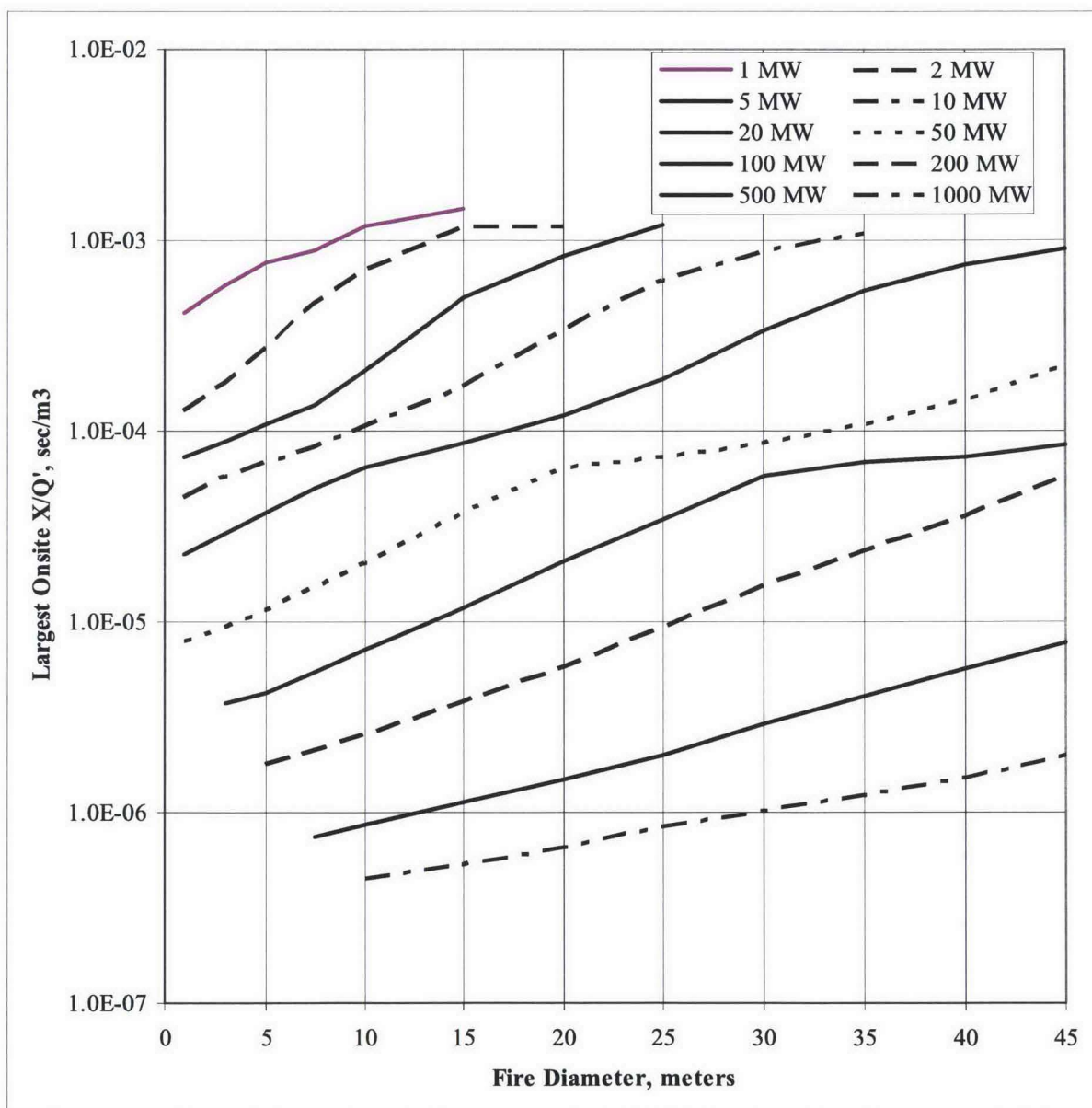
	1 m	3 m	5 m	7.5 m	10 m	15 m	20 m	25 m	30 m	35 m	40 m	45 m
0.01 MW	2.16E-05	2.19E-05	--	--	--	--	--	--	--	--	--	--
0.014 MW	2.10E-05	2.18E-05	--	--	--	--	--	--	--	--	--	--
0.02 MW	2.03E-05	2.11E-05	--	--	--	--	--	--	--	--	--	--
0.032 MW	1.93E-05	2.01E-05	--	--	--	--	--	--	--	--	--	--
0.05 MW	1.82E-05	1.89E-05	--	--	--	--	--	--	--	--	--	--
0.07 MW	1.73E-05	1.81E-05	--	--	--	--	--	--	--	--	--	--
0.1 MW	1.64E-05	1.74E-05	1.82E-05	--	--	--	--	--	--	--	--	--
0.14 MW	1.54E-05	1.64E-05	1.73E-05	--	--	--	--	--	--	--	--	--
0.2 MW	1.44E-05	1.53E-05	1.62E-05	--	--	--	--	--	--	--	--	--
0.32 MW	1.31E-05	1.39E-05	1.46E-05	1.56E-05	--	--	--	--	--	--	--	--
0.5 MW	1.17E-05	1.24E-05	1.31E-05	1.39E-05	1.46E-05	--	--	--	--	--	--	--
0.7 MW	1.06E-05	1.13E-05	1.20E-05	1.26E-05	1.32E-05	--	--	--	--	--	--	--
1 MW	9.49E-06	1.01E-05	1.07E-05	1.13E-05	1.18E-05	1.29E-05	--	--	--	--	--	--
1.4 MW	8.40E-06	8.92E-06	9.45E-06	9.93E-06	1.04E-05	1.14E-05	--	--	--	--	--	--
2 MW	7.25E-06	7.75E-06	8.12E-06	8.54E-06	8.98E-06	9.98E-06	1.09E-05	--	--	--	--	--
3.2 MW	5.97E-06	6.37E-06	6.65E-06	7.01E-06	7.44E-06	8.30E-06	9.24E-06	--	--	--	--	--
5 MW	4.46E-06	4.71E-06	4.94E-06	5.25E-06	5.58E-06	6.18E-06	6.96E-06	7.76E-06	--	--	--	--
7 MW	3.59E-06	3.76E-06	3.94E-06	4.18E-06	4.44E-06	5.04E-06	5.64E-06	6.39E-06	7.13E-06	--	--	--
10 MW	2.74E-06	2.88E-06	3.01E-06	3.19E-06	3.38E-06	3.91E-06	4.50E-06	5.11E-06	5.70E-06	6.33E-06	--	--
14 MW	2.07E-06	2.17E-06	2.27E-06	2.42E-06	2.61E-06	3.07E-06	3.45E-06	3.88E-06	4.41E-06	4.95E-06	5.54E-06	6.13E-06
20 MW	1.49E-06	1.56E-06	1.66E-06	1.80E-06	1.92E-06	2.21E-06	2.57E-06	2.97E-06	3.41E-06	3.87E-06	4.35E-06	4.84E-06
32 MW	9.32E-07	9.79E-07	1.03E-06	1.09E-06	1.16E-06	1.35E-06	1.57E-06	1.84E-06	2.14E-06	2.49E-06	2.89E-06	3.32E-06
50 MW	--	6.26E-07	6.68E-07	7.23E-07	7.70E-07	8.66E-07	9.80E-07	1.11E-06	1.24E-06	1.40E-06	1.57E-06	1.81E-06
70 MW	--	4.48E-07	4.76E-07	5.11E-07	5.44E-07	6.15E-07	6.88E-07	7.72E-07	8.71E-07	9.87E-07	1.11E-06	1.24E-06
100 MW	--	--	3.22E-07	3.39E-07	3.65E-07	4.16E-07	4.79E-07	5.44E-07	6.11E-07	6.83E-07	7.70E-07	8.68E-07
140 MW	--	--	2.34E-07	2.45E-07	2.58E-07	2.80E-07	3.20E-07	3.65E-07	4.19E-07	4.77E-07	5.33E-07	5.92E-07
200 MW	--	--	1.71E-07	1.80E-07	1.80E-07	2.04E-07	2.35E-07	2.43E-07	2.69E-07	2.98E-07	3.37E-07	3.85E-07
320 MW	--	--	--	1.46E-07	1.47E-07	1.57E-07	1.80E-07	1.78E-07	1.85E-07	2.11E-07	2.39E-07	2.40E-07
500 MW	--	--	--	--	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.44E-07	1.64E-07	1.46E-07	1.64E-07
700 MW	--	--	--	--	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.46E-07
1,000 MW	--	--	--	--	--	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.47E-07
1,400 MW	--	--	--	--	--	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.47E-07
2,000 MW	--	--	--	--	--	--	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.47E-07
3,200 MW	--	--	--	--	--	--	--	1.47E-07	1.47E-07	1.47E-07	1.47E-07	1.47E-07
5,000 MW	--	--	--	--	--	--	--	--	--	1.47E-07	1.47E-07	1.47E-07
7,000 MW	--	--	--	--	--	--	--	--	--	--	1.47E-07	1.47E-07

Figure 2-3. Onsite χ/Q' as a Function of Heat Output from the Fire.

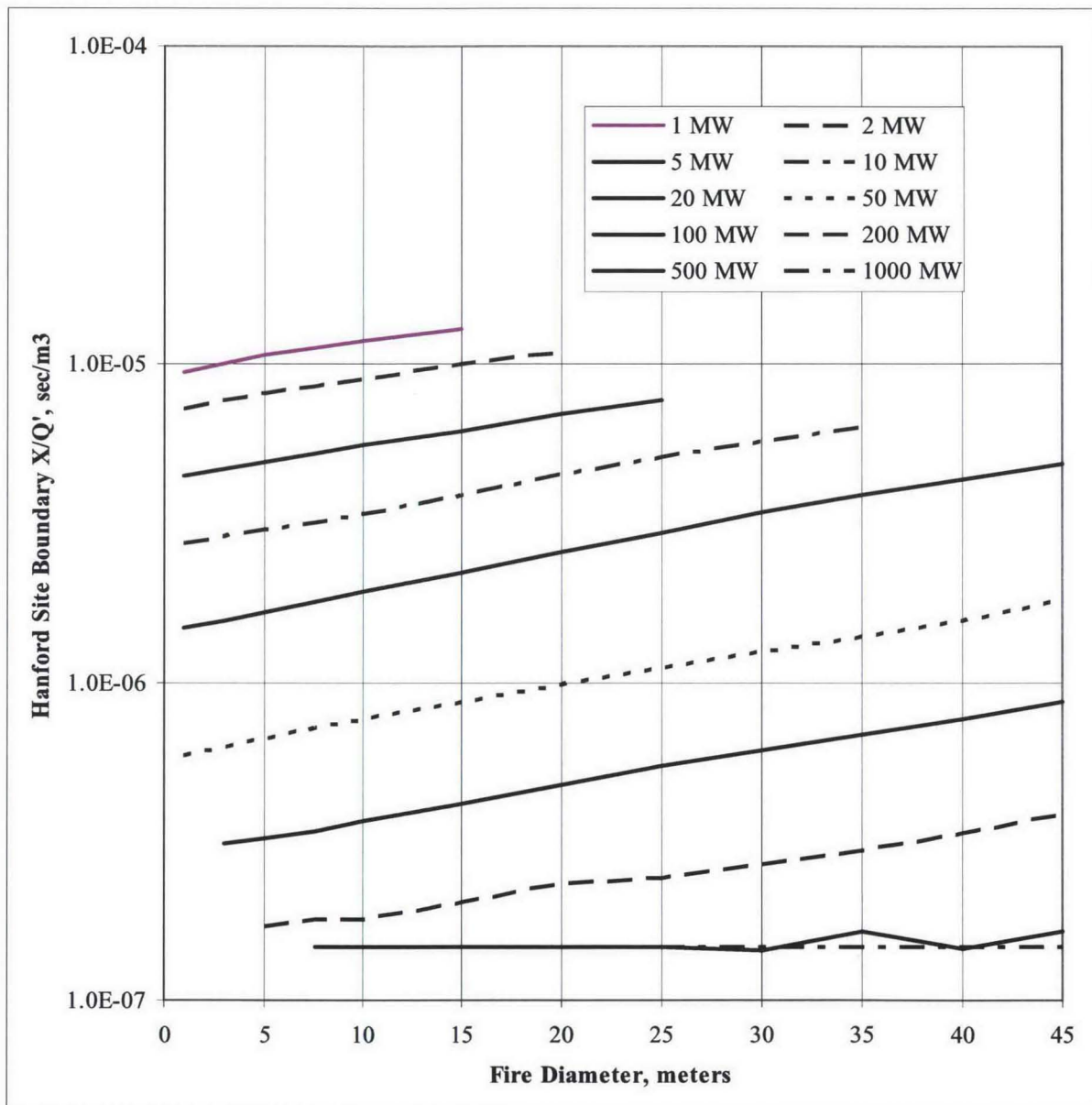
Note for Figure 2-3: The lowest line is 1 m diameter fires while the highest line is for 45 m diameter fires.

Figure 2-4. Hanford Site Boundary χ/Q' as a Function of Heat Output from the Fire.

Note for Figure 2-4: The lowest line is 1 m diameter fires while the highest line is for 45 m diameter fires.

Figure 2-5. Onsite χ/Q' as a Function of Fire Diameter.

Note for Figure 2-5: The highest line shows fires with the smallest convective heat emission rate (1 MW) while the lowest line shows fires with the largest heat emission rate (1,000 MW).

Figure 2-6. Hanford Site Boundary χ/Q' as a Function of Fire Diameter.

Note for Figure 2-6: The highest line shows fires with the smallest convective heat emission rate (1 MW) while the lowest line shows fires with the largest heat emission rate (1,000 MW).

To estimate χ/Q' for heat output or diameters that are not listed, the following method should be used. An example is provided below to illustrate the method.

The first interpolation should be on the convective thermal power using the formula shown below. The formula shows how to calculate χ/Q' at a thermal power P . The thermal powers P_A and P_B are table values that bracket P at a particular fire diameter.

$$(\chi/Q') = (\chi/Q')_A \left(\frac{P}{P_A} \right)^{\text{slope}} \quad \text{and} \quad \text{slope} = \frac{\ln \left[\frac{(\chi/Q')_B}{(\chi/Q')_A} \right]}{\ln \left(\frac{P_B}{P_A} \right)}$$

If the diameter of the fire is a table value, then no further calculations are required. If the diameter is not a table value, then the above interpolation should be carried out for both of the table diameters that bracket the special diameter. The interpolation on fire diameter is carried out using the formula shown below. The formula shows how to calculate χ/Q' at a diameter D . The diameters D_A and D_B are table values that bracket D .

$$(\chi/Q') = (\chi/Q')_A \left[\frac{(\chi/Q')_B}{(\chi/Q')_A} \right]^{\text{frac}} \quad \text{and} \quad \text{frac} = \frac{D - D_A}{D_B - D_A}$$

For example, consider the fire evaluated in Appendix G with a convective thermal power of 6.8 MW and a diameter of 2 m. The onsite χ/Q' table values for thermal power are 5 MW and 7 MW. The table values for fire diameter are 1 m and 3 m. Thus, a two-dimensional interpolation is necessary. The interpolation on thermal power is carried out first. Two interpolations are needed, one for each fire diameter. The first interpolation uses the onsite χ/Q' values for a diameter of 1 m at power levels of 5 MW and 7 MW to find the χ/Q' at 6.8 MW. The calculation is shown below.

$$\text{slope} = \frac{\ln \left(\frac{6.00 \times 10^{-5} \text{ s/m}^3}{7.27 \times 10^{-5} \text{ s/m}^3} \right)}{\ln \left(\frac{7 \text{ MW}}{5 \text{ MW}} \right)} = -0.57062$$

$$(\chi/Q')_{1\text{ m}} = \left(7.27 \times 10^{-5} \text{ s/m}^3 \right) \left(\frac{6.8 \text{ MW}}{5 \text{ MW}} \right)^{-0.57062} = 6.100 \times 10^{-5} \text{ s/m}^3$$

The second interpolation on thermal power uses the onsite χ/Q' table values for a diameter of 3 m at power levels of 5 MW and 7 MW to find the χ/Q' at 6.8 MW. The calculation is shown below.

$$\text{slope} = \frac{\ln\left(\frac{6.93 \times 10^{-5} \text{ s/m}^3}{8.83 \times 10^{-5} \text{ s/m}^3}\right)}{\ln\left(\frac{7 \text{ MW}}{5 \text{ MW}}\right)} = -0.72010$$

$$(\chi/Q')_{3\text{ m}} = \left(8.83 \times 10^{-5} \text{ s/m}^3\right) \left(\frac{6.8 \text{ MW}}{5 \text{ MW}}\right)^{-0.72010} = 7.076 \times 10^{-5} \text{ s/m}^3$$

The final interpolation is between the 1 m and 3 m χ/Q' values calculated above. The semi-logarithmic interpolation on fire diameter is shown below.

$$\text{frac} = \frac{(2 \text{ m}) - (1 \text{ m})}{(3 \text{ m}) - (1 \text{ m})} = 0.50$$

$$(\chi/Q') = \left(6.100 \times 10^{-5} \text{ s/m}^3\right) \left(\frac{7.076 \times 10^{-5} \text{ s/m}^3}{6.100 \times 10^{-5} \text{ s/m}^3}\right)^{0.50} = 6.57 \times 10^{-5} \text{ s/m}^3$$

For comparison with the other fires described in the appendices, Table 2-23 shows the χ/Q' values from the appendices as well as the calculated χ/Q' using the method described above. All of the calculated values were within 10% of the GXQ results.

It should be noted that several of the RPP-13482 values for χ/Q' were calculated assuming a particular receptor elevation rather than trying three elevations (0 m, 1 m, and 2 m) to find the worst case. Table 2-24 shows the changes that would follow from general application of this method. The changed χ/Q' are shown in bold italics. The recalculated χ/Q' values generally agree better with the interpolated values.

Table 2-23. Comparison of χ/Q' from RPP-13482 and Table Interpolation.

Reference	Heat output, MW	Diameter, meters	Heat flux MW/m ²	RPP-13482 appendix		Interpolation from tables		Percent difference	
				Onsite	Boundary	Onsite	Boundary	Onsite	Boundary
Appendix G	6.8	2	2.16	6.55E-05	3.74E-06	6.57E-05	3.74E-06	0.3%	0.1%
	27.1	4	2.16	2.27E-05	1.18E-06	2.27E-05	1.19E-06	-0.1%	0.5%
	1	3.77	0.0896	6.32E-04	1.03E-05	6.46E-04	1.03E-05	2.3%	0.3%
	4	3.77	0.358	1.08E-04	5.51E-06	1.17E-04	5.57E-06	8.2%	1.2%
Appendix J	0.157	2	0.050	1.15E-03	1.56E-05	1.25E-03	1.55E-05	8.4%	-0.3%
	0.220	2	0.070	1.00E-03	1.46E-05	1.05E-03	1.46E-05	4.9%	-0.3%
	0.283	2	0.090	8.54E-04	1.38E-05	8.94E-04	1.38E-05	4.7%	0.2%
	0.353	3	0.050	9.09E-04	1.35E-05	8.98E-04	1.36E-05	-1.2%	0.4%
	0.495	3	0.070	7.82E-04	1.24E-05	7.84E-04	1.24E-05	0.3%	0.3%
	0.636	3	0.090	7.23E-04	1.16E-05	7.60E-04	1.16E-05	5.1%	0.0%
	0.628	4	0.050	8.08E-04	1.20E-05	8.21E-04	1.20E-05	1.6%	-0.1%
	0.880	4	0.070	6.98E-04	1.08E-05	7.09E-04	1.08E-05	1.6%	0.3%
	1.13	4	0.090	5.64E-04	9.93E-06	5.45E-04	9.93E-06	-3.4%	0.0%
Appendix M	24.3	5.25	1.12	3.04E-05	1.36E-06	3.02E-05	1.37E-06	-0.7%	0.9%
	128.2	13	0.966	6.28E-06	2.95E-07	6.39E-06	2.99E-07	1.8%	1.4%
	1880	43	1.29	6.04E-07	1.47E-07	6.08E-07	1.47E-07	0.7%	0.0%
Appendix N	24.2	4.8	1.34	2.89E-05	1.35E-06	2.87E-05	1.36E-06	-0.6%	0.7%
	289	16.9	1.29	2.59E-06	1.71E-07	2.81E-06	1.75E-07	8.4%	2.4%

Notes:

Negative values for percent difference mean the interpolated value is smaller than the value shown in RPP-13482.

Values for χ/Q' shown in bold italics type would change if all three receptor elevations were evaluated and the worst case selected.

Table 2-24. Comparison of Recalculated χ/Q' from GXQ and Table Interpolation.

Reference	Heat output, MW	Diameter, meters	Heat flux MW/m ²	Recalculated RPP-13482 appendix values		Interpolation from tables		Percent difference	
				Onsite	Boundary	Onsite	Boundary	Onsite	Boundary
Appendix G	6.8	2	2.16	6.55E-05	3.74E-06	6.57E-05	3.74E-06	0.3%	0.1%
	27.1	4	2.16	2.27E-05	1.18E-06	2.27E-05	1.19E-06	-0.1%	0.5%
	1	3.77	0.0896	<i>6.57E-04</i>	1.03E-05	6.46E-04	1.03E-05	<i>-1.6%</i>	0.3%
	4	3.77	0.358	1.08E-04	5.51E-06	1.17E-04	5.57E-06	8.2%	1.2%
Appendix J	0.157	2	0.050	<i>1.33E-03</i>	1.56E-05	1.25E-03	1.55E-05	<i>-6.3%</i>	-0.3%
	0.220	2	0.070	<i>1.05E-03</i>	1.46E-05	1.05E-03	1.46E-05	<i>-0.1%</i>	-0.3%
	0.283	2	0.090	8.54E-04	1.38E-05	8.94E-04	1.38E-05	4.7%	0.2%
	0.353	3	0.050	9.09E-04	<i>1.36E-05</i>	8.98E-04	1.36E-05	-1.2%	<i>-0.3%</i>
	0.495	3	0.070	7.82E-04	<i>1.25E-05</i>	7.84E-04	1.24E-05	0.3%	<i>-0.5%</i>
	0.636	3	0.090	<i>7.53E-04</i>	1.16E-05	7.60E-04	1.16E-05	<i>0.9%</i>	0.0%
	0.628	4	0.050	8.08E-04	1.20E-05	8.21E-04	1.20E-05	1.6%	-0.1%
	0.880	4	0.070	<i>7.52E-04</i>	1.08E-05	7.09E-04	1.08E-05	<i>-5.7%</i>	0.3%
	1.13	4	0.090	<i>5.67E-04</i>	<i>9.94E-06</i>	5.45E-04	9.93E-06	<i>-3.9%</i>	<i>-0.1%</i>
Appendix M	24.3	5.25	1.12	3.04E-05	<i>1.37E-06</i>	3.02E-05	1.37E-06	-0.7%	<i>0.1%</i>
	128.2	13	0.966	6.28E-06	<i>2.96E-07</i>	6.39E-06	2.99E-07	1.8%	<i>1.0%</i>
	1880	43	1.29	6.04E-07	1.47E-07	6.08E-07	1.47E-07	0.7%	0.0%
Appendix N	24.2	4.8	1.34	2.89E-05	<i>1.36E-06</i>	2.87E-05	1.36E-06	-0.6%	<i>0.0%</i>
	289	16.9	1.29	2.59E-06	<i>1.72E-07</i>	2.81E-06	1.75E-07	8.4%	<i>1.8%</i>

Notes:

Negative values for percent difference mean the interpolated value is smaller than the recalculated RPP-13482 value.

Values for χ/Q' shown in bold italics type differ from RPP-13482 because all three receptor elevations were evaluated and the worst case selected.

An additional concern when modeling ground-level fires is the presence of nearby buildings or other wind-obstructing structures. The turbulence near the building may trap the plume from the fire and keep it from rising according to the GXQ model. This is especially true for smaller fires. Without plume rise, the χ/Q' will be larger. However, the building turbulence disperses the trapped plume, tending to offset the increase.

The effect of building turbulence on nearby fires was explored in HNF-25195, *Alternate Model for Plume Rise Near Buildings*. A conclusion of that report was that the ground-level fire model in GXQ is conservative for many fires even near large buildings.

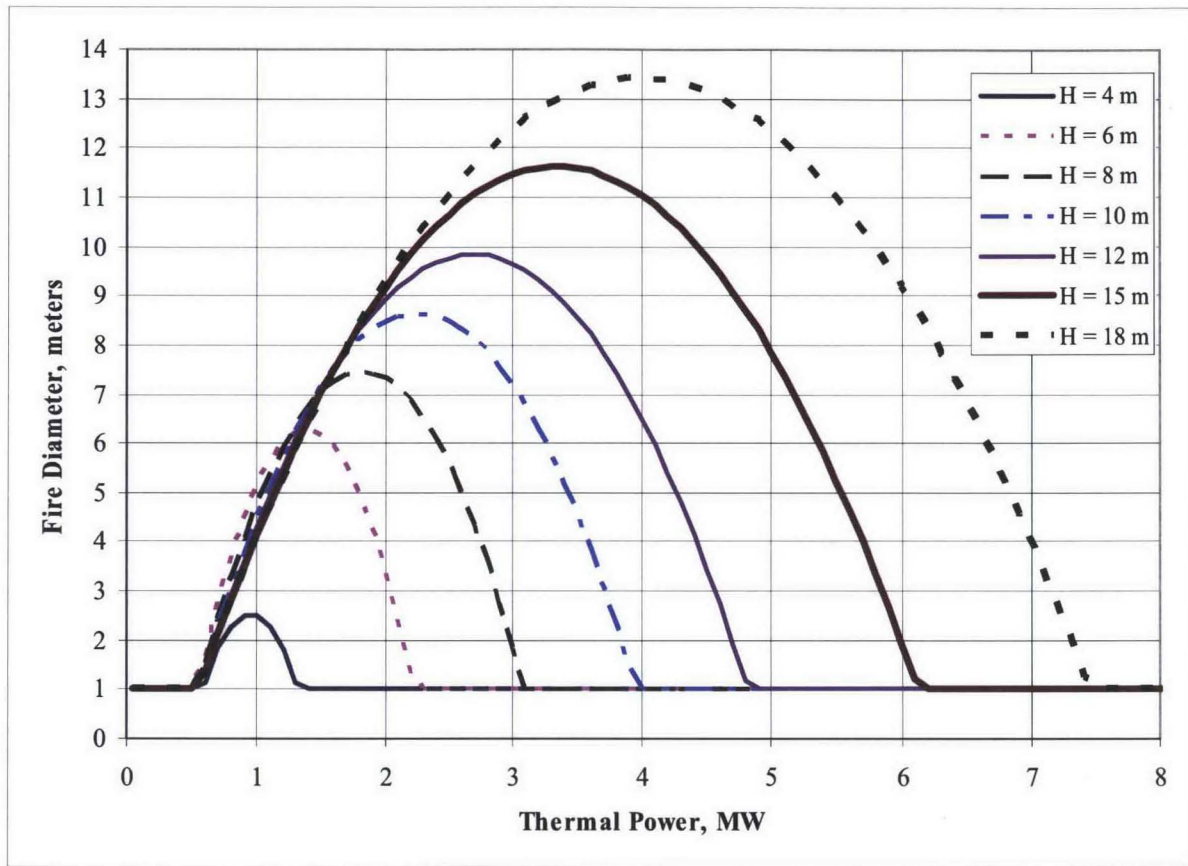
In a narrow range of cases the GXQ ground-level fire will produce χ/Q' values that are smaller than the Alternate Model. Comparing GXQ results with the Alternate Model leads to an approximate graphical definition of when the ground-level fire model in GXQ may be nonconservative. Figure 2-7 illustrates the approximate boundary for various building heights. The building width has little effect on the curves, and is not included.

Figure 2-7 is used to check the validity of the GXQ ground level fire model when a building is located nearby. In general, the taller the nearby building, the greater the range of fires that will be poorly represented using the GXQ ground-level fire model. It has been assumed that no fire has a diameter less than 1 m.

The postulated fire has a particular thermal power and diameter and can be plotted as a point in Figure 2-7. If the postulated fire is inside the hump corresponding to height of a nearby building, the fire should be evaluated using an approach similar to the Alternate Model described in HNF-25195. If the postulated fire is located above or to the side of the hump for a particular building height, then the χ/Q' from GXQ is conservative, i.e., it is larger than the χ/Q' from the Alternate Model.

To illustrate the determination of the boundary between GXQ and the Alternate Model, Tables 2-25 and 2-26 show the respective χ/Q' for a building height of 15 m and a building width of 40 m. Note that the thermal powers and fire diameters are more closely spaced than the ones shown in Table 2-21. In Table 2-27 are ratios of GXQ χ/Q' divided by Alternate Model χ/Q' . The region where the ratios are less than one is the region of concern since GXQ will underestimate the χ/Q' . This region is roughly the same as the area shown in Figure 2-7 for the 15 m building height.

Figure 2-7. Fire Sizes Where the Alternate Model is Recommended.



Note for Figure 2-7: The highest line (dotted) shows the boundary between GXQ and the Alternate Model for the tallest building (18 m height). The boundary for the shortest building (4 m height) is the hump farthest to the left.

Table 2-25. All-Sector 95th Percentile, 1-hr Onsite χ/Q' from GXQ

	1 m	1.5 m	2 m	3 m	4 m	5 m	6 m	7 m	8 m	10 m	12 m	14 m
320 kW	7.33E-04	7.64E-04	7.78E-04	9.34E-04	1.05E-03	1.20E-03	1.27E-03	--	--	--	--	--
380 kW	7.00E-04	7.56E-04	7.62E-04	8.86E-04	9.86E-04	1.09E-03	1.19E-03	1.15E-03	--	--	--	--
460 kW	6.61E-04	7.18E-04	7.43E-04	7.95E-04	9.03E-04	1.02E-03	1.12E-03	1.20E-03	--	--	--	--
560 kW	6.63E-04	6.76E-04	7.31E-04	7.72E-04	8.23E-04	9.66E-04	1.04E-03	1.20E-03	1.14E-03	--	--	--
680 kW	5.98E-04	6.65E-04	6.82E-04	7.42E-04	7.91E-04	8.41E-04	9.64E-04	1.04E-03	1.09E-03	1.15E-03	--	--
830 kW	5.33E-04	5.84E-04	6.37E-04	7.39E-04	7.64E-04	8.02E-04	8.51E-04	9.41E-04	1.04E-03	1.14E-03	--	--
1.0 MW	4.11E-04	4.57E-04	4.98E-04	5.86E-04	6.80E-04	7.56E-04	7.82E-04	8.39E-04	9.28E-04	1.18E-03	1.15E-03	--
1.2 MW	3.08E-04	3.40E-04	3.76E-04	4.49E-04	5.19E-04	5.90E-04	6.60E-04	7.37E-04	8.09E-04	1.04E-03	1.13E-03	--
1.5 MW	1.86E-04	2.04E-04	2.29E-04	2.77E-04	3.29E-04	3.91E-04	4.81E-04	5.81E-04	6.88E-04	8.81E-04	1.08E-03	1.14E-03
1.8 MW	1.30E-04	1.51E-04	1.57E-04	1.94E-04	2.37E-04	3.02E-04	3.91E-04	4.81E-04	5.76E-04	7.39E-04	9.56E-04	1.14E-03
2.2 MW	1.10E-04	1.29E-04	1.30E-04	1.56E-04	1.94E-04	2.35E-04	2.95E-04	3.81E-04	4.64E-04	6.48E-04	7.63E-04	1.00E-03
2.6 MW	1.09E-04	1.09E-04	1.24E-04	1.34E-04	1.60E-04	1.94E-04	2.35E-04	2.93E-04	3.78E-04	5.35E-04	6.93E-04	8.85E-04
3.2 MW	1.04E-04	1.06E-04	1.13E-04	1.10E-04	1.30E-04	1.57E-04	1.88E-04	2.26E-04	2.73E-04	4.12E-04	5.77E-04	7.34E-04
3.8 MW	8.75E-05	8.91E-05	1.04E-04	1.07E-04	1.10E-04	1.29E-04	1.56E-04	1.84E-04	2.22E-04	3.26E-04	4.68E-04	6.21E-04
4.6 MW	7.79E-05	8.30E-05	8.69E-05	9.30E-05	1.07E-04	1.09E-04	1.29E-04	1.53E-04	1.75E-04	2.35E-04	3.47E-04	4.91E-04
5.6 MW	6.67E-05	7.03E-05	7.48E-05	8.60E-05	9.12E-05	1.06E-04	1.08E-04	1.25E-04	1.33E-04	1.85E-04	2.52E-04	3.75E-04
6.8 MW	6.14E-05	6.35E-05	6.55E-05	7.10E-05	8.04E-05	8.76E-05	1.04E-04	1.07E-04	1.10E-04	1.37E-04	1.92E-04	2.59E-04
8.3 MW	5.13E-05	5.62E-05	5.96E-05	6.41E-05	6.94E-05	7.48E-05	8.59E-05	9.03E-05	1.05E-04	1.22E-04	1.41E-04	1.93E-04
10 MW	--	4.70E-05	4.87E-05	5.78E-05	6.23E-05	6.87E-05	7.18E-05	7.68E-05	8.75E-05	1.07E-04	1.22E-04	1.42E-04

Table 2-26. All-Sector 95th Percentile, 1-hr Onsite χ/Q' from the Alternate Model for a Building Height of 15 m

	1 m	1.5 m	2 m	3 m	4 m	5 m	6 m	7 m	8 m	10 m	12 m	14 m
320 kW	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	--	--	--	--	--
380 kW	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	--	--	--	--
460 kW	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	--	--	--	--
560 kW	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	--	--	--
680 kW	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	--	--
830 kW	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	--	--
1.0 MW	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	--
1.2 MW	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	--
1.5 MW	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04	6.70E-04
1.8 MW	6.50E-04	6.50E-04	6.50E-04	6.50E-04	6.50E-04	6.50E-04	6.50E-04	6.50E-04	6.50E-04	6.50E-04	6.50E-04	6.50E-04
2.2 MW	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04
2.6 MW	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04
3.2 MW	5.47E-04	5.47E-04	5.47E-04	5.47E-04	5.47E-04	5.47E-04	5.47E-04	5.47E-04	5.47E-04	5.47E-04	5.47E-04	5.47E-04
3.8 MW	4.48E-04	4.48E-04	4.48E-04	4.48E-04	4.48E-04	4.48E-04	4.48E-04	4.48E-04	4.48E-04	4.48E-04	4.48E-04	4.48E-04
4.6 MW	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	2.45E-04
5.6 MW	1.09E-04	1.09E-04	1.09E-04	1.09E-04	1.09E-04	1.09E-04	1.09E-04	1.09E-04	1.09E-04	1.12E-04	1.33E-04	1.81E-04
6.8 MW	3.80E-05	3.86E-05	4.23E-05	4.64E-05	5.09E-05	5.61E-05	6.13E-05	6.77E-05	7.49E-05	9.35E-05	1.12E-04	1.45E-04
8.3 MW	1.43E-05	1.57E-05	1.66E-05	2.00E-05	2.40E-05	2.93E-05	3.79E-05	4.36E-05	5.65E-05	8.02E-05	9.61E-05	1.15E-04
10 MW	--	5.05E-06	6.11E-06	9.69E-06	1.37E-05	1.88E-05	2.69E-05	3.29E-05	4.52E-05	6.61E-05	8.55E-05	9.89E-05

Table 2-27. Ratios of 1-hr Onsite χ/Q' -- GXQ Divided by Alternate Model

	1 m	1.5 m	2 m	3 m	4 m	5 m	6 m	7 m	8 m	10 m	12 m	14 m
320 kW	1.09	1.14	1.16	1.39	1.57	1.79	1.89	--	--	--	--	--
380 kW	1.04	1.13	1.14	1.32	1.47	1.63	1.78	1.72	--	--	--	--
460 kW	0.99	1.07	1.11	1.19	1.35	1.52	1.67	1.79	--	--	--	--
560 kW	0.99	1.01	1.09	1.15	1.23	1.44	1.55	1.79	1.70	--	--	--
680 kW	0.89	0.99	1.02	1.11	1.18	1.25	1.44	1.55	1.63	1.72	--	--
830 kW	0.80	0.87	0.95	1.10	1.14	1.20	1.27	1.40	1.55	1.70	--	--
1.0 MW	0.61	0.68	0.74	0.87	1.01	1.13	1.17	1.25	1.38	1.76	1.72	--
1.2 MW	0.46	0.51	0.56	0.67	0.77	0.88	0.98	1.10	1.21	1.55	1.69	--
1.5 MW	0.28	0.30	0.34	0.41	0.49	0.58	0.72	0.87	1.03	1.31	1.61	1.70
1.8 MW	0.20	0.23	0.24	0.30	0.36	0.46	0.60	0.74	0.89	1.14	1.47	1.75
2.2 MW	0.18	0.21	0.21	0.25	0.31	0.38	0.48	0.62	0.75	1.05	1.23	1.62
2.6 MW	0.18	0.18	0.20	0.22	0.26	0.31	0.38	0.47	0.61	0.87	1.12	1.43
3.2 MW	0.19	0.19	0.21	0.20	0.24	0.29	0.34	0.41	0.50	0.75	1.05	1.34
3.8 MW	0.20	0.20	0.23	0.24	0.25	0.29	0.35	0.41	0.50	0.73	1.05	1.39
4.6 MW	0.45	0.47	0.50	0.53	0.61	0.62	0.74	0.87	1.00	1.34	1.98	2.01
5.6 MW	0.61	0.65	0.69	0.79	0.84	0.97	0.99	1.15	1.22	1.66	1.90	2.08
6.8 MW	1.61	1.65	1.55	1.53	1.58	1.56	1.70	1.58	1.47	1.47	1.72	1.79
8.3 MW	3.59	3.59	3.58	3.21	2.89	2.56	2.27	2.07	1.86	1.52	1.47	1.69
10 MW	--	9.30	7.96	5.96	4.55	3.66	2.67	2.34	1.94	1.62	1.43	1.44

2.4 SELECTION OF APPROPRIATE DISPERSION COEFFICIENTS

This section discusses the selection of appropriate χ/Q' from the previous sections for radioactive and toxic chemical releases based on the scenario of interest. These guidelines outline the specific dispersion coefficients to be used for most accident scenarios. As discussed in Section 2.3, scenario-specific calculations can be made invoking plume depletion, plume rise, virtual source, and/or entrainment models where appropriate.

2.4.1 Short (< 1 hr) or Variable Rate Releases

For accident scenarios with release durations less than 1 hr, the bounding (95th percentile overall) χ/Q' (known as the 1-hr χ/Q') should be used. The 1-hr χ/Q' should also be used where the release has a longer duration, but has a variable rate (such as an exponentially decreasing rate). The corresponding 50th percentile χ/Q' s may be used for beyond design basis accidents. Comparison of 50th percentile and 95th percentile values can also give an estimate for the degree of conservatism in an analysis. These χ/Q' s are provided in Tables 2-4 and 2-5 for the onsite receptor (worker) and the Hanford Site boundary receptor (MOI), respectively. Plume depletion, plume rise, and large source corrections can be applied to both the 95th and 50th percentile 1-hr χ/Q' s.

Since the 1-hr χ/Q' represents an "instantaneous" concentration at the receptor location, it can be used for toxic chemical releases where the release is given in terms of a release rate. Furthermore, since plume depletion, plume rise, and large source corrections represent continuous, rather than time averaging effects, these modifications can be applied to toxic releases.

2.4.2 Release Durations From One to Two Hours

For accident scenarios with a release duration of at least 1 hr where the release rate is approximately constant, the bounding (95th percentile overall) χ/Q' with plume meander (known as the 2-hr χ/Q') may be used. The corresponding 50th percentile χ/Q' s may be used for beyond design basis accidents. Comparison of 50th percentile and 95th percentile values can also give an estimate for the degree of conservatism in an analysis. These χ/Q' s are provided in Tables 2-4 and 2-5 for the onsite 100-m receptor (worker) and the Hanford Site boundary receptor (MOI), respectively. Plume depletion and plume rise corrections can be applied to both the 95th and 50th percentile 2-hr χ/Q' s. The large source correction, however, cannot be applied to the 2-hr χ/Q' because it already incorporates a plume meander correction (which assumes a point source). Plume meander (i.e., variations in wind direction) will have less effect on a plume from an extended source. Thus, combining the two modifications would overcorrect the χ/Q' in the nonconservative direction.

Since the plume meander correction represents a time averaging effect over 1 hr, and the operative parameter for toxic releases is a maximum concentration at the receptor, the 2-hr χ/Q' cannot ordinarily be used for toxic chemical releases. As discussed in Chapter 4.0, the maximum averaging time for chemicals with an acute (i.e., concentration-dependent) effect, such as those usually of concern in tank farms, is 15 min. The 1-hr χ/Q' therefore should be used in such cases.

2.4.3 Release Durations Greater Than Two Hours

For accident scenarios with release durations from 2 hr to 1 yr (8,760 hr) where the release rate is approximately constant over the release duration, a logarithmically interpolated χ/Q' , as discussed in Section 2.2.4, may be used. The interpolation is between the 2-hr χ/Q' (with plume meander) and the annual average χ/Q' shown in Tables 2-4 and 2-5 for the onsite (worker) and Hanford Site boundary (MOI) receptors, respectively. This produces a bounding (i.e., 95th percentile) χ/Q' averaged over the longer release duration. As an example, interpolated χ/Q' s for a constant-rate 8-hr release are shown in Tables 2-4 and 2-5.

Plume depletion and plume rise corrections can be applied, but not the large source correction for the reasons discussed in Section 2.4.2. Also for reasons previously discussed, the extended-duration χ/Q' cannot be applied to toxic chemical releases.

2.4.4 Puff Releases

The puff release model can be used only for very short duration toxic chemical releases. As discussed in Section 2.2.5, the puff model (which assumes a zero release duration) is advantageous only for the Hanford Site boundary (MOI) receptor where the actual release duration is less than several hundred seconds. Plume depletion, plume rise, and large source corrections can be applied to the puff release model. Details of specific applications of the puff release model as applied to accident analyses in the DSA are shown in Appendix H.

3.0 VERIFICATION OF GXQ VERSION 4.0F CALCULATIONS

This chapter provides hand calculations to verify that the dispersion coefficients (χ/Q') listed in previous sections are correct. In each case, GXQ calculates the χ/Q' 's for the various receptor distances and directions at the wind speeds and stability classes found in the wind data file (JOINTFRE.IN). These χ/Q' 's, along with the associated frequency, are then sorted to construct the cumulative probability distribution used in the calculation of 95th or 50th percentile χ/Q' 's. The 95th percentile is calculated from a distribution that includes data for all 16 wind transport directions, while the 50th percentile is calculated from distributions for each wind transport direction.

All of the GXQ Version 4.0F cases were run with the icdf flag set to true so that the cumulative distributions would be printed out. Verification was then a matter of calculating χ/Q' 's, sorting them, and constructing the cumulative distribution table for comparison with the GXQ output. Because GXQ calculates the χ/Q' 's in one subroutine and does the sorting and interpolation in other subroutines, the verification of the sorting and interpolation is not performed every time. To verify the other cases, it is sufficient to verify that the χ/Q' 's are calculated as described in WHC-SD-GN-SWD-30002.

3.1 BASIC DISPERSION COEFFICIENTS

For the basic case, there were two concerns. First, the 100 m distance is the same in all 16 directions, while the Hanford Site boundary distances vary. Thus, the sorting and interpolation process was checked for both cases. Table 3-1 shows the standard deviation in the horizontal (y) and vertical (z) directions for each distance of interest. These parameters are used in the basic dispersion calculations. The plume reflection parameter (fref) is calculated when the vertical standard deviation is less than 1.2 times the mixing layer depth (1,000 m). These are shown in Table 3-2. Because most of the vertical standard deviations for stability class A are greater than 1,200 m, the only value for fref calculated is at the 100 m distance. The class A column was omitted from Table 3-2.

Table 3-3 shows the hand-calculated χ/Q' 's along with the probabilities and cumulative probabilities for the onsite worker at 100 m. Because the distances are the same in all 16 transport directions, the joint frequencies are the sum of the frequencies in all 16 directions. These were compared with the GXQ output shown in Appendix D. The numbers are the same to four significant digits.

Table 3-4 shows the hand-calculated χ/Q' 's along with the probabilities and cumulative probabilities for the receptors at the Hanford Site boundary. Because the distances vary with direction, the number of entries in the table is greater. These were compared with the GXQ output shown in Appendix D. The numbers are the same to four significant digits.

Table 3-1. Horizontal and Vertical Standard Deviations for Each Distance.

Horizontal standard deviations (m)								
Transport direction	Distance (m)	A	B	C	D	E	F	G
All	100	23.41	17.61	13.37	9.415	6.695	4.621	3.079
S	15,360	2,208	1,660	1,261	887.9	631.3	435.8	290.3
SSW	15,360	2,208	1,660	1,261	887.9	631.3	435.8	290.3
SW	13,200	1,925	1,448	1,100	774.3	550.6	380.0	253.2
WSW	11,100	1,647	1,238	940.3	662.1	470.8	325.0	216.5
W	11,100	1,647	1,238	940.3	662.1	470.8	325.0	216.5
WNW	11,100	1,647	1,238	940.3	662.1	470.8	325.0	216.5
NW	10,800	1,606	1,208	917.3	645.9	459.3	317.0	211.2
NNW	8,690	1,320	992.7	753.8	530.8	377.5	260.5	173.6
N	8,690	1,320	992.7	753.8	530.8	377.5	260.5	173.6
NNE	8,970	1,358	1,022	775.7	546.2	388.4	268.1	178.6
NE	10,430	1,557	1,171	888.9	625.9	445.1	307.2	204.7
ENE	10,530	1,570	1,181	896.6	631.3	448.9	309.9	206.4
E	11,160	1,655	1,244	944.9	665.4	473.1	326.6	217.6
ESE	15,190	2,186	1,644	1,248	879.0	625.0	431.4	287.4
SE	21,050	2,935	2,207	1,676	1,180	839.2	579.3	385.9
SSE	15,360	2,208	1,660	1,261	887.9	631.3	435.8	290.3
Vertical standard deviations (m)								
Transport direction	Distance (m)	A	B	C	D	E	F	G
All	100	14.30	10.89	7.500	4.557	3.489	2.247	1.360
S	15,360	140,115	2,175	736.0	169.2	93.31	53.74	32.20
SSW	15,360	140,115	2,175	736.0	169.2	93.31	53.74	32.20
SW	13,200	102,012	1,842	641.1	155.5	87.56	50.98	30.55
WSW	11,100	70,967	1,523	547.5	141.1	81.30	47.92	28.71
W	11,100	70,967	1,523	547.5	141.1	81.30	47.92	28.71
WNW	11,100	70,967	1,523	547.5	141.1	81.30	47.92	28.71
NW	10,800	67,010	1,478	534.0	138.9	80.34	47.45	28.43
NNW	8,690	42,503	1,165	438.1	122.8	73.01	43.76	26.22
N	8,690	42,503	1,165	438.1	122.8	73.01	43.76	26.22
NNE	8,970	45,422	1,206	450.9	125.0	74.05	44.29	26.54
NE	10,430	62,292	1,422	517.3	136.2	79.13	46.85	28.07
ENE	10,530	63,549	1,437	521.8	136.9	79.46	47.01	28.17
E	11,160	71,773	1,532	550.2	141.5	81.49	48.02	28.77
ESE	15,190	136,887	2,148	728.6	168.2	92.88	53.53	32.08
SE	21,050	271,073	3,073	980.8	201.4	106.2	59.71	35.79
SSE	15,360	140,115	2,175	736.0	169.2	93.31	53.74	32.20

Table 3-2. Plume Reflection Parameter Values.

Transport direction	Distance (m)	B	C	D	E	F	G
All	100	2.000	2.000	2.000	2.000	2.000	2.000
S	15,360	5.447	2.100	2.000	2.000	2.000	2.000
SSW	15,360	5.447	2.100	2.000	2.000	2.000	2.000
SW	13,200	4.616	2.031	2.000	2.000	2.000	2.000
WSW	11,100	3.818	2.005	2.000	2.000	2.000	2.000
W	11,100	3.818	2.005	2.000	2.000	2.000	2.000
WNW	11,100	3.818	2.005	2.000	2.000	2.000	2.000
NW	10,800	3.705	2.004	2.000	2.000	2.000	2.000
NNW	8,690	2.926	2.000	2.000	2.000	2.000	2.000
N	8,690	2.926	2.000	2.000	2.000	2.000	2.000
NNE	8,970	3.027	2.000	2.000	2.000	2.000	2.000
NE	10,430	3.566	2.002	2.000	2.000	2.000	2.000
ENE	10,530	3.603	2.003	2.000	2.000	2.000	2.000
E	11,160	3.840	2.005	2.000	2.000	2.000	2.000
ESE	15,190	5.381	2.092	2.000	2.000	2.000	2.000
SE	21,050	7.546	2.501	2.000	2.000	2.000	2.000
SSE	15,360	5.447	2.100	2.000	2.000	2.000	2.000

Notes:

The plume reflection parameters are calculated from the vertical standard deviations out to the third reflection term. Release height is zero, and receptor elevation is zero. Mixing depth is 1,000 m.

Values are not given for stability class A because they are larger than 1,200 m. Note that the plume reflection factor at 100 m for class A is 2.000.

Table 3-3. Cumulative Probability Distribution for the Worker at 100 m, All Sectors, Centerline Values. (2 sheets)

Stability class	Wind speed (m/s)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
G	0.89	8.540 E-02	1.87	0.935
F	0.89	3.444 E-02	4.16	3.950
G	2.65	2.868 E-02	3.20	7.630
G	4.7	1.617 E-02	1.85	10.155
E	0.89	1.531 E-02	5.45	13.805
F	2.65	1.157 E-02	7.23	20.145
G	7.15	1.063 E-02	0.02	23.770
D	0.89	8.337 E-03	7.42	27.490
F	4.7	6.522 E-03	3.98	33.190
E	2.65	5.142 E-03	8.57	39.465
F	7.15	4.287 E-03	0.29	43.895
G	19	4.000 E-03	0.01	44.045
C	0.89	3.567 E-03	1.17	44.635
F	9.8	3.128 E-03	0.03	45.235
E	4.7	2.899 E-03	7.12	48.810
D	2.65	2.800 E-03	9.21	56.975
F	15.6	1.965 E-03	0.02	61.590
E	7.15	1.906 E-03	3.71	63.455
B	0.89	1.866 E-03	1.21	65.915
F	19	1.613 E-03	0.08	66.560
D	4.7	1.579 E-03	5.73	69.465
E	9.8	1.390 E-03	0.95	72.805
C	2.65	1.198 E-03	1.69	74.125
E	12.7	1.073 E-03	0.19	75.065
A	0.89	1.068 E-03	2.80	76.560
D	7.15	1.038 E-03	3.46	79.690
E	15.6	8.735 E-04	0.04	81.440
D	9.8	7.571 E-04	1.49	82.205
E	19	7.172 E-04	0.19	83.045
C	4.7	6.754 E-04	0.82	83.550
B	2.65	6.266 E-04	1.69	84.805
D	12.7	5.842 E-04	0.43	85.865
D	15.6	4.756 E-04	0.11	86.135
C	7.15	4.439 E-04	0.39	86.385
D	19	3.905 E-04	0.11	86.635

Table 3-3. Cumulative Probability Distribution for the Worker at 100 m, All Sectors, Centerline Values. (2 sheets)

Stability class	Wind speed (m/s)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
A	2.65	3.588 E-04	5.76	89.570
B	4.7	3.533 E-04	0.93	92.915
C	9.8	3.239 E-04	0.20	93.480
C	12.7	2.499 E-04	0.06	93.610
B	7.15	2.322 E-04	0.46	93.870
C	15.6	2.035 E-04	0.03	94.115
A	4.7	2.023 E-04	2.98	95.620
B	9.8	1.694 E-04	0.19	97.205
C	19	1.671 E-04	0.03	97.315
A	7.15	1.330 E-04	1.56	98.110
B	12.7	1.308 E-04	0.05	98.915
B	15.6	1.064 E-04	0.01	98.945
A	9.8	9.702 E-05	0.73	99.315
B	19	8.740 E-05	0.02	99.690
A	12.7	7.486 E-05	0.16	99.780
A	15.6	6.095 E-05	0.04	99.880
A	19	5.004 E-05	0.04	99.920

The interpolation to calculate the 95th percentile χ/Q' is between the second and third rows of numbers. The calculation is shown below for reference. The result agrees with the value shown in the first column of Table 2-4.

$$\left(\frac{0.03444 - 0.02868 \text{ s/m}^3}{3.950 - 7.630 \%} \right) (5 - 7.630 \%) + 0.02868 \text{ s/m}^3 = 0.03280 \text{ s/m}^3$$

Table 3-4. Cumulative Probability Distribution for the Hanford Site Boundary,
All Sectors, Centerline Values. (11 sheets)

Stability class	Wind speed (m/s)	Receptor distance (m)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
G	0.89	8,690	7.859 E-05	0.31	0.155
G	0.89	8,970	7.546 E-05	0.09	0.355
G	0.89	10,430	6.226 E-05	0.10	0.450
G	0.89	10,530	6.151 E-05	0.09	0.545
G	0.89	10,800	5.956 E-05	0.13	0.655
G	0.89	11,100	5.753 E-05	0.34	0.890
G	0.89	11,160	5.714 E-05	0.22	1.170
G	0.89	13,200	4.624 E-05	0.08	1.320
G	0.89	15,190	3.879 E-05	0.14	1.430
G	0.89	15,360	3.826 E-05	0.23	1.615
F	0.89	8,690	3.137 E-05	0.61	2.035
F	0.89	8,970	3.012 E-05	0.23	2.455
G	2.65	8,690	2.640 E-05	0.43	2.785
G	0.89	21,050	2.590 E-05	0.14	3.070
G	2.65	8,970	2.534 E-05	0.08	3.180
F	0.89	10,430	2.485 E-05	0.22	3.330
F	0.89	10,530	2.455 E-05	0.27	3.575
F	0.89	10,800	2.377 E-05	0.28	3.850
F	0.89	11,100	2.296 E-05	0.68	4.330
F	0.89	11,160	2.281 E-05	0.48	4.910
G	2.65	10,430	2.091 E-05	0.10	5.200
G	2.65	10,530	2.066 E-05	0.20	5.350
G	2.65	10,800	2.000 E-05	0.20	5.550
G	2.65	11,100	1.932 E-05	0.22	5.760
G	2.65	11,160	1.919 E-05	0.82	6.280
F	0.89	13,200	1.846 E-05	0.12	6.750
G	2.65	13,200	1.553 E-05	0.02	6.820
F	0.89	15,190	1.549 E-05	0.36	7.010
F	0.89	15,360	1.527 E-05	0.59	7.485
G	4.7	8,690	1.488 E-05	0.16	7.860
G	4.7	8,970	1.429 E-05	0.01	7.945
G	2.65	15,190	1.303 E-05	0.69	8.295
E	0.89	8,690	1.298 E-05	0.64	8.960
G	2.65	15,360	1.285 E-05	0.14	9.350
E	0.89	8,970	1.244 E-05	0.21	9.525

Table 3-4. Cumulative Probability Distribution for the Hanford Site Boundary, All Sectors, Centerline Values. (11 sheets)

Stability class	Wind speed (m/s)	Receptor distance (m)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
G	4.7	10,430	1.179 E-05	0.02	9.640
G	4.7	10,530	1.165 E-05	0.09	9.695
G	4.7	10,800	1.128 E-05	0.01	9.745
G	4.7	11,100	1.089 E-05	0.01	9.755
G	4.7	11,160	1.082 E-05	0.56	10.040
F	2.65	8,690	1.053 E-05	0.89	10.765
F	0.89	21,050	1.034 E-05	0.32	11.370
E	0.89	10,430	1.015 E-05	0.25	11.655
F	2.65	8,970	1.012 E-05	0.21	11.885
E	0.89	10,530	1.003 E-05	0.29	12.135
G	7.15	8,690	9.783 E-06	0.01	12.285
E	0.89	10,800	9.692 E-06	0.31	12.445
E	0.89	11,100	9.343 E-06	1.05	13.125
E	0.89	11,160	9.276 E-06	0.49	13.895
G	2.65	21,050	8.698 E-06	0.30	14.290
F	2.65	10,430	8.346 E-06	0.27	14.575
F	2.65	10,530	8.245 E-06	0.46	14.940
F	2.65	10,800	7.985 E-06	0.39	15.365
F	2.65	11,100	7.712 E-06	0.42	15.770
F	2.65	11,160	7.660 E-06	1.60	16.780
E	0.89	13,200	7.419 E-06	0.28	17.720
G	4.7	15,190	7.346 E-06	0.84	18.280
G	4.7	15,360	7.244 E-06	0.02	18.710
F	2.65	13,200	6.200 E-06	0.05	18.745
E	0.89	15,190	6.161 E-06	0.44	18.990
E	0.89	15,360	6.071 E-06	1.04	19.730
F	4.7	8,690	5.940 E-06	0.31	20.405
F	4.7	8,970	5.703 E-06	0.03	20.575
D	0.89	8,690	5.487 E-06	0.59	20.885
D	0.89	8,970	5.236 E-06	0.19	21.275
F	2.65	15,190	5.201 E-06	1.69	22.215
F	2.65	15,360	5.129 E-06	0.43	23.275
G	4.7	21,050	4.904 E-06	0.13	23.555
G	7.15	15,190	4.829 E-06	0.01	23.625
F	4.7	10,430	4.706 E-06	0.07	23.665
F	4.7	10,530	4.649 E-06	0.20	23.800

Table 3-4. Cumulative Probability Distribution for the Hanford Site Boundary,
All Sectors, Centerline Values. (11 sheets)

Stability class	Wind speed (m/s)	Receptor distance (m)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
F	4.7	10,800	4.502 E-06	0.05	23.925
E	2.65	8,690	4.359 E-06	0.98	24.440
F	4.7	11,100	4.348 E-06	0.04	24.950
F	4.7	11,160	4.319 E-06	1.19	25.565
D	0.89	10,430	4.195 E-06	0.21	26.265
E	2.65	8,970	4.176 E-06	0.21	26.475
D	0.89	10,530	4.137 E-06	0.17	26.665
E	0.89	21,050	4.015 E-06	0.45	26.975
D	0.89	10,800	3.986 E-06	0.43	27.415
F	7.15	8,690	3.904 E-06	0.03	27.645
D	0.89	11,100	3.829 E-06	1.86	28.590
D	0.89	11,160	3.798 E-06	0.40	29.720
F	4.7	13,200	3.495 E-06	0.01	29.925
F	2.65	21,050	3.473 E-06	0.82	30.340
E	2.65	10,430	3.410 E-06	0.29	30.895
E	2.65	10,530	3.367 E-06	0.48	31.280
E	2.65	10,800	3.255 E-06	0.47	31.755
E	2.65	11,100	3.138 E-06	0.78	32.380
E	2.65	11,160	3.115 E-06	1.58	33.560
F	7.15	10,430	3.093 E-06	0.01	34.355
F	7.15	10,530	3.056 E-06	0.02	34.370
D	0.89	13,200	2.971 E-06	0.59	34.675
F	4.7	15,190	2.933 E-06	1.60	35.770
F	4.7	15,360	2.892 E-06	0.16	36.650
F	9.8	8,690	2.849 E-06	0.01	36.735
F	7.15	11,160	2.839 E-06	0.07	36.775
E	2.65	13,200	2.492 E-06	0.11	36.865
E	4.7	8,690	2.458 E-06	0.47	37.155
D	0.89	15,190	2.420 E-06	0.44	37.610
D	0.89	15,360	2.381 E-06	2.00	38.830
E	4.7	8,970	2.355 E-06	0.12	39.890
E	2.65	15,190	2.069 E-06	1.68	40.790
E	2.65	15,360	2.039 E-06	0.88	42.070
F	4.7	21,050	1.958 E-06	0.32	42.670
F	7.15	15,190	1.928 E-06	0.08	42.870
E	4.7	10,430	1.923 E-06	0.18	43.000

Table 3-4. Cumulative Probability Distribution for the Hanford Site Boundary,
All Sectors, Centerline Values. (11 sheets)

Stability class	Wind speed (m/s)	Receptor distance (m)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
F	7.15	15,360	1.901 E-06	0.05	43.115
E	4.7	10,530	1.898 E-06	0.39	43.335
D	2.65	8,690	1.843 E-06	0.88	43.970
E	4.7	10,800	1.835 E-06	0.15	44.485
G	19	15,360	1.792 E-06	0.01	44.565
E	4.7	11,100	1.769 E-06	0.13	44.635
D	2.65	8,970	1.759 E-06	0.18	44.790
E	4.7	11,160	1.757 E-06	1.98	45.870
E	7.15	8,690	1.616 E-06	0.12	46.920
E	7.15	8,970	1.548 E-06	0.08	47.020
D	0.89	21,050	1.505 E-06	0.54	47.330
D	2.65	10,430	1.409 E-06	0.24	47.720
E	4.7	13,200	1.405 E-06	0.04	47.860
D	2.65	10,530	1.389 E-06	0.28	48.020
F	9.8	15,360	1.387 E-06	0.02	48.170
E	2.65	21,050	1.348 E-06	1.11	48.735
D	2.65	10,800	1.339 E-06	0.75	49.665
F	7.15	21,050	1.287 E-06	0.03	50.055
D	2.65	11,100	1.286 E-06	1.56	50.850
D	2.65	11,160	1.276 E-06	0.69	51.975
E	7.15	10,430	1.264 E-06	0.17	52.405
E	7.15	10,530	1.248 E-06	0.30	52.640
E	7.15	10,800	1.206 E-06	0.01	52.795
E	9.8	8,690	1.179 E-06	0.01	52.805
E	4.7	15,190	1.167 E-06	2.50	54.060
E	7.15	11,160	1.155 E-06	0.65	55.635
E	4.7	15,360	1.150 E-06	0.41	56.165
E	9.8	8,970	1.129 E-06	0.05	56.395
C	0.89	8,690	1.083 E-06	0.08	56.460
D	4.7	8,690	1.039 E-06	0.51	56.755
C	0.89	8,970	1.023 E-06	0.02	57.020
D	2.65	13,200	9.977 E-07	0.40	57.230
D	4.7	8,970	9.916 E-07	0.13	57.495
E	7.15	13,200	9.235 E-07	0.01	57.565
E	9.8	10,430	9.222 E-07	0.11	57.625
E	9.8	10,530	9.105 E-07	0.15	57.755

Table 3-4. Cumulative Probability Distribution for the Hanford Site Boundary,
All Sectors, Centerline Values. (11 sheets)

Stability class	Wind speed (m/s)	Receptor distance (m)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
E	12.7	8,970	8.714 E-07	0.01	57.835
F	15.6	15,360	8.714 E-07	0.02	57.850
E	9.8	11,160	8.424 E-07	0.06	57.890
D	2.65	15,190	8.127 E-07	1.09	58.465
D	2.65	15,360	7.996 E-07	2.09	60.055
D	4.7	10,430	7.943 E-07	0.23	61.215
D	4.7	10,530	7.833 E-07	0.39	61.525
C	0.89	10,430	7.787 E-07	0.02	61.730
E	7.15	15,190	7.669 E-07	1.75	62.615
C	0.89	10,530	7.654 E-07	0.02	63.500
E	4.7	21,050	7.602 E-07	0.75	63.885
E	7.15	15,360	7.557 E-07	0.21	64.365
D	4.7	10,800	7.547 E-07	0.25	64.595
C	0.89	10,800	7.315 E-07	0.06	64.750
D	4.7	11,100	7.250 E-07	0.27	64.915
D	4.7	11,160	7.193 E-07	0.83	65.465
F	19	15,360	7.154 E-07	0.08	65.920
E	12.7	10,430	7.116 E-07	0.04	65.980
E	12.7	10,530	7.026 E-07	0.02	66.010
C	0.89	11,100	6.965 E-07	0.36	66.200
C	0.89	11,160	6.898 E-07	0.04	66.400
D	7.15	8,690	6.830 E-07	0.17	66.505
E	9.8	13,200	6.737 E-07	0.01	66.595
D	7.15	8,970	6.518 E-07	0.11	66.655
E	12.7	11,160	6.501 E-07	0.01	66.715
E	15.6	10,430	5.793 E-07	0.01	66.725
D	4.7	13,200	5.625 E-07	0.09	66.775
E	9.8	15,190	5.595 E-07	0.38	67.010
E	9.8	15,360	5.514 E-07	0.07	67.235
D	7.15	10,430	5.222 E-07	0.25	67.395
E	12.7	13,200	5.199 E-07	0.01	67.525
C	0.89	13,200	5.152 E-07	0.09	67.575
D	7.15	10,530	5.149 E-07	0.38	67.810
D	2.65	21,050	5.054 E-07	1.05	68.525
E	7.15	21,050	4.997 E-07	0.41	69.255
D	9.8	8,690	4.983 E-07	0.02	69.470

Table 3-4. Cumulative Probability Distribution for the Hanford Site Boundary, All Sectors, Centerline Values. (11 sheets)

Stability class	Wind speed (m/s)	Receptor distance (m)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
D	7.15	10,800	4.961 E-07	0.03	69.495
D	7.15	11,100	4.766 E-07	0.02	69.520
D	9.8	8,970	4.755 E-07	0.07	69.565
D	7.15	11,160	4.728 E-07	0.58	69.890
D	4.7	15,190	4.582 E-07	1.46	70.910
B	0.89	8,690	4.527 E-07	0.08	71.680
D	4.7	15,360	4.508 E-07	0.73	72.085
B	0.89	8,970	4.388 E-07	0.02	72.460
E	12.7	15,190	4.317 E-07	0.05	72.495
E	12.7	15,360	4.255 E-07	0.02	72.530
C	0.89	15,190	4.114 E-07	0.04	72.560
C	0.89	15,360	4.046 E-07	0.34	72.750
B	0.89	10,430	3.829 E-07	0.01	72.925
D	9.8	10,430	3.810 E-07	0.16	73.010
B	0.89	10,530	3.796 E-07	0.03	73.105
D	9.8	10,530	3.757 E-07	0.24	73.240
B	0.89	10,800	3.711 E-07	0.07	73.395
D	7.15	13,200	3.698 E-07	0.03	73.445
D	12.7	8,970	3.670 E-07	0.02	73.470
E	9.8	21,050	3.646 E-07	0.11	73.535
C	2.65	8,690	3.638 E-07	0.16	73.670
B	0.89	11,100	3.620 E-07	0.36	73.930
B	0.89	11,160	3.602 E-07	0.04	74.130
E	15.6	15,360	3.464 E-07	0.03	74.165
D	9.8	11,160	3.450 E-07	0.13	74.245
C	2.65	8,970	3.435 E-07	0.02	74.320
A	0.89	8,690	3.396 E-07	0.20	74.430
A	0.89	8,970	3.300 E-07	0.06	74.560
B	0.89	13,200	3.096 E-07	0.10	74.640
D	7.15	15,190	3.012 E-07	1.14	75.260
D	7.15	15,360	2.963 E-07	0.25	75.955
D	12.7	10,430	2.940 E-07	0.09	76.125
D	12.7	10,530	2.899 E-07	0.09	76.215
A	0.89	10,430	2.880 E-07	0.06	76.290
A	0.89	10,530	2.855 E-07	0.06	76.350
D	4.7	21,050	2.850 E-07	0.84	76.800

Table 3-4. Cumulative Probability Distribution for the Hanford Site Boundary,
All Sectors, Centerline Values. (11 sheets)

Stability class	Wind speed (m/s)	Receptor distance (m)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
E	19	15,360	2.844 E-07	0.19	77.315
E	12.7	21,050	2.814 E-07	0.03	77.425
A	0.89	10,800	2.791 E-07	0.17	77.525
B	0.89	15,190	2.727 E-07	0.05	77.635
A	0.89	11,100	2.722 E-07	0.90	78.110
C	0.89	21,050	2.721 E-07	0.10	78.610
A	0.89	11,160	2.709 E-07	0.10	78.710
B	0.89	15,360	2.700 E-07	0.38	78.950
D	9.8	13,200	2.698 E-07	0.01	79.145
D	12.7	11,160	2.662 E-07	0.03	79.165
C	2.65	10,430	2.615 E-07	0.03	79.195
C	2.65	10,530	2.571 E-07	0.05	79.235
C	2.65	10,800	2.457 E-07	0.19	79.355
D	15.6	10,430	2.393 E-07	0.03	79.465
D	15.6	10,530	2.360 E-07	0.03	79.495
C	2.65	11,100	2.339 E-07	0.35	79.685
A	0.89	13,200	2.328 E-07	0.23	79.975
C	2.65	11,160	2.317 E-07	0.08	80.130
D	9.8	15,190	2.198 E-07	0.50	80.420
D	15.6	11,160	2.167 E-07	0.02	80.680
D	9.8	15,360	2.162 E-07	0.07	80.725
C	4.7	8,690	2.051 E-07	0.09	80.805
A	0.89	15,190	2.051 E-07	0.10	80.900
B	0.89	21,050	2.031 E-07	0.07	80.985
A	0.89	15,360	2.030 E-07	0.78	81.410
C	4.7	8,970	1.937 E-07	0.02	81.810
D	7.15	21,050	1.873 E-07	0.50	82.070
C	2.65	13,200	1.730 E-07	0.06	82.350
D	12.7	15,190	1.696 E-07	0.07	82.415
D	12.7	15,360	1.668 E-07	0.05	82.475
A	0.89	21,050	1.527 E-07	0.14	82.570
B	2.65	8,690	1.520 E-07	0.17	82.725
C	4.7	10,430	1.475 E-07	0.03	82.825
B	2.65	8,970	1.474 E-07	0.04	82.860
C	4.7	10,530	1.449 E-07	0.06	82.910
C	4.7	10,800	1.385 E-07	0.04	82.960

Table 3-4. Cumulative Probability Distribution for the Hanford Site Boundary, All Sectors, Centerline Values. (11 sheets)

Stability class	Wind speed (m/s)	Receptor distance (m)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
C	2.65	15,190	1.382 E-07	0.10	83.030
D	9.8	21,050	1.367 E-07	0.29	83.225
C	2.65	15,360	1.359 E-07	0.46	83.600
D	15.6	15,360	1.358 E-07	0.03	83.845
C	7.15	8,690	1.348 E-07	0.03	83.875
C	4.7	11,100	1.319 E-07	0.05	83.915
C	4.7	11,160	1.306 E-07	0.09	83.985
B	2.65	10,430	1.286 E-07	0.03	84.045
B	2.65	10,530	1.275 E-07	0.05	84.085
C	7.15	8,970	1.273 E-07	0.01	84.115
B	2.65	10,800	1.246 E-07	0.13	84.185
B	2.65	11,100	1.216 E-07	0.37	84.435
B	2.65	11,160	1.210 E-07	0.07	84.655
A	2.65	8,690	1.140 E-07	0.53	84.955
D	19	15,360	1.115 E-07	0.11	85.275
A	2.65	8,970	1.108 E-07	0.12	85.390
D	12.7	21,050	1.055 E-07	0.08	85.490
B	2.65	13,200	1.040 E-07	0.06	85.560
C	9.8	8,690	9.837 E-08	0.01	85.595
C	4.7	13,200	9.755 E-08	0.03	85.615
C	7.15	10,430	9.693 E-08	0.02	85.640
A	2.65	10,430	9.672 E-08	0.17	85.735
A	2.65	10,530	9.589 E-08	0.19	85.915
C	7.15	10,530	9.528 E-08	0.07	86.045
A	2.65	10,800	9.372 E-08	0.45	86.305
B	2.65	15,190	9.158 E-08	0.09	86.575
A	2.65	11,100	9.143 E-08	1.43	87.335
C	2.65	21,050	9.138 E-08	0.19	88.145
A	2.65	11,160	9.099 E-08	0.25	88.365
B	2.65	15,360	9.067 E-08	0.52	88.750
C	7.15	11,160	8.587 E-08	0.06	89.040
B	4.7	8,690	8.572 E-08	0.08	89.110
B	4.7	8,970	8.309 E-08	0.02	89.160
A	2.65	13,200	7.819 E-08	0.29	89.315
C	4.7	15,190	7.791 E-08	0.13	89.525
C	4.7	15,360	7.662 E-08	0.16	89.670

Table 3-4. Cumulative Probability Distribution for the Hanford Site Boundary, All Sectors, Centerline Values. (11 sheets)

Stability class	Wind speed (m/s)	Receptor distance (m)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
B	4.7	10,430	7.251 E-08	0.05	89.775
B	4.7	10,530	7.189 E-08	0.07	89.835
C	9.8	10,430	7.072 E-08	0.02	89.880
B	4.7	10,800	7.026 E-08	0.04	89.910
C	9.8	10,530	6.952 E-08	0.05	89.955
A	2.65	15,190	6.887 E-08	0.30	90.130
B	4.7	11,100	6.855 E-08	0.07	90.315
B	4.7	11,160	6.821 E-08	0.10	90.400
B	2.65	21,050	6.821 E-08	0.16	90.530
A	2.65	15,360	6.819 E-08	1.61	91.415
A	4.7	8,690	6.430 E-08	0.25	92.345
C	7.15	13,200	6.413 E-08	0.01	92.475
C	9.8	11,160	6.265 E-08	0.02	92.490
A	4.7	8,970	6.249 E-08	0.07	92.535
B	4.7	13,200	5.862 E-08	0.03	92.585
B	7.15	8,690	5.635 E-08	0.03	92.615
B	7.15	8,970	5.462 E-08	0.01	92.635
C	12.7	10,430	5.457 E-08	0.02	92.650
A	4.7	10,430	5.453 E-08	0.14	92.730
A	4.7	10,530	5.406 E-08	0.34	92.970
C	12.7	10,530	5.364 E-08	0.01	93.145
A	4.7	10,800	5.284 E-08	0.10	93.200
B	4.7	15,190	5.164 E-08	0.14	93.320
A	4.7	11,100	5.155 E-08	0.21	93.495
C	4.7	21,050	5.153 E-08	0.12	93.660
A	4.7	11,160	5.130 E-08	0.35	93.895
A	2.65	21,050	5.130 E-08	0.42	94.280
C	7.15	15,190	5.121 E-08	0.07	94.525
B	4.7	15,360	5.112 E-08	0.21	94.665
C	7.15	15,360	5.036 E-08	0.06	94.800
B	7.15	10,430	4.767 E-08	0.04	94.850
B	7.15	10,530	4.726 E-08	0.08	94.910
B	7.15	11,100	4.506 E-08	0.01	94.955
B	7.15	11,160	4.484 E-08	0.06	94.990
A	4.7	13,200	4.408 E-08	0.10	95.070
C	15.6	10,530	4.367 E-08	0.01	95.125

Table 3-4. Cumulative Probability Distribution for the Hanford Site Boundary, All Sectors, Centerline Values. (11 sheets)

Stability class	Wind speed (m/s)	Receptor distance (m)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
A	7.15	8,690	4.227 E-08	0.07	95.165
A	7.15	8,970	4.108 E-08	0.04	95.220
A	4.7	15,190	3.883 E-08	0.35	95.415
B	7.15	13,200	3.853 E-08	0.01	95.595
B	4.7	21,050	3.846 E-08	0.12	95.660
A	4.7	15,360	3.844 E-08	0.67	96.055
C	9.8	15,190	3.736 E-08	0.03	96.405
C	9.8	15,360	3.675 E-08	0.02	96.430
A	7.15	10,430	3.585 E-08	0.11	96.495
A	7.15	10,530	3.554 E-08	0.25	96.675
B	9.8	10,430	3.478 E-08	0.02	96.810
A	7.15	10,800	3.474 E-08	0.01	96.825
B	9.8	10,530	3.448 E-08	0.04	96.850
B	7.15	15,190	3.394 E-08	0.07	96.905
A	7.15	11,100	3.389 E-08	0.01	96.945
C	7.15	21,050	3.387 E-08	0.06	96.980
A	7.15	11,160	3.372 E-08	0.25	97.135
B	7.15	15,360	3.360 E-08	0.06	97.290
B	9.8	11,160	3.272 E-08	0.02	97.330
A	9.8	8,690	3.084 E-08	0.01	97.345
A	9.8	8,970	2.997 E-08	0.01	97.355
A	7.15	13,200	2.898 E-08	0.05	97.385
A	4.7	21,050	2.892 E-08	0.40	97.610
C	12.7	15,190	2.883 E-08	0.01	97.815
C	12.7	15,360	2.835 E-08	0.01	97.825
B	12.7	10,430	2.684 E-08	0.01	97.835
B	12.7	10,530	2.660 E-08	0.02	97.850
A	9.8	10,430	2.615 E-08	0.05	97.885
A	9.8	10,530	2.593 E-08	0.16	97.990
A	7.15	15,190	2.553 E-08	0.25	98.195
B	7.15	21,050	2.528 E-08	0.09	98.365
A	7.15	15,360	2.527 E-08	0.19	98.505
B	12.7	11,160	2.524 E-08	0.01	98.605
B	9.8	15,190	2.476 E-08	0.03	98.625
C	9.8	21,050	2.471 E-08	0.05	98.665
A	9.8	11,160	2.460 E-08	0.10	98.740

Table 3-4. Cumulative Probability Distribution for the Hanford Site Boundary, All Sectors, Centerline Values. (11 sheets)

Stability class	Wind speed (m/s)	Receptor distance (m)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
B	9.8	15,360	2.452 E-08	0.02	98.800
C	15.6	15,360	2.308 E-08	0.02	98.820
A	9.8	13,200	2.114 E-08	0.01	98.835
A	12.7	10,430	2.018 E-08	0.02	98.850
A	12.7	10,530	2.001 E-08	0.06	98.890
C	12.7	21,050	1.907 E-08	0.01	98.925
A	7.15	21,050	1.901 E-08	0.33	99.095
A	12.7	11,160	1.899 E-08	0.02	99.270
C	19	15,360	1.895 E-08	0.03	99.295
A	9.8	15,190	1.862 E-08	0.11	99.365
B	9.8	21,050	1.844 E-08	0.06	99.450
A	9.8	15,360	1.844 E-08	0.04	99.500
A	15.6	10,530	1.629 E-08	0.01	99.525
B	15.6	15,360	1.540 E-08	0.01	99.535
A	12.7	15,190	1.437 E-08	0.02	99.550
B	12.7	21,050	1.423 E-08	0.01	99.565
A	12.7	15,360	1.423 E-08	0.01	99.575
A	9.8	21,050	1.387 E-08	0.24	99.700
B	19	15,360	1.265 E-08	0.02	99.830
A	15.6	15,360	1.158 E-08	0.02	99.850
A	12.7	21,050	1.070 E-08	0.03	99.875
A	19	15,360	9.510 E-09	0.04	99.910
A	15.6	21,050	8.714 E-09	0.01	99.935

The interpolation to calculate the 95th percentile χ/Q' uses numbers from midway down the first page of Table 3-4. The calculation is shown below for reference. This agrees with the value shown in the first column of numbers in Table 2-5.

$$\left(\frac{2.281 \times 10^{-5} - 2.091 \times 10^{-5} \text{ s/m}^3}{4.910 - 5.200 \%} \right) (5 - 5.200 \%) + 2.091 \times 10^{-5} \text{ s/m}^3 = 2.222 \times 10^{-5} \text{ s/m}^3$$

The next part of the basic calculation is the verification of the 50th percentile value. This is calculated from the same χ/Q' used above for the 1-hr χ/Q' . However, the 16 transport directions are evaluated separately. For the Hanford Site boundary, GXQ indicates the direction with the largest χ/Q' is north. The cumulative probability distribution for the north direction is shown in Table 3-5.

When a normalized cumulative distribution is constructed, there is one additional step in the process. This step is the normalization of the curve. To normalize the cumulative distribution, each point is divided by the sum of all the observed frequencies. When normalized, the cumulative frequency distribution begins at 0% and ends at 100%.

Table 3-5. Cumulative Probability Distribution for the Site Boundary, North Sector, Centerline Values. (2 sheets)

Stability class	Wind speed (m/s)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
G	0.89	7.859 E-05	0.17	1.950
F	0.89	3.137 E-05	0.35	7.913
G	2.65	2.640 E-05	0.20	14.220
G	4.7	1.488 E-05	0.07	17.317
E	0.89	1.298 E-05	0.34	22.018
F	2.65	1.053 E-05	0.45	31.078
F	4.7	5.940 E-06	0.14	37.844
D	0.89	5.487 E-06	0.27	42.546
E	2.65	4.359 E-06	0.46	50.917
F	7.15	3.904 E-06	0.02	56.422
F	9.8	2.849 E-06	0.01	56.766
E	4.7	2.458 E-06	0.22	59.404
D	2.65	1.843 E-06	0.35	65.940
E	7.15	1.616 E-06	0.07	70.757
E	9.8	1.179 E-06	0.01	71.674
C	0.89	1.083 E-06	0.04	72.248
D	4.7	1.039 E-06	0.24	75.459
D	7.15	6.830 E-07	0.10	79.358
D	9.8	4.983 E-07	0.02	80.734
B	0.89	4.527 E-07	0.05	81.537
C	2.65	3.638 E-07	0.06	82.798
A	0.89	3.396 E-07	0.10	84.633
C	4.7	2.051 E-07	0.05	86.353
B	2.65	1.520 E-07	0.08	87.844
C	7.15	1.348 E-07	0.02	88.991
A	2.65	1.140 E-07	0.24	91.972
C	9.8	9.837 E-08	0.01	94.839

Table 3-5. Cumulative Probability Distribution for the Site Boundary, North Sector, Centerline Values. (2 sheets)

Stability class	Wind speed (m/s)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
B	4.7	8.572 E-08	0.03	95.298
A	4.7	6.430 E-08	0.12	97.018
B	7.15	5.635 E-08	0.02	98.624
A	7.15	4.227 E-08	0.04	99.312
A	9.8	3.084 E-08	0.01	99.885

Notes:

The total fraction for transport to the north is 4.36%. This is the sum of the observed frequencies.

The cumulative distribution has been normalized so that the final sum is 100%.

The first point in the cumulative frequency distribution is half of 0.17% divided by 0.0436, which is 1.950%, as shown in the first line of Table 3-5. The second point is the sum of the first observed frequency plus half the second frequency, as shown below:

$$F_2 = \frac{0.17\% + (0.5)(0.35\%)}{0.0436} = 7.913\%$$

Each point in the cumulative distribution is calculated as before, except that the resulting cumulative frequencies are divided by the total frequency (0.0436) for this wind direction. In this way, the normalized cumulative probability distribution can be calculated.

The interpolation to calculate the 50th percentile χ/Q' for transport to the north is shown below for reference. This agrees with the value shown in the first column of numbers in Table 2-5.

$$\left(\frac{5.487 \times 10^{-6} - 4.359 \times 10^{-6} \text{ s/m}^3}{42.546 - 50.917 \%} \right) (50 - 50.917 \%) + 4.359 \times 10^{-6} \text{ s/m}^3 = 4.482 \times 10^{-6} \text{ s/m}^3$$

The 2-hr χ/Q 's shown in the second column of numbers in Tables 2-4 and 2-5 include plume meander using the method described in NRC Regulatory Guide 1.145. The horizontal standard deviation is increased by a factor ranging from 1 to 6. The actual value depends on the stability class, wind speed, and distance. Because the same χ/Q 's are calculated for both 95th and 50th percentiles, only the maximum sector (north) for the onsite worker will be compared in detail with GXQ. Hand-calculated χ/Q 's are shown in Table 3-6. The corresponding GXQ output is shown for comparison in Appendix E.

Table 3-6. Cumulative Probability Distribution for the Worker at 100 m, North Sector, with Plume Meander.

Stability class	Wind speed (m/s)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
G	0.89	1.423 E-02	0.17	1.950
G	4.7	1.086 E-02	0.07	4.702
F	0.89	8.611 E-03	0.35	9.518
G	2.65	7.564 E-03	0.20	15.826
E	0.89	5.103 E-03	0.34	22.018
F	4.7	4.792 E-03	0.14	27.523
F	7.15	4.287 E-03	0.02	29.358
D	0.89	4.168 E-03	0.27	32.683
F	2.65	4.125 E-03	0.45	40.940
C	0.89	3.567 E-03	0.04	46.560
F	9.8	3.128 E-03	0.01	47.133
E	2.65	2.271 E-03	0.46	52.523
E	4.7	2.271 E-03	0.22	60.321
E	7.15	1.906 E-03	0.07	63.647
B	0.89	1.866 E-03	0.05	65.023
D	2.65	1.672 E-03	0.35	69.610
E	9.8	1.390 E-03	0.01	73.739
D	4.7	1.353 E-03	0.24	76.606
C	2.65	1.198 E-03	0.06	80.046
A	0.89	1.068 E-03	0.10	81.881
D	7.15	1.038 E-03	0.10	84.174
D	9.8	7.571 E-04	0.02	85.550
C	4.7	6.754 E-04	0.05	86.353
B	2.65	6.266 E-04	0.08	87.844
C	7.15	4.439 E-04	0.02	88.991
A	2.65	3.588 E-04	0.24	91.972
B	4.7	3.533 E-04	0.03	95.069
C	9.8	3.239 E-04	0.01	95.528
B	7.15	2.322 E-04	0.02	95.872
A	4.7	2.023 E-04	0.12	97.477
A	7.15	1.330 E-04	0.04	99.312
A	9.8	9.702 E-05	0.01	99.885

Notes:

The total fraction for transport to the north is 4.36%. This is the sum of the observed frequencies.

The cumulative distribution has been normalized so that the final sum is 100%.

The interpolation to calculate the 50th percentile χ/Q' for transport to the north is shown below for reference. This does not agree with the value shown in the second column of numbers in Table 2-4.

$$\left(\frac{3.128 \times 10^{-3} - 2.271 \times 10^{-3} \text{ s/m}^3}{47.133 - 52.523 \%} \right) (50 - 52.523 \%) + 2.271 \times 10^{-3} \text{ s/m}^3 = 2.672 \times 10^{-3} \text{ s/m}^3$$

Table 3-6 reveals a flaw in the method used by GXQ Version 4.0F to construct the cumulative frequency distribution. What GXQ tries to do is combine any χ/Q' 's that are equal. However, because of the way computers represent real numbers, two identical χ/Q' 's (class E at 2.65 m/s and class E at 4.70 m/s) are slightly different in GXQ. In the hand calculation, they are the same and the sort puts the low wind speed value first. In GXQ, the low wind speed number is slightly smaller, so the test for equality fails and the low wind speed value is placed second. The relevant GXQ output is shown in Table 3-7.

Table 3-7. Portion of the GXQ Cumulative Distribution that is Different.

Stability class	Wind speed (m/s)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
F	9.8	3.128 E-03	0.01	47.133
E	4.7	2.271 E-03	0.22	49.771
E	2.65	2.271 E-03	0.46	57.569
E	7.15	1.906 E-03	0.07	63.647

Notes:

The complete GXQ component data file output is shown in Appendix E.

The 50th percentile dispersion coefficient is 2.271 E-03 s/m³.

In Table 3-7, the linear interpolation is between two values that are essentially the same. The result matches the value shown in Table 2-4 for the 50th percentile with plume meander. Note that if the two identical χ/Q' 's are combined first, the cumulative distribution has the values shown in Table 3-8 at that part of the cumulative frequency curve. In addition, the interpolated result is $2.817 \times 10^{-3} \text{ s/m}^3$, which is 24% larger than the value shown in Table 2-4.

Table 3-8. Cumulative Distribution When Equal Values are Combined.

Stability class	Wind speed (m/s)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Cumulative frequency (%)
F	9.8	3.128 E-03	0.01	47.133
E	2.65	2.271 E-03	0.68	55.046
E	7.15	1.906 E-03	0.07	63.647

Note:

The 50th percentile dispersion coefficient is 2.817 E-03 s/m³.

The annual average χ/Q 's use a sector-averaged, horizontal standard deviation rather than the numbers shown in Table 3-1. The GXQ values can be verified by calculating the χ/Q 's, multiplying them by the frequencies, and summing to get the annual average value for the selected sector. The calculation for the east-southeast sector at 100 m is shown in Table 3-9. The calculated annual average agrees with the value shown in Table 2-4.

Table 3-9. Calculation of the Annual Average for the Worker at 100 m, East-Southeast Sector. (2 sheets)

Stability class	Wind speed (m/s)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Weighted dispersion coefficient (s/m ³)
A	0.89	1.596 E-03	0.10	1.596 E-06
B	0.89	2.097 E-03	0.05	1.048 E-06
C	0.89	3.044 E-03	0.04	1.218 E-06
D	0.89	5.010 E-03	0.44	2.204 E-05
E	0.89	6.542 E-03	0.44	2.879 E-05
F	0.89	1.016 E-02	0.36	3.657 E-05
G	0.89	1.678 E-02	0.14	2.349 E-05
A	2.65	5.362 E-04	0.30	1.609 E-06
B	2.65	7.043 E-04	0.09	6.338 E-07
C	2.65	1.022 E-03	0.10	1.022 E-06
D	2.65	1.683 E-03	1.09	1.834 E-05
E	2.65	2.197 E-03	1.68	3.691 E-05
F	2.65	3.412 E-03	1.69	5.766 E-05
G	2.65	5.636 E-03	0.69	3.889 E-05
A	4.7	3.023 E-04	0.35	1.058 E-06
B	4.7	3.971 E-04	0.14	5.559 E-07
C	4.7	5.764 E-04	0.13	7.493 E-07
D	4.7	9.487 E-04	1.46	1.385 E-05
E	4.7	1.239 E-03	2.50	3.097 E-05
F	4.7	1.924 E-03	1.60	3.078 E-05

Table 3-9. Calculation of the Annual Average for the Worker at 100 m, East-Southeast Sector. (2 sheets)

Stability class	Wind speed (m/s)	Dispersion coefficient (s/m ³)	Observed frequency (%)	Weighted dispersion coefficient (s/m ³)
G	4.7	3.178 E-03	0.84	2.669 E-05
A	7.15	1.987 E-04	0.25	4.968 E-07
B	7.15	2.610 E-04	0.07	1.827 E-07
C	7.15	3.789 E-04	0.07	2.652 E-07
D	7.15	6.236 E-04	1.14	7.109 E-06
E	7.15	8.144 E-04	1.75	1.425 E-05
F	7.15	1.265 E-03	0.08	1.012 E-06
G	7.15	2.089 E-03	0.01	2.089 E-07
A	9.8	1.450 E-04	0.11	1.595 E-07
B	9.8	1.904 E-04	0.03	5.713 E-08
C	9.8	2.764 E-04	0.03	8.293 E-08
D	9.8	4.550 E-04	0.50	2.275 E-06
E	9.8	5.942 E-04	0.38	2.258 E-06
F	9.8	9.226 E-04	0.00	0.000 E+00
G	9.8	1.524 E-03	0.00	0.000 E+00
A	12.7	1.119 E-04	0.02	2.238 E-08
B	12.7	1.470 E-04	0.00	0.000 E+00
C	12.7	2.133 E-04	0.01	2.133 E-08
D	12.7	3.511 E-04	0.07	2.458 E-07
E	12.7	4.585 E-04	0.05	2.292 E-07

Notes:

The total fraction for transport to the east-southeast is 18.80%. This is the sum of the observed frequencies.

The weighted dispersion coefficients are the product of the dispersion coefficients and the frequency. The sum of the weighted dispersion coefficients is 4.034 E-04 s/m³.

The maximum puff concentration factors shown in Tables 2-4 and 2-5 are calculated using a formula similar to the χ/Q 's. The standard deviation in the transport direction is assumed to be the same as in the horizontal direction because the release duration is very small. The puff χ/Q s are independent of the wind speed. An example calculation is shown in Table 3-10. Note that the units for the normalized air concentrations are 1/m³ rather than s/m³. Note also that GXQ has correctly combined all χ/Q s that are equal.

Table 3-10. Cumulative Probability Distribution for the Worker at 100 m, All Sectors, Short Duration (Puff) Release.

Stability class	Dispersion coefficient (1/m ³)	Observed frequency (%)	Cumulative frequency (%)
G	9.849 E-03	6.95	3.475
F	2.646 E-03	15.79	14.845
E	8.120 E-04	26.22	35.850
D	3.144 E-04	27.96	62.940
C	9.471 E-05	4.39	79.115
B	3.762 E-05	4.56	83.590
A	1.620 E-05	14.07	92.905

The interpolation to calculate the 95th percentile χ/Q uses numbers from Table 3-10. The calculation is shown below for reference. This agrees with the value shown in the third column of numbers in Table 2-4. The corresponding GXQ output is shown in Appendix F.

$$\left(\frac{9.849 \times 10^{-3} - 2.646 \times 10^{-3} \text{ s/m}^3}{3.475 - 14.845 \%} \right) (5 - 14.845 \%) + 2.646 \times 10^{-3} \text{ s/m}^3 = 8.883 \times 10^{-3} \text{ s/m}^3$$

Comparing the GXQ output with the corresponding hand calculations shows that the centerline plume and the puff model air transport factors are calculated correctly. The 95th percentile overall site χ/Q at onsite, as well as offsite locations, matches the hand calculations. When plume meander is included in the calculation, a weakness in the software affects the calculation of 50th percentile values. The 50th percentile result from GXQ at the onsite location was 24% smaller than the hand calculation indicated it should be. It should be noted that 50th percentile air transport factors are only used in the evaluation of beyond design basis accidents. In these accidents, the quantity of hazardous material released into the air as respirable particles is based on order-of-magnitude estimates. Thus, a small change in the air transport factor has no significance.

3.2 DISPERSION COEFFICIENTS WITH PLUME DEPLETION

Having established that GXQ Version 4.0F carries out the interpolation to find the 95th and 50th percentile χ/Q s correctly, the calculation of χ/Q 's with modifications such as plume depletion, plume rise, and building wake effects will be performed for selected combinations of wind speed and stability class. GXQ was run with $ichk = 1$ to show the intermediate parameters that enter these calculations. For example, with plume depletion, the fraction remaining was calculated by hand and compared with the GXQ result. Agreement verifies the GXQ calculation.

The plume depletion factor is the fraction of the initial quantity airborne that is still in the plume or puff at some distance downwind. This fraction ranges from 0 to 1. The formula used to calculate this factor is shown in WHC-SD-GN-SWD-30002, Section 4.1.3. The depletion factor

depends only on the vertical standard deviation, the wind speed, and the ground deposition speed. The mixing depth limits the vertical dispersion. Because the horizontal spread of the plume has no effect on the plume depletion factor, the factors are the same for centerline, plume meander, annual average, and puff release χ/Q_s .

The plume depletion factors were calculated at two distances (100 m and 10 km), one wind speed (0.89 m/s), and all seven stability classes for a deposition speed of 0.15 cm/s. The hand calculation uses many more integration points than does GXQ, but follows a simple trapezoid rule when calculating the integral. The hand calculations and GXQ results are shown in Table 3-11.

Table 3-11. Comparison of Plume Depletion Factors for a Ground Deposition Speed of 0.15 cm/s.

Stability class	Hand calculation		GXQ Version 4.0F		Percent differences	
	100 m	10 km	100 m	10 km	100 m	10 km
A	0.9584	0.9283	0.9583	0.9282	0.01%	0.01%
B	0.9491	0.8964	0.9491	0.8964	0.00%	0.00%
C	0.9330	0.8425	0.9330	0.8425	0.00%	0.00%
D	0.9045	0.7182	0.9045	0.7182	0.00%	0.00%
E	0.8841	0.6251	0.8841	0.6252	0.00%	0.00%
F	0.8488	0.4890	0.8488	0.4891	0.00%	-0.01%
G	0.7869	0.3142	0.7869	0.3142	0.00%	-0.01%

The influence of fumigation in the numeric integration is captured in the class A calculations at 10 km. In all cases, GXQ Version 4.0F agrees with the hand calculations. The minor differences shown in Table 3-11 can be attributed to the different numeric methods used in the hand calculations and GXQ. To verify that the depletion factors are correctly multiplied by the χ/Q 's, the centerline χ/Q 's are shown in Table 3-12. The wind speed is 0.89 m/s, and the downwind distances are 100 m and 10 km.

Table 3-12. Comparison of Plume Dispersion Coefficients with Plume Depletion.

Stability class	Hand calculation		GXQ Version 4.0F		Percent differences	
	100 m	10 km	100 m	10 km	100 m	10 km
A	1.024 E-03	2.777 E-07	1.024 E-03	2.777 E-07	0.01%	0.01%
B	1.771 E-03	3.566 E-07	1.771 E-03	3.565 E-07	0.00%	0.00%
C	3.328 E-03	7.078 E-07	3.328 E-03	7.078 E-07	0.00%	0.00%
D	7.541 E-03	3.205 E-06	7.541 E-03	3.205 E-06	0.00%	0.00%
E	1.353 E-02	6.716 E-06	1.353 E-02	6.717 E-06	0.00%	0.00%
F	2.924 E-02	1.282 E-05	2.924 E-02	1.282 E-05	0.00%	-0.01%
G	6.720 E-02	2.064 E-05	6.720 E-02	2.064 E-05	0.00%	-0.01%

Notes:

The plume dispersion coefficients have units of s/m^3 .

The wind speed is 0.89 m/s. The release and receptor elevations are zero.

From Table 3-12, it is concluded that GXQ correctly calculates the plume depletion χ/Q 's when no other modeling options (e.g., building wake or plume rise) are used.

3.3 DISPERSION COEFFICIENTS WITH PLUME RISE

In these cases, there are combinations of options. The first combination uses only the downwash and flow rate adjustments. The flow rate adjustment increases the standard deviations shown in Table 3-1. The vertical standard deviation also depends on the wind speed. The downwash lowers the release height by 0.230 m for the 100 ft³/min case, and not at all for the 1,000 ft³/min case. The resulting χ/Q 's for a wind speed of 0.89 m/s and a flow rate of 100 ft³/min are shown in Table 3-13.

Table 3-13. Plume Dispersion Coefficients for the 100 ft³/min Stack with Downwash and Flow Rate Adjustments.

Stability class	Hand calculation		GXQ Version 4.0F		Percent differences	
	100 m	10 km	100 m	10 km	100 m	10 km
A	1.035 E-03	2.991 E-07	1.035 E-03	2.991 E-07	0.00%	0.00%
B	1.770 E-03	3.978 E-07	1.770 E-03	3.978 E-07	0.00%	0.00%
C	3.215 E-03	8.400 E-07	3.215 E-03	8.400 E-07	0.00%	0.00%
D	6.509 E-03	4.461 E-06	6.509 E-03	4.461 E-06	0.00%	0.00%
E	1.049 E-02	1.073 E-05	1.049 E-02	1.073 E-05	0.00%	0.00%
F	1.810 E-02	2.614 E-05	1.810 E-02	2.614 E-05	0.00%	0.00%
G	3.646 E-02	6.518 E-05	3.646 E-02	6.518 E-05	0.00%	0.00%

Notes:

The plume dispersion coefficients have units of s/m³.

The wind speed is 0.89 m/s. The release height is 2.9 m and receptor elevation is 2 m. The stack diameter is 0.254 m and the exhaust flow rate is 0.472 m³/s.

The agreement between the hand calculation and GXQ Version 4.0F is good to four significant figures. This means that the models for the flow rate adjustment and stack downwash are correctly implemented in GXQ.

The second combination uses the ISC2 plume rise with the entrainment and wind speed adjustments in addition to the downwash and flow rate adjustments. The entrainment model increases the standard deviations based on the amount of plume rise. This increase becomes less as the distance from the stack increases. For the 100 ft³/min case, the effective plume height is close enough to the release height that the entrainment adjustment is not used at the lower wind speeds. For the 1,000 ft³/min case, the entrainment adjustment is larger than the flow rate adjustment at 100 m. At 10 km, the entrainment adjustment is slightly smaller.

The amount of plume rise depends on the stack flow rate, the stack diameter, the wind speed, and the stability class. When the effective plume height is greater than 10 m, the effective wind

speed increases. The effective plume heights and wind speeds for a wind speed at the stack of 0.89 m/s and a flow rate of 1,000 ft³/min are shown in Table 3-14. The hand calculations and GXQ Version 4.0F results agree to four significant digits.

Table 3-14. Effective Release Height and Wind Speed for the
1,000 ft³/min Stack with ISC2 Plume Rise.

Stability class	Hand calculation		GXQ Version 4.0F		Percent differences	
	H _{eff}	U _{eff}	H _{eff}	U _{eff}	H _{eff}	U _{eff}
A	10.853	0.8926	10.852	0.8926	0.01%	0.00%
B	10.853	0.8926	10.852	0.8926	0.01%	0.00%
C	10.843	0.8936	10.842	0.8936	0.01%	0.00%
D	10.828	0.8953	10.825	0.8953	0.02%	0.00%
E	9.102	0.8900	9.102	0.8900	0.00%	0.00%
F	8.216	0.8900	8.216	0.8900	0.00%	0.00%
G	7.661	0.8900	7.661	0.8900	0.00%	0.00%

Notes:

The effective plume height has units of m. The effective wind speed has units of m/s.

The wind speed at the stack is 0.89 m/s. The release height is 2.9 m and receptor elevation is 2 m. The stack diameter is 0.254 m and the exhaust flow rate is 0.472 m³/s.

The calculated dispersion coefficients are shown in Table 3-15. The hand calculations and GXQ 4.0 F results agree to four significant digits.

Table 3-15. Plume Dispersion Coefficients for the
1,000 ft³/min Stack with ISC2 Plume Rise.

Stability class	Hand calculation		GXQ Version 4.0F		Percent differences	
	100 m	10 km	100 m	10 km	100 m	10 km
A	7.801 E-04	2.983 E-07	7.802 E-04	2.983 E-07	0.00%	0.00%
B	1.118 E-03	3.966 E-07	1.118 E-03	3.966 E-07	-0.01%	0.00%
C	1.355 E-03	8.358 E-07	1.355 E-03	8.358 E-07	-0.02%	0.00%
D	1.005 E-03	4.417 E-06	1.006 E-03	4.417 E-06	-0.10%	0.00%
E	1.567 E-03	1.066 E-05	1.567 E-03	1.066 E-05	0.01%	0.00%
F	1.125 E-03	2.575 E-05	1.125 E-03	2.575 E-05	0.01%	0.00%
G	4.187 E-04	6.292 E-05	4.186 E-04	6.292 E-05	0.02%	0.00%

Notes:

The plume dispersion coefficients have units of s/m³.

The wind speed is 0.89 m/s. The release height is 2.9 m and receptor elevation is 2 m. The stack diameter is 0.254 m and the exhaust flow rate is 0.472 m³/s.

3.4 DISPERSION COEFFICIENTS FOR AREA SOURCES

The area source is represented in GXQ using the MACCS building wake model with a building height of zero, and the building width corresponding to the width of the area source. Hand calculations to verify the GXQ calculations are needed only to evaluate the effect of source width on the horizontal standard deviation. The vertical standard deviation is not changed from Table 3-1.

The MACCS model inserts a virtual distance that corresponds to the distance at which the horizontal standard deviation is the width of the source divided by 4.3. These distances are shown in Table 3-16.

Table 3-16. Comparison of Virtual Source Distances for Two Area Sources.

Stability class	Hand calculation		GXQ Version 4.0F		Percent differences	
	10 m	100 m	10 m	100 m	10 m	100 m
A	7.753	99.26	7.753	99.26	0.00%	0.00%
B	10.63	136.1	10.63	136.1	0.00%	0.00%
C	14.42	184.6	14.42	184.6	0.00%	0.00%
D	21.26	272.2	21.26	272.2	0.00%	0.00%
E	31.01	397.0	31.01	397.0	0.00%	0.00%
F	46.75	598.5	46.75	598.5	0.00%	0.00%
G	73.30	938.5	73.30	938.5	0.00%	0.00%

Notes:

The virtual source distances are for source widths of 10 m and 100 m. The source height is zero.

The virtual source distances have units of meters.

The agreement between the hand calculation and the GXQ output is very good. This verifies that GXQ calculates the virtual distances correctly. To verify that the virtual distances are used correctly in GXQ, the χ/Q 's for the 10-m wide source are shown in Table 3-17. The wind speed is 0.89 m/s, and the downwind distances are 100 m and 10 km.

Table 3-17. Comparison of Plume Dispersion Coefficients for the 10-m Wide Source.

Stability class	Hand calculation		GXQ Version 4.0F		Percent differences	
	100 m	10 km	100 m	10 km	100 m	10 km
A	9.986 E-04	2.989 E-07	9.986 E-04	2.989 E-07	0.00%	0.00%
B	1.703 E-03	3.974 E-07	1.703 E-03	3.974 E-07	0.00%	0.00%
C	3.158 E-03	8.390 E-07	3.158 E-03	8.390 E-07	0.00%	0.00%
D	7.005 E-03	4.454 E-06	7.005 E-03	4.454 E-06	0.00%	0.00%
E	1.200 E-02	1.071 E-05	1.200 E-02	1.071 E-05	0.00%	0.00%
F	2.436 E-02	2.611 E-05	2.436 E-02	2.611 E-05	0.00%	0.00%
G	5.197 E-02	6.525 E-05	5.197 E-02	6.525 E-05	0.00%	0.00%

Notes:

The plume dispersion coefficients have units of s/m^3 .

The wind speed is 0.89 m/s. The release and receptor elevations are zero.

From Table 3-17, it is concluded that GXQ correctly calculates the source-adjusted χ/Q 's using the MACCS building wake model when the source height is zero, and no other modeling options are used.

3.5 AIR TRANSPORT FACTORS FOR POOL SOURCES

The pool source is represented in GXQ using the MACCS building wake model with a building height of zero, and the building width corresponding to the width of the pool. In addition, the source scale factor option 2 is used to modify the air transport factors by the wind speed raised to the 3.762 power. Hand calculations to verify the GXQ calculations are needed only to evaluate the effect of scaling factors. The scale factors for various wind speeds are shown in Table 3-18.

Table 3-18. Scale Factors for Pool Releases.

Wind speed (m/s)	Hand calculation	GXQ Version 4.0F	Percent differences
0.89	0.6451	0.6451	0.00%
2.65	39.11	39.11	0.00%
4.70	337.6	337.6	0.00%
7.15	1,636	1,636	0.00%
9.80	5,358	5,358	0.00%
12.70	14,210	14,210	0.00%
15.60	30,800	30,800	0.00%
19.00	64,670	64,670	0.00%

The agreement between the hand calculation and the GXQ output is very good. This verifies that GXQ calculates the wind speed dependent scale factors correctly. To verify that the scale factors

are used correctly in GXQ, the air transport factors for the 10-m wide source were calculated for a wind speed of 0.89 m/s. The air transport factors shown in Table 3-17 are multiplied by the scale factor shown in Table 3-18. The resulting air transport factors are shown in Table 3-19.

Table 3-19. Plume Air Transport Factors for a 10 m Wide Pool.

Stability class	Hand calculation		GXQ Version 4.0F		Percent differences	
	100 m	10 km	100 m	10 km	100 m	10 km
A	6.442 E-04	1.928 E-07	6.442 E-04	1.928 E-07	0.00%	0.00%
B	1.099 E-03	2.563 E-07	1.099 E-03	2.563 E-07	0.00%	0.00%
C	2.037 E-03	5.412 E-07	2.037 E-03	5.412 E-07	0.00%	0.00%
D	4.518 E-03	2.873 E-06	4.518 E-03	2.873 E-06	0.00%	0.00%
E	7.738 E-03	6.911 E-06	7.738 E-03	6.911 E-06	0.00%	0.00%
F	1.571 E-02	1.684 E-05	1.571 E-02	1.684 E-05	0.00%	0.00%
G	3.353 E-02	4.209 E-05	3.353 E-02	4.209 E-05	0.00%	0.00%

Notes:

The plume air transport factors have units of s/m^3 .

The wind speed is 0.89 m/s. The release and receptor elevations are zero. The pool width is 10 m.

From Table 3-19, it is concluded that GXQ correctly calculates the source-adjusted air transport factors using the MACCS building wake model when the source height is zero, and the wind speed dependent scale factor is also used.

3.6 BUILDING WAKE

The ground level release with building wake and plume meander is represented using the model from NRC Regulatory Guide 1.145. Air transport factors without building wake are calculated by setting the building cross-sectional area to zero.

3.6.1 Formulas for NRC Regulatory Guide 1.145 Building Wake and Plume Meander

The formulas used in GXQ to implement NRC Regulatory Guide 1.145 are shown below. Note that "MIN" is a function that returns the smaller of the two quantities. Also, "ln" is the natural logarithm (base e). On the surface, these formulas look quite different from those given in NRC Regulatory Guide 1.145. However, the only real difference is the inclusion of plume reflection, which increases the χ/Q for unstable cases at large distances.

Note that the procedure of comparing χ/Q adjusted for building wake and plume meander to find the smaller is equivalent to comparing the adjustment factors (F_{BW} and F_{PM}) and selecting the larger. If only plume meander or only building wake adjustments are used, then the comparison is unnecessary.

$$(\chi/Q)_{BW} = \frac{F_{ref}}{2 \pi u \sigma_y \sigma_z F_{BW}} \quad \text{with} \quad F_{BW} = \text{MIN} \left(3, 1 + \frac{A_{bldg}}{2 \pi \sigma_y \sigma_z} \right)$$

$$(\chi/Q)_{PM} = \frac{F_{ref}}{2 \pi u \sigma_y \sigma_z F_{PM}} \quad \text{with} \quad F_{PM} = M \quad \text{for } x \leq 800 \text{ m}$$

$$\text{and} \quad F_{PM} = 1 + (M-1) \frac{\sigma_y(800 \text{ m})}{\sigma_y} \quad \text{for } x > 800 \text{ m}$$

$$\text{and} \quad M = \text{MIN} \left[C, \left(\frac{6}{u} \right)^P \right] \quad \text{for } u < 6 \text{ m/s} \quad \text{and} \quad M = 1 \quad \text{otherwise}$$

$$\text{and} \quad P = \frac{\ln C}{\ln 3}$$

where:

A_{bldg}	=	Cross sectional area of the building in the direction of the wind (m^2). Calculated as the product of the effective height and width of the building.
C	=	Plume meander constant. Stability classes A, B, and C use the value $C=1$. Stability class D uses $C=2$. Stability class E uses $C=3$. Stability class F uses $C=4$. Stability class G uses $C=6$.
F_{BW}	=	Building wake adjustment factor, $1 \leq F_{BW} \leq 3$
F_{PM}	=	Plume meander adjustment factor, $1 \leq F_{PM} \leq 6$
F_{ref}	=	Plume reflection factor, $F_{ref} \geq 2$ (see WHC-SD-GN-SWD-30002)
M	=	Plume meander scale factor, $1 \leq M \leq 6$
P	=	Exponent in the function used to calculate M .
u	=	Wind speed near ground level (m/s).
x	=	Distance from the release location to the receptor location downwind (m).
$(\chi/Q)_{BW}$	=	Air transport factor with the building wake adjustment (s/m^3)
$(\chi/Q)_{PM}$	=	Air transport factor with the plume meander adjustment (s/m^3)
σ_y	=	Horizontal standard deviation function, in m. Increases as the distance to the receptor downwind increases. Depends on stability class.
$\sigma_y(800 \text{ m})$	=	Horizontal standard deviation function at a distance 800 m downwind (m). Depends on stability class.
σ_z	=	Vertical standard deviation function, in m. Increases as the distance to the receptor downwind increases. Depends on stability class.

One additional detail in the calculation of GXQ is the adjustment for mixing layer depth. The vertical standard deviation is allowed to grow until $\sigma_z > 1.2 \cdot h_m$. After that a fumigation condition is present. The air concentration between the ground and the mixing layer depth (h_m) is uniform. In the above equations a new σ_z and R_{ref} are defined as shown below.

$$\text{Fumigation means } \sigma_z = \frac{h_m}{\sqrt{2\pi}} \quad \text{and} \quad F_{\text{ref}} = 1$$

3.6.2 Verification Testing of the GXQ Building Wake and Plume Meander Model

The first check on the GXQ calculations is the values for the standard deviations. These were shown in Table 3-1, but for different distances. Three distances will be used in these tests: 100 m; 1,000 m; and 10,000 m. The standard deviations are shown in Table 3-20. An additional distance at 800 m is needed for the plume meander calculation. Because the assumed mixing layer depth is 1,000 m, the fumigation model will be needed for stability classes A and B at 10,000 m.

Table 3-20. Plume Standard Deviations.

Stability class	Horizontal standard deviation (σ_y), m				Stability class	Vertical parameter (σ_z), m		
	100 m	800 m	1,000 m	10,000 m		100 m	1,000 m	10,000 m
A	23.41	153.1	187.3	1,498.5	A	14.30	448.4	57,035
B	17.61	115.2	140.9	1,126.9	B	10.89	110.2	1,358
C	13.37	87.44	107.0	855.7	C	7.500	61.11	497.8
D	9.415	61.57	75.32	602.6	D	4.557	31.52	133.0
E	6.695	43.78	53.56	428.5	E	3.489	21.52	77.69
F	4.621	30.22	36.97	295.8	F	2.247	13.92	46.13
G	3.079	20.13	24.63	197.0	G	1.360	8.420	27.64

The building width is 30 m and the building height is 10 m. Thus the building cross-sectional area is 300 m². The building wake adjustment factor (F_{BW}) cannot exceed 3.00 as shown in the formulas for the model in NRC Regulatory Guide 1.145. The numbers calculated without this limit are shown in Table 3-21.

Table 3-21. Building Wake Factors.

Stability class	Building wake factor (F_{BW})		
	100 m	1,000 m	10,000 m
A	1.143	1.001	1.000
B	1.249	1.003	1.000
C	1.476	1.007	1.000
D	2.113	1.020	1.001
E	3.044	1.041	1.001
F	5.598	1.093	1.003
G	12.401	1.230	1.009

Notes:

The building area used in this table is 300 m².

The building wake adjustment factor used in the χ/Q calculation is not allowed to exceed 3.00.

The plume meander factors (values for M) are shown in Table 3-22. Only 3 wind speeds are used because they test the wind speed dependence over its entire range, namely, less than 2 m/s, between 2 and 6 m/s, and above 6 m/s. In addition, the distances chosen lie on both sides of the 800 m transition distance.

Table 3-22. Plume Meander Parameters. (2 sheets)

Wind speed, m/s	Stability class	Plume meander factor (F_{PM})		
		100 m	1,000 m	10,000 m
0.89	A	1	1	1
0.89	B	1	1	1
0.89	C	1	1	1
0.89	D	2.000	1.817	1.102
0.89	E	3.000	2.635	1.204
0.89	F	4.000	3.452	1.307
0.89	G	6.000	5.087	1.511
2.65	A	1	1	1
2.65	B	1	1	1
2.65	C	1	1	1
2.65	D	1.675	1.552	1.069
2.65	E	2.264	2.033	1.129
2.65	F	2.804	2.475	1.184
2.65	G	3.792	3.282	1.285

Table 3-22. Plume Meander Parameters. (2 sheets)

Wind speed, m/s	Stability class	Plume meander factor (F_{PM})		
		100 m	1,000 m	10,000 m
7.15	A	1	1	1
7.15	B	1	1	1
7.15	C	1	1	1
7.15	D	1	1	1
7.15	E	1	1	1
7.15	F	1	1	1
7.15	G	1	1	1

Note:

Wind speeds and distance cover the range of formulas used in GXQ.

The third adjustment factor is the plume reflection parameter. These are listed in Table 3-23. The plume reflection adjustment is not important for most combination of distance and stability. Only at 10,000 m for the unstable classes (A, B, and C) does plume reflection matter. For class A and B the fumigation model is used, so F_{ref} becomes 1.0 for these two cases. The plume reflection parameters at 10,000 m differ from those shown in Table 3-23 because the plume elevation was very large for some combinations of wind speed and stability class.

Table 3-23. Plume Reflection Factors.

Stability class	Plume reflection factors (F_{ref})		
	100 m	1,000 m	10,000 m
A	2.000	2.000	13.966
B	2.000	2.000	3.406
C	2.000	2.000	2.001
D	2.000	2.000	2.000
E	2.000	2.000	2.000
F	2.000	2.000	2.000
G	2.000	2.000	2.000

Notes:

The mixing layer depth is 1,000 m. The downwind receptor elevation (z) is zero.

All numbers on this table are calculated without considering fumigation for large values of σ_z .

Note that the adjustment factors shown in Tables 3-21, 3-22, and 3-23 are independent of one another. Tables 3-22 and 3-23 do not depend on building dimensions. Tables 3-21 and 3-22 do not depend on whether plume meander is used. Thus, the χ/Q values can be calculated from the numbers shown on these tables. The calculated χ/Q numbers are shown in Table 3-24. Also

shown in Table 3-24 are the χ/Q results from GXQ Version 4.0F. The input files are shown in the first attachment. The two sets of numbers are the same. Therefore, the NRC Regulatory Guide 1.145 models are calculated correctly in GXQ Version 4.0F.

Table 3-24. Computed and Calculated Air Transport Factors. (3 sheets)

Distance (m)	Wind speed (m/s)	Stability class	Results from GXQ 4.0F			Results from hand calculations		
			Building wake	Plume meander	Both	Building wake	Plume meander	Both
100	0.89	A	9.35 E-04	1.07 E-03	9.35 E-04	9.35 E-04	1.07 E-03	9.35 E-04
100	0.89	B	1.49 E-03	1.87 E-03	1.49 E-03	1.49 E-03	1.87 E-03	1.49 E-03
100	0.89	C	2.42 E-03	3.57 E-03	2.42 E-03	2.42 E-03	3.57 E-03	2.42 E-03
100	0.89	D	3.95 E-03	4.17 E-03	3.95 E-03	3.95 E-03	4.17 E-03	3.95 E-03
100	0.89	E	5.10 E-03	5.10 E-03	5.10 E-03	5.10 E-03	5.10 E-03	5.10 E-03
100	0.89	F	1.15 E-02	8.61 E-03	8.61 E-03	1.15 E-02	8.61 E-03	8.61 E-03
100	0.89	G	2.85 E-02	1.42 E-02	1.42 E-02	2.85 E-02	1.42 E-02	1.42 E-02
100	2.65	A	3.14 E-04	3.59 E-04	3.14 E-04	3.14 E-04	3.59 E-04	3.14 E-04
100	2.65	B	5.02 E-04	6.27 E-04	5.02 E-04	5.02 E-04	6.27 E-04	5.02 E-04
100	2.65	C	8.11 E-04	1.20 E-03	8.11 E-04	8.11 E-04	1.20 E-03	8.11 E-04
100	2.65	D	1.33 E-03	1.67 E-03	1.33 E-03	1.33 E-03	1.67 E-03	1.33 E-03
100	2.65	E	1.71 E-03	2.27 E-03	1.71 E-03	1.71 E-03	2.27 E-03	1.71 E-03
100	2.65	F	3.86 E-03	4.12 E-03	3.86 E-03	3.86 E-03	4.12 E-03	3.86 E-03
100	2.65	G	9.56 E-03	7.56 E-03	7.56 E-03	9.56 E-03	7.56 E-03	7.56 E-03
100	7.15	A	1.16 E-04	1.33 E-04	1.16 E-04	1.16 E-04	1.33 E-04	1.16 E-04
100	7.15	B	1.86 E-04	2.32 E-04	1.86 E-04	1.86 E-04	2.32 E-04	1.86 E-04
100	7.15	C	3.01 E-04	4.44 E-04	3.01 E-04	3.01 E-04	4.44 E-04	3.01 E-04
100	7.15	D	4.91 E-04	1.04 E-03	4.91 E-04	4.91 E-04	1.04 E-03	4.91 E-04
100	7.15	E	6.35 E-04	1.91 E-03	6.35 E-04	6.35 E-04	1.91 E-03	6.35 E-04
100	7.15	F	1.43 E-03	4.29 E-03	1.43 E-03	1.43 E-03	4.29 E-03	1.43 E-03
100	7.15	G	3.54 E-03	1.06 E-02	3.54 E-03	3.54 E-03	1.06 E-02	3.54 E-03
1,000	0.89	A	4.26 E-06	4.26 E-06	4.26 E-06	4.26 E-06	4.26 E-06	4.26 E-06
1,000	0.89	B	2.30 E-05	2.30 E-05	2.30 E-05	2.30 E-05	2.30 E-05	2.30 E-05
1,000	0.89	C	5.43 E-05	5.47 E-05	5.43 E-05	5.43 E-05	5.47 E-05	5.43 E-05
1,000	0.89	D	1.48 E-04	8.29 E-05	8.29 E-05	1.48 E-04	8.29 E-05	8.29 E-05
1,000	0.89	E	2.98 E-04	1.18 E-04	1.18 E-04	2.98 E-04	1.18 E-04	1.18 E-04
1,000	0.89	F	6.36 E-04	2.01 E-04	2.01 E-04	6.36 E-04	2.01 E-04	2.01 E-04
1,000	0.89	G	1.40 E-03	3.39 E-04	3.39 E-04	1.40 E-03	3.39 E-04	3.39 E-04
1,000	2.65	A	1.43 E-06	1.43 E-06	1.43 E-06	1.43 E-06	1.43 E-06	1.43 E-06
1,000	2.65	B	7.71 E-06	7.74 E-06	7.71 E-06	7.71 E-06	7.74 E-06	7.71 E-06

Table 3-24. Computed and Calculated Air Transport Factors. (3 sheets)

Distance (m)	Wind speed (m/s)	Stability class	Results from GXQ 4.0F			Results from hand calculations		
			Building wake	Plume meander	Both	Building wake	Plume meander	Both
1,000	2.65	C	1.82 E-05	1.84 E-05	1.82 E-05	1.82 E-05	1.84 E-05	1.82 E-05
1,000	2.65	D	4.96 E-05	3.26 E-05	3.26 E-05	4.96 E-05	3.26 E-05	3.26 E-05
1,000	2.65	E	1.00 E-04	5.13 E-05	5.13 E-05	1.00 E-04	5.13 E-05	5.13 E-05
1,000	2.65	F	2.14 E-04	9.43 E-05	9.43 E-05	2.14 E-04	9.43 E-05	9.43 E-05
1,000	2.65	G	4.71 E-04	1.76 E-04	1.76 E-04	4.71 E-04	1.76 E-04	1.76 E-04
1,000	7.15	A	5.30 E-07	5.30 E-07	5.30 E-07	5.30 E-07	5.30 E-07	5.30 E-07
1,000	7.15	B	2.86 E-06	2.87 E-06	2.86 E-06	2.86 E-06	2.87 E-06	2.86 E-06
1,000	7.15	C	6.76 E-06	6.81 E-06	6.76 E-06	6.76 E-06	6.81 E-06	6.76 E-06
1,000	7.15	D	1.84 E-05	1.88 E-05	1.84 E-05	1.84 E-05	1.88 E-05	1.84 E-05
1,000	7.15	E	3.71 E-05	3.86 E-05	3.71 E-05	3.71 E-05	3.86 E-05	3.71 E-05
1,000	7.15	F	7.92 E-05	8.65 E-05	7.92 E-05	7.92 E-05	8.65 E-05	7.92 E-05
1,000	7.15	G	1.75 E-04	2.15 E-04	1.75 E-04	1.75 E-04	2.15 E-04	1.75 E-04
10,000	0.89	A	2.99 E-07	2.99 E-07	2.99 E-07	2.99 E-07	2.99 E-07	2.99 E-07
10,000	0.89	B	3.98 E-07	3.98 E-07	3.98 E-07	3.98 E-07	3.98 E-07	3.98 E-07
10,000	0.89	C	8.40 E-07	8.40 E-07	8.40 E-07	8.40 E-07	8.40 E-07	8.40 E-07
10,000	0.89	D	4.46 E-06	4.05 E-06	4.05 E-06	4.46 E-06	4.05 E-06	4.05 E-06
10,000	0.89	E	1.07 E-05	8.92 E-06	8.92 E-06	1.07 E-05	8.92 E-06	8.92 E-06
10,000	0.89	F	2.61 E-05	2.01 E-05	2.01 E-05	2.61 E-05	2.01 E-05	2.01 E-05
10,000	0.89	G	6.51 E-05	4.35 E-05	4.35 E-05	6.51 E-05	4.35 E-05	4.35 E-05
10,000	2.65	A	1.00 E-07	1.00 E-07	1.00 E-07	1.00 E-07	1.00 E-07	1.00 E-07
10,000	2.65	B	1.34 E-07	1.34 E-07	1.34 E-07	1.34 E-07	1.34 E-07	1.34 E-07
10,000	2.65	C	2.82 E-07	2.82 E-07	2.82 E-07	2.82 E-07	2.82 E-07	2.82 E-07
10,000	2.65	D	1.50 E-06	1.40 E-06	1.40 E-06	1.50 E-06	1.40 E-06	1.40 E-06
10,000	2.65	E	3.60 E-06	3.20 E-06	3.20 E-06	3.60 E-06	3.20 E-06	3.20 E-06
10,000	2.65	F	8.77 E-06	7.43 E-06	7.43 E-06	8.77 E-06	7.43 E-06	7.43 E-06
10,000	2.65	G	2.19 E-05	1.72 E-05	1.72 E-05	2.19 E-05	1.72 E-05	1.72 E-05
10,000	7.15	A	3.72 E-08	3.72 E-08	3.72 E-08	3.72 E-08	3.72 E-08	3.72 E-08
10,000	7.15	B	4.95 E-08	4.95 E-08	4.95 E-08	4.95 E-08	4.95 E-08	4.95 E-08
10,000	7.15	C	1.05 E-07	1.05 E-07	1.05 E-07	1.05 E-07	1.05 E-07	1.05 E-07
10,000	7.15	D	5.55 E-07	5.55 E-07	5.55 E-07	5.55 E-07	5.55 E-07	5.55 E-07
10,000	7.15	E	1.34 E-06	1.34 E-06	1.34 E-06	1.34 E-06	1.34 E-06	1.34 E-06
10,000	7.15	F	3.25 E-06	3.26 E-06	3.25 E-06	3.25 E-06	3.26 E-06	3.25 E-06
10,000	7.15	G	8.10 E-06	8.18 E-06	8.10 E-06	8.10 E-06	8.18 E-06	8.10 E-06

Table 3-24. Computed and Calculated Air Transport Factors. (3 sheets)

Distance (m)	Wind speed (m/s)	Stability class	Results from GXQ 4.0F			Results from hand calculations		
			Building wake	Plume meander	Both	Building wake	Plume meander	Both

Notes:

Units for the air transport factors are s/m^3 . These are time-integrated air concentrations at the receptor location.

The "Building wake" columns show the χ/Q without plume meander.

The "Plume meander" columns show the χ/Q without building wake.

The "Both" columns show the χ/Q with both building wake and plume meander adjustments.

3.7 GXQ VERSION 4.0F SOURCE CODE LISTING

GXQ Version 4.0F is written in the FORTRAN¹ language. A few of the 1990 FORTRAN enhancements have been used. The name of the file is GXQ4F.F. The source code is listed in Appendix A.

¹ FORTRAN is a trademark of Lahey Computer Systems, Inc., Incline Village, Nevada.

4.0 RADIOLOGICAL DOSE CALCULATIONS

The risk evaluation guideline for exposure to radioactive materials is given in the DSA, Chapter 3.0.

4.1 EXPOSURE PATHWAYS

The radiological dose received by a receptor is a time-integrated dose, i.e., the exposure rate from the various pathways must be integrated over the exposure time of the receptor. The total radiological dose received by an individual is the sum of the dose contributions from internal and external pathways. The external exposure pathways include direct radiation from the passing plume of material (submersion), direct radiation from material on the ground that has fallen out of the passing plume (ground shine), and direct radiation from a radioactive source, such as a pool of liquid on the ground. Submersion doses are generally of concern only for plumes containing very short-lived (and therefore very active) gases such as those due to a criticality. For the types of releases of concern in tank farms, the submersion dose will be negligible compared to inhalation doses from the passing plume. Likewise, doses from ground shine are negligible compared to inhalation doses from the associated air plume unless the receptor is exposed for a long period of time (years) after the plume passes. Direct shine from a radioactive source, however, is an important contributor to the total dose to the onsite receptor for scenarios involving a pool of liquid on the ground, such as waste transfer line breaks. Any such direct dose to the Hanford Site boundary receptor is negligible due to geometric attenuation.

The major internal exposure pathway of concern at tank farms is the inhalation pathway. Exposure through the inhalation pathway occurs when an accident results in a release of airborne radioactive material that is transported downwind and inhaled by the receptor. A second source for the inhalation pathway is radioactive material that has been deposited on the ground during plume passage and then re-suspended. The dose contribution from inhalation of re-suspended material is generally orders of magnitude less than that from the inhalation of the material in the primary plume, however, and so is not normally considered.

The other internal exposure pathway is ingestion. DOE-STD-3009-94, Appendix A, Section A3, recommends that slow developing pathways, such as ingestion, not be included in the consequence calculations used to identify safety systems, structures, and components. The DSA does not include ingestion in consequence calculations.

Exposure through the ingestion pathway occurs when radioactive material that has been deposited offsite is ingested, either by eating crops grown in, or animals raised on contaminated soil, or through drinking contaminated water or milk. Potential doses from the ingestion pathway are not included in the comparison to risk guidelines because there are U.S. Department of Energy (DOE), state, and federal programs in place to prevent ingestion of contaminated food in the event of an accident. The primary determinant of exposure from the ingestion pathway is the effectiveness of public health measures (i.e., interdiction) rather than the severity of the accident itself. The ingestion pathway, if it occurs, is a slow-to-develop pathway and is not considered an immediate threat to an exposed population in the same sense as airborne plume

exposures. A method of including doses from ingestion of leafy vegetables and fruit during the first 24 hr following the accident was developed using the GENII code (PNL-6584, *GENII – The Hanford Environmental Radiation Dosimetry Software System*). The contribution from the ingestion pathway during the first 24 hr was found to be a minor component of the total dose to the offsite receptor. The current version of the GENII code (Version 1.485) is based on dose conversion factors (DCF) from International Commission on Radiological Protection (ICRP) (ICRP-26, *Recommendations of the International Commission on Radiological Protection*), and is considered obsolete. It is recommended, therefore, that if a total offsite dose including the 24-hr ingestion dose is desired, that the inhalation dose be adjusted by a factor of 1.1 to envelop the effect of the ingestion dose.

4.2 SOURCE TERM DEVELOPMENT

Inhalation doses are directly proportional to the time-integrated air concentration of the radioactive material at the receptor location. The time-integrated concentration at the receptor is in turn proportional to the total release of radioactive material at the source location during the exposure time of the receptor. This total release is commonly referred to as the "source term." The source term for inhalation dose is normally considered to include only respirable particle sizes; that is, particles with AEDs of 10 μm or less. The AED is the diameter of a spherical particle with a density of 1 g/cm^3 that has the same gravitational fall velocity as the actual particle in question. A particle with an AED of 10 μm is considered to have a fall velocity less than the average speed of random vorticity of the air outdoors. Respirable particles therefore tend to flow with the air and to have a very low settling rate. Particles larger than respirable size are generally assumed to fall out relatively close to the source with only a small fraction reaching the receptor under the stable, low wind speed conditions normally used to maximize doses in an accident analysis.

The source term, i.e., the amount of respirable material released to the air at the accident location, is calculated in terms of five factors as follows:

$$\text{Source Term} = \text{MAR} \times \text{DR} \times \text{ARF} \times \text{RF} \times \text{LPF}$$

A detailed discussion of the five factors is given in DOE-HDBK-3010-94, Section 1.2; however, summary definitions are given here.

- MAR is the Material at Risk. This is the total amount of radioactive material (in g, Ci, L, etc.) available to be acted on by the accident stresses. Generally, this is the maximum inventory reasonably expected to be present in the facility, process, or activity. The MAR is dependent on the scenario. For example, for a spill, the MAR could be the contents of only one container, but for a seismic event, it could be the entire contents of a building.
- DR is the Damage Ratio. This is the fraction of the MAR actually impacted by the accident-generated conditions. There is an obvious interdependence in the definitions of MAR and DR. Material determined not to be affected by the accident forces could be excluded from the MAR, or it could be included and accounted for using the DR.

- ARF is the Airborne Release Fraction. This is the fraction of the material impacted by the accident conditions that is suspended in the air as an aerosol in the immediate vicinity of the accident event and is thus available for transport. The ARF can also be given in terms of an airborne release rate, which must be multiplied by a release time to arrive at the ARF. This often occurs, for example, in cases of air entrainment from liquid pools or powder beds.
- RF is the Respirable Fraction. This is the fraction of the particles (by mass or activity) suspended at the event site that can be transported through the air and inhaled into the human respiratory system. This fraction is normally assumed to include particles with diameters of 10 μm AED or less. In many cases, the RF is unknown and in such cases it is usual to set $\text{RF} = 1$ for conservatism. In some cases, the RF can be estimated based on the particle size mix of the material being released (such as a powder). Care should be taken, however, because some release scenarios (such as pool or powder bed entrainment) preferentially release the finer particles, leaving the larger particles behind. In such cases, the RF is normally set equal to 1.
- LPF is the Leakpath Factor. This is the fraction of material in the aerosol transported through some confinement, such as a building or a ventilation system with long ducts and/or filters. This is generally estimated based on the leak paths involved (which can be multiple in series or parallel) with associated losses by depletion mechanisms, specified filter efficiencies, etc. Note that for unmitigated scenarios, the LPF is normally set equal to 1.

These five factors involved in the estimation of the source term are discussed in much greater detail in DOE-HDBK-3010-94. The analyst should be thoroughly familiar with this material. Values of ARF and RF derived from experimental data are given for many types of scenarios in DOE-HDBK-3010-94, which is a standard source for this type of information. The MAR and DR must be determined by the analyst based on the details of the specific case at hand. The estimation of the LPF for a mitigated scenario, if required, is probably the most difficult and demanding part of the analysis, requiring a high degree of knowledge and experience.

4.3 RADIOLOGICAL DOSE CALCULATIONS

The basic formulation of inhalation dose due to a release to the air is given by Equation 4-1:

$$D = Q \left(\frac{\chi}{Q'} \right) (BR)(DCF) \quad (4-1)$$

where:

- D = inhalation dose
- Q = total release at the source point
- χ/Q' = atmospheric dispersion coefficient
- BR = receptor breathing rate
- DCF = dose conversion factor for the radionuclide involved.

In the usual case of multiple radionuclide inventories, the dose due to each radionuclide must be calculated and the results summed. The factors above must have mutually consistent dimensions. Typically, Q has units of Ci, χ/Q' has units of s/m³, BR is terms of m³/s, and DCF is rem/Ci inhaled. It should be noted that, for radiological doses, the release rate is not a consideration as long as the receptor is exposed to the entire release. For example, if the release duration is doubled, the plume becomes twice as long, but the concentration is cut in half. The time-integrated air concentration at the receptor during the passage of the plume is therefore the same as before.

If the radioactive material is in the form of a gas or aerosol (e.g., coming from an exhaust system), the effects of the initial dilution at the source can be accounted for by the GXQ code as discussed in Section 2.3.2. The effect of an initial source concentration and volume source rate can also be approximated using a modified form of Equation 4-1 (Section 3.4 of NUREG/CR-6331, *Atmospheric Relative Concentrations in Building Wakes*), depicted here as Equation 4-2:

$$D = Q \left[\frac{\left(\chi/Q' \right)}{1 + V' \left(\chi/Q' \right)} \right] (BR)(DCF) \quad (4-2)$$

where:

V' = volumetric rate of the source.

Most releases at tank farms are given in terms of liters of waste aerosolized into the air. The DCF then becomes a unit-liter dose (ULD) having units of dose per liter of material inhaled as aerosol. The ULD includes the effects of all the radionuclides in the particular mix. A different ULD is therefore required for each type of waste (liquids, solids, double-shell tank waste, single-shell tank waste, etc.).

The maximum exposure time for the onsite or Hanford Site boundary receptor is normally 8 hr in accordance with DOE-STD-3009-94, Appendix A. For scenarios with long release durations, Q is the release during the first 8 hr following start of the release event.

The footnote to Table 1 of ICRP-68, *Dose Coefficients for Intakes of Radionuclides by Workers—Replacement of ICRP Publication 61*, specifies a breathing rate for light work assuming the individual spends 2.5 hours sitting with a breathing rate of 0.54 m³/h, and 5.5 hours at light exercise with a breathing rate of 1.5 m³/h. The total quantity breathed in 8 hours is 9.6 m³, giving an average breathing rate of 3.33×10^{-4} m³/s. This is the light-activity breathing rate that is used in the DSA. While the peak breathing rate is higher, use of the light-activity value is reasonable because it reflects an average of typical activities during a working day.

In the footnote to Table 6 of ICRP-71, *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 4 Inhalation Dose Coefficients*, the breathing rate for the offsite adult receptor is calculated assuming the receptor spends 6 hours sitting at a breathing rate of 0.54 m³/h, 9.75 hours at light exercise at a breathing rate of 1.5 m³/h, 0.25 hours at heavy

exercise at a breathing rate of $3.0 \text{ m}^3/\text{h}$, and 8 hours sleeping at a breathing rate of $0.45 \text{ m}^3/\text{h}$. The total air breathed in 24 hours is 22.2 m^3 for an average breathing rate of $2.57 \times 10^{-4} \text{ m}^3/\text{s}$. This is an average breathing rate. Since many releases in the DSA are considerably shorter than 24 hours, it would be conservative to use the light-activity breathing rate for short releases ($3.33 \times 10^{-4} \text{ m}^3/\text{s}$), but the $2.57 \times 10^{-4} \text{ m}^3/\text{s}$ could be used for releases of 24 hours or longer.

The usual form of the inhalation dose formula applicable to tank farms is shown in Equation 4-3:

$$D = Q \left(\frac{\chi}{Q'} \right) (BR)(ULD) \quad (4-3)$$

where:

- D = inhalation dose to receptor (rem or Sv)
- Q = liters of respirable tank waste released (L)
- χ/Q' = atmospheric dispersion coefficient (s/m^3)
- BR = breathing rate (m^3/s)
- ULD = dose per unit liter of waste inhaled as aerosol (rem/L or Sv/L).

The χ/Q' to be used (1-hr, 2-hr, logarithmically averaged, etc.) will depend on the scenario. If the release rate is approximately constant over at least 1 hr, then the 2-hr χ/Q' (i.e., with plume meander) is used. If the release duration is less than 1 hr, or if the release rate is variable (e.g., exponentially decreasing), then the 1-hr χ/Q' (i.e., without plume meander) is used. If the release has a duration greater than 2 hr with an approximately constant rate over that duration, then a logarithmically averaged χ/Q' can be used as discussed in Section 2.2.4. The 50th percentile χ/Q' s may be used for beyond design basis accidents and for comparative calculations to determine the degree of conservatism in bounding calculations. The puff χ/Q s are not applicable to radiological releases.

This page intentionally left blank.

5.0 TOXICOLOGICAL EXPOSURE CALCULATIONS

The evaluation guidelines for exposure to toxic chemicals are given in the DSA, Section 3.3.1, and are based on the U.S. Department of Energy's protective action criteria (PAC).

For the chemicals in tank waste, the total quantity taken up by the body (i.e., integrated dose dependent) is not the prime consideration. For accident analysis purposes, most toxic chemical mixes of concern at tank farms (e.g., aerosolized waste, ammonia) should be assumed to have consequences that are acute (i.e., concentration dependent).

For concentration dependent exposures, a reasonably conservative exposure time is needed. Based on a review of DOE complex guidance and a review of tank waste chemicals (see Appendix P), a 15-min peak average concentration provides a reasonably conservative consequence for comparison to the 1-hr PAC guidelines for the offsite public and onsite worker for accidents involving tank farm wastes.

To determine whether a chemical consequence exceeds a guideline value, therefore, the highest time-weighted average (TWA) concentration for any 15-min period (i.e., the maximum or peak 15-min TWA concentration) should be compared to the guideline value. To determine the average concentration, the following formula can be used.

$$TWA = \frac{C_1 T_1 + C_2 T_2 + \dots + C_n T_n}{T_1 + T_2 + \dots + T_n} = \frac{\sum C_n T_n}{\sum T_n}$$

where:

C = Concentration (mg/m³), and

T = Time period of exposure (min).

It is not recommended that individual time intervals less than 1 min be used in the numerator of the above formula for calculating the TWA. For the peak 15-min TWA, the 15-min period of maximum exposure (concentration) is selected and input (as 15 1-min segments) into the above formula. For exposure periods of less than 15 min, the product of C_xT_x may equal zero during the exposure period. These "zero" results may be factored into the 15-min average.

Under special circumstances (i.e., immediately toxic chemical exposures), the use of a shorter averaging duration, such as the actual exposure period, may be warranted depending on the immediate toxicity of the chemical of interest and the peak concentration observed. However, an averaging period of less than 1 min should not be used. Under these special circumstances a short release can also be treated using the puff model where the release is assumed to take place in zero time and to spread in all three dimensions as the cloud moves downwind. Either the steady-state or puff model (whichever gives the lower result) can be used. Both models are always conservative. Note: Tank farm accident consequence analysis does not include this special circumstance. That is, a peak 15-min TWA is used for tank farm accident consequence calculations (see Appendix P).

Other chemicals have toxic effects that are dose-dependent, i.e., the severity of the effect increases as the total quantity of the chemical absorbed increases. For these chemicals only, the average exposure concentration over a longer period (up to 1 hr) may be used.

It should be emphasized that these categories are not mutually exclusive. There are chemicals that elicit concentration-dependent responses at high concentrations that also produce dose-related responses at lower concentrations. For example, acute exposure to high concentrations of benzene can affect the central nervous system, while exposures at lower levels can cause hematopoietic effects and leukemia. Chemicals such as beryllium, chloroform, ethylene oxide, and formaldehyde can also produce dose-dependent effects at low concentrations and display acute toxicity at high concentrations.

If it is known that the toxic effects of a chemical are not concentration-dependent, but depend on the total quantity of chemical taken up by the body (i.e., dose dependent), then the peak 1-hr average concentration may be used. Note: A peak 15-min TWA is used for tank farm accident consequence calculations.

5.1 STEADY-STATE MODEL

If it is assumed that the toxic material is released at some average rate over some period of time, the peak concentration at the receptor is obtained directly from the definition of the steady-state χ/Q' as shown by Equation 5-1:

$$C = Q' \left(\frac{\chi}{Q'} \right) \quad (5-1)$$

where:

- C = peak concentration (mg/m^3)
- Q' = toxic material release rate (mg/s)
- χ/Q' = steady-state 1-hr dispersion coefficient (s/m^3).

If the toxic material is in the form of a gas or aerosol (e.g., coming from a short stack), the effects of the initial dilution at the source can be accounted for by the GXQ code as discussed in Section 2.3.2. The effect of an initial source concentration and volume source rate can also be approximated using a modified form of Equation 5-1 (NUREG/CR-6331), shown here as Equation 5-2:

$$C = S V' \left[\frac{\left(\chi/Q' \right)}{1 + V' \left(\chi/Q' \right)} \right] \quad (5-2)$$

where:

$$\begin{aligned} S &= \text{toxic material concentration at source (mg/m}^3\text{)} \\ V' &= \text{volumetric rate of source (m}^3\text{/s).} \end{aligned}$$

If the toxic material is in the form of an aerosol suspended in the air by some mechanism such as a spray, the peak concentration can also be calculated as shown in Equation 5-3.

$$C = \rho \left(10^3 \frac{\text{cm}^3}{\text{L}} \right) \left(10^3 \frac{\text{mg}}{\text{g}} \right) Q' \left(\frac{\chi}{Q'} \right) \quad (5-3)$$

where:

$$\begin{aligned} \rho &= \text{density of source material (g/cm}^3\text{)} \\ Q' &= \text{toxic material release rate (L/s).} \end{aligned}$$

5.2 PUFF RELEASE MODEL

If it is assumed that the toxic material is released over a period of time that is very short compared to the transit time to the receptor, the peak concentration at the receptor may be calculated using the puff χ/Q . Note that the puff χ/Q gives the concentration at the receptor location (χ) per unit total release at the release point (Q) and has dimensions of $1/\text{m}^3$ as shown in Equation 5-4:

$$C = Q \left(\frac{\chi}{Q} \right) \quad (5-4)$$

where:

$$\begin{aligned} C &= \text{peak concentration (mg/m}^3\text{)} \\ Q &= \text{total release of toxic material (mg)} \\ \chi/Q &= \text{puff dispersion coefficient (1/m}^3\text{).} \end{aligned}$$

If the release of toxic material is initially in the form of a cloud of gas or aerosol (e.g., from an explosion or tank rupture), the effects of the initial dilution at the source can be accounted for by the GXQ code using an initial source size correction as discussed in Section 2.3.3. The effect of an initial source concentration and volume can also be approximated using a modified form of Equation 5-2 (easily derived from Equation 5-2), as shown here by Equation 5-5:

$$C = S V \left[\frac{\left(\frac{\chi}{Q} \right)}{1 + V \left(\frac{\chi}{Q} \right)} \right] \quad (5-5)$$

where:

- S = toxic material concentration in the initial cloud (mg/m^3)
 V = initial volume of source (m^3).

If the toxic material is in the form of an aerosol suspended in the air by some fast mechanism such as a short-duration spray, the peak concentration can also be calculated as shown in Equation 5-6:

$$C = \rho \left(10^3 \frac{\text{cm}^3}{\text{L}} \right) \left(10^3 \frac{\text{mg}}{\text{g}} \right) Q \left(\frac{\chi}{Q} \right) \quad (5-6)$$

where:

- ρ = density of source material (g/cm^3)
 Q = total release of toxic material (L).

At some value of the release duration, the steady-state (i.e., 1-hr χ/Q) will yield the same concentration as the puff χ/Q . If the release duration is less than this cross-over value, it is advantageous to use the puff model. If the release duration is greater than the cross-over value, it is advantageous to use the steady-state model. Note that both models are always conservative. Each model, if used outside its range of application, will tend to be overly conservative. As discussed in Section 2.2.4, it can be shown that for any particular receptor location the cross-over release duration is just the ratio of the steady-state χ/Q to the puff χ/Q . Using the basic values for the 95th percentile coefficients in Tables 2-4 and 2-5, the cross-over release duration times are 3.7 sec and 439 sec for the onsite and Hanford Site boundary receptors, respectively. A very short duration release can always be averaged over at least 1 min so that it is always advantageous to use the steady-state model for the onsite receptor. For the site boundary receptor, on the other hand, it is advantageous to use the puff model for release durations less than 439 sec (7 min, 19 sec).

5.3 TOXIC CHEMICAL MIXES

The formulas in Sections 5.1 and 5.2 are applied to only one chemical or analyte at a time. If there is more than one chemical in the toxic material, the SOF rule is applied. The concentration of each chemical is divided by the risk guideline for that species. These fractions of risk guidelines are then summed over all the chemical species in the mix. If the sum is less than 1, the mix is below guideline concentration at the receptor location. If the risk guideline is in terms of ppm (parts per million by volume), it can be converted to mg/m^3 at standard temperature and pressure by using Equation 5-7:

$$\frac{\text{mg}}{\text{m}^3} = \text{ppm} \frac{(MW) \left(10^3 \frac{\text{mg}}{\text{g}} \right) \left(10^3 \frac{\text{L}}{\text{m}^3} \right)}{(22.4 \frac{\text{L}}{\text{mole}}) (10^6 \text{ ppm})} \quad (5-7)$$

where:

MW = molecular weight of the toxic species (g/mole).

For other than standard conditions, e.g., in a tank headspace, the molar gas volume (22.4 L/mole) should be corrected for the actual conditions using the standard gas laws.

The basic equation for concentration at the receptor in the steady-state model can be used to obtain the SOF for a mixture of chemicals as shown in Equation 5-8:

$$\sum_j \frac{C_j}{RG_j} = \left(\frac{\chi}{Q'} \right) \sum_j \frac{Q'_j}{RG_j} \quad (5-8)$$

where:

RG_j = risk guideline for the j^{th} species.

Reformulating the release rate, Q'_j , in terms of a volume release rate (L/s) times a waste concentration (mg/L) for each species, yields Equation 5-9:

$$\sum_j \frac{C_j}{RG_j} = V' \left(\frac{\chi}{Q'} \right) \sum_j \frac{c_j}{RG_j} \quad (5-9)$$

where:

V' = volume release rate of the waste mixture (L/s)

c_j = concentration of species j in the waste mixture ($\text{g/L} \times 10^6 = \text{mg/m}^3$).

The summation on the right side of Equation 5-9 is a dimensionless number referred to as the unit (release rate) sum of fractions (USOF) for continuous releases. In tank farms, many of the waste mixes have been characterized in terms of USOF. Since the RG_j is a function of consequence guideline and whether the receptor is a worker or a member of the public, the USOFs must be tabulated for both consequence guidelines ("moderate" and "high" consequence thresholds) and for both types of receptors. The SOFs for a particular consequence guideline and receptor is therefore given by Equation 5-10:

$$\sum_j \frac{C_j}{RG_j} = V' \left(\frac{\chi}{Q'} \right) (\text{USOF}) \quad (5-10)$$

In an analogous way, the SOF using the puff model is given by Equation 5-11:

$$\sum_j \frac{C_j}{RG_j} = V \left(\frac{\chi}{Q} \right) (\text{USOF}) \quad (5-11)$$

where:

- V = total volume of material released
- $USOF$ = unit release sum of fractions for puff releases (which have also been tabulated for many types of waste in tank farms).

In both cases, the puff γ/Q can be corrected for initial source volume rate or volume as discussed in Sections 5.1 and 5.2, respectively. If the SOFs (the left side of Equations 5-10 and 5-11) is less than 1, the concentration at the receptor location is less than the consequence guideline in question for that mix.

6.0 REFERENCES

- DOE-HDBK-3010-94, 2000, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Change Notice No. 1, U.S. Department of Energy, Washington, D.C.
- DOE-STD-3009-94, 2002, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, Change Notice No. 2, U.S. Department of Energy, Washington, D.C.
- DOE/TIC-27601, 1984, *Atmospheric Science and Power Production*, U.S. Department of Energy, Washington, D.C.
- HNF-25195, 2005, *Alternate Model for Plume Rise Near Buildings*, Rev. 0, Fluor Hanford, Richland, Washington.
- HNF-SD-WM-CN-096, 1997, *Refined Radiological and Toxicological Consequences of Bounding Spray Leak Accidents in the Tank Farm Waste Transfer Pits*, Rev. 0-A, Fluor Daniel Northwest, Richland, Washington.
- ICRP-26, 1977, *Recommendations of the International Commission on Radiological Protection*, Annals of the International Commission on Radiological Protection, Volume 1, Number 3, Elsevier Science, Tarrytown, New York.
- ICRP-68, 1994, *Dose Coefficients for Intakes of Radionuclides by Workers—Replacement of ICRP Publication 61*, Annals of the International Commission on Radiological Protection, Volume 24, Number 4, Elsevier Science, Tarrytown, New York.
- ICRP-71, 1995, *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 4 Inhalation Dose Coefficients*, Annals of the International Commission on Radiological Protection, Volume 25, Number 3-4, Elsevier Science, Tarrytown, New York.
- NRC Regulatory Guide 1.145, 1982, *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*, U.S. Nuclear Regulatory Commission Guide, Rev. 1, U.S. Nuclear Regulatory Commission, Washington, D.C.
- NUREG/CR-6331, 1997, *Atmospheric Relative Concentrations in Building Wakes*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington.
- PNL-6584, 1988, *GENII – The Hanford Environmental Radiation Dosimetry Software System*, Pacific Northwest Laboratory, Richland, Washington.
- TID-24190, 1968, *Meteorology and Atomic Energy – 1968*, D. H. Slade, ed., U.S. Atomic Energy Commission/Division of Technical Information, Washington, D.C.

TWR-3958, 1999, *Refined Consequence Analysis of Subsurface Leaks from TWRS Facilities that Result in a Surface Pool*, Rev. 0, Fluor Daniel Northwest, Richland, Washington.

WHC-SD-GN-SWD-30002, 1994, *GXQ 4.0 Program Users' Guide*, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

RPP-13482 REV 7

APPENDIX A

PROGRAM LISTING OF THE GXQ CODE VERSION 4.0F

This page intentionally left blank.

APPENDIX A

PROGRAM LISTING OF THE GXQ CODE VERSION 4.0F

```

! CHANGE HISTORY:
! -----
! GXQ12 - base code
! GXQ13 - added momentum/buoyancy plume rise model
! GXQ14 - added 2nd order effective rel. ht. calculation, deleted chronic mode
! GXQ15 - increased size of JF arrays, added v0 to X/Q denominator
! GXQ152 - added scaling factor to pop. wt. X/Q, added 5th power law PM
! GXQ153 - changed some integer variables to logical variables
! GXQ2 - revised code structure to allow joint selection of isite, ipop, ifox
!      eliminated population, overall site and interpolation modes
! GXQ22 - special compilation to read in w0, drel, qh, fact for M. Medsker
! GXQ23 - special compilation to population weight mode 2 X/Q for R. Britton
! GXQ24 - corrected execution time calculation and renamed ntot, nsec, nsite
! GXQ241 - special compilation to calculate cdf based on histogram
! GXQ25 - corrected puff model when volume flow rate non-zero
! GXQ251 - added option to select jet or buoyant stack downwash
! GXQ252 - special compilation for Mark Medsker
! GXQ253 - special compilation for Mark Medsker/Brit Hey
! GXQ254 - added more output to debug option and added iflow option
! GXQ255 - special compilation for Mark Medsker
! GXQ256 - added buoyant plume rise limits, removed isa flag
! GXQ257 - revised downwash and plume rise models
! GXQ258 - corrected u**3 to u**9 in subroutine rise
!      corrected undefined x to xvz in xvz function
!      included he in parameter list for dep and simpson subroutines
! GXQ259 - added sector frequency output
! GXQ26 - revised logical choice echo
!      power function eqns. for NRC plume meander
! GXQ3 - independent review version
!      Plume rise/settling/downwash and vertically corrected wind speed is
!      iterated until the change in he is less than 1 m.
!      Revised dry dep. integration to start @ 0.1 m and use evenly spaced
!      logarithmic intervals and to include fumigation condition.
!      Revised flow correction to a correction of sigmay and sigmaz based
!      on virtual distance.
!      Added option to base buoyancy rise on initial plume density in
!      addition to sensible heat emission rate.
!      Added lift-off criterion to plume rise
!      Revised code to separately track lateral and vertical virtual
!      distances. Maximum of flow and building wake chosen.
!      Deleted entry of plume vertical velocity. Calculated internally.
!      Fref more complicated and added z to receptor input requirements.
!      Increased wind speed array size to 9
! GXQ31 - Added stability class and wind speed to mode 1 output
!      Allowed wind speed adjustment for other than 10 m
!      Incorporated NRC RG 1.145 building wake
!      Corrected density difference in plume rise based on density
!      Limit effective plume height to 0.1 m minimum for depletion calcs.
!      Automatic selection of buoyant or momentum dominant downwash
!      Deleted ipuff flag and revised code to calculate max. air concentra.
! GXQ31A - Added code to make temporary GXQ.TMP file for receptor locations
!      This version put on G drive.
! GXQ31B - Corrected unit 4 to tmpio in subroutine cdf
!      Corrected do loop to calculate sector frequency before testing popt
!      Added warning # 11
!      Revised sector frequency output to indicate 100% when inorm=t.
!      Warning #3 revised
!      Correct cdf.out print logic
! GXQ31C - Corrected warning #7 logic and to not exit
!      Changed warning #3 to only activate when scale .ne. 1.0
!      Changed wording of error #22.
!      Added error #24.
! GXQ4 - Changed stability factors to coincide with MACCS and depend on Tamb
!      Set sx3=sy3 to allow for virtual source adjusted sigma x
!      Changed system calls and EOF query for Lahey F77L Compiler
!      Changed plume density input to temperature input

```


RPP-13482 REV 7

```

!      Put scaling option in ISRC=1
!      Added wind speed power scaling option in ISRC=2
!      Removed momentum rise to strictly implement MACCS buoyant plume rise model
!      Added ISC2 momentum/buoyancy rise model
!      Employ method of Pasquill for air entrainment in rising plume
!      Added Mills' modified buoyant rise for open area fires
!      Divide overall site annual average to individual X/Q by 16
!      Adding Warning #11 to warn against zero stack height plume rise w/o Mills adjustment
!      Modified Warning #10 to alert user to entrainment during plume rise
!      Eliminated Error #23
!      Added Error #23 to prevent divide by zero error.
!      Changed logic in 1/5th power law PM to (rd.le.1 hr) as in MACCS
!      Changed plume rise code to calculate urel (wind speed at rel. ht.)
!      Added Error #29 to prevent hrel > h.
!      Fixed error identified by PDF when puff model used and iflow=1.
!      Made he a function of x when evaluating integral in depletion factor
!      Changed the way overall site X/Q calculated bin frequencies
!      Added Error #30 to flag overall site input error
! GXQ4A - Defined virtual distance xvz for source depletion model
! GXQ4B - Fixed problem with sector population tally when first jf entry is 0
! GXQ4D - Included arrays for sector and distance so that these could be
!         printed out to cdf.out file
! GXQ4F - Eliminate unnecessary output when ICHK=1 but add virtual distances
!         Fumigation criteria changed from 0.8*h to 1.2*h
!         Correct stack wind speed initialization (urel not ua)
!         Correct stable, buoyant formula for xf in ISC model
!         Correct the vertical stack flow adjustment to use fref0
!         Increase the accuracy of the search for uhe
!         Correct the ground deposition integral to include entrainment and
!         fumigation. Also, increased the accuracy of the integration.
!         Correct normalization of X/Q when the last frequency is not zero.
!         Correct population-weighted calculation of average individual value.
!
! VARIABLE DEFINITIONS:
! drel  -release diameter (m)
! dwash  -stack downwash (m)
! fact   -scaling factor applied to X/Q
! fref   -plume trapping reflection parameter
! freq   -frequency at which calculated X/Q will be exceeded
! h       -mixing height (m) (1000 meters typical)
! hb      -building height (m)
! he      -effective release height (m)
! ha      -reference anemometer height (m)
! hrel    -stack or release height (m)
! ichk    -debug flag (T to select)
! icdf    -print out cdf flag (T to select)
! iclass  -atmospheric stability class (1-7 is Pasquill A-G)
! idep    -plume depletion flag (1 to select)
! ientr   -air entrainment at point of release (1 to select)
! ifox    -joint frequency treatment flag (T for frequency to exceed
!         (F for annual average)
! igrav   -gravitational settling to reduce plume height (1 to select)
! igrnd   -Mills' buoyant plume rise modification for ground effects (1 to select)
! inorm    -jf normalization flag (T to select)
! ipm     -plume meander (1 to select NRC RG 1.145)
!         (2 to select 5th power law)
! isec    -sector number (1=S, 2=SSW, etc., if 0 then all 16 sectors)
! isite    -overall site (T to select)
! ipop     -population weighted (T to select)
! ipuff    -calculation air concentrations (1 to select)
! irise    -plume rise flag (1 or 2 to select)
! iflow    -flow rate adjustment option (1 to select)
! iwake    -building wake flag (1 to select)
! iwash    -downwash model (0 to turn off)
!         (1 to select jet model)
!         (2 to select buoyant model)
! iwind    -correction to 10m wind speed for higher elevations (1 to select)
! isrc     -source term model flag (1 multiply by scalar, fact)
!         (2 multiply by fact*[ue**(wsexp)] )
!         (3 multiply by fact*[10**(ue*wsexp)] )
! mode     -operational mode flag of code (1-3)

```

RPP-13482 REV 7

```

! nall -number of stability class and wind speed bins x 1 or 16
! nbin -number of stability class and wind speed bins in JF file
! nsbin -number of stability class bins in JF file
! nsec -either 1 or 16 depending upon isite
! nubin -number of wind speed bins in JF file
! power -power law grid density factor
! qh -convective heat release rate (w)
! rd -release duration (hr)
! t0 -initial plume temperature (C)
! tamb -ambient temperature (C)
! title -problem title
! ua -wind speed at reference anemometer height (m/s)
! ue -effective wind speed (m/s)
! uhe -wind speed at he (m/s)
! uc -critical wind speed preventing lift-off (m/s)
! urel -wind speed at release height (m/s)
! v0 -initial volume flow rate of plume (m3/s)
! vd -deposition velocity (m/s)
! vg -gravitational settling velocity (m/s)
! w0 -initial velocity of plume (m/s)
! wb -building width (m)
! wsexp -exponential constant in the scale factors
! x -distance from release point to receptor (m)
! xint -number of distance intervals for plot file
! xmax -maximum distance for plot file (m)
! xqmin -minimum scaled xq to compute
! y -receptor offset from centerline (m)
! yint -number of offset intervals for plot file
! ymax -maximum offset for plot file (m)
! z -receptor height above ground level (m)
!

```

```

! ARRAY DEFINITIONS:
! sjf - joint frequency vector for sector
! xq - X/Q vector corresponding to sjf vector
! ws - wind speed vector corresponding to sjf vector
! cl - stability class vector corresponding to sjf vector
! cd - cumulative distribution vector corresponding to sjf vector
! ubin - wind speed vector read from joint frequency file
! jf - joint frequency array for all sectors
! sname - character array of compass sector names
! cname - character array of stability class names
!

```

```

!
! program gxq
! common /dat5/ p(16,10),dmid(10)
! common /dat6/ cname(7), sname(16)
! character cname*2, sname*3
! common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),
&nbin, isector(0:1008),distance(0:1008)
! integer cl
! common /dat2/ ubin(9),jf(63,16),nsbin,nubin,ha
! real jf
! common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
! logical ifox,inorm,icdf,ichk,isite,ipop
! character*80 title, line
! integer stdout,stdin,tmpio,unit4,unit8
! stdin=5
! stdout=6
! tmpio=2
! unit4=4
! unit8=8
!
! print header read and echo first portion of standard input file
!
! call head(0,stdout)
! OPEN(stdin,file='gxq.in',STATUS='OLD',ERR=5)
! goto 6
5 print *,'ERROR #1 - Could not open gxq.in file.'
```

RPP-13482 REV 7

```

        call exit
6      call input(stdin,stdout,tmpio)
        call message
!
! mode is site specific
! read sector and distance from standard input
!
        if (mode.eq.1) then
          OPEN(unit4,file='gxq.tmp',STATUS='OLD')
          call readjf(tmpio)
          if(ipop)call readpop(tmpio)
          call head(mode,stdout)
          if(icdf) then
            OPEN(unit8,FILE='CDF.OUT',FORM='FORMATTED',STATUS='UNKNOWN')
            call head(0,unit8)
            call head(4,unit8)
          endif
!
! Prepare for 16 sectors worth of receptor data if overall site selected
!
        if(isite)then
          nsec=16
        else
          nsec=1
        endif
        nall=nbin*nsec
!
! return here if more receptors to calculate
!
126  continue
!
! read receptor location from pre-processed data on unit4
!
        popt=0.0
        do 500 k=1,nsec
          read(unit4,*,end=700) isec,xmax,z
!
! fill joint frequency array if first time through read loop
!
          if(k.eq.1)call fill(isec)
!
! calculate single sector xq for each non-zero joint frequency array element
!
          pops=0.0
          do 400 i=1,nbin
            ii=i+(k-1)*nbin
            isector(ii)=isec
            distance(ii)=xmax
            if(sjf(ii).gt.0.0)then
              if(.not.ipop)then
                call xqsub(xmax,0.0,z,ws(ii),cl(ii),xq(ii))
              else
                xq(ii)=0.0
                do 192 j=1,10
                  x=dmid(j)
                  if(x.gt.xmax)goto 193
                  pop=p(isec,j)
                  if(pop.eq.0.0)goto 192
                  call xqsub(x,0.0,z,ws(ii),cl(ii),xqp)
                  xq(ii)=xq(ii)+xqp*pop
                  if(i.eq.1)pops=pops+pop
192              continue
193              continue
                endif
              else
                xq(ii)=0.0
              endif
            400  continue
!
! tally total population
!

```

RPP-13482 REV 7

```

      popt=popt+pops
500  continue
      !
      ! calculate total sector frequency in percent
      !
      sfreq=0.0
      do 600 i=1,nall
        sfreq=sfreq+sjf(i)
600  continue
      !
      ! set population totals to 1 if zero or no population weighting
      !
      poptt=popt
      if(poptt.eq.0.0)poptt=1.0
      if(ipop.and.popt.eq.0)then
        xqp=0.0
        index=1
        goto 650
      endif
      if(.not.ipop)popt=1.0
      !
      ! calculate annual average or frequency of exceedance X/Q
      !
      if(.not.ifox) then
        xqp=0.0
        do 610 i=1,nall
          xqp=xqp+sjf(i)*xq(i)
610  continue
          if(inorm)xqp=xqp/sfreq*100.
          if(isite.and..not.ipop)xqp=xqp/16.
          xqp=xqp/100.
          if(icdf)then
            call sort(nall)
            call condense(nall,ncond)
            call cdf(ncond,unit8)
          endif
        else
          call sort(nall)
          call condense(nall,ncond)
          call cdf(ncond,unit8)
          call inter(xqp,freq,ncond,index)
        endif
      !
      ! write results to standard out
      !
650  continue
      write(line(1:80),'(80x)')
      if(isite)then
        write(line(2:4),'(a)') 'ALL'
        write(line(9:16),'(i8)') int(xmax)
        write(line(18:25),'(i8)') int(z)
      else
        write(line(2:4),'(a)') sname(isec)
        write(line(9:16),'(i8)') int(xmax)
        write(line(18:25),'(i8)') int(z)
      endif
      if(inorm)then
        write(line(27:32),'(f6.2)') 100.00
      else
        write(line(27:32),'(f6.2)') sfreq
      endif
      write(line(34:43),'(i10)') int(popt)
      write(line(45:54),'(1pe10.2)') xqp
      write(line(56:65),'(1pe10.2)') xqp/poptt
      if(ifox)then
        write(line(67:68),'(a)') cname(cl(index))
        write(line(74:78),'(f5.2)') ws(index)
      endif
      write(stdout,'(a)') line
      goto 126
700  continue

```

RPP-13482 REV 7

```

      if(k.ne.1)then
        print *, 'ERROR #30 - 16 sectors of data required for overall-site calculation.'
      endif
      close (unit4,status='delete')
!
! mode is by stability class and wind speed
! read stability class, wind wpeed, distance and offset from standard input
!
      elseif (mode.eq.2) then
        call head(mode,stdout)
        call comment(stdin,stdout)
710    read(stdin,*,end=140) iclass,ua,x,y,z
        call xqsub(x,y,z,ua,iclass,xqp)
        write(stdout,1010) cname(iclass),ua,int(x),int(y),int(z),xqp
1010   format(1x,a2,6x,f8.2,2x,3(i8,2x),1pe10.2)
        goto 710
140    continue
!
! mode is to make plot file
! read stability class, wind wpeed, max distance, distance intervals,
! max offset, offset intervals, and min xq from standard input
!
      elseif (mode.eq.3) then
        call comment(stdin,stdout)
        read(stdin,*) iclass,ua,xmax,imax,ymax,jmax,xqmin,power
        z=0.0
        print *
        write(stdout,99) title
99     format(1x,a79)
        print *
        print *, 'stability class: ',cname(iclass)
        print *, 'wind speed:',ua,'m/s'
        print *, 'max distance and intervals:',xmax,imax
        print *, 'max offset and intervals: ',ymax,jmax
        print *, 'minimum X/Q calculated and power:',xqmin,power
        xmin=0.0
        if(xmax.lt.xmin.or.ymax.lt.0.0) then
          print *, 'ERROR #2 - Xmax or ymax less than or equal to zero.'
          call exit
        endif
        call head(mode,stdout)
!
        xstp=(xmax-xmin)**(1/power)/imax
        ystp=ymax**(1/power)/jmax
        write(stdout,1011) 0.0,0.0,0.0
        do 145 j=1,jmax
          y=(float(j)*ystp)**power
          write(stdout,1011) 0.0,y,0.0
          write(stdout,1011) 0.0,-y,0.0
145    continue
        do 160 i=1,imax
          x=(float(i)*xstp)**power+xmin
          y=0.0
          call xqsub(x,y,z,ua,iclass,xqp)
          xqp=xqp
          write(stdout,1011) x,y,xqp
          do 150 j=1,jmax
            y=(float(j)*ystp)**power
            call xqsub(x,y,z,ua,iclass,xqp)
            xqp=xqp
            write(stdout,1011) x,y,xqp
            write(stdout,1011) x,-y,xqp
            if(xqp.lt.xqmin)goto 160
1011   format(1x,2(1pe11.3,1x),1pe10.2)
150    continue
160    continue
!
        endif
        call exit
      end
!

```

RPP-13482 REV 7

```

! Block data subroutine
!
  block data names
  common /dat6/ cname(7), sname(16)
  character cname*2, sname*3
  data sname/'S ','SSW','SW ','WSW','W ','WNW','NW ','NNW','N '
&,'NNE','NE ','ENE','E ','ESE','SE ','SSE'/
  data cname/'A ','B ','C ','D ','E ','F ','G '/
  end
!
! Subroutine to read joint frequency data
!
  subroutine readjff(tmpio)
  common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),
&nbin,isor(0:1008),distance(0:1008)
  integer cl, tmpio
  common /dat2/ ubin(9),jf(63,16),nsbin,nubin,ha
  real jf
  character*80 tit1,tit2
  OPEN(tmpio,FILE='jointfre.in',STATUS='OLD',err=100)
  read(tmpio,9) tit1
  read(tmpio,9) tit2
  print *
  write(*,98) 'JOINT FREQUENCY DATA:
  write(*,99) tit1
  write(*,99) tit2
  read(tmpio,*) nubin,nsbin,ndum,ndum,ha
  read(tmpio,*) (ubin(i),i=1,nubin)
  nbin=nubin*nsbin
  do 10 i=1,nbin
10  read(tmpio,*) (jf(i,j),j=1,16)
9  FORMAT(A80)
98  format(1x,a42)
99  format(1x,a79)
  close (tmpio)
  return
100 print *,'ERROR #3 - Could not open jointfre.in file.'
  call exit
  end
!
! Subroutine to read population data
!
  subroutine readpop(tmpio)
  common /dat5/ p(16,10),dmid(10)
  character*80 tit1,tit2
  integer tmpio
  OPEN(tmpio,FILE='pop.in',STATUS='OLD',err=100)
  read(tmpio,9) tit1
  read(tmpio,9) tit2
  print *
  write(*,98) 'POPULATION DATA:
  write(*,99) tit1
  write(*,99) tit2
  read(tmpio,'()')
  do 5 i=1,16
5  read(tmpio,*) (p(i,j),j=1,10)
  read(tmpio,'(/////)' )
  read(tmpio,*) (dmid(j),j=1,10)
9  FORMAT(A80)
98  format(1x,a42)
99  format(1x,a79)
  close (tmpio)
  return
100 print *,'ERROR #4 - Could not open pop.in file.'
  call exit
  end
!
! Subroutine to calculate X/Q
!
  subroutine xqsub(x,y,z,ua,iclass,xq)
  common /dat6/ cname(7), sname(16)

```

RPP-13482 REV 7

```

character cname*2, sname*3
common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mde,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
logical ifox,inorm,icdf,ichk,isite,ipop
character*80 title
common /dat2/ ubin(9),jf(63,16),nsbin,nubin,ha
real jf
! input error check on receptor data
if (x) 35,35,36
35 print *, 'ERROR #5 - Distance is less than or equal to zero.'
call exit
36 continue
if(iclass.lt.1.or.iclass.gt.7)then
print *, 'ERROR #6 - Stability class must be between 1 and 7.'
endif
if(ua.le.0.0)then
print *, 'ERROR #7 - Wind speed must be greater than zero.'
endif
!
! ***** EFFECTIVE RELEASE HEIGHT CALCULATIONS *****
!
! function fhe returns effective release height, he, plume height wind speed,
! uhe, and the effective wind speed, ue, which is the average of the wind speed
! at the release height, hrel, and the wind speed at the effective release
! height, he.
! First, calculate wind speed at release height.
!
urel=ua
if(iwind.eq.1)urel=ueff(ua,ha,hrel,iclass)
he=fhe(x,ue,uhe,urel,ua,uc,iclass,hprb,hprm,hprl,fm,fb,hwash,hgrav,w0)
!
! ***** SIGMA CALCULATIONS *****
!
! initialize all sigmas to zero
!
sx1=0.0
sy1=0.0
sz1=0.0
sx2=0.0
sy2=0.0
sz2=0.0
sx3=0.0
sy3=0.0
sz3=0.0
sy4=0.0
sx5=0.0
sy5=0.0
sz5=0.0
xvz2=0.0
xvz3=0.0
!
! calculate unadjusted sigmas
!
sy1=sigmay(iclass,x)
sx1=amax1(urel*rd/2.5066,sy1)
sz1=sigmaz(iclass,x)
!
! calculate flow adjusted sigmas (virtual source method)
!
if(iflow.eq.1)then
xvy2=xvy(iclass,drel/2.5066)
sz2=v0/(2.5066*urel*drel)
sx2=fref0(sx2)*sz2
xvz2=xvz(iclass,sx2)
sy2=sigmay(iclass,x+xvy2)
sx2=amax1(sy2,sx1)
sz2=sigmaz(iclass,x+xvz2)
endif

```

RPP-13482 REV 7

```

!
! calculate building wake adjusted sigmas (MACCS virtual source model)
! NRC RG 1.145 building wake model incorporated in X/Q Calculation below
!
      if(iwake.eq.2)then
        xvy3=xvy(iclass,wb/4.3)
        xvz3=xvz(iclass,hb/2.15)
        sy3=sigmay(iclass,x+xvy3)
        sx3=amax1(sy3,sx1)
        sz3=sigmaz(iclass,x+xvz3)
      endif
!
! calculate sigmay adjusted for plume meander if selected
! ipm=1 for NRC RG 1.145 plume meander model
! ipm=2 for 5th power law plume meander model
! ipm=3 for sector average model
!
      if(ipm.eq.1.and.x.ge.800.)then
        sy4=(pml(iclass,ue)-1)*sigmay(iclass,800.)+sy1
      elseif(ipm.eq.1.and.x.lt.800.)then
        sy4=pml(iclass,ue)*sy1
      elseif(ipm.eq.2)then
        sy4=pm2(rd)*sy1
      elseif(ipm.eq.3)then
        sy4=0.15666*x
        sy1=sy4
        sy2=sy4
        sy3=sy4
      endif
!
! adjust sigmas to account for air entrainment in rising plume using
! method of Pasquill
!
      if(ientr.eq.1)then
        tmp=((he-hrel)/3.5)**2
        sy5=sqrt(sy1**2+tmp)
        sz5=sqrt(sz1**2+tmp)
        sx5=amax1(sy5,sx1)
      endif
!
! select maximum of sigmas calculated above
!
      sx=max(sx1,sx2)

      sx=max(sx,sx3)
      sx=max(sx,sx5)
      sy=max(sy1,sy2)
      sy=max(sy,sy3)
      sy=max(sy,sy4)
      sy=max(sy,sy5)
      sz=max(sz1,sz2)
      sz=max(sz,sz3)
      sz=max(sz,sz5)
!
! adjust sigmaz for uniform vertical mixing if conditions appropriate
!
      ifum=0
      if(sz.ge.1.2*h)then
        sz=h/2.5066
        ifum=1
      endif
!
! ***** OFFSET CALCULATIONS *****
!
      if(ipm.eq.3)then
        fyl=1.0
      else
        fyl=fy(y,sy)
      endif
      if(ifum.eq.1)then

```


RPP-13482 REV 7

```

      gz1=1.0
    else
      gz1=gz(he,z,sz)
    endif
!
! ***** ATMOSPHERIC DISPERSION - X/Q' *****
!
      if(iwake.eq.1)then
! continuous release with NRC RG 1.145 building wake
        xq1=fy1*gz1/(6.2832*ue*(sy1*sz+wb*hb/6.2832))
        xq2=fy1*gz1/(18.850*ue*sy1*sz)
        xq3=fy1*gz1/(6.2832*ue*sy*sz)
        xq=max(xq1,xq2)
        xq=min(xq,xq3)
      else
        xq=fy1*gz1/(6.2832*ue*sy*sz)
      endif
!
! ***** AIR CONCENTRATION - X/Q *****
!
! calculate transition distance from plume to puff behavior
      if(ipuff.eq.1)then
        xtrans=xvy(iclass,ue*rd*3600./2.5066)
        if(iwake.eq.1.or.x.lt.xtrans)then
! plume behavior. Note: NRC model is always continuous release plume
          xq=xq/(rd*3600.)
        else
! puff behavior
          xq=fy1*gz1/(15.750*sx*sy*sz)
        endif
      endif
!
! ***** SCALING *****
!
! determine wind speed scaling factor
      if(isrc.eq.1) then
        sfact=fact
      elseif(isrc.eq.2) then
        sfact=fact*ue**wsexp
      elseif(isrc.eq.3) then
        sfact=fact*10**(ue*wsexp)
      else
        sfact=1.0
      endif
!
! multiply X/Q by plume depletion factor if selected
! limit he to 0.1 for minimum surface roughness
      if(idcp.eq.1) then
        xvzm=max(xvz2,xvz3)
        dfact=df(iclass,x,xvzm,urel,ua)
      else
        dfact=1.0
      endif
      xq=xq*sfact*dfact
!
! ***** CHECK PRINT *****
!
      if(ichk) then
        print *, '-----'
        print *, 'atmospheric stability class      =',cname(iclass)
        print *, 'receptor distance                =',x      , ' m'
        if(ipuff.gt.0) then
          print *, 'trans. dist. from plume to puff =',xtrans, ' m'
        endif
        print *, 'receptor horizontal offset          =',y      , ' m'
        print *, 'receptor height                    =',z      , ' m'
        print *, ' '
        if(irise.gt.0) then
          print *, 'momentum flux                          =',fm      , ' m4/s2'
          print *, 'buoyancy flux                            =',fb      , ' m4/s3'
        endif
      endif

```

RPP-13482 REV 7

```

print *, 'distance dependent momentum rise=', hprm , ' m'
print *, 'distance dependent buoyancy rise=', hprb , ' m'
print *, 'plume rise limit          =', hprl , ' m'
endif
if(iwash.gt.0)
&print *, 'stack downwash          =', hwash , ' m'
  if(igrav.gt.0)
&print *, 'gravitational settling  =', hgrav , ' m'
    print *, 'effective release height (he) =', he , ' m'
    print *, ' '
    print *, 'anemometer wind speed      =', ua , ' m/s'
    if(iwind.gt.0) then
      print *, 'wind speed at release height =', urel , ' m/s'
      print *, 'wind speed at he          =', uhe , ' m/s'
      print *, 'effective wind speed      =', ue , ' m/s'
    if(irise.gt.0)
&print *, 'crit. wind spd. prevent. liftoff=', uc , ' m/s'
    endif
    if(drel.gt.0.0)
&print *, 'initial vertical plume speed =', w0 , ' m/s'
    print *, ' '
    if(ipuff.gt.0)
&print *, 'Pasquill sigma x (unadjusted) =', sx1 , ' m'
      print *, 'Pasquill sigma y (unadjusted) =', sy1 , ' m'
      print *, 'Pasquill sigma z (unadjusted) =', sz1 , ' m'
      if(iflow.gt.0) then
        if(ipuff.gt.0)
&print *, 'Pasquill sigma x (flow adj.) =', sx2 , ' m'
          print *, 'Pasquill sigma y (flow adj.) =', sy2 , ' m'
          print *, 'Pasquill sigma z (flow adj.) =', sz2 , ' m'
          print *, 'virtual distance Y (flow adj.) =', xvy2 , ' m'
          print *, 'virtual distance Z (flow adj.) =', xvz2 , ' m'
        endif
        if(iwake.gt.0) then
          if(ipuff.gt.0)
&print *, 'Pasquill sigma x (wake adj.) =', sx3 , ' m'
          print *, 'Pasquill sigma y (wake adj.) =', sy3 , ' m'
          print *, 'Pasquill sigma z (wake adj.) =', sz3 , ' m'
          if(iwake.eq.2) then
            print *, 'virtual distance Y (MACCS wake) =', xvy3 , ' m'
            print *, 'virtual distance Z (MACCS wake) =', xvz3 , ' m'
          endif
        endif
        if(ipm.gt.0)
&print *, 'Pasquill sigma y (meander adj.) =', sy4 , ' m'
        if(ientr.gt.0) then
          if(ipuff.gt.0)
&print *, 'Pasquill sigma x (rise adj.) =', sx5 , ' m'
          print *, 'Pasquill sigma y (rise adj.) =', sy5 , ' m'
          print *, 'Pasquill sigma z (rise adj.) =', sz5 , ' m'
        endif
        print *, ' '
        print *, 'off-axis horizontal factor      =', fyl
        print *, 'plume trapping reflection factor=', fref(he,z,sz)
        print *, 'off-axis vertical factor      =', gzl
        if(idep.gt.0) then
          print *, 'virtual distance Z (depletion) =', xvzm , ' m'
          print *, 'plume depletion factor      =', dfact
        endif
        if(isrc.eq.2) then
          print *, 'source term factor          =', sfact , ' mg/s'
        else
          print *, 'source term factor          =', sfact
        endif
        print *, 'atmospheric disper. coeff. (X/Q) =', xq
      endif
      return
    end
  !
! function to determine effective release height and corresponding wind speed
!

```

RPP-13482 REV 7

```

function fhe(x,ue,uhe,urel,ua,uc,iclass,hprb,hprm,hprl,fm,fb,hwash,hgrav,w0)
common /dat2/ ubin(9),jf(63,16),nsbin,nubin,ha
real jf
common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
logical ifox,inorm,icdf,ichk,isite,ipop
character*80 title
data pi/3.1415927/
fhe=hrel
ue=urel
uhe=uhe
hrise=0.0
hwash=0.0
hgrav=0.0
hprm=0.0
hprb=0.0
hprl=0.0
fb=0.0
fm=0.0
uc=0.0
w0=0.0
if(drel.gt.0.0) w0=4.0*v0/(pi*drel*drel)
!
! iterate on effective release height to account for plume rise and
! gravitational settling if selected
!
do 100 i=1,5
fheold=fhe
if(irise.eq.1)hrise=hmaccs(x,ue,ua,uc,iclass,hprb,hprm,hprl,fm,fb,w0)
if(irise.eq.2)hrise= hisc2(x,ue,ua,uc,iclass,hprb,hprm,hprl,fm,fb,w0)
if(iwash.eq.1)hwash=dwash(urel,w0)
if(igrav.eq.1)hgrav=vg*x/ue
! calculate new effective release height
fhe=hrel+hrise-hgrav-hwash
! limit effective release height between ground and height of mixing layer
fhe=max(0.0,fhe)
fhe=min(h,fhe)
!
! calculate wind speed at adjusted effective release
! height if measured height is 10 meters and effective release height
! greater than 10 meters.
!
if(iwind.eq.1)uhe=ueff(ua,ha,fhe,iclass)
!
! calculate average wind speed between ground and effective release height
!
ue=(uhe+urel)/2.0
print '(1p7e11.3)',hprl,hrise,hwash,hgrav,fhe,uhe,ue
!
! exit loop if last calculation of effective release height changed by less
! than 1 meter
!
if(abs(fhe-fheold).lt.0.1)goto 101
100 continue
101 continue
return
end
!
! function to return the xq horizontal correction term
!
function fy(y,sy)
fy=exp((- (y/sy)**2)/2.0)
return
end
!
! function to return the xq vertical correction term
!
function gz(he,z,sz)

```

RPP-13482 REV 7

```

      gz=fref(he,z,sz)*exp(-((z-he)/sz)**2)/2.0)
      return
    end

!
! function to return the plume trapping reflection factor
!
      function fref(he,z,sz)
      common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
      logical ifox,inorm,icdf,ichk,isite,ipop
      character*80 title
      z2=2.0/(sz*sz)
      fref=0.0
      hn=0.0
      do 10 n=1,5
        fold=fref
        hn=hn+h
        val=exp(z2*(he-hn)*( hn-z))+exp(z2*hn*( he-hn-z))+
&      exp(z2*(he+hn)*(-hn-z))+exp(z2*hn*(-he-hn+z))
        fref=fref+val
        if(abs(fref-fold).lt.0.001)goto 20
10      continue
20      fref=1.0+exp(-z2*z*he)+fref
      return
      end

!
! function to return the plume trapping reflection factor at x=0m and z=hrel
!
      function fref0(e0)
      common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
      logical ifox,inorm,icdf,ichk,isite,ipop
      character*80 title
      fref0=1.2
10      fold=fref0
      et=-2.0/(fref0*e0)**2
      fref0=1.0+exp(et*hrel*hrel)
      hn=0.0
      do 20 n=1,4
        hn=hn+h
        val=exp(et*(hrel-hn)**2)+2.0*exp(et*hn*hn)+exp(et*(hrel+hn)**2)
        fref0=fref0+val
20      continue
      if(abs(fref0-fold).gt.0.001)goto 10
      return
      end

!
! Function to return effective wind speed at altitude z
! Ref. Hanna page 32 (rural roughness)
!
      function ueff(ua,ha,he,iclass)
      dimension p(7)
      data p/.07,.07,.1,.15,.35,.55,.60/
      helim=min(he,200.)
      helim=max(helim,10.)
      ueff=ua*(helim/ha)**p(iclass)
      return
      end

!
! Function sigmay determines sy given distance
!
      function sigmay(iclass,x)
      dimension ay(7)
      data ay/.3658,.2751,.2089,.1471,.1046,.0722,.0481/
      sigmay=ay(iclass)*x**0.9031

```

RPP-13482 REV 7

```

        return
    end

!
! Function xvy determines distance given sy
!
    function xvy(iclass,sy)
        dimension ay(7)
        data ay/.3658,.2751,.2089,.1471,.1046,.0722,.0481/
        xvy=(sy/ay(iclass))**(1./0.9031)
        return
    end

!
! Function sigmaz determines sz given distance
!
    function sigmaz(iclass,x)
        dimension az1(7),az2(7),az3(7),bz1(7),bz2(7),bz3(7),cz2(7),cz3(7)
        data az1/.192,.156,.116,.079,.063,.053,.032/
        data az2/.00066,.0382,.113,.222,.211,.086,.052/
        data az3/.00024,.055,.113,1.26,6.73,18.05,10.83/
        data bz1/.936,.922,.905,.881,.871,.814,.814/
        data bz2/1.941,1.149,.911,.725,.678,.74,.74/
        data bz3/2.094,1.098,.911,.516,.305,.18,.18/
        data cz2/9.27,3.3,.0,-1.7,-1.3,-.35,-.21/
        data cz3/-9.6,2.,.0,-13.,-34.,-48.6,-29.2/
        if (x.lt.100.) then
            sigmaz=az1(iclass)*x**bz1(iclass)
        elseif (x.le.1000.) then
            sigmaz=az2(iclass)*x**bz2(iclass)+cz2(iclass)
        else
            sigmaz=az3(iclass)*x**bz3(iclass)+cz3(iclass)
        endif
        return
    end

!
! Function xvz determines distance given sz
!
    function xvz(iclass,sz)
        dimension az1(7),az2(7),az3(7),bz1(7),bz2(7),bz3(7),cz2(7),cz3(7)
        data az1/.192,.156,.116,.079,.063,.053,.032/
        data az2/.00066,.0382,.113,.222,.211,.086,.052/
        data az3/.00024,.055,.113,1.26,6.73,18.05,10.83/
        data bz1/.936,.922,.905,.881,.871,.814,.814/
        data bz2/1.941,1.149,.911,.725,.678,.74,.74/
        data bz3/2.094,1.098,.911,.516,.305,.18,.18/
        data cz2/9.27,3.3,.0,-1.7,-1.3,-.35,-.21/
        data cz3/-9.6,2.,.0,-13.,-34.,-48.6,-29.2/
        xvz=(sz/az1(iclass))**(1/bz1(iclass))
        if (xvz.lt.100.) return
        xvz=((sz-cz2(iclass))/az2(iclass))**(1/bz2(iclass))
        if (xvz.lt.1000.) return
        xvz=((sz-cz3(iclass))/az3(iclass))**(1/bz3(iclass))
        return
    end

!
! Subroutine to fill joint frequency, wind speed and class vectors given
!   sector isec. All sectors are filled if isite=.true.
!
    subroutine fill(isec)
        common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),
        &nbin, isector(0:1008),distance(0:1008)
        integer cl
        common /dat2/ ubin(9),jf(63,16),nsbin,nubin,ha
        real jf
        common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
        &tamb,t0,v0,drel,fact,wsexp,
        &mode,ifox,inorm,icdf,ichk,isite,ipop,
        &iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
        &idep,isrc,ipuff,iwind
        logical ifox,inorm,icdf,ichk,isite,ipop
        character*80 title
        if(isite)then

```

```

do 200 k=1,16
  j=0
  do 100 i=1,nbin
    ii=i+(k-1)*nbin
    sjf(ii)=jf(i,k)
    ws(ii)=ubin((i-1)/nsbin+1)
    isector(ii)=k
    j=j+1
    if (j.gt.nsbin) j=1
    cl(ii)=j
100  continue
200  continue
  else
    do 300 i=1,nbin
      sjf(i)=jf(i,isec)
      ws(i)=ubin((i-1)/nsbin+1)
      j=j+1
      if (j.gt.nsbin) j=1
      cl(i)=j
300  continue
    endif
    return
  end
!
! Subroutine to sort xq and corresponding sjf, cl and ws vectors in
!   descending X/Q order.
!
  subroutine sort(n)
    common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),
&nbin, isector(0:1008),distance(0:1008)
    integer cl
    do 20 ii=1,n
      rmax=xq(ii)
      imax=ii
      do 10 i=ii+1,n
        if (rmax.lt.xq(i)) then
          rmax=xq(i)
          imax=i
        endif
10    continue
      !
      t=xq(ii)
      xq(ii)=xq(imax)
      xq(imax)=t
      !
      t=sjf(ii)
      sjf(ii)=sjf(imax)
      sjf(imax)=t
      !
      t=ws(ii)
      ws(ii)=ws(imax)
      ws(imax)=t
      !
      t=cl(ii)
      cl(ii)=cl(imax)
      cl(imax)=t
      !
      t=isector(ii)
      isector(ii)=isector(imax)
      isector(imax)=t
      !
      t=distance(ii)
      distance(ii)=distance(imax)
      distance(imax)=t
      !
20    continue
    return
  end
!
! Subroutine to condense equal X/Qs into a single bin
! n - current length of array

```

RPP-13482 REV 7

```

! m - condensed length of array
!
      subroutine condense(n,m)
      common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),
&nbin, isector(0:1008),distance(0:1008)
      integer cl
      m=n
      do 20 ii=2,n
      xx=xq(ii-1)
5      continue
! PDR smoothing factor is 1%
      if(xx.le.xq(ii))then
          sjf(ii-1)=sjf(ii-1)+sjf(ii)
          m=m-1
          do 10 i=ii,m
          xq(i)=xq(i+1)
          sjf(i)=sjf(i+1)
          ws(i)=ws(i+1)
          cl(i)=cl(i+1)
          isector(i)=isector(i+1)
          distance(i)=distance(i+1)
10      continue
          if(ii.eq.m)return
          goto 5
          elseif(ii.eq.m-1)then
              return
          endif
20      continue
      end

!
! Subroutine cdf creates a cumulative distribution out of vector sjf
! and normalizes if inorm=.true.
!
      subroutine cdf(n,unit8)
      common /dat6/ cname(7), sname(16)
      character cname*2, sname*3
      common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),
&nbin, isector(0:1008),distance(0:1008)
      integer cl, unit8
      common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
      logical ifox,inorm,icdf,ichk,isite,ipop
      character*80 title
      cd(0)=0.0
      sjf(0)=0.0
      do 10 i=1,n
      cd(i)=cd(i-1)+(sjf(i)+sjf(i-1))/2.0
10      continue
      if(sjf(n).gt.0.0)then
          cd(n)=cd(n)+0.5*sjf(n)
      endif
      if(inorm)then
          t=cd(n)/100.
          do 20 i=1,n
20      cd(i)=cd(i)/t
          endif
          if(icdf)then
              write(unit8,'(1x)')
              do 50 i=1,n
50      write(unit8,99) sname(isector(i)),distance(i),cname(cl(i)),ws(i),
& sjf(i),cd(i),xq(i)
99      format(1x,a3,f12.0,3x,a2,2x,2f6.2,f8.3,1pe11.3)
          endif
          return
      end

!
! Subroutine inter interpolates xqp based on freq
!

```

RPP-13482 REV 7

```

subroutine inter(xqp,freq,n,index)
common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),
&nbin, isector(0:1008),distance(0:1008)
integer cl
if (freq.gt.cd(n)) then
print *
print *, 'ERROR #8 - Selected frequency above joint freq. range.'
print *, '      Selected frequency is      ',freq
print *, '      Maximum sector frequency is',cd(n)
call exit
endif
if (freq.lt.cd(1)) then
print *
print *, 'WARNING #1 - Selected frequency is below minimum available.'
print *, '      Selected frequency is      ',freq
print *, '      Minimum cumulative frequency is',cd(1)
print *, '      X/Q below set equal to value corresponding'
print *, '      to minimum cumulative frequency.'
xqp=xq(1)
index=1
return
endif
do 10 i=2,n
if (freq.lt.cd(i)) then
xqp=(freq-cd(i-1))/(cd(i)-cd(i-1))*(xq(i)-xq(i-1))+xq(i-1)
!   return index whose xq is closest to interpolated value
index=i
if((xq(i-1)-xqp).lt.(xqp-xq(i)))index=i-1
return
endif
10 continue
end

!
! Calculate plume meander correction factor as given by NRC R.G. 1.145
!
function pml(iclass,u)
pml=1.0
if(iclass.lt. 4 .or. u.ge. 6.0) return
select case(iclass)
case(4)
pml=2.
case(5)
pml=3.
case(6)
pml=4.
case(7)
pml=6.
end select
if(u.lt.2.0) return
pml=(u/6)**(-log(pml)/1.0986)
return
end

!
! Calculate 5th power law plume meander correction factor
!
function pm2(rd)
tb=10./60.
t1=10./60.
t2=1.0
t3=100.0

if(rd.lt.t1.or.rd.gt.t3)then
print *, 'WARNING #2 - Release duration outside validity of One-fifth'
print *, '      Power Law. Release duration must be'
print *, '      between 10 min. and 100 hrs.'
endif

if(rd.le.t2)then
alpha=0.2
else
alpha=0.25

```


RPP-13482 REV 7

```

endif
pm2=(rd/tb)**alpha
return
end

!
! Subroutine to print out input options selected and warning messages
!
      subroutine message
      common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
      logical ifox,inorm,icdf,ichk,isite,ipop
      character*80 title
      print *
      print *, 'MODE : '
      if (mode.eq.1)then
      print *, 'Site specific X/Q calculated.'
      elseif(mode.eq.2)then
      print *, 'X/Q calculated by stability class and wind speed.'
      elseif(mode.eq.3)then
      print *, 'Plot file of distance, offset and X/Q created.'
      else
      print *, 'ERROR #9 - Invalid mode specified.'
      endif

!
      print *
      print *, 'LOGICAL CHOICES:'
      if(mode.eq.1)then
        if(ifox)then
          print *, 'Joint frequency used to calculate X/Q based on frequency of exceedance.'
        else
          print *, 'Joint frequency used to calculate annual average X/Q.'
        endif

        if(inorm)then
          print *, 'Joint frequency data normalized.'
        else
          print *, 'No normalization of joint frequency.'
        endif

        if(icdf)then
          print *, 'Cumulative distribution contained in file CDF.OUT.'
        endif

        if(isite)then
          print *, 'X/Q calculated for overall site.'
        else
          print *, 'X/Q calculated for single sector.'
        endif

        if(ipop)then
          print *, 'X/Q is population weighted.'
        endif
      endif

      if(ichk)then
        print *, 'X/Q parameter print option selected.'
      endif

      print *
      print *, 'MODELS SELECTED:'
      if(ipuff.eq.1)then
        print *, 'Air concentrations will be calculated (1/m3).'
      else
        print *, 'Time-integrated air concentration calculated (s/m3).'
      endif

      if(iflow.eq.1)then
        print *, 'Flow rate adjustment model.'
      endif

```

RPP-13482 REV 7

```

elseif(iflow.ne.0)then
  print *, 'ERROR #16 - Invalid flow rate adjustment model selected.'
  call exit
endif

if(iwake.eq.1)then
  print *, 'NRC RG 1.145 building wake model selected.'
elseif(iwake.eq.2)then
  print *, 'MACCS Virtual source building wake model selected.'
elseif(iwake.ne.0)then
  print *, 'ERROR #11 - Invalid building wake model selected.'
  call exit
endif

if(ipm.eq.1)then
  print *, 'NRC RG 1.145 plume meander model selected.'
elseif(ipm.eq.2)then
  print *, '5th power law plume meander model selected.'
elseif(ipm.eq.3)then
  print *, 'Sector average model selected.'
elseif(ipm.ne.0)then
  print *, 'ERROR #12 - Invalid plume meander model selected.'
  call exit
endif

if(ientr.eq.1)then
  print *, 'Plume rise air entrainment model selected.'
elseif(ientr.ne.0)then
  print *, 'ERROR #28 - Invalid plume rise air entrainment model selected.'
  call exit
endif

if(irise.eq.1)then
  if(qh.ne.0.0)then
    print *, 'MACCS buoyancy plume rise model based on convective heat.'
  else
    print *, 'MACCS buoyancy plume rise model based on temperature difference.'
  endif
elseif(irise.eq.2)then
  if(qh.ne.0.0)then
    print *, 'ISC2 momentum/buoyancy plume model based on convective heat.'
  else
    print *, 'ISC2 momentum/buoyancy plume model based on temperature difference.'
  endif
elseif(irise.ne.0)then
  print *, 'ERROR #13 - Invalid plume rise model selected.'
  call exit
endif

if(irise.ne.0.and.igrnd.eq.1)then
  print *, 'Mills buoyant rise modification for pool fire selected.'
endif

if(igrnd.ne.0.and.igrnd.ne.1)then
  print *, 'ERROR #27 - Invalid ground effect model selected.'
  call exit
endif

if(iwash.eq.1)then
  print *, 'Stack downwash model selected.'
endif

if(iwash.ne.0.and.iwash.ne.1)then
  print *, 'ERROR #15 - Invalid downwash model selected.'
  call exit
endif

if(igrav.eq.1)then
  print *, 'Gravitational settling model selected.'
elseif(igrav.ne.0)then
  print *, 'ERROR #14 - Invalid gravitational settling model selected.'
  call exit
endif

```

```

if(idep.eq.1)then
  print *, 'Source depletion model selected.'
elseif(idep.ne.0)then
  print *, 'ERROR #10 - Invalid plume depletion model selected.'
  call exit
endif

if(isrc.eq.1)then
  print *, 'X/Q adjusted by scaling factor.'
elseif(isrc.eq.2)then
  print *, 'X/Q adjusted for wind speed dependent source term (c u^a).'
elseif(isrc.eq.3)then
  print *, 'X/Q adjusted for wind speed dependent source term (c 10^au).'
elseif(isrc.ne.0)then
  print *, 'ERROR #25 - Invalid source adjustment model selected.'
  call exit
endif

if(iwind.eq.1)then
  print *, 'Wind velocity corrected for average plume height.'
elseif(iwind.ne.0)then
  print *, 'ERROR #17 - Invalid wind adjustment model selected.'
  call exit
endif

print *
print *, 'WARNING/ERROR MESSAGES:'
if(isrc.ne.0.and.fact.ne.1.0)then
  print *, 'WARNING #3 - Scaled X/Q units do not reflect the user specified scaling factor.'
endif

if(mode.eq.1.and..not.ifox.and.ipm.ne.3)then
  print *, 'WARNING #4 - Annual average X/Q is normally sector averaged.'
endif

if(iwake.eq.1.and.iflow.ne.0)then
  print *, 'WARNING #5 - NRC RG 1.145 building wake model may not'
  print *, 'be compatible with plume flow adjustment.'
endif

if(mode.eq.1.and.ipop.and.ipm.ne.3)then
  print *, 'WARNING #6 - Population weighted X/Q is normally sector'
  print *, 'averaged to simulate uniform distribution.'
endif

if(((ipm.eq.1.or.ipm.eq.2).or.(ipm.eq.3.and..not.ipop)).and.ipuff.eq.1)then
  print *, 'WARNING #7 - Maximum normalized air concentration may'
  print *, 'be underestimated with plume meander on.'
endif

! if(irise.ne.0.and.idep.ne.0)then
!   print *, 'WARNING #8 - Plume depletion may be underestimated if plume is rising.'
!   endif

! if(igrav.ne.0.and.idep.ne.0)then
!   print *, 'WARNING #9 - Plume depletion may be overestimated if plume is falling.'
!   endif

if(irise.ne.0.and.ientr.eq.0)then
  print *, 'WARNING #10 - X/Q may be underestimated for plume rise scenario without'
  print *, 'accounting for entrainment.'
endif

if(irise.ne.0.and.hrel.eq.0.and.igrnd.ne.1)then
  print *, 'WARNING #11 - Effective plume rise from ground level may be overestimated'
  print *, 'using Briggs plume rise model for stacks. Consider Mills'
  print *, 'modification.'
endif

if(irise.eq.2.and.v0.le.0.0)then

```

RPP-13482 REV 7

```

print *,'ERROR #18 - Momentum rise requires non-zero initial vertical plume flow rate
(v0).'
```

```

    call exit
endif

if(irise.ne.0.and.drel.le.0.0)then
print *,'ERROR #19 - Plume rise requires non-zero release diameter (d).'
```

```

    call exit
endif

if(iwash.ne.0.and.drel.le.0.0)then
print *,'ERROR #20 - Stack down wash requires non-zero release diameter (d).'
```

```

    call exit
endif

if(iflow.ne.0.and.drel.le.0.0)then
print *,'ERROR #21 - Flow adjustment requires non-zero release diameter (d).'
```

```

    call exit
endif

if(isrc.eq.2.and.ipuff.eq.1)then
print *,'ERROR #26 - Evaporation model inconsistent with puff source.'
```

```

    call exit
endif

if(iwake.eq.1.and.ipuff.eq.1.and.rd.eq.0)then
print *,'ERROR #23 - Puff model requires non-zero release duration.'
```

```

    call exit
endif

if(hrel.gt.h)then
print *,'ERROR #29 - Code does not handle releases above mixing layer.'
```

```

    call exit
endif

return
end

!
! Subroutine head prints output headers
!

subroutine head(n,i)
common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
logical ifox,inorm,icdf,ichk,isite,ipop
character*80 title
character*80 line
character*11 ctime
character*8 cdate
if(n.gt.0) write(i,'(//,1x,a,/)' ) title
if(n.eq.0)then
write(i,900)
format(
900      &/'
&/'
&/'                                GXQ Version 4.0F
&/'                                October 9, 2002
&/'
&/' \
&/' General Purpose Atmospheric Dispersion Code
&/' Produced by Fluor Federal Services, Inc.
&/' \
&/' Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
&/' Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
&/' Code Custodian is: Paul D. Rittmann, PhD CHP
&/'                      Fluor Federal Services, Inc. E6-17'
&/'                      P.O. Box 1050
&/'                      Richland, WA 99352-1050
&/'                      (509) 376-8715

```

RPP-13482 REV 7

```

&/'
&/)
call date(cdate)
call time(ctime)
write(i,990)cdate
990 format(1x,'Run Date = ',a8)
write(i,991)ctime
991 format(1x,'Run Time = ',a11)

elseif(n.eq.1)then
write(i,91) '
TOTAL AVERAGE
write(i,91) '
POPULATION INDIVIDUAL
write(i,91) '
RECEPT SECT. SCALED SCALED
ATM. WIND '
write(i,91) ' DISTANCE HEIGHT FREQ. X/Q X/Q
STAB. SPEED '
write(line(1:79),'(a)') 'SECTOR (m) (m) (%) POPULATION (s/m3) (s/m3)
CLASS (m/s) '
if(ipuff.eq.1)then
write(line(46:52),'(a)') '(1/m3) '
write(line(57:63),'(a)') '(1/m3) '
elseif(isrc.eq.2)then
write(line(46:52),'(a)') ' '
write(line(57:63),'(a)') ' '
endif
write(i,91) line(1:79)
write(i,91) '
'

elseif(n.eq.2)then
write(i,91) 'ATM. WIND RECEPTOR SCALED'
write(i,91) 'STAB. SPEED DISTANCE OFFSET HEIGHT X/Q '
write(line(1:58),'(a)') 'CLASS (m/s) (m) (m) (m) (s/m3)'
if(ipuff.eq.1)then
write(line(51:57),'(a)') '(1/m3) '
elseif(isrc.eq.2)then
write(line(51:57),'(a)') ' '
endif
write(i,91) line(1:58)
write(i,91) '
'

elseif(n.eq.3)then
write(i,91) '
write(i,91) ' DISTANCE OFFSET SCALED '
write(i,91) ' X/Q '
write(line(1:35),'(a)') ' (m) (m) (1/m3) '
if(ipuff.eq.1)then
write(line(28:34),'(a)') '(1/m3) '
elseif(isrc.eq.2)then
write(line(28:34),'(a)') ' '
endif
write(i,91) line(1:35)
write(i,91) '
'

elseif(n.eq.4)then
write(i,91) 'CUMULATIVE DISTRIBUTION'
write(i,91) '
write(i,91) ' ATM. WIND SECTR CUM. SCALED'
write(i,91) ' DISTANCE STAB. SPEED FREQ FREQ. X/Q'
write(line(1:52),'(a)') 'SECTOR (m) CLASS (m/s) (%) (%) (s/m3)'
if(ipuff.eq.1)then
write(line(46:52),'(a)') '(1/m3) '
elseif(isrc.eq.2)then
write(line(46:52),'(a)') ' '
endif
write(i,91) line(1:52)
write(i,91) '
endif

91 format(1x,a)
return

```

RPP-13482 REV 7

```

end
!
! calculate plume depletion as given by Meteorology and Atomic Energy (1968)
!
      function df(iclass,x,xvzm,urel,ua)
      common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
      logical ifox,inorm,icdf,ichk,isite,ipop
      character*80 title
      data xstp,xmin,imax/4.0,0.1,16/
! imax must be even
      df=1.0
      val=0.0
      if(x.le.xmin) return
      xl=xmin

      do 160 i=1,12
      x2=amin1(xl*xstp,x)
      val=val+simpson(iclass,xvzm,xl,x2,imax,urel,ua)
      if(x2.eq.x) goto 170
      xl=x2
160    continue

170    continue
      df=exp(-vd/2.5066*val)
      return
      end

!
! perform 1/3 rule simpson integration
!
      function simpson(iclass,xvzm,a,b,n,urel,ua)
      d=(b-a)/n
      val=0.0
      do 10 j=2,n-2,2
      val=val+4.*f(iclass,d*(j-1)+a,xvzm,urel,ua)+2.*f(iclass,d*j+a,xvzm,urel,ua)
10    continue
      val=f(iclass,a,xvzm,urel,ua)+val+4.*f(iclass,d*(n-
1) +a,xvzm,urel,ua)+f(iclass,d*n+a,xvzm,urel,ua)
      simpson=val*(b-a)/(3.*n)
      return
      end

!
! plume depletion function to be integrated
!
      function f(iclass,x,xvzm,urel,ua)
      common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
      logical ifox,inorm,icdf,ichk,isite,ipop
      character*80 title
      sz=sigmaz(iclass,x+xvzm)
      he=fhe(x,ue,uhe,urel,ua,uc,iclass,hprb,hprm,hprl,fm,fb,hwash,hgrav,w0)
      he=max(0.1,he)
      if(ientr.eq.1) sz=sqrt(sz**2+((he-hrel)/3.5)**2)
      if(sz.gt.1.2*h) then
        f=2.5066/(h*uhe)
      else
        f=gz(he,0.0,sz)/(sz*uhe)
      endif
!      print '(1p3e12.3)', x,sz,f
      return
      end

!
! read and echo input data
!
      subroutine input(stdin,stdout,unit4)

```

RPP-13482 REV 7

```

common /dat2/ ubin(9),jf(63,16),nsbin,nubin,ha
real jf
common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
logical ifox,inorm,icdf,ichk,isite,ipop
character*80 title
integer stdin,stdout,unit4
write(stdout,' (/)')
write(stdout,98)
98 format(1x,'INPUT ECHO:')
read(stdin,9) title
9 FORMAT(A80)
write(stdout,99) title
99 format(1x,a79)
call comment(stdin,stdout)
read(stdin,*) mode
write(stdout,91) mode
call comment(stdin,stdout)
read(stdin,*) ifox,inorm,icdf,ichk,isite,ipop
write(stdout,92) ifox,inorm,icdf,ichk,isite,ipop
call comment(stdin,stdout)
read(stdin,*) ipuff,idep,isrc,iwind
write(stdout,93) ipuff,idep,isrc,iwind
call comment(stdin,stdout)
read(stdin,*) iwake,ipm,iflow,ientr
write(stdout,93) iwake,ipm,iflow,ientr
call comment(stdin,stdout)
read(stdin,*) irise,igrnd,iwash,igrav
write(stdout,93) irise,igrnd,iwash,igrav
91 format(5x,il)
92 format(5x,12(11,5x))
93 format(5x,12(il,5x))
call comment(stdin,stdout)
read(stdin,*) hrel,ha,h,freq
write(stdout,1000) hrel,ha,h,freq
call comment(stdin,stdout)
read(stdin,*) wb,hb,rd,vd,vg
write(stdout,1000) wb,hb,rd,vd,vg
call comment(stdin,stdout)
read(stdin,*) tamb,t0,v0,drel,qh
write(stdout,1000) tamb,t0,v0,drel,qh
call comment(stdin,stdout)
read(stdin,*) fact,wsexp
write(stdout,1000) fact,wsexp
call comment(stdin,stdout)
1000 format(3x,6(1p13.5,2x))
!
! Unit changes
!
tamb=tamb+273.0
t0=t0+273.0
!
! For mode 1 allow zero entries as input shortcut meaning all sectors
!
if(mode.eq.1)then
OPEN(unit4,file='gxq.tmp',STATUS='UNKNOWN')
100 read(stdin,*,err=102,end=200) isec,xmax,z
GOTO 104
102 print *, 'ERROR #24 - GXQ encountered an error reading the receptor location data.'
print *, ' Most likely this is caused by a carriage return after the last
line.'
call exit
104 CONTINUE
if(isec.lt.0.or.isec.gt.16)then
print *, 'ERROR #22 - Sector must be an integer from 0 to 16.'
call exit
endif
if(isec.eq.0)then

```

RPP-13482 REV 7

```

        do 110 i=1,16
110      write(unit4,*) i,xmax,z
        else
          write(unit4,*) isec,xmax,z
        endif
        goto 100
200      continue
        close (unit4)
        endif
        return
        end

!
! print and skip over comment lines
!
      subroutine comment(stdin,stdout)
      integer stdin,stdout
      character*80 dummy
12      read(stdin,9) dummy
9       FORMAT(A80)
      if(dummy(1:1).ne.'c'.and.dummy(1:1).ne.'C') goto 13
      write(stdout,99) dummy
99      format(1x,a79)
      goto 12
13      backspace(stdin)
      return
      end

!
! MACCS plume rise model
!
! References:
!
! Randerson, D., ed., 1984, Atmospheric Science and Power Production,
! DE84-005177, U.S. Department of Energy, Washington, DC., p. 334-339.
!
! NRC, 1977, Methods for Estimating Atmospheric Transport and Dispersion
! of Gaseous Effluents in Routine Releases from Light-Water-Cooled
! Reactors, NRC Regulatory Guide 1.111, Washington, DC.
!
! MACCS Users' Manual page 2-7
!
      function hmaccs(x,ue,ua,uc,iclass,hprb,hprm,hprl,fm,fb,w0)
      common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
      logical ifox,inorm,icdf,ichk,isite,ipop
      character*80 title
      data g,betab/9.807,0.6/

!
! initial plume temperature difference
      dt=t0-tamb
      sp=s(iclass,tamb)
      hprb=0.0
      hprm=0.0
      hprl=0.0
      hmaccs=0.0
      fm=0.0

!
! buoyancy flux (based on convective heat flux or temperature difference)
      if(qh.le.0.0)then
        fb=g*w0*drel**2*dt/(4.0*t0)
      else
        fb=0.002575*qh/tamb
      endif
      if(fb.le.0.0)return

! lift-off criterion
      uc=9999.0
      if(hb.gt.0.0.and.hrel.le.hb)then
        uc=(9.09*fb/hb)**0.333333

```


RPP-13482 REV 7

```

        if (ua.ge.uc) return
    endif

! Briggs buoyancy plume rise
    select case (iclass)
! Buoyancy rise in unstable and neutral conditions
        case (1:4)
            hprb = 1.6*fb**0.333333*x**0.666667/ue
! limit buoyant plume rise as recommended by Briggs
            hprl1 = ((300.0*fb)/ue**3)
            hprl2 = (1.94E+7*fb/(betab*betab*ue))**0.333333
            hprl = min(hprl1,hprl2)
! Buoyancy rise in stable conditions
        case (5:7)
            hprb = 1.6*fb**0.333333*x**0.666667/ue
            hprl = 2.6*(fb/(ue*sp))**0.333333
        end select
        hprb = min(hprb,hprl)
!
! employ Mills modification for buoyant rise from a burning pool if selected
    if (igrnd.eq.1) then
        r = drel/(2*betab)
        hmaccs = (hprb**3+r**3)**0.333333-r
    else
        hmaccs = hprb
    endif
    hmaccs = max(hmaccs,0.0)
    return
end

!
! Stability parameter function
!
    function s(iclass,tamb)
    data g/9.8/
    select case (iclass)
    case (5)
        s = g/tamb*(0.005+0.0098)
    case (6)
        s = g/tamb*(0.0275+0.0098)
    case (7)
        s = g/tamb*(0.0625+0.0098)
    end select
    return
end

!
!
! Stack downwash function
!
    function dwash(urel,w0)
    common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
    logical ifox,inorm,icdf,ichk,isite,ipop
    character*80 title
    data g/9.807/
!
! buoyancy flux (based on convective heat or temperature difference)
    if (qh.le.0.0) then
        dt = t0-tamb
        fb = g*w0*drel**2*dt/(4.0*t0)
    else
        fb = 0.002575*qh/tamb
    endif
    fb = max(fb,0.0)
!
    r1 = w0/urel
    if (fb.gt.0.0) then
        r2 = 0.45*w0*(drel/(2.0*fb))**0.333333

```

RPP-13482 REV 7

```

else
  r2=0.0
endif
rvel=max(r1,r2)
rvel=max(rvel,0.0)
!
  if(rvel.lt.1.5)then
    dwash=2*(1.5-rvel)*drel
  else
    dwash=0.0
  endif
  return
end
!
!
!
! ISC2 plume rise model
!
  function hisc2(x,ue,ua,uc,iclass,hprb,hprm,hprl,fm,fb,w0)
    common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
    &tamb,t0,v0,drel,fact,wsexp,
    &mode,ifox,inorm,icdf,ichk,isite,ipop,
    &iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
    &idep,isrc,ipuff,iwind
    logical ifox,inorm,icdf,ichk,isite,ipop
    character*80 title
    data pi,g/3.1415926,9.807/
!
! initial plume temperature difference
  dt=t0-tamb
  sp=s(iclass,tamb)
  hprb=0.0
  hprm=0.0
!
! momentum flux
  fm=w0**2*drel**2*tamb/(4.0*t0)
!
! buoyancy flux (based on convective heat or temperature difference)
  if(qh.le.0.0)then
    fb=g*w0*drel**2*dt/(4.0*t0)
  else
    fb=0.002575*qh/tamb
  endif
  fb=max(fb,0.0)
!
! unstable or neutral - crossover between momentum and buoyancy
  select case(iclass)
  case(1:4)
    if(fb.lt.55.0)then
      dtc=0.0297*t0*(w0/(drel*drel))**0.333333
    else
      dtc=0.00575*t0*(w0*w0/drel)**0.333333
    endif
!
! unstable or neutral - buoyancy rise
  if(dt.ge.dtc.and.t0.gt.tamb)then
    if(fb.lt.55.0)then
      xf=49.0*fb**0.625
      hprl=21.425*fb**0.75/ue
    else
      xf=119.0*fb**0.4
      hprl=38.71*fb**0.6/ue
    endif
    hprb=hprl
    if(x.lt.xf)then
      hprb=1.6*fb**0.333333*x**0.666667/ue
      hprb=min(hprb,hprl)
    endif
!
! lift-off criterion
  uc=9999.0

```

RPP-13482 REV 7

```

        if (hb.gt.0.0.and.hrel.le.hb) then
            uc=(9.09*fb/hb)**0.333333
            if (ua.ge.uc) then
                hprb=0.0
                hprl=0.0
            endif
        endif
!
! unstable or neutral - momentum rise
    else
        if (fb.le.55.0) then
            xmax=49.0*fb**0.625
        else
            xmax=119.0*fb**0.4
        endif
        temp=4.0*drel*(w0+3.0*ue)**2/(w0*ue)
        xmax=max(temp,xmax)
        xl=min(x,xmax)
        bj=0.333333+ue/w0
        hprm=(3.0*fm*xl/(bj*ue)**2)**0.333333
        hprl=3.0*drel*w0/ue
        hprm=min(hprm,hprl)
    endif
!
! stable - crossover between momentum and buoyancy
    case(5:7)
        dtc=0.019582*t0*w0*sqrt(sp)
!
! stable - buoyancy rise
        if (dt.ge.dtc.and.t0.gt.tamb) then
            xf=2.0715*ue/sqrt(sp)
            hprl=2.6*(fb/(ue*sp))**0.333333
            hprb=hprl
            if (x.lt.xf) then
                hprb=1.6*fb**0.333333*x**0.666667/ue
                hprb=min(hprb,hprl)
            endif
!
! lift-off criterion
            uc=9999.0
            if (hb.gt.0.0.and.hrel.le.hb) then
                uc=(9.09*fb/hb)**0.333333
                if (ua.ge.uc) then
                    hprb=0.0
                    hprl=0.0
                endif
            endif
!
! stable - momentum rise
            else
                xmax=0.5*pi*ue/sqrt(sp)
                xl=min(x,xmax)
                bj=0.333333+ue/w0
                hprm=(3.0*fm*sin(xl*sqrt(sp)/ue)/(bj**2*ue*sqrt(sp)))**0.333333
                hprm1=1.5*(fm/(ue*sqrt(sp)))**0.333333
                hprm2=3.0*drel*w0/ue
                hprl=min(hprm1,hprm2)
                hprm=min(hprm,hprl)
            endif
        end select
        hisc2=hprm+hprb
!
! employ Mills modification for buoyant rise from a burning pool if selected
        if (igrnd.eq.1) then
            r=drel/1.2
            hisc2=(hisc2**3+r**3)**0.333333-r
        endif
        return
    end
!
! terminate program

```

```
!  
  subroutine exit  
  close(2)  
  close(3)  
  close(4)  
  close(5)  
  close(8)  
  stop  
  end
```

This page intentionally left blank.

APPENDIX B

**SAMPLE INPUT FILE AND RUN FILES FOR BASIC
DISPERSION COEFFICIENT CALCULATIONS IN SECTION 2.2**

This page intentionally left blank.

APPENDIX B

**SAMPLE INPUT FILE AND RUN FILES FOR BASIC
DISPERSION COEFFICIENT CALCULATIONS IN SECTION 2.2**

- Sample input file – 95th percentile overall, 1 hr, 100 m and site boundary
- Run file – 95th percentile overall, 1 hr, 100 m and site boundary
- Run file – 50th percentile by sector, 1 hr, 100 m and site boundary
- Run file – 95th percentile overall, 2 hr, 100 m and site boundary
- Run file – 50th percentile by sector, 2 hr, 100 m and site boundary
- Run file – annual average by sector, 100 m and site boundary
- Run file – 95th percentile overall, puff, 100 m and site boundary
- Run file – 50th percentile by sector, puff, 100 m and site boundary

RPP-13482 REV 7

Tank Farms - 95 percentile all sectors - 1 hour - 100 m and site boundary
c GXQ Version 4.0 Input File

c mode
1

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology

c mode = 2 then X/Q based on atmospheric stability class and wind speed

c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T f f f T f

c ifox = t then joint frequency used to compute frequency to exceed X/Q

c = f then joint frequency used to compute annual average X/Q

c inorm = t then joint frequency data is normalized (as in GENII)

c = f then joint frequency data is un-normalized

c icdf = t then cumulative distribution file created (CDF.OUT)

c = f then no cumulative distribution file created

c ichk = t then X/Q parameter print option turned on

c = f then no parameter print

c isite = t then X/Q based on joint frequency data for all 16 sectors

c = f then X/Q based on joint frequency data of individual sectors

c ipop = t then X/Q is population weighted

c = f then no population weighting

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd)iwash igrav
0 0 0 0

c ipuff = 1 then X/Q calculated using puff model

c = 0 then X/Q calculated using default continuous plume model

c idep = 1 then plume depletion model turned on (Chamberlain model)

c isrc = 1 then X/Q multiplied by scalar

c = 2 then X/Q adjusted by wind speed function

c iwind = 1 then wind speed corrected for plume height

c iwake = 1 then NRC RG 1.145 building wake model turned on

c = 2 then MACCS virtual distance building wake model turned on

c ipm = 1 then NRC RG 1.145 plume meander model turned on

c = 2 then 5th Power Law plume meander model turned on

c = 3 then sector average model turned on

c iflow = 1 then sigmas adjusted for volume flow rate

c ientr = 1 then method of Pasquill used to account for entrainment

c irise = 1 then MACCS buoyant plume rise model turned on

c = 2 then ISC2 momentum/buoyancy plume rise model turned on

c igrnd = 1 then Mills buoyant plume rise modification for ground effects

c iwash = 1 then stack downwash model turned on

c igrav = 1 then gravitational settling model turned on

c = 0 unless specified otherwise, 0 turns model off

c

c PARAMETER INPUT:

	reference		frequency
release	anemometer	mixing	to
height	height	height	exceed
hs(m)	ha(m)	hm(m)	Cx(%)
0.0	10.0	1000	5.0

c

	initial		deposition	gravitational
plume	plume	release	velocity	settling
width	height	duration	velocity	velocity
Wb(m)	Hb(m)	trd(hr)	vd(m/s)	vg(m/s)
0.0	0.0	0.0	0.00	0.00

c

	initial		convective
ambient	plume	plume	heat release

RPP-13482 REV 7

```

c   temperature      temperature      flow rate      diameter      rate(1)
c   Tamb(C)          T0(C)            V0(m3/s)       d(m)          qh(w)
c   _____      _____      _____      _____      _____
c   20                38                1.0            1.0            0
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c   X/Q              Wind
c   scaling          Speed
c   factor            Exponent
c   c(?)             a(?)
c   _____      _____
c   1                .78
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE          make          RECEPTOR DEPENDENT DATA
c 1 (site specific) sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file) class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
0   100   0
1   15360 0
2   15360 0
3   13200 0
4   11100 0
5   11100 0
6   11100 0
7   10800 0
8    8690 0
9    8690 0
10   8970 0
11  10430 0
12  10530 0
13  11160 0
14  15190 0
15  21050 0
16  15360 0

```

RPP-13482 REV 7

GXQ Version 4.0F
October 8, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/09/02
Run Time = 09:10:48.44

INPUT ECHO:

Tank Farms - 95 percentile all sectors - 1 hour - 100 m and site boundary
c GXQ Version 4.0 Input File
c mode
c 1
c
c MODE CHOICE:
c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created
c
c LOGICAL CHOICES:
c ifox inorm icdf ichk isite ipop
c T F F F T F
c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting
c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:
c ipuff idep isrc iwind
c 0 0 0 0
c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:
c iwake ipm iflow ientr
c 0 0 0 0
c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:
c (irise igrnd)iwash igrav
c 0 0 0 0
c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on

RPP-13482 REV 7

```

c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height     to
c      hs(m)       ha(m)          hm(m)      exceed
c                                     Cx(%)
c
c      0.00000E+00  1.00000E+01  1.00000E+03  5.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height      trd(hr)      velocity        velocity
c      Wb(m)        Hb(m)          vd(m/s)      vd(m/s)         vg(m/s)
c
c      0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        flow rate    d(m)         rate(1)
c                                     V0(m3/s)      qh(w)
c
c      2.00000E+01  3.80000E+01  1.00000E+00  1.00000E+00  0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c
c      1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:
200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

```

RPP-13482 REV 7

Created 8/26/92 KR

Tank Farms - 95 percentile all sectors - 1 hour - 100 m and site boundary

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	3.28E-02	3.28E-02	F	0.89
ALL	15360	0	99.94	1	2.22E-05	2.22E-05	F	0.89

RPP-13482 REV 7

GXQ Version 4.0F
October 8, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/09/02
Run Time = 09:23:57.12

INPUT ECHO:

Tank Farms - 50 percentile by sector - 1 hour - 100 m and site boundary
c GXQ Version 4.0 Input File

c mode
1

c
c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created

c
c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T T F F F F

c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting

c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd)iwash igrav
0 0 0 0

c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on

RPP-13482 REV 7

```

c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height     to
c      hs(m)       ha(m)          hm(m)      exceed
c
c      0.00000E+00  1.00000E+01    1.00000E+03  5.00000E+01
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height       trd(hr)       velocity        velocity
c      Wb(m)        Hb(m)         (hr)         vd(m/s)         vg(m/s)
c
c      0.00000E+00  0.00000E+00    0.00000E+00  0.00000E+00    0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        flow rate   d(m)         rate(1)
c                  T0(C)        V0(m3/s)    d(m)         qh(w)
c
c      2.00000E+01  3.80000E+01    1.00000E+00  1.00000E+00    0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c
c      1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)    class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
c MODE:
c Site specific X/Q calculated.
c
c LOGICAL CHOICES:
c Joint frequency used to calculate X/Q based on frequency of exceedance.
c Joint frequency data normalized.
c X/Q calculated for single sector.
c
c MODELS SELECTED:
c Time-integrated air concentration calculated (s/m3).
c
c WARNING/ERROR MESSAGES:
c
c JOINT FREQUENCY DATA:
c 200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

```

RPP-13482 REV 7

Created 8/26/92 KR

Tank Farms - 50 percentile by sector - 1 hour - 100 m and site boundary

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
S	100	0	100.00	1	2.35E-03	2.35E-03	F	15.60
SSW	100	0	100.00	1	1.73E-03	1.73E-03	F	19.00
SW	100	0	100.00	1	2.86E-03	2.86E-03	E	4.70
WSW	100	0	100.00	1	3.36E-03	3.36E-03	C	0.89
W	100	0	100.00	1	2.97E-03	2.97E-03	E	4.70
WNW	100	0	100.00	1	3.07E-03	3.07E-03	E	4.70
NW	100	0	100.00	1	3.19E-03	3.19E-03	E	4.70
NNW	100	0	100.00	1	4.92E-03	4.92E-03	E	2.65
N	100	0	100.00	1	5.33E-03	5.33E-03	E	2.65
NNE	100	0	100.00	1	3.91E-03	3.91E-03	C	0.89
NE	100	0	100.00	1	2.41E-03	2.41E-03	D	2.65
ENE	100	0	100.00	1	1.98E-03	1.98E-03	E	7.15
E	100	0	100.00	1	4.65E-03	4.65E-03	F	7.15
ESE	100	0	100.00	1	2.89E-03	2.89E-03	E	4.70
SE	100	0	100.00	1	2.81E-03	2.81E-03	D	2.65
SSE	100	0	100.00	1	2.86E-03	2.86E-03	E	4.70
S	15360	0	100.00	1	7.65E-07	7.65E-07	E	7.15
SSW	15360	0	100.00	1	4.50E-07	4.50E-07	D	4.70
SW	13200	0	100.00	1	1.06E-06	1.06E-06	D	2.65
WSW	11100	0	100.00	1	1.56E-06	1.56E-06	E	4.70
W	11100	0	100.00	1	1.59E-06	1.59E-06	E	4.70
WNW	11100	0	100.00	1	1.65E-06	1.65E-06	E	4.70
NW	10800	0	100.00	1	1.82E-06	1.82E-06	E	4.70
NNW	8690	0	100.00	1	4.24E-06	4.24E-06	E	2.65
N	8690	0	100.00	1	4.48E-06	4.48E-06	E	2.65
NNE	8970	0	100.00	1	3.18E-06	3.18E-06	E	4.70
NE	10430	0	100.00	1	1.33E-06	1.33E-06	E	7.15
ENE	10530	0	100.00	1	1.25E-06	1.25E-06	E	7.15
E	11160	0	100.00	1	2.96E-06	2.96E-06	F	7.15
ESE	15190	0	100.00	1	1.13E-06	1.13E-06	E	4.70
SE	21050	0	100.00	1	5.11E-07	5.11E-07	D	2.65
SSE	15360	0	100.00	1	9.36E-07	9.36E-07	D	2.65

RPP-13482 REV 7

GXQ Version 4.0F
October 8, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/09/02
Run Time = 09:26:46.95

INPUT ECHO:

Tank Farms - 95 percentile all sectors - 2 hour - 100 m and site boundary

c GXQ Version 4.0 Input File

c mode
1

c
c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created

c
c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T F F F T F

c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting

c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 1 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd)iwash igrav
0 0 0 0

c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on

RPP-13482 REV 7

```

c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      height      height      to
c      hs(m)      ha(m)      hm(m)      exceed
c
c      0.00000E+00      1.00000E+01      1.00000E+03      5.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume      plume      duration      velocity      settling
c      width      height      trd(hr)      vd(m/s)      velocity
c      Wb(m)      Hb(m)
c
c      0.00000E+00      0.00000E+00      0.00000E+00      0.00000E+00      0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature      plume      plume      diameter      heat release
c      Tamb(C)      T0(C)      V0(m3/s)      d(m)      rate(1)
c
c      2.00000E+01      3.80000E+01      1.00000E+00      1.00000E+00      0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q      Wind
c      scaling      Speed
c      factor      Exponent
c      c(?)      a(?)
c
c      1.00000E+00      7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)      class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
NRC RG 1.145 plume meander model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

```

RPP-13482 REV 7

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

Tank Farms - 95 percentile all sectors - 2 hour - 100 m and site boundary

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	9.40E-03	9.40E-03	F	0.89
ALL	15360	0	99.94	1	1.74E-05	1.74E-05	F	0.89

RPP-13482 REV 7

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/09/02
Run Time = 11:05:50.71

INPUT ECHO:

Tank Farms - 50 percentile by sector - 2 hour - 100 m and site boundary
c GXQ Version 4.0 Input File
c mode
1
c
c MODE CHOICE:
c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created
c
c LOGICAL CHOICES:
c ifox inorm icdf ichk isite ipop
T T F F F F
c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting
c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:
c ipuff idep isrc iwind
0 0 0 0
c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:
c iwake ipm iflow ientr
0 1 0 0
c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:
c (irise igrnd)iwash igrav
0 0 0 0
c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on

RPP-13482 REV 7

```

c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height     to
c      hs(m)       ha(m)          hm(m)      exceed
c                                     Cx(%)
c
c      0.00000E+00  1.00000E+01  1.00000E+03  5.00000E+01
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height       trd(hr)      velocity        velocity
c      Wb(m)        Hb(m)        trd(hr)      vd(m/s)         vg(m/s)
c
c      0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        flow rate   d(m)         rate(1)
c                                     V0(m3/s)
c                                     qh(w)
c
c      2.00000E+01  3.80000E+01  1.00000E+00  1.00000E+00  0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c
c      1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
Joint frequency data normalized.
X/Q calculated for single sector.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
NRC RG 1.145 plume meander model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

```

RPP-13482 REV 7

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

Tank Farms - 50 percentile by sector - 2 hour - 100 m and site boundary

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
S	100	0	100.00	1	1.67E-03	1.67E-03	D	2.65
SSW	100	0	100.00	1	1.62E-03	1.62E-03	F	19.00
SW	100	0	100.00	1	1.85E-03	1.85E-03	B	0.89
WSW	100	0	100.00	1	2.22E-03	2.22E-03	E	2.65
W	100	0	100.00	1	2.07E-03	2.07E-03	E	2.65
WNW	100	0	100.00	1	2.04E-03	2.04E-03	B	0.89
NW	100	0	100.00	1	2.10E-03	2.10E-03	E	2.65
NNW	100	0	100.00	1	2.27E-03	2.27E-03	E	4.70
N	100	0	100.00	1	2.27E-03	2.27E-03	E	4.70
NNE	100	0	100.00	1	2.27E-03	2.27E-03	E	2.65
NE	100	0	100.00	1	1.81E-03	1.81E-03	B	0.89
ENE	100	0	100.00	1	1.75E-03	1.75E-03	D	2.65
E	100	0	100.00	1	2.27E-03	2.27E-03	E	4.70
ESE	100	0	100.00	1	2.27E-03	2.27E-03	E	2.65
SE	100	0	100.00	1	1.87E-03	1.87E-03	B	0.89
SSE	100	0	100.00	1	1.85E-03	1.85E-03	B	0.89
S	15360	0	100.00	1	7.57E-07	7.57E-07	E	7.15
SSW	15360	0	100.00	1	4.45E-07	4.45E-07	D	4.70
SW	13200	0	100.00	1	1.01E-06	1.01E-06	D	2.65
WSW	11100	0	100.00	1	1.50E-06	1.50E-06	E	4.70
W	11100	0	100.00	1	1.54E-06	1.54E-06	E	4.70
WNW	11100	0	100.00	1	1.59E-06	1.59E-06	E	4.70
NW	10800	0	100.00	1	1.77E-06	1.77E-06	E	4.70
NNW	8690	0	100.00	1	3.58E-06	3.58E-06	E	2.65
N	8690	0	100.00	1	3.83E-06	3.83E-06	E	2.65
NNE	8970	0	100.00	1	2.91E-06	2.91E-06	E	4.70
NE	10430	0	100.00	1	1.29E-06	1.29E-06	E	7.15
ENE	10530	0	100.00	1	1.25E-06	1.25E-06	E	7.15
E	11160	0	100.00	1	2.54E-06	2.54E-06	E	2.65
ESE	15190	0	100.00	1	1.11E-06	1.11E-06	E	4.70
SE	21050	0	100.00	1	4.95E-07	4.95E-07	E	7.15
SSE	15360	0	100.00	1	9.05E-07	9.05E-07	D	2.65

RPP-13482 REV 7

GXQ Version 4.0F
October 8, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/09/02
Run Time = 09:35:20.06

INPUT ECHO:

Tank Farms - Annual average by sector - 100 m and site boundary

c GXQ Version 4.0 Input File

c mode
1

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology

c mode = 2 then X/Q based on atmospheric stability class and wind speed

c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F F F F

c ifox = t then joint frequency used to compute frequency to exceed X/Q

c = f then joint frequency used to compute annual average X/Q

c inorm = t then joint frequency data is normalized (as in GENII)

c = f then joint frequency data is un-normalized

c icdf = t then cumulative distribution file created (CDF.OUT)

c = f then no cumulative distribution file created

c ichk = t then X/Q parameter print option turned on

c = f then no parameter print

c isite = t then X/Q based on joint frequency data for all 16 sectors

c = f then X/Q based on joint frequency data of individual sectors

c ipop = t then X/Q is population weighted

c = f then no population weighting

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 3 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd)iwash igrav
0 0 0 0

c ipuff = 1 then X/Q calculated using puff model

c = 0 then X/Q calculated using default continuous plume model

c idep = 1 then plume depletion model turned on (Chamberlain model)

c isrc = 1 then X/Q multiplied by scalar

c = 2 then X/Q adjusted by wind speed function

c iwind = 1 then wind speed corrected for plume height

c iwake = 1 then NRC RG 1.145 building wake model turned on

c = 2 then MACCS virtual distance building wake model turned on

c ipm = 1 then NRC RG 1.145 plume meander model turned on

c = 2 then 5th Power Law plume meander model turned on

c = 3 then sector average model turned on

c iflow = 1 then sigmas adjusted for volume flow rate

c ientr = 1 then method of Pasquill used to account for entrainment

c irise = 1 then MACCS buoyant plume rise model turned on

RPP-13482 REV 7

```

c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height      to
c      hs(m)       ha(m)          hm(m)       exceed
c                                     Cx(%)
c      0.00000E+00  1.00000E+01  1.00000E+03  0.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height      trd(hr)      velocity        velocity
c      Wb(m)        Hb(m)          vd(m/s)      vd(m/s)         vg(m/s)
c      0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        flow rate   d(m)         rate(1)
c                                     qh(w)
c      2.00000E+01  3.80000E+01  1.00000E+00  1.00000E+00  0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c      1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)    class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate annual average X/Q.
No normalization of joint frequency.
X/Q calculated for single sector.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
Sector average model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

```


RPP-13482 REV 7

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

Tank Farms - Annual avearage by sector - 100 m and site boundary

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
S	100	0	6.30	1	1.68E-04	1.68E-04		
SSW	100	0	4.53	1	1.04E-04	1.04E-04		
SW	100	0	2.93	1	9.93E-05	9.93E-05		
WSW	100	0	2.72	1	9.97E-05	9.97E-05		
W	100	0	4.80	1	1.73E-04	1.73E-04		
WNW	100	0	3.98	1	1.39E-04	1.39E-04		
NW	100	0	4.72	1	1.57E-04	1.57E-04		
NNW	100	0	4.58	1	1.54E-04	1.54E-04		
N	100	0	4.36	1	1.61E-04	1.61E-04		
NNE	100	0	2.49	1	9.04E-05	9.04E-05		
NE	100	0	3.90	1	1.07E-04	1.07E-04		
ENE	100	0	6.17	1	1.42E-04	1.42E-04		
E	100	0	14.05	1	3.78E-04	3.78E-04		
ESE	100	0	18.80	1	4.03E-04	4.03E-04		
SE	100	0	10.83	1	2.52E-04	2.52E-04		
SSE	100	0	4.78	1	1.47E-04	1.47E-04		
S	15360	0	6.30	1	3.50E-08	3.50E-08		
SSW	15360	0	4.53	1	2.10E-08	2.10E-08		
SW	13200	0	2.93	1	2.57E-08	2.57E-08		
WSW	11100	0	2.72	1	3.30E-08	3.30E-08		
W	11100	0	4.80	1	5.94E-08	5.94E-08		
WNW	11100	0	3.98	1	4.91E-08	4.91E-08		
NW	10800	0	4.72	1	5.95E-08	5.95E-08		
NNW	8690	0	4.58	1	8.25E-08	8.25E-08		
N	8690	0	4.36	1	8.76E-08	8.76E-08		
NNE	8970	0	2.49	1	4.67E-08	4.67E-08		
NE	10430	0	3.90	1	4.44E-08	4.44E-08		
ENE	10530	0	6.17	1	5.83E-08	5.83E-08		
E	11160	0	14.05	1	1.47E-07	1.47E-07		
ESE	15190	0	18.80	1	1.00E-07	1.00E-07		
SE	21050	0	10.83	1	3.78E-08	3.78E-08		
SSE	15360	0	4.78	1	3.22E-08	3.22E-08		

RPP-13482 REV 7

GXQ Version 4.0F
October 8, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/09/02
Run Time = 09:37:59.29

INPUT ECHO:

Tank Farms - 95 percentile all sectors - Puff - 100 m and site boundary
c GXQ Version 4.0 Input File
c mode
1
c
c MODE CHOICE:
c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created
c
c LOGICAL CHOICES:
c ifox inorm icdf ichk isite ipop
T F F F T F
c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting
c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:
c ipuff idep isrc iwind
1 0 0 0
c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:
c iwake ipm iflow ientr
0 0 0 0
c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:
c (irise igrnd)iwash igrav
0 0 0 0
c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on

RPP-13482 REV 7

```

c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height     to
c      hs(m)       ha(m)          hm(m)      exceed
c
c      0.00000E+00  1.00000E+01    1.00000E+03  5.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height       trd(hr)      vd(m/s)         velocity
c      Wb(m)        Hb(m)          (hr)         (m/s)           (m/s)
c
c      0.00000E+00  0.00000E+00    0.00000E+00  0.00000E+00    0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        flow rate   d(m)         rate(1)
c
c      2.00000E+01  3.80000E+01    1.00000E+00  1.00000E+00    0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c
c      1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Air concentrations will be calculated (1/m3).

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:
200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

```

RPP-13482 REV 7

Created 8/26/92 KR

Tank Farms - 95 percentile all sectors - Puff - 100 m and site boundary

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (1/m3)	AVERAGE INDIVIDUAL SCALED X/Q (1/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	8.88E-03	8.88E-03	G	0.89
ALL	15360	0	99.94	1	5.06E-08	5.06E-08	G	0.89

RPP-13482 REV 7

GXQ Version 4.0F
October 8, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/09/02
Run Time = 09:53:32.37

INPUT ECHO:

Tank Farms - 50 percentile by sector - Puff - 100 m and site boundary
c GXQ Version 4.0 Input File
c mode
c 1
c
c MODE CHOICE:
c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created
c
c LOGICAL CHOICES:
c ifox inorm icdf ichk isite ipop
c T T F F F F
c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting
c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:
c ipuff idep isrc iwind
c 1 0 0 0
c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:
c iwake ipm iflow ientr
c 0 0 0 0
c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:
c (irise igrnd)iwash igrav
c 0 0 0 0
c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on

RPP-13482 REV 7

```

c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height     to
c      hs(m)       ha(m)          hm(m)      exceed
c
c      0.00000E+00  1.00000E+01    1.00000E+03  5.00000E+01
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height       trd(hr)      vd(m/s)         velocity
c      Wb(m)        Hb(m)         vd(m/s)      vg(m/s)
c
c      0.00000E+00  0.00000E+00    0.00000E+00  0.00000E+00    0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        flow rate   d(m)         rate(1)
c                  T0(C)        V0(m3/s)    d(m)         qh(w)
c
c      2.00000E+01  3.80000E+01    1.00000E+00  1.00000E+00    0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c
c      1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
Joint frequency data normalized.
X/Q calculated for single sector.

MODELS SELECTED:
Air concentrations will be calculated (1/m3).

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:
200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

```

RPP-13482 REV 7

Created 8/26/92 KR

Tank Farms - 50 percentile by sector - Puff - 100 m and site boundary

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (1/m3)	AVERAGE INDIVIDUAL SCALED X/Q (1/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
S	100	0	100.00	1	2.59E-04	2.59E-04	D	2.65
SSW	100	0	100.00	1	2.54E-04	2.54E-04	D	2.65
SW	100	0	100.00	1	2.59E-04	2.59E-04	D	0.89
WSW	100	0	100.00	1	2.50E-04	2.50E-04	D	2.65
W	100	0	100.00	1	2.92E-04	2.92E-04	D	2.65
WNW	100	0	100.00	1	3.38E-04	3.38E-04	D	2.65
NW	100	0	100.00	1	4.68E-04	4.68E-04	D	2.65
NNW	100	0	100.00	1	6.48E-04	6.48E-04	E	2.65
N	100	0	100.00	1	7.07E-04	7.07E-04	E	2.65
NNE	100	0	100.00	1	6.28E-04	6.28E-04	E	2.65
NE	100	0	100.00	1	5.32E-04	5.32E-04	D	4.70
ENE	100	0	100.00	1	5.21E-04	5.21E-04	D	4.70
E	100	0	100.00	1	9.48E-04	9.48E-04	E	2.65
ESE	100	0	100.00	1	7.61E-04	7.61E-04	E	2.65
SE	100	0	100.00	1	5.01E-04	5.01E-04	D	4.70
SSE	100	0	100.00	1	3.36E-04	3.36E-04	D	2.65
S	15360	0	100.00	1	7.39E-10	7.39E-10	D	2.65
SSW	15360	0	100.00	1	7.23E-10	7.23E-10	D	2.65
SW	13200	0	100.00	1	1.06E-09	1.06E-09	D	0.89
WSW	11100	0	100.00	1	1.53E-09	1.53E-09	D	2.65
W	11100	0	100.00	1	1.87E-09	1.87E-09	D	2.65
WNW	11100	0	100.00	1	2.29E-09	2.29E-09	D	2.65
NW	10800	0	100.00	1	3.83E-09	3.83E-09	D	2.65
NNW	8690	0	100.00	1	9.40E-09	9.40E-09	E	2.65
N	8690	0	100.00	1	1.04E-08	1.04E-08	E	2.65
NNE	8970	0	100.00	1	8.42E-09	8.42E-09	E	2.65
NE	10430	0	100.00	1	4.89E-09	4.89E-09	D	4.70
ENE	10530	0	100.00	1	4.65E-09	4.65E-09	D	4.70
E	11160	0	100.00	1	8.28E-09	8.28E-09	E	2.65
ESE	15190	0	100.00	1	3.24E-09	3.24E-09	E	2.65
SE	21050	0	100.00	1	9.20E-10	9.20E-10	D	4.70
SSE	15360	0	100.00	1	1.06E-09	1.06E-09	D	2.65

APPENDIX C

**SAMPLE RUN FILES FOR MODIFICATIONS
TO THE BASIC DISPERSION COEFFICIENTS**

This page intentionally left blank.

APPENDIX C

**SAMPLE RUN FILES FOR MODIFICATIONS TO THE
BASIC DISPERSION COEFFICIENTS IN SECTION 2.3**

- Run file – 95th percentile overall, 1 hr, with deposition (0.15 cm/s)
- Run file – 95th percentile overall, 1 hr, elevated source with no momentum rise (9.5-ft stack, 1,000 ft³/min)
- Run file – 95th percentile overall, 1 hr, elevated source with momentum rise (9.5-ft stack, 1,000 ft³/min, 10-in.-diameter opening)
- Run file – 95th percentile overall, 1 hr, initial source width of 50 m
- Run file – 95th percentile overall, 1 hr, wind entrainment from 50-m-diameter pool
- Run file – 95th percentile overall, 1 hr, 100 kW ground-level fire with 5-m-diameter
- Run file – 95th percentile overall, 1 hr, release from building with 300 m² minimum cross-section

RPP-13482 REV 7

GXQ Version 4.0F
October 8, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/09/02
Run Time = 10:05:10.85

INPUT ECHO:

Tank Farms - 95 percentile all sectors - 1 hour - with deposition

c GXQ Version 4.0 Input File

c mode
1

c
c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created

c
c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T F F F T F

c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting

c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 1 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd)iwash igrav
0 0 0 0

c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on

RPP-13482 REV 7

```

c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height     to
c      hs(m)       ha(m)          hm(m)      exceed
c                                     Cx(%)
c
c      0.00000E+00  1.00000E+01  1.00000E+03  5.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height       trd(hr)      velocity        velocity
c      Wb(m)        Hb(m)        trd(hr)      vd(m/s)         vg(m/s)
c
c      0.00000E+00  0.00000E+00  0.00000E+00  1.50000E-03  0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        flow rate    d(m)         rate(1)
c                                     V0(m3/s)      qh(w)
c
c      2.00000E+01  2.00000E+01  1.00000E+00  1.00000E+00  0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c
c      1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
Source depletion model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

```

RPP-13482 REV 7

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

Tank Farms - 95 percentile all sectors - 1 hour - 100 m and site boundary

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	2.84E-02	2.84E-02	F	0.89
ALL	15360	0	99.94	1	1.14E-05	1.14E-05	F	0.89

RPP-13482 REV 7

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/15/02
Run Time = 15:08:16.90

INPUT ECHO:

Tank Farms - 95% all sectors - 1 hour - volume rate source - no momentum

c GXQ Version 4.0 Input File

c mode
1

c
c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created

c
c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T F F F T F

c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting

c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 1

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 1 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd)iwash igrav
0 0 1 0

c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on

RPP-13482 REV 7

```

c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height     to
c      hs(m)       ha(m)          hm(m)      exceed
c                                     Cx(%)
c
c      2.90000E+00  1.00000E+01  1.00000E+03  5.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height       trd(hr)      velocity        velocity
c      Wb(m)        Hb(m)                vd(m/s)        vg(m/s)
c
c      0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        flow rate    d(m)         rate(1)
c                                     qh(w)
c
c      2.00000E+01  2.00000E+01  4.72000E-01  2.54000E-01  0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c
c      1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
Flow rate adjustment model.
Wind velocity corrected for average plume height.

WARNING/ERROR MESSAGES:

```

RPP-13482 REV 7

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

Created 8/26/92 KR

Tank Farms - 95% all sectors - 1 hour - volume rate source - no momentum

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	2	99.94	1	1.44E-02	1.44E-02	F	0.89
ALL	15360	2	99.94	1	2.21E-05	2.21E-05	F	0.89

RPP-13482 REV 7

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/15/02
Run Time = 15:17:26.76

INPUT ECHO:

Tank Farms - 95% all sectors - 1 hour - volume rate source - momentum up
c GXQ Version 4.0 Input File
c mode
1
c
c MODE CHOICE:
c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created
c
c LOGICAL CHOICES:
c ifox inorm icdf ichk isite ipop
T F F F T F
c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting
c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:
c ipuff idep isrc iwind
0 0 0 1
c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:
c iwake ipm iflow ientr
0 0 1 1
c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:
c (irise igrnd)iwash igrav
2 0 1 0
c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on

RPP-13482 REV 7

```

c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height     to
c      hs(m)       ha(m)          hm(m)      exceed
c                                     Cx(%)
c
c      2.90000E+00  1.00000E+01  1.00000E+03  5.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height      trd(hr)      velocity        velocity
c      Wb(m)        Hb(m)          vd(m/s)      vg(m/s)
c
c      0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        V0(m3/s)     d(m)         rate(1)
c                                     qh(w)
c
c      2.00000E+01  2.00000E+01  4.72000E-01  2.54000E-01  0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c
c      1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
Flow rate adjustment model.
Plume rise air entrainment model selected.
ISC2 momentum/buoyancy plume model based on temperature difference.
Stack downwash model selected.
Wind velocity corrected for average plume height.

```

RPP-13482 REV 7

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

Created 8/26/92 KR

Tank Farms - 95% all sectors - 1 hour - volume rate source - momentum up

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	2	99.94	1	1.85E-03	1.85E-03	G	4.70
ALL	15360	2	99.94	1	2.18E-05	2.18E-05	F	0.89

RPP-13482 REV 7

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/17/02
Run Time = 09:30:53.35

INPUT ECHO:

Tank Farms - 95 percentile all sectors - 1 hour - wide source

c GXQ Version 4.0 Input File

c mode
1

c
c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created

c
c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T F F F T F

c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting

c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
2 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd)iwash igrav
0 0 0 0

c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on

RPP-13482 REV 7

```

c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height     to
c      hs(m)       ha(m)          hm(m)      exceed
c                                     Cx(%)
c
c      0.00000E+00  1.00000E+01  1.00000E+03  5.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height       trd(hr)      vd(m/s)         velocity
c      Wb(m)        Hb(m)                                     vg(m/s)
c
c      5.00000E+01  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        flow rate   d(m)         rate(1)
c                                     V0(m3/s)
c                                     qh(w)
c
c      2.00000E+01  3.80000E+01  1.00000E+00  1.00000E+00  0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c
c      1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
MACCS Virtual source building wake model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

```

RPP-13482 REV 7

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

Tank Farms - 95 percentile all sectors - 1 hour - 100 m and site boundary

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	9.21E-03	9.21E-03	F	0.89
ALL	15360	0	99.94	1	2.16E-05	2.16E-05	F	0.89

RPP-13482 REV 7

Current Input File Name: zimm4e.IN

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 12/16/02
Run Time = 08:31:37.85

INPUT ECHO:

Tank Farms - 95% all sectors - 1 hour - point source - entrainment

c GXQ Version 4.0 Input File

c mode
1

c
c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created

c
c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T F F F T F

c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting

c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 2 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
2 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd)iwash igrav
0 0 0 0

c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on

RPP-13482 REV 7

```

c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on
c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c      reference      frequency
c      release      anemometer      mixing      to
c      height      height      height      exceed
c      hs(m)      ha(m)      hm(m)      Cx(%)
c
c      0.00000E+00      1.00000E+01      1.00000E+03      5.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume      plume      duration      velocity      settling
c      width      height      trd(hr)      vd(m/s)      velocity
c      Wb(m)      Hb(m)      vd(m/s)      vg(m/s)
c
c      5.00000E+01      0.00000E+00      0.00000E+00      0.00000E+00      0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature      plume      plume      diameter      heat release
c      Tamb(C)      T0(C)      V0(m3/s)      d(m)      rate(1)
c
c      2.00000E+01      3.80000E+01      1.00000E+00      1.00000E+00      0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q      Wind
c      scaling      Speed
c      factor      Exponent
c      c(?)      a(?)
c
c      1.00000E+00      3.76200E+00
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed)      class windspeed distance offset receptor-height
c 3 (create plot file)      class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
MACCS Virtual source building wake model selected.
X/Q adjusted for wind speed dependent source term (c u^a).

```


RPP-13482 REV 7

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

Tank Farms - 95% all sectors - 1 hour - point source - entrainment

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q	AVERAGE INDIVIDUAL SCALED X/Q	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	1.28E+00	1.28E+00	A	15.60
ALL	15360	0	99.94	1	1.99E-03	1.99E-03	D	9.80

RPP-13482 REV 7

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/11/04
Run Time = 09:15:54.76

INPUT ECHO:

generic pool fire 5 m diameter, 100 kW

c GXQ Version 4.0 Input File

1

c MODE SELECTION:

c 1 - X/Q based on site-specific wind data from JOINTFRE.IN
c 2 - X/Q based on input stability class and wind speed
c 3 - X/Q plot file table is created

c

c SITE WIND & POPULATION OPTIONS:

c	ifox	inorm	icdf	ichk	isite	ipop
	T	F	F	T	F	

c ifox = T compute probabilistic X/Q from a cumulative distribution
c = F compute annual average X/Q (usually sector average with ipm=3)
c inorm = T normalize joint frequency data in a sector (as in GENII)
c = F use joint frequency data as is
c icdf = T put cumulative distributions in the CDF.OUT file
c = F no cumulative distribution file created
c ichk = T show details for each X/Q (long output)
c = F standard length output
c isite = T compute overall site X/Q (need groups of 16 sectors)
c = F compute X/Q for individual sectors
c ipop = T population-weighted using the file POP.IN (use ipm=3)
c = F no population weighting

c

c GAUSSIAN PLUME/PUFF MODEL OPTIONS: (enter 0 to inactivate option)

c	ipuff	idep	isrc	iwind
	0	0	1	

c	iwake	ipm	iflow	ientr
	0	0	1	

c	irise	igrnd	iwash	igrav
	1	1	0	0

c ipuff = 0 compute time-integrated air concentrations (s/m3)
c = 1 compute air concentrations (1/m3) (need release duration)
c idep = 1 plume depletion model (source depletion)
c isrc = 1 multiply X/Q by scale factor (input below)
c = 2 multiply by wind speed function: (factor)*[speed**(exponent)]
c = 3 multiply by wind speed function: (factor)*[10**(speed*exponent)]
c iwind = 1 wind speed corrected for plume height using power law
c iwake = 1 NRC Reg Guide 1.145 building wake model
c = 2 MACCS virtual source building wake model
c ipm = 1 NRC Reg Guide 1.145 plume meander model
c = 2 MACCS time-dependent plume meander model
c = 3 sector average X/Q computed
c iflow = 1 exhaust flow rate adjustment using virtual source method
c ientr = 1 entrainment method of Pasquill
c irise = 1 MACCS buoyant plume rise (uses building height)
c = 2 ISC momentum/buoyancy plume rise
c igrnd = 1 modifies buoyant plume rise for ground-level effects

RPP-13482 REV 7

```

c iwash = 1  stack downwash
c igrav = 1  gravitational settling
c
c PARAMETER INPUT:
c   release      anemometer      mixing      % of X/Q
c   height,m     height,m (*)    height,m   larger
c   0.00000E+00  1.00000E+01    1.00000E+03  5.00000E+00
c (* In MODE=1 this input is superseded by the value read from JOINTFRE.IN)
c
c   building      building      release      deposition      gravitational
c   width,m       height,m     duration,h   speed,m/s      settling,m/s
c   0.00000E+00  0.00000E+00    0.00000E+00  0.00000E+00    0.00000E+00
c
c   ambient      stack gas      stack flow   stack(pool)    heat exhaust
c   temp,C       temp,C        rate,m3/s    diameter,m     rate,W (**)
c   2.00000E+01  2.00000E+01    0.00000E+00  5.00000E+00    1.00000E+05
c (** If this is 0 then buoyant flux computed from temps & flow rate)
c
c   scale        speed
c   factor       exponent
c   1.00000E+00  7.80000E-01
c
c RECEPTOR LOCATIONS (no line limit, 3 kinds)
c   MODE = 1  wind data read from JOINTFRE.IN
c   input:   sector, distance, elevation
c   MODE = 2  user supplies stability class, wind speed and receptor X,Y,Z
c   input:   class, windspeed, distance, offset, elevation
c   MODE = 3  output file has X/Q table for plotting isopleths (note Z=0)
c   input:   class, windspeed, xmax, xint, ymax, yint, xqmin, power
c
c RECEPTOR PARAMETERS
c   sector = 0, 1, 2, . . . (all, S, SSW, SW, WSW, etc.)
c   distance (X) = receptor distance from point of release (m)
c   offset (Y) = offset from plume centerline (m)
c   elevation (Z) = height of receptor above grade (m)
c   class = 1,2,3,4,5,6,7 (Pasquill stability A,B,C,D,E,F,G)
c   windspeed = anemometer wind speed (m/s)
c   xmax,xint = maximum distance (m) and number of distance intervals
c   ymax,yint = maximum offset distance (m) and number of distance intervals
c   xqmin = minimum value of X/Q to show on table (s/m3 or 1/m3)
c   power = exponent in power function step size (1 or 2)
c
c sector distance elevation

```

MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
Plume rise air entrainment model selected.
MACCS buoyancy plume rise model based on convective heat.
Mills buoyant rise modification for pool fire selected.
Wind velocity corrected for average plume height.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:
200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

generic pool fire 5 m diameter, 100 kW

TOTAL AVERAGE
POPULATION INDIVIDUAL

RPP-13482 REV 7

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	SCALED X/Q (s/m3)	SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	1.93E-03	1.93E-03	F	15.60
ALL	110	0	99.94	1	1.63E-03	1.63E-03	F	15.60
ALL	120	0	99.94	1	1.39E-03	1.39E-03	F	15.60
ALL	130	0	99.94	1	1.17E-03	1.17E-03	F	15.60
ALL	140	0	99.94	1	9.59E-04	9.59E-04	E	7.15
ALL	150	0	99.94	1	8.34E-04	8.34E-04	E	7.15
ALL	100	1	99.94	1	2.39E-03	2.39E-03	F	4.70
ALL	110	1	99.94	1	1.91E-03	1.91E-03	G	4.70
ALL	120	1	99.94	1	1.45E-03	1.45E-03	G	4.70
ALL	130	1	99.94	1	1.13E-03	1.13E-03	G	4.70
ALL	140	1	99.94	1	1.01E-03	1.01E-03	F	15.60
ALL	150	1	99.94	1	8.73E-04	8.73E-04	F	15.60
ALL	100	2	99.94	1	2.77E-03	2.77E-03	F	7.15
ALL	110	2	99.94	1	2.08E-03	2.08E-03	F	4.70
ALL	120	2	99.94	1	1.75E-03	1.75E-03	F	4.70
ALL	130	2	99.94	1	1.49E-03	1.49E-03	F	4.70
ALL	140	2	99.94	1	1.23E-03	1.23E-03	F	4.70
ALL	150	2	99.94	1	1.02E-03	1.02E-03	F	4.70
ALL	15360	0	99.94	1	1.82E-05	1.82E-05	G	2.65

RPP-13482 REV 7

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/15/04
Run Time = 09:39:46.89

INPUT ECHO:

Tank farms X/Q with building wake - 300 m2

c GXQ Version 4.0 Input File

1

c MODE SELECTION:

c 1 - X/Q based on site-specific wind data from JOINTFRE.IN
c 2 - X/Q based on input stability class and wind speed
c 3 - X/Q plot file table is created

c

c SITE WIND & POPULATION OPTIONS:

c ifox inorm icdf ichk isite ipop

T	F	F	F	T	F
c ifox = T	compute probabilistic X/Q from a cumulative distribution				
c = F	compute annual average X/Q (usually sector average with ipm=3)				
c inorm = T	normalize joint frequency data in a sector (as in GENII)				
c = F	use joint frequency data as is				
c icdf = T	put cumulative distributions in the CDF.OUT file				
c = F	no cumulative distribution file created				
c ichk = T	show details for each X/Q (long output)				
c = F	standard length output				

c isite = T compute overall site X/Q (need groups of 16 sectors)

c = F compute X/Q for individual sectors

c ipop = T population-weighted using the file POP.IN (use ipm=3)

c = F no population weighting

c

c GAUSSIAN PLUME/PUFF MODEL OPTIONS: (enter 0 to inactivate option)

c ipuff idep isrc iwind

0 0 0 0

c iwake ipm iflow ientr

1 0 0 0

c irise igrnd iwash igrav

0 0 0 0

c ipuff = 0 compute time-integrated air concentrations (s/m3)

c = 1 compute air concentrations (1/m3) (need release duration)

c idep = 1 plume depletion model (source depletion)

c isrc = 1 multiply X/Q by scale factor (input below)

c = 2 multiply by wind speed function: (factor)*[speed**(exponent)]

c = 3 multiply by wind speed function: (factor)*[10**(speed*exponent)]

c iwind = 1 wind speed corrected for plume height using power law

c iwake = 1 NRC Reg Guide 1.145 building wake model

c = 2 MACCS virtual source building wake model

c ipm = 1 NRC Reg Guide 1.145 plume meander model

c = 2 MACCS time-dependent plume meander model

c = 3 sector average X/Q computed

c iflow = 1 exhaust flow rate adjustment using virtual source method

c ientr = 1 entrainment method of Pasquill

c irise = 1 MACCS buoyant plume rise (uses building height)

c = 2 ISC momentum/buoyancy plume rise

RPP-13482 REV 7

```

c igrnd = 1  modifies buoyant plume rise for ground-level effects
c iwash = 1  stack downwash
c igrav = 1  gravitational settling
c
c PARAMETER INPUT:
c  release      anemometer      mixing      % of X/Q
c  height,m     height,m (*)    height,m   larger
c  0.00000E+00  1.00000E+01     1.00000E+03 5.00000E+00
c (* In MODE=1 this input is superceded by the value read from JOINTFRE.IN)
c
c  building      building      release      deposition      gravitational
c  width,m       height,m     duration,h   speed,m/s       settling,m/s
c  3.00000E+01   1.00000E+01    0.00000E+00 0.00000E+00    0.00000E+00
c
c  ambient      stack gas      stack flow   stack(pool)     heat exhaust
c  temp,C       temp,C        rate,m3/s    diameter,m      rate,W (**)
c  2.00000E+01  2.00000E+01    0.00000E+00 0.00000E+00    0.00000E+00
c (** If this is 0 then buoyant flux computed from temps & flow rate)
c
c  scale        speed
c  factor       exponent
c  1.00000E+00  7.80000E-01
c
c RECEPTOR LOCATIONS (no line limit, 3 kinds)
c  MODE = 1  wind data read from JOINTFRE.IN
c  input:   sector, distance, elevation
c  MODE = 2  user supplies stability class, wind speed and receptor X,Y,Z
c  input:   class, windspeed, distance, offset, elevation
c  MODE = 3  output file has X/Q table for plotting isopleths (note Z=0)
c  input:   class, windspeed, xmax, xint, ymax, yint, xqmin, power
c
c RECEPTOR PARAMETERS
c  sector = 0, 1, 2, . . . (all, S, SSW, SW, WSW, etc.)
c  distance (X) = receptor distance from point of release (m)
c  offset (Y) = offset from plume centerline (m)
c  elevation (Z) = height of receptor above grade (m)
c  class = 1,2,3,4,5,6,7 (Pasquill stability A,B,C,D,E,F,G)
c  windspeed = anemometer wind speed (m/s)
c  xmax,xint = maximum distance (m) and number of distance intervals
c  ymax,yint = maximum offset distance (m) and number of distance intervals
c  xqmin = minimum value of X/Q to show on table (s/m3 or 1/m3)
c  power = exponent in power function step size (1 or 2)
c
c sector distance elevation

MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
NRC RG 1.145 building wake model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:
200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

```

Tank farms X/Q with building wake - 300 m2

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL	AVERAGE	ATM. STAB.	WIND SPEED (m/s)
					POPULATION SCALED X/Q (s/m3)	INDIVIDUAL SCALED X/Q (s/m3)		

RPP-13482 REV 7

ALL	100	0	99.94	1	1.09E-02	1.09E-02 F	0.89
ALL	15360	0	99.94	1	2.21E-05	2.21E-05 F	0.89

APPENDIX D

GXQ CDF OUTPUT FOR THE BASE CASE CENTERLINE PLUME

This page intentionally left blank.

APPENDIX D

GXQ CDF OUTPUT FOR THE BASE CASE CENTERLINE PLUME

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/24/02
Run Time = 08:45:12.01

Ground Level, Plume, 95th Percentile

CUMULATIVE DISTRIBUTION

SECTOR	DISTANCE (m)	ATM. STAB. CLASS	WIND SPEED (m/s)	SECTR FREQ (%)	CUM. FREQ. (%)	SCALED X/Q (s/m3)
S	100.	G	0.89	1.87	0.935	8.540E-02
SSW	100.	F	0.89	4.16	3.950	3.444E-02
SSW	100.	G	2.65	3.20	7.630	2.868E-02
S	100.	G	4.70	1.85	10.155	1.617E-02
SSW	100.	E	0.89	5.45	13.805	1.531E-02
SW	100.	F	2.65	7.23	20.145	1.157E-02
NNW	100.	G	7.15	0.02	23.770	1.063E-02
SW	100.	D	0.89	7.42	27.490	8.337E-03
SW	100.	F	4.70	3.98	33.190	6.522E-03
WSW	100.	E	2.65	8.57	39.465	5.142E-03
NNW	100.	F	7.15	0.29	43.895	4.287E-03
SSW	100.	G	19.00	0.01	44.045	4.000E-03
WSW	100.	C	0.89	1.17	44.635	3.566E-03
N	100.	F	9.80	0.03	45.235	3.128E-03
S	100.	E	4.70	7.12	48.810	2.899E-03
W	100.	D	2.65	9.21	56.975	2.800E-03
SSW	100.	F	15.60	0.02	61.590	1.965E-03
NW	100.	E	7.15	3.71	63.455	1.906E-03
W	100.	B	0.89	1.21	65.915	1.866E-03
SSW	100.	F	19.00	0.08	66.560	1.613E-03
W	100.	D	4.70	5.73	69.465	1.579E-03
SW	100.	E	9.80	0.95	72.805	1.390E-03
SSW	100.	C	2.65	1.69	74.125	1.198E-03
SW	100.	E	12.70	0.19	75.065	1.073E-03
NW	100.	A	0.89	2.80	76.560	1.068E-03
WNW	100.	D	7.15	3.46	79.690	1.038E-03

RPP-13482 REV 7

SSW	100.	E	15.60	0.04	81.440	8.735E-04
SW	100.	D	9.80	1.49	82.205	7.571E-04
S	100.	E	19.00	0.19	83.045	7.172E-04
NW	100.	C	4.70	0.82	83.550	6.754E-04
WSW	100.	B	2.65	1.69	84.805	6.266E-04
S	100.	D	12.70	0.43	85.865	5.842E-04
SSW	100.	D	15.60	0.11	86.135	4.756E-04
S	100.	C	7.15	0.39	86.385	4.439E-04
S	100.	D	19.00	0.11	86.635	3.905E-04
S	100.	A	2.65	5.76	89.570	3.588E-04
W	100.	B	4.70	0.93	92.915	3.533E-04
N	100.	C	9.80	0.20	93.480	3.239E-04
NE	100.	C	12.70	0.06	93.610	2.499E-04
SSW	100.	B	7.15	0.46	93.870	2.322E-04
SSW	100.	C	15.60	0.03	94.115	2.035E-04
NW	100.	A	4.70	2.98	95.620	2.023E-04
SSW	100.	B	9.80	0.19	97.205	1.694E-04
S	100.	C	19.00	0.03	97.315	1.671E-04
SW	100.	A	7.15	1.56	98.110	1.330E-04
NE	100.	B	12.70	0.05	98.915	1.308E-04
SSW	100.	B	15.60	0.01	98.945	1.064E-04
SSW	100.	A	9.80	0.73	99.315	9.702E-05
S	100.	B	19.00	0.02	99.690	8.740E-05
NE	100.	A	12.70	0.16	99.780	7.486E-05
S	100.	A	15.60	0.04	99.880	6.095E-05
SSW	100.	A	19.00	0.04	99.920	5.004E-05
WNW	100.	A	9.80	0.00	99.940	0.000E+00
SSE	100.	G	19.00	0.00	99.940	0.000E+00

NNW	8690.	G	0.89	0.31	0.155	7.859E-05
NNE	8970.	G	0.89	0.09	0.355	7.546E-05
NE	10430.	G	0.89	0.10	0.450	6.226E-05
ENE	10530.	G	0.89	0.09	0.545	6.151E-05
NW	10800.	G	0.89	0.13	0.655	5.956E-05
WSW	11100.	G	0.89	0.34	0.890	5.753E-05
E	11160.	G	0.89	0.22	1.170	5.714E-05
SW	13200.	G	0.89	0.08	1.320	4.624E-05
ESE	15190.	G	0.89	0.14	1.430	3.879E-05
SSW	15360.	G	0.89	0.23	1.615	3.826E-05
NNW	8690.	F	0.89	0.61	2.035	3.137E-05

NNE	8970.	F	0.89	0.23	2.455	3.012E-05
NNW	8690.	G	2.65	0.43	2.785	2.640E-05
SE	21050.	G	0.89	0.14	3.070	2.590E-05
NNE	8970.	G	2.65	0.08	3.180	2.534E-05
NE	10430.	F	0.89	0.22	3.330	2.485E-05
ENE	10530.	F	0.89	0.27	3.575	2.455E-05
NW	10800.	F	0.89	0.28	3.850	2.377E-05
WSW	11100.	F	0.89	0.68	4.330	2.296E-05
E	11160.	F	0.89	0.48	4.910	2.281E-05
NE	10430.	G	2.65	0.10	5.200	2.091E-05
ENE	10530.	G	2.65	0.20	5.350	2.066E-05
NW	10800.	G	2.65	0.20	5.550	2.000E-05
WSW	11100.	G	2.65	0.22	5.760	1.932E-05
E	11160.	G	2.65	0.82	6.280	1.919E-05
SW	13200.	F	0.89	0.12	6.750	1.846E-05
SW	13200.	G	2.65	0.02	6.820	1.553E-05
ESE	15190.	F	0.89	0.36	7.010	1.549E-05
SSW	15360.	F	0.89	0.59	7.485	1.527E-05
NNW	8690.	G	4.70	0.16	7.860	1.488E-05
NNE	8970.	G	4.70	0.01	7.945	1.429E-05
ESE	15190.	G	2.65	0.69	8.295	1.303E-05

RPP-13482 REV 7

NNW	8690.	E	0.89	0.64	8.960	1.298E-05
SSW	15360.	G	2.65	0.14	9.350	1.285E-05
NNE	8970.	E	0.89	0.21	9.525	1.244E-05
NE	10430.	G	4.70	0.02	9.640	1.179E-05
ENE	10530.	G	4.70	0.09	9.695	1.165E-05
NW	10800.	G	4.70	0.01	9.745	1.128E-05
WNW	11100.	G	4.70	0.01	9.755	1.089E-05
E	11160.	G	4.70	0.56	10.040	1.082E-05
NNW	8690.	F	2.65	0.89	10.765	1.053E-05
SE	21050.	F	0.89	0.32	11.370	1.034E-05
NE	10430.	E	0.89	0.25	11.655	1.015E-05

NNE	8970.	F	2.65	0.21	11.885	1.012E-05
ENE	10530.	E	0.89	0.29	12.135	1.003E-05
NNW	8690.	G	7.15	0.01	12.285	9.783E-06
NW	10800.	E	0.89	0.31	12.445	9.692E-06
WSW	11100.	E	0.89	1.05	13.125	9.343E-06
E	11160.	E	0.89	0.49	13.895	9.276E-06
SE	21050.	G	2.65	0.30	14.290	8.698E-06
NE	10430.	F	2.65	0.27	14.575	8.346E-06
ENE	10530.	F	2.65	0.46	14.940	8.245E-06
NW	10800.	F	2.65	0.39	15.365	7.985E-06
WSW	11100.	F	2.65	0.42	15.770	7.712E-06
E	11160.	F	2.65	1.60	16.780	7.660E-06
SW	13200.	E	0.89	0.28	17.720	7.419E-06
ESE	15190.	G	4.70	0.84	18.280	7.346E-06
S	15360.	G	4.70	0.02	18.710	7.244E-06
SW	13200.	F	2.65	0.05	18.745	6.200E-06
ESE	15190.	E	0.89	0.44	18.990	6.161E-06
SSW	15360.	E	0.89	1.04	19.730	6.071E-06
NNW	8690.	F	4.70	0.31	20.405	5.940E-06
NNE	8970.	F	4.70	0.03	20.575	5.703E-06
NNW	8690.	D	0.89	0.59	20.885	5.487E-06
NNE	8970.	D	0.89	0.19	21.275	5.236E-06
ESE	15190.	F	2.65	1.69	22.215	5.201E-06
S	15360.	F	2.65	0.43	23.275	5.129E-06
SE	21050.	G	4.70	0.13	23.555	4.904E-06
ESE	15190.	G	7.15	0.01	23.625	4.829E-06
NE	10430.	F	4.70	0.07	23.665	4.706E-06
ENE	10530.	F	4.70	0.20	23.800	4.649E-06
NW	10800.	F	4.70	0.05	23.925	4.502E-06
NNW	8690.	E	2.65	0.98	24.440	4.359E-06
WSW	11100.	F	4.70	0.04	24.950	4.348E-06
E	11160.	F	4.70	1.19	25.565	4.319E-06

NE	10430.	D	0.89	0.21	26.265	4.195E-06
NNE	8970.	E	2.65	0.21	26.475	4.176E-06
ENE	10530.	D	0.89	0.17	26.665	4.136E-06
SE	21050.	E	0.89	0.45	26.975	4.015E-06
NW	10800.	D	0.89	0.43	27.415	3.986E-06
NNW	8690.	F	7.15	0.03	27.645	3.904E-06
WSW	11100.	D	0.89	1.86	28.590	3.829E-06
E	11160.	D	0.89	0.40	29.720	3.798E-06
SW	13200.	F	4.70	0.01	29.925	3.495E-06
SE	21050.	F	2.65	0.82	30.340	3.473E-06
NE	10430.	E	2.65	0.29	30.895	3.410E-06
ENE	10530.	E	2.65	0.48	31.280	3.367E-06
NW	10800.	E	2.65	0.47	31.755	3.255E-06
WSW	11100.	E	2.65	0.78	32.380	3.138E-06
E	11160.	E	2.65	1.58	33.560	3.115E-06
NE	10430.	F	7.15	0.01	34.355	3.093E-06

RPP-13482 REV 7

ENE	10530.	F	7.15	0.02	34.370	3.056E-06
SW	13200.	D	0.89	0.59	34.675	2.971E-06
ESE	15190.	F	4.70	1.60	35.770	2.933E-06
SSW	15360.	F	4.70	0.16	36.650	2.892E-06
N	8690.	F	9.80	0.01	36.735	2.849E-06
E	11160.	F	7.15	0.07	36.775	2.839E-06
SW	13200.	E	2.65	0.11	36.865	2.492E-06
NNW	8690.	E	4.70	0.47	37.155	2.458E-06
ESE	15190.	D	0.89	0.44	37.610	2.420E-06
S	15360.	D	0.89	2.00	38.830	2.381E-06
NNE	8970.	E	4.70	0.12	39.890	2.355E-06
ESE	15190.	E	2.65	1.68	40.790	2.069E-06
SSW	15360.	E	2.65	0.88	42.070	2.039E-06
SE	21050.	F	4.70	0.32	42.670	1.958E-06
ESE	15190.	F	7.15	0.08	42.870	1.928E-06
NE	10430.	E	4.70	0.18	43.000	1.923E-06
S	15360.	F	7.15	0.05	43.115	1.901E-06
ENE	10530.	E	4.70	0.39	43.335	1.898E-06
NNW	8690.	D	2.65	0.88	43.970	1.843E-06
NW	10800.	E	4.70	0.15	44.485	1.835E-06
SSW	15360.	G	19.00	0.01	44.565	1.792E-06
WSW	11100.	E	4.70	0.13	44.635	1.769E-06
NNE	8970.	D	2.65	0.18	44.790	1.759E-06
E	11160.	E	4.70	1.98	45.870	1.757E-06
NNW	8690.	E	7.15	0.12	46.920	1.616E-06
NNE	8970.	E	7.15	0.08	47.020	1.548E-06
SE	21050.	D	0.89	0.54	47.330	1.505E-06
NE	10430.	D	2.65	0.24	47.720	1.409E-06
SW	13200.	E	4.70	0.04	47.860	1.405E-06
ENE	10530.	D	2.65	0.28	48.020	1.389E-06
S	15360.	F	9.80	0.02	48.170	1.387E-06
SE	21050.	E	2.65	1.11	48.735	1.348E-06
NW	10800.	D	2.65	0.75	49.665	1.339E-06
SE	21050.	F	7.15	0.03	50.055	1.287E-06
WSW	11100.	D	2.65	1.56	50.850	1.286E-06
E	11160.	D	2.65	0.69	51.975	1.276E-06
NE	10430.	E	7.15	0.17	52.405	1.264E-06
ENE	10530.	E	7.15	0.30	52.640	1.248E-06
NW	10800.	E	7.15	0.01	52.795	1.206E-06
N	8690.	E	9.80	0.01	52.805	1.179E-06
ESE	15190.	E	4.70	2.50	54.060	1.167E-06
E	11160.	E	7.15	0.65	55.635	1.155E-06
SSW	15360.	E	4.70	0.41	56.165	1.150E-06
NNE	8970.	E	9.80	0.05	56.395	1.129E-06
NNW	8690.	C	0.89	0.08	56.460	1.083E-06
NNW	8690.	D	4.70	0.51	56.755	1.039E-06
NNE	8970.	C	0.89	0.02	57.020	1.023E-06
SW	13200.	D	2.65	0.40	57.230	9.977E-07
NNE	8970.	D	4.70	0.13	57.495	9.916E-07
SW	13200.	E	7.15	0.01	57.565	9.235E-07
NE	10430.	E	9.80	0.11	57.625	9.222E-07
ENE	10530.	E	9.80	0.15	57.755	9.105E-07
NNE	8970.	E	12.70	0.01	57.835	8.714E-07
S	15360.	F	15.60	0.02	57.850	8.714E-07
E	11160.	E	9.80	0.06	57.890	8.424E-07
ESE	15190.	D	2.65	1.09	58.465	8.127E-07
SSW	15360.	D	2.65	2.09	60.055	7.996E-07
NE	10430.	D	4.70	0.23	61.215	7.943E-07
ENE	10530.	D	4.70	0.39	61.525	7.833E-07
NE	10430.	C	0.89	0.02	61.730	7.787E-07
ESE	15190.	E	7.15	1.75	62.615	7.669E-07
ENE	10530.	C	0.89	0.02	63.500	7.654E-07
SE	21050.	E	4.70	0.75	63.885	7.602E-07

RPP-13482 REV 7

SSW	15360.	E	7.15	0.21	64.365	7.557E-07
NW	10800.	D	4.70	0.25	64.595	7.547E-07
NW	10800.	C	0.89	0.06	64.750	7.315E-07
WSW	11100.	D	4.70	0.27	64.915	7.250E-07
E	11160.	D	4.70	0.83	65.465	7.193E-07
S	15360.	F	19.00	0.08	65.920	7.154E-07
NE	10430.	E	12.70	0.04	65.980	7.116E-07
ENE	10530.	E	12.70	0.02	66.010	7.026E-07
W	11100.	C	0.89	0.36	66.200	6.965E-07
E	11160.	C	0.89	0.04	66.400	6.898E-07
NNW	8690.	D	7.15	0.17	66.505	6.830E-07
SW	13200.	E	9.80	0.01	66.595	6.737E-07
NNE	8970.	D	7.15	0.11	66.655	6.518E-07
E	11160.	E	12.70	0.01	66.715	6.501E-07
NE	10430.	E	15.60	0.01	66.725	5.793E-07
SW	13200.	D	4.70	0.09	66.775	5.625E-07
ESE	15190.	E	9.80	0.38	67.010	5.595E-07
S	15360.	E	9.80	0.07	67.235	5.514E-07
NE	10430.	D	7.15	0.25	67.395	5.222E-07
SW	13200.	E	12.70	0.01	67.525	5.199E-07
SW	13200.	C	0.89	0.09	67.575	5.152E-07
ENE	10530.	D	7.15	0.38	67.810	5.149E-07
SE	21050.	D	2.65	1.05	68.525	5.054E-07
SE	21050.	E	7.15	0.41	69.255	4.997E-07
N	8690.	D	9.80	0.02	69.470	4.983E-07
NW	10800.	D	7.15	0.03	69.495	4.961E-07
WNW	11100.	D	7.15	0.02	69.520	4.766E-07
NNE	8970.	D	9.80	0.07	69.565	4.755E-07
E	11160.	D	7.15	0.58	69.890	4.728E-07
ESE	15190.	D	4.70	1.46	70.910	4.582E-07
NNW	8690.	B	0.89	0.08	71.680	4.527E-07
S	15360.	D	4.70	0.73	72.085	4.508E-07
NNE	8970.	B	0.89	0.02	72.460	4.388E-07
ESE	15190.	E	12.70	0.05	72.495	4.317E-07
S	15360.	E	12.70	0.02	72.530	4.255E-07
ESE	15190.	C	0.89	0.04	72.560	4.114E-07
SSW	15360.	C	0.89	0.34	72.750	4.046E-07
NE	10430.	B	0.89	0.01	72.925	3.829E-07
NE	10430.	D	9.80	0.16	73.010	3.810E-07
ENE	10530.	B	0.89	0.03	73.105	3.796E-07
ENE	10530.	D	9.80	0.24	73.240	3.757E-07
NW	10800.	B	0.89	0.07	73.395	3.711E-07
SW	13200.	D	7.15	0.03	73.445	3.698E-07
NNE	8970.	D	12.70	0.02	73.470	3.670E-07
SE	21050.	E	9.80	0.11	73.535	3.646E-07
NNW	8690.	C	2.65	0.16	73.670	3.638E-07
WNW	11100.	B	0.89	0.36	73.930	3.620E-07
E	11160.	B	0.89	0.04	74.130	3.602E-07
S	15360.	E	15.60	0.03	74.165	3.464E-07
E	11160.	D	9.80	0.13	74.245	3.450E-07
NNE	8970.	C	2.65	0.02	74.320	3.435E-07
NNW	8690.	A	0.89	0.20	74.430	3.396E-07
NNE	8970.	A	0.89	0.06	74.560	3.300E-07
SW	13200.	B	0.89	0.10	74.640	3.096E-07
ESE	15190.	D	7.15	1.14	75.260	3.012E-07
S	15360.	D	7.15	0.25	75.955	2.963E-07
NE	10430.	D	12.70	0.09	76.125	2.940E-07
ENE	10530.	D	12.70	0.09	76.215	2.899E-07
NE	10430.	A	0.89	0.06	76.290	2.880E-07
ENE	10530.	A	0.89	0.06	76.350	2.855E-07
SE	21050.	D	4.70	0.84	76.800	2.850E-07

RPP-13482 REV 7

SSW	15360.	E	19.00	0.19	77.315	2.844E-07
SE	21050.	E	12.70	0.03	77.425	2.813E-07
NW	10800.	A	0.89	0.17	77.525	2.791E-07
ESE	15190.	B	0.89	0.05	77.635	2.727E-07
WNW	11100.	A	0.89	0.90	78.110	2.722E-07
SE	21050.	C	0.89	0.10	78.610	2.721E-07
E	11160.	A	0.89	0.10	78.710	2.709E-07
SSW	15360.	B	0.89	0.38	78.950	2.700E-07
SW	13200.	D	9.80	0.01	79.145	2.698E-07
E	11160.	D	12.70	0.03	79.165	2.662E-07
NE	10430.	C	2.65	0.03	79.195	2.615E-07
ENE	10530.	C	2.65	0.05	79.235	2.571E-07
NW	10800.	C	2.65	0.19	79.355	2.457E-07
NE	10430.	D	15.60	0.03	79.465	2.393E-07
ENE	10530.	D	15.60	0.03	79.495	2.360E-07
WNW	11100.	C	2.65	0.35	79.685	2.339E-07
SW	13200.	A	0.89	0.23	79.975	2.328E-07
E	11160.	C	2.65	0.08	80.130	2.317E-07
ESE	15190.	D	9.80	0.50	80.420	2.198E-07
E	11160.	D	15.60	0.02	80.680	2.167E-07
S	15360.	D	9.80	0.07	80.725	2.162E-07
NNW	8690.	C	4.70	0.09	80.805	2.051E-07
ESE	15190.	A	0.89	0.10	80.900	2.051E-07
SE	21050.	B	0.89	0.07	80.985	2.031E-07
S	15360.	A	0.89	0.78	81.410	2.030E-07
NNE	8970.	C	4.70	0.02	81.810	1.937E-07
SE	21050.	D	7.15	0.50	82.070	1.873E-07
SW	13200.	C	2.65	0.06	82.350	1.730E-07
ESE	15190.	D	12.70	0.07	82.415	1.696E-07
SSW	15360.	D	12.70	0.05	82.475	1.668E-07
SE	21050.	A	0.89	0.14	82.570	1.527E-07
NNW	8690.	B	2.65	0.17	82.725	1.520E-07
NE	10430.	C	4.70	0.03	82.825	1.475E-07
NNE	8970.	B	2.65	0.04	82.860	1.474E-07
ENE	10530.	C	4.70	0.06	82.910	1.449E-07
NW	10800.	C	4.70	0.04	82.960	1.385E-07
ESE	15190.	C	2.65	0.10	83.030	1.382E-07
SE	21050.	D	9.80	0.29	83.225	1.367E-07
S	15360.	C	2.65	0.46	83.600	1.359E-07
SSW	15360.	D	15.60	0.03	83.845	1.358E-07
NNW	8690.	C	7.15	0.03	83.875	1.348E-07
W	11100.	C	4.70	0.05	83.915	1.319E-07
E	11160.	C	4.70	0.09	83.985	1.306E-07
NE	10430.	B	2.65	0.03	84.045	1.286E-07
ENE	10530.	B	2.65	0.05	84.085	1.275E-07
NNE	8970.	C	7.15	0.01	84.115	1.273E-07
NW	10800.	B	2.65	0.13	84.185	1.246E-07
WSW	11100.	B	2.65	0.37	84.435	1.216E-07
E	11160.	B	2.65	0.07	84.655	1.210E-07
NNW	8690.	A	2.65	0.53	84.955	1.140E-07
SSW	15360.	D	19.00	0.11	85.275	1.115E-07
NNE	8970.	A	2.65	0.12	85.390	1.108E-07

SE	21050.	D	12.70	0.08	85.490	1.055E-07
SW	13200.	B	2.65	0.06	85.560	1.040E-07
N	8690.	C	9.80	0.01	85.595	9.837E-08
SW	13200.	C	4.70	0.03	85.615	9.755E-08
NE	10430.	C	7.15	0.02	85.640	9.693E-08
NE	10430.	A	2.65	0.17	85.735	9.672E-08
ENE	10530.	A	2.65	0.19	85.915	9.589E-08
ENE	10530.	C	7.15	0.07	86.045	9.528E-08
NW	10800.	A	2.65	0.45	86.305	9.372E-08

RPP-13482 REV 7

ESE	15190.	B	2.65	0.09	86.575	9.158E-08
W	11100.	A	2.65	1.43	87.335	9.143E-08
SE	21050.	C	2.65	0.19	88.145	9.138E-08
E	11160.	A	2.65	0.25	88.365	9.098E-08
S	15360.	B	2.65	0.52	88.750	9.066E-08
E	11160.	C	7.15	0.06	89.040	8.587E-08
NNW	8690.	B	4.70	0.08	89.110	8.572E-08
NNE	8970.	B	4.70	0.02	89.160	8.309E-08
SW	13200.	A	2.65	0.29	89.315	7.819E-08
ESE	15190.	C	4.70	0.13	89.525	7.791E-08
S	15360.	C	4.70	0.16	89.670	7.662E-08
NE	10430.	B	4.70	0.05	89.775	7.251E-08
ENE	10530.	B	4.70	0.07	89.835	7.189E-08
NE	10430.	C	9.80	0.02	89.880	7.072E-08
NW	10800.	B	4.70	0.04	89.910	7.026E-08
ENE	10530.	C	9.80	0.05	89.955	6.952E-08
ESE	15190.	A	2.65	0.30	90.130	6.887E-08
W	11100.	B	4.70	0.07	90.315	6.855E-08
E	11160.	B	4.70	0.10	90.400	6.821E-08
SE	21050.	B	2.65	0.16	90.530	6.821E-08
S	15360.	A	2.65	1.61	91.415	6.818E-08
N	8690.	A	4.70	0.25	92.345	6.430E-08
SW	13200.	C	7.15	0.01	92.475	6.413E-08

E	11160.	C	9.80	0.02	92.490	6.265E-08
NNE	8970.	A	4.70	0.07	92.535	6.249E-08
SW	13200.	B	4.70	0.03	92.585	5.862E-08
NNW	8690.	B	7.15	0.03	92.615	5.635E-08
NNE	8970.	B	7.15	0.01	92.635	5.462E-08
NE	10430.	C	12.70	0.02	92.650	5.457E-08
NE	10430.	A	4.70	0.14	92.730	5.453E-08
ENE	10530.	A	4.70	0.34	92.970	5.406E-08
ENE	10530.	C	12.70	0.01	93.145	5.364E-08
NW	10800.	A	4.70	0.10	93.200	5.284E-08
ESE	15190.	B	4.70	0.14	93.320	5.164E-08
WSW	11100.	A	4.70	0.21	93.495	5.155E-08
SE	21050.	C	4.70	0.12	93.660	5.153E-08
E	11160.	A	4.70	0.35	93.895	5.130E-08
SE	21050.	A	2.65	0.42	94.280	5.130E-08
ESE	15190.	C	7.15	0.07	94.525	5.121E-08
S	15360.	B	4.70	0.21	94.665	5.112E-08
S	15360.	C	7.15	0.06	94.800	5.036E-08
NE	10430.	B	7.15	0.04	94.850	4.766E-08
ENE	10530.	B	7.15	0.08	94.910	4.726E-08
WSW	11100.	B	7.15	0.01	94.955	4.506E-08
E	11160.	B	7.15	0.06	94.990	4.484E-08
SW	13200.	A	4.70	0.10	95.070	4.408E-08
ENE	10530.	C	15.60	0.01	95.125	4.367E-08
N	8690.	A	7.15	0.07	95.165	4.227E-08
NNE	8970.	A	7.15	0.04	95.220	4.108E-08
ESE	15190.	A	4.70	0.35	95.415	3.883E-08
SW	13200.	B	7.15	0.01	95.595	3.853E-08
SE	21050.	B	4.70	0.12	95.660	3.846E-08
SSW	15360.	A	4.70	0.67	96.055	3.844E-08
ESE	15190.	C	9.80	0.03	96.405	3.736E-08
S	15360.	C	9.80	0.02	96.430	3.674E-08

NE	10430.	A	7.15	0.11	96.495	3.585E-08
ENE	10530.	A	7.15	0.25	96.675	3.554E-08
NE	10430.	B	9.80	0.02	96.810	3.478E-08
NW	10800.	A	7.15	0.01	96.825	3.474E-08

RPP-13482 REV 7

ENE	10530.	B	9.80	0.04	96.850	3.448E-08
ESE	15190.	B	7.15	0.07	96.905	3.394E-08
WSW	11100.	A	7.15	0.01	96.945	3.389E-08
SE	21050.	C	7.15	0.06	96.980	3.387E-08
E	11160.	A	7.15	0.25	97.135	3.372E-08
S	15360.	B	7.15	0.06	97.290	3.360E-08
E	11160.	B	9.80	0.02	97.330	3.271E-08
N	8690.	A	9.80	0.01	97.345	3.084E-08
NNE	8970.	A	9.80	0.01	97.355	2.997E-08
SW	13200.	A	7.15	0.05	97.385	2.898E-08
SE	21050.	A	4.70	0.40	97.610	2.892E-08
ESE	15190.	C	12.70	0.01	97.815	2.883E-08
SSW	15360.	C	12.70	0.01	97.825	2.835E-08
NE	10430.	B	12.70	0.01	97.835	2.683E-08
ENE	10530.	B	12.70	0.02	97.850	2.660E-08
NE	10430.	A	9.80	0.05	97.885	2.615E-08
ENE	10530.	A	9.80	0.16	97.990	2.593E-08
ESE	15190.	A	7.15	0.25	98.195	2.553E-08
SE	21050.	B	7.15	0.09	98.365	2.528E-08
SSW	15360.	A	7.15	0.19	98.505	2.527E-08
E	11160.	B	12.70	0.01	98.605	2.524E-08
ESE	15190.	B	9.80	0.03	98.625	2.476E-08
SE	21050.	C	9.80	0.05	98.665	2.471E-08
E	11160.	A	9.80	0.10	98.740	2.460E-08
S	15360.	B	9.80	0.02	98.800	2.452E-08
S	15360.	C	15.60	0.02	98.820	2.308E-08
SW	13200.	A	9.80	0.01	98.835	2.114E-08
NE	10430.	A	12.70	0.02	98.850	2.018E-08
ENE	10530.	A	12.70	0.06	98.890	2.001E-08
SE	21050.	C	12.70	0.01	98.925	1.907E-08
SE	21050.	A	7.15	0.33	99.095	1.901E-08
E	11160.	A	12.70	0.02	99.270	1.899E-08
S	15360.	C	19.00	0.03	99.295	1.895E-08
ESE	15190.	A	9.80	0.11	99.365	1.862E-08
SE	21050.	B	9.80	0.06	99.450	1.844E-08
SSW	15360.	A	9.80	0.04	99.500	1.844E-08
ENE	10530.	A	15.60	0.01	99.525	1.629E-08
SSW	15360.	B	15.60	0.01	99.535	1.540E-08
ESE	15190.	A	12.70	0.02	99.550	1.437E-08
SE	21050.	B	12.70	0.01	99.565	1.423E-08
SSW	15360.	A	12.70	0.01	99.575	1.423E-08
SE	21050.	A	9.80	0.24	99.700	1.387E-08
SSW	15360.	B	19.00	0.02	99.830	1.265E-08
SSW	15360.	A	15.60	0.02	99.850	1.158E-08
SE	21050.	A	12.70	0.03	99.875	1.070E-08
S	15360.	A	19.00	0.04	99.910	9.510E-09
SE	21050.	A	15.60	0.01	99.935	8.714E-09
WNW	11100.	C	9.80	0.00	99.940	0.000E+00
SSE	15360.	G	19.00	0.00	99.940	0.000E+00

APPENDIX E

GXQ CDF OUTPUT FOR THE CENTERLINE PLUME WITH MEANDER

This page intentionally left blank.

APPENDIX E

GXQ CDF OUTPUT FOR THE CENTERLINE PLUME WITH MEANDER

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/24/02
Run Time = 08:45:13.50

Ground Level, NRC Plume Meander, 50th Percentile

CUMULATIVE DISTRIBUTION

SECTOR	DISTANCE (m)	ATM. STAB. CLASS	WIND SPEED (m/s)	SECTR FREQ (%)	CUM. FREQ. (%)	SCALED X/Q (s/m3)
S	100.	G	0.89	0.10	0.794	1.423E-02
S	100.	G	4.70	0.01	1.667	1.086E-02
S	100.	F	0.89	0.23	3.571	8.610E-03
S	100.	G	2.65	0.04	5.714	7.564E-03
S	100.	E	0.89	0.39	9.127	5.103E-03
S	100.	F	4.70	0.04	12.540	4.792E-03
S	100.	F	7.15	0.03	13.095	4.287E-03
S	100.	D	0.89	0.87	20.238	4.168E-03
S	100.	F	2.65	0.13	28.175	4.125E-03
S	100.	C	0.89	0.14	30.317	3.566E-03
S	100.	F	9.80	0.01	31.508	3.128E-03
S	100.	E	4.70	0.19	33.095	2.271E-03
S	100.	E	2.65	0.32	37.143	2.271E-03
S	100.	F	15.60	0.01	39.762	1.965E-03
S	100.	E	7.15	0.07	40.397	1.906E-03
S	100.	B	0.89	0.15	42.143	1.866E-03
S	100.	D	2.65	0.84	50.000	1.672E-03
S	100.	F	19.00	0.03	56.905	1.613E-03
S	100.	E	9.80	0.01	57.222	1.390E-03
S	100.	D	4.70	0.32	59.841	1.353E-03
S	100.	C	2.65	0.19	63.889	1.198E-03
S	100.	E	12.70	0.01	65.476	1.073E-03
S	100.	A	0.89	0.36	68.413	1.068E-03
S	100.	D	7.15	0.10	72.063	1.038E-03
S	100.	E	15.60	0.01	72.937	8.735E-04
S	100.	D	9.80	0.02	73.175	7.571E-04
S	100.	E	19.00	0.07	73.889	7.172E-04

RPP-13482 REV 7

S	100.	C	4.70	0.08	75.079	6.754E-04
S	100.	B	2.65	0.21	77.381	6.266E-04
S	100.	D	12.70	0.02	79.206	5.842E-04
S	100.	D	15.60	0.01	79.444	4.756E-04
S	100.	C	7.15	0.02	79.683	4.439E-04
S	100.	D	19.00	0.04	80.159	3.905E-04
S	100.	A	2.65	0.69	85.952	3.588E-04
S	100.	B	4.70	0.09	92.143	3.533E-04
S	100.	C	9.80	0.01	92.936	3.239E-04
S	100.	B	7.15	0.02	93.175	2.322E-04
S	100.	C	15.60	0.01	93.413	2.035E-04
S	100.	A	4.70	0.26	95.556	2.023E-04
S	100.	B	9.80	0.01	97.698	1.694E-04
S	100.	C	19.00	0.01	97.857	1.671E-04
S	100.	A	7.15	0.07	98.492	1.330E-04
S	100.	A	9.80	0.02	99.206	9.702E-05
S	100.	B	19.00	0.01	99.444	8.740E-05
S	100.	A	15.60	0.01	99.603	6.095E-05
S	100.	A	19.00	0.02	99.841	5.004E-05
S	100.	G	12.70	0.00	100.000	0.000E+00
S	100.	G	19.00	0.00	100.000	0.000E+00

SSW	100.	G	0.89	0.04	0.442	1.423E-02
SSW	100.	F	0.89	0.13	2.318	8.610E-03
SSW	100.	G	2.65	0.02	3.974	7.564E-03
SSW	100.	E	0.89	0.26	7.064	5.103E-03
SSW	100.	F	4.70	0.06	10.596	4.792E-03
SSW	100.	F	7.15	0.02	11.479	4.287E-03
SSW	100.	D	0.89	0.58	18.102	4.168E-03
SSW	100.	F	2.65	0.05	25.055	4.125E-03
SSW	100.	G	19.00	0.01	25.717	4.000E-03
SSW	100.	C	0.89	0.10	26.932	3.566E-03
SSW	100.	F	9.80	0.01	28.146	3.128E-03
SSW	100.	E	4.70	0.09	29.249	2.271E-03
SSW	100.	E	2.65	0.17	32.119	2.271E-03
SSW	100.	F	15.60	0.01	34.106	1.965E-03
SSW	100.	E	7.15	0.12	35.541	1.906E-03
SSW	100.	B	0.89	0.13	38.300	1.866E-03
SSW	100.	D	2.65	0.48	45.033	1.672E-03
SSW	100.	F	19.00	0.05	50.883	1.613E-03
SSW	100.	E	9.80	0.06	52.097	1.390E-03
SSW	100.	D	4.70	0.20	54.967	1.353E-03
SSW	100.	C	2.65	0.12	58.499	1.198E-03
SSW	100.	E	12.70	0.01	59.934	1.073E-03
SSW	100.	A	0.89	0.20	62.252	1.068E-03
SSW	100.	D	7.15	0.10	65.563	1.038E-03
SSW	100.	E	15.60	0.02	66.887	8.735E-04
SSW	100.	D	9.80	0.04	67.550	7.571E-04
SSW	100.	E	19.00	0.12	69.316	7.172E-04
SSW	100.	C	4.70	0.05	71.192	6.754E-04
SSW	100.	B	2.65	0.15	73.400	6.266E-04
SSW	100.	D	12.70	0.03	75.386	5.842E-04
SSW	100.	D	15.60	0.02	75.938	4.756E-04
SSW	100.	C	7.15	0.03	76.490	4.439E-04
SSW	100.	D	19.00	0.07	77.594	3.905E-04
SSW	100.	A	2.65	0.44	83.223	3.588E-04
SSW	100.	B	4.70	0.06	88.742	3.533E-04
SSW	100.	C	9.80	0.01	89.514	3.239E-04
SSW	100.	C	12.70	0.01	89.735	2.499E-04
SSW	100.	B	7.15	0.03	90.177	2.322E-04
SSW	100.	C	15.60	0.01	90.618	2.035E-04
SSW	100.	A	4.70	0.24	93.377	2.023E-04
SSW	100.	B	9.80	0.01	96.137	1.694E-04

RPP-13482 REV 7

SSW	100.	C	19.00	0.02	96.468	1.671E-04
SSW	100.	A	7.15	0.07	97.461	1.330E-04
SSW	100.	B	15.60	0.01	98.344	1.064E-04
SSW	100.	A	9.80	0.02	98.675	9.702E-05
SSW	100.	B	19.00	0.01	99.007	8.740E-05
SSW	100.	A	12.70	0.01	99.227	7.486E-05
SSW	100.	A	15.60	0.01	99.448	6.095E-05
SSW	100.	A	19.00	0.02	99.779	5.004E-05
SSW	100.	G	15.60	0.00	100.000	0.000E+00
SSW	100.	F	12.70	0.00	100.000	0.000E+00

SW	100.	G	0.89	0.08	1.365	1.423E-02
SW	100.	F	0.89	0.12	4.778	8.610E-03
SW	100.	G	2.65	0.02	7.167	7.564E-03
SW	100.	E	0.89	0.28	12.287	5.103E-03
SW	100.	F	4.70	0.01	17.235	4.792E-03
SW	100.	D	0.89	0.59	27.474	4.168E-03
SW	100.	F	2.65	0.05	38.396	4.125E-03
SW	100.	C	0.89	0.09	40.785	3.566E-03
SW	100.	E	4.70	0.04	43.003	2.271E-03
SW	100.	E	2.65	0.11	45.563	2.271E-03
SW	100.	E	7.15	0.01	47.611	1.906E-03
SW	100.	B	0.89	0.10	49.488	1.866E-03
SW	100.	D	2.65	0.40	58.020	1.672E-03
SW	100.	E	9.80	0.01	65.017	1.390E-03
SW	100.	D	4.70	0.09	66.724	1.353E-03
SW	100.	C	2.65	0.06	69.283	1.198E-03
SW	100.	E	12.70	0.01	70.478	1.073E-03
SW	100.	A	0.89	0.23	74.573	1.068E-03
SW	100.	D	7.15	0.03	79.010	1.038E-03
SW	100.	D	9.80	0.01	79.693	7.571E-04
SW	100.	C	4.70	0.03	80.375	6.754E-04
SW	100.	B	2.65	0.06	81.911	6.266E-04
SW	100.	C	7.15	0.01	83.106	4.439E-04
SW	100.	A	2.65	0.29	88.225	3.588E-04
SW	100.	B	4.70	0.03	93.686	3.533E-04
SW	100.	B	7.15	0.01	94.369	2.322E-04
SW	100.	A	4.70	0.10	96.246	2.023E-04
SW	100.	A	7.15	0.05	98.805	1.330E-04
SW	100.	A	9.80	0.01	99.829	9.702E-05
SW	100.	B	9.80	0.00	100.000	0.000E+00
SW	100.	G	19.00	0.00	100.000	0.000E+00

WSW	100.	G	0.89	0.08	1.471	1.423E-02
WSW	100.	F	0.89	0.14	5.515	8.610E-03
WSW	100.	G	2.65	0.03	8.640	7.564E-03
WSW	100.	E	0.89	0.25	13.787	5.103E-03
WSW	100.	F	4.70	0.01	18.566	4.792E-03
WSW	100.	D	0.89	0.59	29.596	4.168E-03
WSW	100.	F	2.65	0.05	41.360	4.125E-03
WSW	100.	C	0.89	0.12	44.485	3.566E-03
WSW	100.	E	4.70	0.01	46.875	2.271E-03
WSW	100.	E	2.65	0.13	49.449	2.271E-03
WSW	100.	B	0.89	0.11	53.860	1.866E-03
WSW	100.	D	2.65	0.33	61.949	1.672E-03
WSW	100.	D	4.70	0.04	68.750	1.353E-03
WSW	100.	C	2.65	0.09	71.140	1.198E-03
WSW	100.	A	0.89	0.26	77.574	1.068E-03
WSW	100.	D	7.15	0.01	82.537	1.038E-03
WSW	100.	C	4.70	0.01	82.904	6.754E-04
WSW	100.	B	2.65	0.08	84.559	6.266E-04
WSW	100.	A	2.65	0.32	91.912	3.588E-04
WSW	100.	B	4.70	0.01	97.978	3.533E-04

RPP-13482 REV 7

WSW	100.	B	7.15	0.01	98.346	2.322E-04
WSW	100.	A	4.70	0.03	99.081	2.023E-04
WSW	100.	A	7.15	0.01	99.816	1.330E-04
WSW	100.	C	7.15	0.00	100.000	0.000E+00
WSW	100.	G	19.00	0.00	100.000	0.000E+00
W	100.	G	0.89	0.13	1.354	1.423E-02
W	100.	F	0.89	0.31	5.938	8.610E-03
W	100.	G	2.65	0.09	10.104	7.564E-03
W	100.	E	0.89	0.46	15.833	5.103E-03
W	100.	F	4.70	0.01	20.729	4.792E-03
W	100.	D	0.89	0.77	28.854	4.168E-03
W	100.	F	2.65	0.16	38.542	4.125E-03
W	100.	C	0.89	0.14	41.667	3.566E-03
W	100.	E	4.70	0.06	43.750	2.271E-03
W	100.	E	2.65	0.31	47.604	2.271E-03
W	100.	B	0.89	0.16	52.500	1.866E-03
W	100.	D	2.65	0.66	61.042	1.672E-03
W	100.	D	4.70	0.12	69.167	1.353E-03
W	100.	C	2.65	0.13	71.771	1.198E-03
W	100.	A	0.89	0.40	77.292	1.068E-03
W	100.	C	4.70	0.02	81.667	6.754E-04
W	100.	B	2.65	0.16	83.542	6.266E-04
W	100.	A	2.65	0.60	91.458	3.588E-04
W	100.	B	4.70	0.03	98.021	3.533E-04
W	100.	A	4.70	0.08	99.167	2.023E-04
W	100.	G	4.70	0.00	100.000	0.000E+00
W	100.	G	19.00	0.00	100.000	0.000E+00
WNW	100.	G	0.89	0.13	1.633	1.423E-02
WNW	100.	G	4.70	0.01	3.392	1.086E-02
WNW	100.	F	0.89	0.23	6.407	8.610E-03
WNW	100.	G	2.65	0.10	10.553	7.564E-03
WNW	100.	E	0.89	0.34	16.080	5.103E-03
WNW	100.	F	4.70	0.02	20.603	4.792E-03
WNW	100.	D	0.89	0.50	27.136	4.168E-03
WNW	100.	F	2.65	0.21	36.055	4.125E-03
WNW	100.	C	0.89	0.10	39.950	3.566E-03
WNW	100.	E	4.70	0.06	41.960	2.271E-03
WNW	100.	E	2.65	0.34	46.985	2.271E-03
WNW	100.	B	0.89	0.09	52.387	1.866E-03
WNW	100.	D	2.65	0.57	60.678	1.672E-03
WNW	100.	D	4.70	0.11	69.221	1.353E-03
WNW	100.	C	2.65	0.13	72.236	1.198E-03
WNW	100.	A	0.89	0.24	76.884	1.068E-03
WNW	100.	D	7.15	0.01	80.025	1.038E-03
WNW	100.	C	4.70	0.02	80.402	6.754E-04
WNW	100.	B	2.65	0.13	82.286	6.266E-04
WNW	100.	A	2.65	0.51	90.327	3.588E-04
WNW	100.	B	4.70	0.03	97.111	3.533E-04
WNW	100.	A	4.70	0.10	98.744	2.023E-04
WNW	100.	B	7.15	0.00	100.000	0.000E+00
WNW	100.	G	19.00	0.00	100.000	0.000E+00
NW	100.	G	0.89	0.13	1.377	1.423E-02
NW	100.	G	4.70	0.01	2.860	1.086E-02
NW	100.	F	0.89	0.28	5.932	8.610E-03
NW	100.	G	2.65	0.20	11.017	7.564E-03
NW	100.	E	0.89	0.31	16.419	5.103E-03
NW	100.	F	4.70	0.05	20.233	4.792E-03
NW	100.	D	0.89	0.43	25.318	4.168E-03
NW	100.	F	2.65	0.39	34.004	4.125E-03
NW	100.	C	0.89	0.06	38.771	3.566E-03

RPP-13482 REV 7

NW	100.	E	4.70	0.15	40.996	2.271E-03
NW	100.	E	2.65	0.47	47.564	2.271E-03
NW	100.	E	7.15	0.01	52.648	1.906E-03
NW	100.	B	0.89	0.07	53.496	1.866E-03
NW	100.	D	2.65	0.75	62.182	1.672E-03
NW	100.	D	4.70	0.25	72.775	1.353E-03
NW	100.	C	2.65	0.19	77.436	1.198E-03
NW	100.	A	0.89	0.17	81.250	1.068E-03
NW	100.	D	7.15	0.03	83.369	1.038E-03
NW	100.	C	4.70	0.04	84.110	6.754E-04
NW	100.	B	2.65	0.13	85.911	6.266E-04
NW	100.	A	2.65	0.45	92.055	3.588E-04
NW	100.	B	4.70	0.04	97.246	3.533E-04
NW	100.	A	4.70	0.10	98.729	2.023E-04
NW	100.	A	7.15	0.01	99.894	1.330E-04
NW	100.	B	7.15	0.00	100.000	0.000E+00
NW	100.	G	19.00	0.00	100.000	0.000E+00

NNW	100.	G	0.89	0.14	1.528	1.423E-02
NNW	100.	G	4.70	0.09	4.039	1.086E-02
NNW	100.	G	7.15	0.01	5.131	1.063E-02
NNW	100.	F	0.89	0.26	8.079	8.610E-03
NNW	100.	G	2.65	0.23	13.428	7.564E-03
NNW	100.	E	0.89	0.30	19.214	5.103E-03
NNW	100.	F	4.70	0.17	24.345	4.792E-03
NNW	100.	F	7.15	0.01	26.310	4.287E-03
NNW	100.	D	0.89	0.32	29.913	4.168E-03
NNW	100.	F	2.65	0.44	38.210	4.125E-03
NNW	100.	C	0.89	0.04	43.450	3.566E-03
NNW	100.	E	4.70	0.25	46.616	2.271E-03
NNW	100.	E	2.65	0.52	55.022	2.271E-03
NNW	100.	E	7.15	0.05	61.245	1.906E-03
NNW	100.	B	0.89	0.03	62.118	1.866E-03
NNW	100.	D	2.65	0.53	68.231	1.672E-03
NNW	100.	D	4.70	0.27	76.965	1.353E-03
NNW	100.	C	2.65	0.10	81.004	1.198E-03
NNW	100.	A	0.89	0.10	83.188	1.068E-03
NNW	100.	D	7.15	0.07	85.044	1.038E-03
NNW	100.	C	4.70	0.04	86.245	6.754E-04
NNW	100.	B	2.65	0.09	87.664	6.266E-04
NNW	100.	C	7.15	0.01	88.755	4.439E-04
NNW	100.	A	2.65	0.29	92.031	3.588E-04
NNW	100.	B	4.70	0.05	95.742	3.533E-04
NNW	100.	B	7.15	0.01	96.397	2.322E-04
NNW	100.	A	4.70	0.13	97.926	2.023E-04
NNW	100.	A	7.15	0.03	99.672	1.330E-04
NNW	100.	A	9.80	0.00	100.000	0.000E+00
NNW	100.	G	19.00	0.00	100.000	0.000E+00

N	100.	G	0.89	0.17	1.950	1.423E-02
N	100.	G	4.70	0.07	4.702	1.086E-02
N	100.	F	0.89	0.35	9.518	8.610E-03
N	100.	G	2.65	0.20	15.826	7.564E-03
N	100.	E	0.89	0.34	22.018	5.103E-03
N	100.	F	4.70	0.14	27.523	4.792E-03
N	100.	F	7.15	0.02	29.358	4.287E-03
N	100.	D	0.89	0.27	32.683	4.168E-03
N	100.	F	2.65	0.45	40.940	4.125E-03
N	100.	C	0.89	0.04	46.560	3.566E-03
N	100.	F	9.80	0.01	47.133	3.128E-03
N	100.	E	4.70	0.22	49.771	2.271E-03
N	100.	E	2.65	0.46	57.569	2.271E-03
N	100.	E	7.15	0.07	63.647	1.906E-03

RPP-13482 REV 7

N	100.	B	0.89	0.05	65.023	1.866E-03
N	100.	D	2.65	0.35	69.610	1.672E-03
N	100.	E	9.80	0.01	73.739	1.390E-03
N	100.	D	4.70	0.24	76.605	1.353E-03
N	100.	C	2.65	0.06	80.046	1.198E-03
N	100.	A	0.89	0.10	81.881	1.068E-03
N	100.	D	7.15	0.10	84.174	1.038E-03
N	100.	D	9.80	0.02	85.550	7.571E-04
N	100.	C	4.70	0.05	86.353	6.754E-04
N	100.	B	2.65	0.08	87.844	6.266E-04
N	100.	C	7.15	0.02	88.991	4.439E-04
N	100.	A	2.65	0.24	91.972	3.588E-04
N	100.	B	4.70	0.03	95.069	3.533E-04
N	100.	C	9.80	0.01	95.528	3.239E-04
N	100.	B	7.15	0.02	95.872	2.322E-04
N	100.	A	4.70	0.12	97.477	2.023E-04
N	100.	A	7.15	0.04	99.312	1.330E-04
N	100.	A	9.80	0.01	99.885	9.702E-05
N	100.	G	7.15	0.00	100.000	0.000E+00
N	100.	G	19.00	0.00	100.000	0.000E+00

NNE	100.	G	0.89	0.09	1.807	1.423E-02
NNE	100.	G	4.70	0.01	3.815	1.086E-02
NNE	100.	F	0.89	0.23	8.635	8.610E-03
NNE	100.	G	2.65	0.08	14.859	7.564E-03
NNE	100.	E	0.89	0.21	20.683	5.103E-03
NNE	100.	F	4.70	0.03	25.502	4.792E-03
NNE	100.	D	0.89	0.19	29.920	4.168E-03
NNE	100.	F	2.65	0.21	37.952	4.125E-03
NNE	100.	C	0.89	0.02	42.570	3.566E-03
NNE	100.	E	4.70	0.12	45.382	2.271E-03
NNE	100.	E	2.65	0.21	52.008	2.271E-03
NNE	100.	E	7.15	0.08	57.831	1.906E-03
NNE	100.	B	0.89	0.02	59.839	1.866E-03
NNE	100.	D	2.65	0.18	63.855	1.672E-03
NNE	100.	E	9.80	0.05	68.474	1.390E-03
NNE	100.	D	4.70	0.13	72.088	1.353E-03
NNE	100.	C	2.65	0.02	75.100	1.198E-03
NNE	100.	E	12.70	0.01	75.703	1.073E-03
NNE	100.	A	0.89	0.06	77.108	1.068E-03
NNE	100.	D	7.15	0.11	80.522	1.038E-03
NNE	100.	D	9.80	0.07	84.137	7.571E-04
NNE	100.	C	4.70	0.02	85.944	6.754E-04
NNE	100.	B	2.65	0.04	87.149	6.266E-04
NNE	100.	D	12.70	0.02	88.353	5.842E-04
NNE	100.	C	7.15	0.01	88.956	4.439E-04
NNE	100.	A	2.65	0.12	91.566	3.588E-04
NNE	100.	B	4.70	0.02	94.377	3.533E-04
NNE	100.	B	7.15	0.01	94.980	2.322E-04
NNE	100.	A	4.70	0.07	96.586	2.023E-04
NNE	100.	A	7.15	0.04	98.795	1.330E-04
NNE	100.	A	9.80	0.01	99.799	9.702E-05
NNE	100.	B	9.80	0.00	100.000	0.000E+00
NNE	100.	G	19.00	0.00	100.000	0.000E+00

NE	100.	G	0.89	0.10	1.282	1.423E-02
NE	100.	G	4.70	0.02	2.821	1.086E-02
NE	100.	F	0.89	0.22	5.897	8.610E-03
NE	100.	G	2.65	0.10	10.000	7.564E-03
NE	100.	E	0.89	0.25	14.487	5.103E-03
NE	100.	F	4.70	0.07	18.590	4.792E-03
NE	100.	F	7.15	0.01	19.615	4.287E-03
NE	100.	D	0.89	0.21	22.436	4.168E-03

RPP-13482 REV 7

NE	100.	F	2.65	0.27	28.590	4.125E-03
NE	100.	C	0.89	0.02	32.308	3.566E-03
NE	100.	E	4.70	0.18	34.872	2.271E-03
NE	100.	E	2.65	0.29	40.897	2.271E-03
NE	100.	E	7.15	0.17	46.795	1.906E-03
NE	100.	B	0.89	0.01	49.103	1.866E-03
NE	100.	D	2.65	0.24	52.308	1.672E-03
NE	100.	E	9.80	0.11	56.795	1.390E-03
NE	100.	D	4.70	0.23	61.154	1.353E-03
NE	100.	C	2.65	0.03	64.487	1.198E-03
NE	100.	E	12.70	0.04	65.385	1.073E-03
NE	100.	A	0.89	0.06	66.667	1.068E-03
NE	100.	D	7.15	0.25	70.641	1.038E-03
NE	100.	E	15.60	0.01	73.974	8.735E-04
NE	100.	D	9.80	0.16	76.154	7.571E-04
NE	100.	C	4.70	0.03	78.590	6.754E-04
NE	100.	B	2.65	0.03	79.359	6.266E-04
NE	100.	D	12.70	0.09	80.897	5.842E-04
NE	100.	D	15.60	0.03	82.436	4.756E-04
NE	100.	C	7.15	0.02	83.077	4.439E-04
NE	100.	A	2.65	0.17	85.513	3.588E-04
NE	100.	B	4.70	0.05	88.333	3.533E-04
NE	100.	C	9.80	0.02	89.231	3.239E-04
NE	100.	C	12.70	0.02	89.744	2.499E-04
NE	100.	B	7.15	0.04	90.513	2.322E-04
NE	100.	A	4.70	0.14	92.821	2.023E-04
NE	100.	B	9.80	0.02	94.872	1.694E-04
NE	100.	A	7.15	0.11	96.538	1.330E-04
NE	100.	B	12.70	0.01	98.077	1.308E-04
NE	100.	A	9.80	0.05	98.846	9.702E-05
NE	100.	A	12.70	0.02	99.744	7.486E-05
NE	100.	F	9.80	0.00	100.000	0.000E+00
NE	100.	G	19.00	0.00	100.000	0.000E+00
ENE	100.	G	0.89	0.09	0.729	1.423E-02
ENE	100.	G	4.70	0.09	2.188	1.086E-02
ENE	100.	F	0.89	0.27	5.105	8.610E-03
ENE	100.	G	2.65	0.20	8.914	7.564E-03
ENE	100.	E	0.89	0.29	12.885	5.103E-03
ENE	100.	F	4.70	0.20	16.856	4.792E-03
ENE	100.	F	7.15	0.02	18.639	4.287E-03
ENE	100.	D	0.89	0.17	20.178	4.168E-03
ENE	100.	F	2.65	0.46	25.284	4.125E-03
ENE	100.	C	0.89	0.02	29.173	3.566E-03
ENE	100.	E	4.70	0.39	32.496	2.271E-03
ENE	100.	E	2.65	0.48	39.546	2.271E-03
ENE	100.	E	7.15	0.30	45.867	1.906E-03
ENE	100.	B	0.89	0.03	48.541	1.866E-03
ENE	100.	D	2.65	0.28	51.053	1.672E-03
ENE	100.	E	9.80	0.15	54.538	1.390E-03
ENE	100.	D	4.70	0.39	58.914	1.353E-03
ENE	100.	C	2.65	0.05	62.480	1.198E-03
ENE	100.	E	12.70	0.02	63.047	1.073E-03
ENE	100.	A	0.89	0.06	63.695	1.068E-03
ENE	100.	D	7.15	0.38	67.261	1.038E-03
ENE	100.	D	9.80	0.24	72.285	7.571E-04
ENE	100.	C	4.70	0.06	74.716	6.754E-04
ENE	100.	B	2.65	0.05	75.608	6.266E-04
ENE	100.	D	12.70	0.09	76.742	5.842E-04
ENE	100.	D	15.60	0.03	77.715	4.756E-04
ENE	100.	C	7.15	0.07	78.525	4.439E-04
ENE	100.	A	2.65	0.19	80.632	3.588E-04
ENE	100.	B	4.70	0.07	82.739	3.533E-04

RPP-13482 REV 7

ENE	100.	C	9.80	0.05	83.711	3.239E-04
ENE	100.	C	12.70	0.01	84.198	2.499E-04
ENE	100.	B	7.15	0.08	84.927	2.322E-04
ENE	100.	C	15.60	0.01	85.656	2.035E-04
ENE	100.	A	4.70	0.34	88.493	2.023E-04
ENE	100.	B	9.80	0.04	91.572	1.694E-04
ENE	100.	A	7.15	0.25	93.922	1.330E-04
ENE	100.	B	12.70	0.02	96.110	1.308E-04
ENE	100.	A	9.80	0.16	97.569	9.702E-05
ENE	100.	A	12.70	0.06	99.352	7.486E-05
ENE	100.	A	15.60	0.01	99.919	6.095E-05
ENE	100.	F	12.70	0.00	100.000	0.000E+00
ENE	100.	G	19.00	0.00	100.000	0.000E+00

E	100.	G	0.89	0.22	0.783	1.423E-02
E	100.	G	4.70	0.56	3.559	1.086E-02
E	100.	F	0.89	0.48	7.260	8.610E-03
E	100.	G	2.65	0.82	11.886	7.564E-03
E	100.	E	0.89	0.49	16.548	5.103E-03
E	100.	F	4.70	1.19	22.527	4.792E-03
E	100.	F	7.15	0.07	27.011	4.287E-03
E	100.	D	0.89	0.40	28.683	4.168E-03
E	100.	F	2.65	1.60	35.801	4.125E-03
E	100.	C	0.89	0.04	41.637	3.566E-03
E	100.	E	4.70	1.98	48.826	2.271E-03
E	100.	E	2.65	1.58	61.495	2.271E-03
E	100.	E	7.15	0.65	69.431	1.906E-03
E	100.	B	0.89	0.04	71.886	1.866E-03
E	100.	D	2.65	0.69	74.484	1.672E-03
E	100.	E	9.80	0.06	77.153	1.390E-03
E	100.	D	4.70	0.83	80.320	1.353E-03
E	100.	C	2.65	0.08	83.559	1.198E-03
E	100.	E	12.70	0.01	83.879	1.073E-03
E	100.	A	0.89	0.10	84.270	1.068E-03
E	100.	D	7.15	0.58	86.690	1.038E-03
E	100.	D	9.80	0.13	89.217	7.571E-04
E	100.	C	4.70	0.09	90.000	6.754E-04
E	100.	B	2.65	0.07	90.569	6.266E-04
E	100.	D	12.70	0.03	90.925	5.842E-04
E	100.	D	15.60	0.02	91.103	4.756E-04
E	100.	C	7.15	0.06	91.388	4.439E-04
E	100.	A	2.65	0.25	92.491	3.588E-04
E	100.	B	4.70	0.10	93.737	3.533E-04
E	100.	C	9.80	0.02	94.164	3.239E-04
E	100.	B	7.15	0.06	94.448	2.322E-04
E	100.	A	4.70	0.35	95.907	2.023E-04
E	100.	B	9.80	0.02	97.224	1.694E-04
E	100.	A	7.15	0.25	98.185	1.330E-04
E	100.	B	12.70	0.01	99.110	1.308E-04
E	100.	A	9.80	0.10	99.502	9.702E-05
E	100.	A	12.70	0.02	99.929	7.486E-05
E	100.	C	12.70	0.00	100.000	0.000E+00
E	100.	G	19.00	0.00	100.000	0.000E+00

ESE	100.	G	0.89	0.14	0.372	1.423E-02
ESE	100.	G	4.70	0.84	2.979	1.086E-02
ESE	100.	G	7.15	0.01	5.239	1.063E-02
ESE	100.	F	0.89	0.36	6.223	8.610E-03
ESE	100.	G	2.65	0.69	9.016	7.564E-03
ESE	100.	E	0.89	0.44	12.021	5.103E-03
ESE	100.	F	4.70	1.60	17.447	4.792E-03
ESE	100.	F	7.15	0.08	21.915	4.287E-03
ESE	100.	D	0.89	0.44	23.298	4.168E-03

RPP-13482 REV 7

ESE	100.	F	2.65	1.69	28.963	4.125E-03
ESE	100.	C	0.89	0.04	33.564	3.566E-03
ESE	100.	E	4.70	2.50	40.319	2.271E-03
ESE	100.	E	2.65	1.68	51.436	2.271E-03
ESE	100.	E	7.15	1.75	60.559	1.906E-03
ESE	100.	B	0.89	0.05	65.346	1.866E-03
ESE	100.	D	2.65	1.09	68.378	1.672E-03
ESE	100.	E	9.80	0.38	72.287	1.390E-03
ESE	100.	D	4.70	1.46	77.181	1.353E-03
ESE	100.	C	2.65	0.10	81.330	1.198E-03
ESE	100.	E	12.70	0.05	81.729	1.073E-03
ESE	100.	A	0.89	0.10	82.128	1.068E-03
ESE	100.	D	7.15	1.14	85.426	1.038E-03
ESE	100.	D	9.80	0.50	89.787	7.571E-04
ESE	100.	C	4.70	0.13	91.463	6.754E-04
ESE	100.	B	2.65	0.09	92.048	6.266E-04
ESE	100.	D	12.70	0.07	92.473	5.842E-04
ESE	100.	C	7.15	0.07	92.846	4.439E-04
ESE	100.	A	2.65	0.30	93.830	3.588E-04
ESE	100.	B	4.70	0.14	95.000	3.533E-04
ESE	100.	C	9.80	0.03	95.452	3.239E-04
ESE	100.	C	12.70	0.01	95.559	2.499E-04
ESE	100.	B	7.15	0.07	95.771	2.322E-04
ESE	100.	A	4.70	0.35	96.888	2.023E-04
ESE	100.	B	9.80	0.03	97.899	1.694E-04
ESE	100.	A	7.15	0.25	98.644	1.330E-04
ESE	100.	A	9.80	0.11	99.601	9.702E-05
ESE	100.	A	12.70	0.02	99.947	7.486E-05
ESE	100.	F	9.80	0.00	100.000	0.000E+00
ESE	100.	G	19.00	0.00	100.000	0.000E+00

SE	100.	G	0.89	0.14	0.646	1.423E-02
SE	100.	G	4.70	0.13	1.893	1.086E-02
SE	100.	F	0.89	0.32	3.970	8.610E-03
SE	100.	G	2.65	0.30	6.833	7.564E-03
SE	100.	E	0.89	0.45	10.295	5.103E-03
SE	100.	F	4.70	0.32	13.850	4.792E-03
SE	100.	F	7.15	0.03	15.466	4.287E-03
SE	100.	D	0.89	0.54	18.098	4.168E-03
SE	100.	F	2.65	0.82	24.377	4.125E-03
SE	100.	C	0.89	0.10	28.624	3.566E-03
SE	100.	E	4.70	0.75	32.548	2.271E-03
SE	100.	E	2.65	1.11	41.136	2.271E-03
SE	100.	E	7.15	0.41	48.153	1.906E-03
SE	100.	B	0.89	0.07	50.369	1.866E-03
SE	100.	D	2.65	1.05	55.540	1.672E-03
SE	100.	E	9.80	0.11	60.896	1.390E-03
SE	100.	D	4.70	0.84	65.282	1.353E-03
SE	100.	C	2.65	0.19	70.037	1.198E-03
SE	100.	E	12.70	0.03	71.053	1.073E-03
SE	100.	A	0.89	0.14	71.837	1.068E-03
SE	100.	D	7.15	0.50	74.792	1.038E-03
SE	100.	D	9.80	0.29	78.440	7.571E-04
SE	100.	C	4.70	0.12	80.332	6.754E-04
SE	100.	B	2.65	0.16	81.625	6.266E-04
SE	100.	D	12.70	0.08	82.733	5.842E-04
SE	100.	C	7.15	0.06	83.380	4.439E-04
SE	100.	A	2.65	0.42	85.596	3.588E-04
SE	100.	B	4.70	0.12	88.089	3.533E-04
SE	100.	C	9.80	0.05	88.873	3.239E-04
SE	100.	C	12.70	0.01	89.151	2.499E-04
SE	100.	B	7.15	0.09	89.612	2.322E-04
SE	100.	A	4.70	0.40	91.874	2.023E-04

RPP-13482 REV 7

SE	100.	B	9.80	0.06	93.998	1.694E-04
SE	100.	A	7.15	0.33	95.799	1.330E-04
SE	100.	B	12.70	0.01	97.368	1.308E-04
SE	100.	A	9.80	0.24	98.523	9.702E-05
SE	100.	A	12.70	0.03	99.769	7.486E-05
SE	100.	A	15.60	0.01	99.954	6.095E-05
SE	100.	G	9.80	0.00	100.000	0.000E+00
SE	100.	G	19.00	0.00	100.000	0.000E+00

SSE	100.	G	0.89	0.09	0.941	1.423E-02
-----	------	---	------	------	-------	-----------

SSE	100.	G	4.70	0.01	1.987	1.086E-02
SSE	100.	F	0.89	0.23	4.498	8.610E-03
SSE	100.	G	2.65	0.08	7.741	7.564E-03
SSE	100.	E	0.89	0.39	12.657	5.103E-03
SSE	100.	F	4.70	0.06	17.364	4.792E-03
SSE	100.	D	0.89	0.55	23.745	4.168E-03
SSE	100.	F	2.65	0.25	32.113	4.125E-03
SSE	100.	C	0.89	0.10	35.774	3.566E-03
SSE	100.	E	4.70	0.13	38.180	2.271E-03
SSE	100.	E	2.65	0.39	43.619	2.271E-03
SSE	100.	E	7.15	0.02	47.908	1.906E-03
SSE	100.	B	0.89	0.10	49.163	1.866E-03
SSE	100.	D	2.65	0.77	58.264	1.672E-03
SSE	100.	D	4.70	0.21	68.515	1.353E-03
SSE	100.	C	2.65	0.15	72.280	1.198E-03
SSE	100.	A	0.89	0.22	76.151	1.068E-03
SSE	100.	D	7.15	0.05	78.975	1.038E-03
SSE	100.	D	9.80	0.01	79.603	7.571E-04
SSE	100.	C	4.70	0.03	80.021	6.754E-04
SSE	100.	B	2.65	0.16	82.008	6.266E-04
SSE	100.	C	7.15	0.01	83.787	4.439E-04
SSE	100.	A	2.65	0.48	88.912	3.588E-04
SSE	100.	B	4.70	0.06	94.561	3.533E-04
SSE	100.	B	7.15	0.01	95.293	2.322E-04
SSE	100.	A	4.70	0.17	97.176	2.023E-04
SSE	100.	A	7.15	0.05	99.477	1.330E-04
SSE	100.	G	7.15	0.00	100.000	0.000E+00
SSE	100.	G	19.00	0.00	100.000	0.000E+00

S	15360.	G	0.89	0.10	0.794	2.841E-05
S	15360.	F	0.89	0.23	3.413	1.264E-05
S	15360.	G	2.65	0.04	5.556	1.076E-05
S	15360.	G	4.70	0.01	5.952	7.007E-06
S	15360.	E	0.89	0.39	9.127	5.332E-06
S	15360.	F	2.65	0.13	13.254	4.559E-06
S	15360.	F	4.70	0.04	14.603	2.822E-06
S	15360.	D	0.89	0.87	21.825	2.226E-06
S	15360.	F	7.15	0.03	28.968	1.901E-06
S	15360.	E	2.65	0.32	31.746	1.875E-06
S	15360.	F	9.80	0.01	34.365	1.387E-06
S	15360.	E	4.70	0.19	35.952	1.128E-06
S	15360.	F	15.60	0.01	37.540	8.714E-07
S	15360.	D	2.65	0.84	44.286	7.638E-07
S	15360.	E	7.15	0.07	51.508	7.557E-07
S	15360.	F	19.00	0.03	52.302	7.154E-07
S	15360.	E	9.80	0.01	52.619	5.514E-07
S	15360.	D	4.70	0.32	55.238	4.457E-07
S	15360.	E	12.70	0.01	57.857	4.255E-07
S	15360.	C	0.89	0.14	59.048	4.046E-07
S	15360.	E	15.60	0.01	60.238	3.464E-07
S	15360.	D	7.15	0.10	61.111	2.963E-07
S	15360.	E	19.00	0.07	62.460	2.844E-07

RPP-13482 REV 7

S	15360.	B	0.89	0.15	64.206	2.700E-07
S	15360.	D	9.80	0.02	65.556	2.162E-07
S	15360.	A	0.89	0.36	68.571	2.030E-07
S	15360.	D	12.70	0.02	71.587	1.668E-07
S	15360.	C	2.65	0.19	73.254	1.359E-07
S	15360.	D	15.60	0.01	74.841	1.358E-07
S	15360.	D	19.00	0.04	75.238	1.115E-07
S	15360.	B	2.65	0.21	77.222	9.066E-08
S	15360.	C	4.70	0.08	79.524	7.662E-08
S	15360.	A	2.65	0.69	85.635	6.818E-08
S	15360.	B	4.70	0.09	91.825	5.112E-08
S	15360.	C	7.15	0.02	92.698	5.036E-08
S	15360.	A	4.70	0.26	94.921	3.844E-08
S	15360.	C	9.80	0.01	97.063	3.674E-08
S	15360.	B	7.15	0.02	97.302	3.360E-08
S	15360.	A	7.15	0.07	98.016	2.527E-08
S	15360.	B	9.80	0.01	98.651	2.452E-08
S	15360.	C	15.60	0.01	98.810	2.308E-08
S	15360.	C	19.00	0.01	98.968	1.895E-08
S	15360.	A	9.80	0.02	99.206	1.844E-08
S	15360.	B	19.00	0.01	99.444	1.265E-08
S	15360.	A	15.60	0.01	99.603	1.158E-08
S	15360.	A	19.00	0.02	99.841	9.510E-09
S	15360.	B	12.70	0.00	100.000	0.000E+00
S	15360.	G	19.00	0.00	100.000	0.000E+00

SSW	15360.	G	0.89	0.04	0.442	2.841E-05
SSW	15360.	F	0.89	0.13	2.318	1.264E-05
SSW	15360.	G	2.65	0.02	3.974	1.076E-05
SSW	15360.	E	0.89	0.26	7.064	5.332E-06
SSW	15360.	F	2.65	0.05	10.486	4.559E-06
SSW	15360.	F	4.70	0.06	11.700	2.822E-06
SSW	15360.	D	0.89	0.58	18.764	2.226E-06
SSW	15360.	F	7.15	0.02	25.386	1.901E-06
SSW	15360.	E	2.65	0.17	27.483	1.875E-06
SSW	15360.	G	19.00	0.01	29.470	1.792E-06
SSW	15360.	F	9.80	0.01	29.691	1.387E-06
SSW	15360.	E	4.70	0.09	30.795	1.128E-06
SSW	15360.	F	15.60	0.01	31.898	8.714E-07
SSW	15360.	D	2.65	0.48	37.307	7.638E-07
SSW	15360.	E	7.15	0.12	43.929	7.557E-07
SSW	15360.	F	19.00	0.05	45.806	7.154E-07
SSW	15360.	E	9.80	0.06	47.020	5.514E-07
SSW	15360.	D	4.70	0.20	49.890	4.457E-07
SSW	15360.	E	12.70	0.01	52.208	4.255E-07
SSW	15360.	C	0.89	0.10	53.422	4.046E-07
SSW	15360.	E	15.60	0.02	54.746	3.464E-07
SSW	15360.	D	7.15	0.10	56.071	2.963E-07
SSW	15360.	E	19.00	0.12	58.499	2.844E-07
SSW	15360.	B	0.89	0.13	61.258	2.700E-07
SSW	15360.	D	9.80	0.04	63.135	2.162E-07
SSW	15360.	A	0.89	0.20	65.784	2.030E-07
SSW	15360.	D	12.70	0.03	68.322	1.668E-07
SSW	15360.	C	2.65	0.12	69.978	1.359E-07
SSW	15360.	D	15.60	0.02	71.523	1.358E-07
SSW	15360.	D	19.00	0.07	72.517	1.115E-07
SSW	15360.	B	2.65	0.15	74.945	9.066E-08
SSW	15360.	C	4.70	0.05	77.152	7.662E-08
SSW	15360.	A	2.65	0.44	82.561	6.818E-08
SSW	15360.	B	4.70	0.06	88.079	5.112E-08
SSW	15360.	C	7.15	0.03	89.073	5.036E-08
SSW	15360.	A	4.70	0.24	92.053	3.844E-08
SSW	15360.	C	9.80	0.01	94.812	3.674E-08

RPP-13482 REV 7

SSW	15360.	B	7.15	0.03	95.254	3.360E-08
SSW	15360.	C	12.70	0.01	95.695	2.835E-08
SSW	15360.	A	7.15	0.07	96.578	2.527E-08
SSW	15360.	B	9.80	0.01	97.461	2.452E-08
SSW	15360.	C	15.60	0.01	97.682	2.308E-08
SSW	15360.	C	19.00	0.02	98.013	1.895E-08
SSW	15360.	A	9.80	0.02	98.455	1.844E-08
SSW	15360.	B	15.60	0.01	98.786	1.540E-08
SSW	15360.	A	12.70	0.01	99.007	1.423E-08
SSW	15360.	B	19.00	0.01	99.227	1.265E-08
SSW	15360.	A	15.60	0.01	99.448	1.158E-08
SSW	15360.	A	19.00	0.02	99.779	9.510E-09
SSW	15360.	G	15.60	0.00	100.000	0.000E+00
SSW	15360.	G	7.15	0.00	100.000	0.000E+00

SW	13200.	G	0.89	0.08	1.365	3.309E-05
SW	13200.	F	0.89	0.12	4.778	1.490E-05
SW	13200.	G	2.65	0.02	7.167	1.271E-05
SW	13200.	E	0.89	0.28	12.287	6.401E-06
SW	13200.	F	2.65	0.05	17.918	5.422E-06
SW	13200.	F	4.70	0.01	18.942	3.398E-06
SW	13200.	D	0.89	0.59	29.181	2.752E-06
SW	13200.	E	2.65	0.11	41.126	2.264E-06
SW	13200.	E	4.70	0.04	43.686	1.375E-06
SW	13200.	D	2.65	0.40	51.195	9.469E-07
SW	13200.	E	7.15	0.01	58.191	9.235E-07
SW	13200.	E	9.80	0.01	58.532	6.737E-07
SW	13200.	D	4.70	0.09	60.239	5.552E-07
SW	13200.	E	12.70	0.01	61.945	5.199E-07
SW	13200.	C	0.89	0.09	63.652	5.152E-07
SW	13200.	D	7.15	0.03	65.700	3.698E-07
SW	13200.	B	0.89	0.10	67.918	3.096E-07
SW	13200.	D	9.80	0.01	69.795	2.698E-07
SW	13200.	A	0.89	0.23	73.891	2.328E-07
SW	13200.	C	2.65	0.06	78.840	1.730E-07
SW	13200.	B	2.65	0.06	80.887	1.040E-07
SW	13200.	C	4.70	0.03	82.423	9.755E-08
SW	13200.	A	2.65	0.29	87.884	7.819E-08
SW	13200.	C	7.15	0.01	93.003	6.413E-08
SW	13200.	B	4.70	0.03	93.686	5.862E-08
SW	13200.	A	4.70	0.10	95.904	4.408E-08
SW	13200.	B	7.15	0.01	97.782	3.853E-08
SW	13200.	A	7.15	0.05	98.805	2.898E-08
SW	13200.	A	9.80	0.01	99.829	2.114E-08
SW	13200.	B	9.80	0.00	100.000	0.000E+00
SW	13200.	G	19.00	0.00	100.000	0.000E+00

WSW	11100.	G	0.89	0.08	1.471	3.927E-05
WSW	11100.	F	0.89	0.14	5.515	1.795E-05
WSW	11100.	G	2.65	0.03	8.640	1.534E-05
WSW	11100.	E	0.89	0.25	13.787	7.878E-06
WSW	11100.	F	2.65	0.05	19.301	6.604E-06
WSW	11100.	F	4.70	0.01	20.404	4.207E-06
WSW	11100.	D	0.89	0.59	31.434	3.503E-06
WSW	11100.	E	2.65	0.13	44.669	2.808E-06
WSW	11100.	E	4.70	0.01	47.243	1.725E-06
WSW	11100.	D	2.65	0.33	53.493	1.210E-06
WSW	11100.	D	4.70	0.04	60.294	7.139E-07
WSW	11100.	C	0.89	0.12	63.235	6.965E-07
WSW	11100.	D	7.15	0.01	65.625	4.766E-07
WSW	11100.	B	0.89	0.11	67.831	3.620E-07
WSW	11100.	A	0.89	0.26	74.632	2.722E-07
WSW	11100.	C	2.65	0.09	81.066	2.339E-07

RPP-13482 REV 7

WSW	11100.	C	4.70	0.01	82.904	1.319E-07
WSW	11100.	B	2.65	0.08	84.559	1.216E-07
WSW	11100.	A	2.65	0.32	91.912	9.143E-08
WSW	11100.	B	4.70	0.01	97.978	6.855E-08
WSW	11100.	A	4.70	0.03	98.713	5.155E-08
WSW	11100.	B	7.15	0.01	99.449	4.506E-08
WSW	11100.	A	7.15	0.01	99.816	3.389E-08
WSW	11100.	C	7.15	0.00	100.000	0.000E+00
WSW	11100.	G	19.00	0.00	100.000	0.000E+00

W	11100.	G	0.89	0.13	1.354	3.927E-05
W	11100.	F	0.89	0.31	5.938	1.795E-05
W	11100.	G	2.65	0.09	10.104	1.534E-05
W	11100.	E	0.89	0.46	15.833	7.878E-06
W	11100.	F	2.65	0.16	22.292	6.604E-06
W	11100.	F	4.70	0.01	24.063	4.207E-06
W	11100.	D	0.89	0.77	32.188	3.503E-06
W	11100.	E	2.65	0.31	43.438	2.808E-06
W	11100.	E	4.70	0.06	47.292	1.725E-06
W	11100.	D	2.65	0.66	54.792	1.210E-06
W	11100.	D	4.70	0.12	62.917	7.139E-07
W	11100.	C	0.89	0.14	65.625	6.965E-07
W	11100.	B	0.89	0.16	68.750	3.620E-07
W	11100.	A	0.89	0.40	74.583	2.722E-07
W	11100.	C	2.65	0.13	80.104	2.339E-07
W	11100.	C	4.70	0.02	81.667	1.319E-07
W	11100.	B	2.65	0.16	83.542	1.216E-07
W	11100.	A	2.65	0.60	91.458	9.143E-08
W	11100.	B	4.70	0.03	98.021	6.855E-08
W	11100.	A	4.70	0.08	99.167	5.155E-08
W	11100.	G	4.70	0.00	100.000	0.000E+00
W	11100.	G	19.00	0.00	100.000	0.000E+00

WNW	11100.	G	0.89	0.13	1.633	3.927E-05
WNW	11100.	F	0.89	0.23	6.156	1.795E-05
WNW	11100.	G	2.65	0.10	10.302	1.534E-05
WNW	11100.	G	4.70	0.01	11.683	1.042E-05
WNW	11100.	E	0.89	0.34	16.080	7.878E-06
WNW	11100.	F	2.65	0.21	22.990	6.604E-06
WNW	11100.	F	4.70	0.02	25.879	4.207E-06
WNW	11100.	D	0.89	0.50	32.412	3.503E-06
WNW	11100.	E	2.65	0.34	42.965	2.808E-06
WNW	11100.	E	4.70	0.06	47.990	1.725E-06
WNW	11100.	D	2.65	0.57	55.905	1.210E-06
WNW	11100.	D	4.70	0.11	64.447	7.139E-07
WNW	11100.	C	0.89	0.10	67.085	6.965E-07
WNW	11100.	D	7.15	0.01	68.467	4.766E-07
WNW	11100.	B	0.89	0.09	69.724	3.620E-07
WNW	11100.	A	0.89	0.24	73.869	2.722E-07
WNW	11100.	C	2.65	0.13	78.518	2.339E-07
WNW	11100.	C	4.70	0.02	80.402	1.319E-07
WNW	11100.	B	2.65	0.13	82.286	1.216E-07
WNW	11100.	A	2.65	0.51	90.327	9.143E-08
WNW	11100.	B	4.70	0.03	97.111	6.855E-08
WNW	11100.	A	4.70	0.10	98.744	5.155E-08
WNW	11100.	B	7.15	0.00	100.000	0.000E+00
WNW	11100.	G	19.00	0.00	100.000	0.000E+00

NW	10800.	G	0.89	0.13	1.377	4.034E-05
NW	10800.	F	0.89	0.28	5.720	1.849E-05
NW	10800.	G	2.65	0.20	10.805	1.580E-05
NW	10800.	G	4.70	0.01	13.030	1.078E-05
NW	10800.	E	0.89	0.31	16.419	8.140E-06

RPP-13482 REV 7

NW	10800.	F	2.65	0.39	23.835	6.813E-06
NW	10800.	F	4.70	0.05	28.496	4.352E-06
NW	10800.	D	0.89	0.43	33.581	3.639E-06
NW	10800.	E	2.65	0.47	43.114	2.905E-06
NW	10800.	E	4.70	0.15	49.682	1.788E-06
NW	10800.	D	2.65	0.75	59.216	1.258E-06
NW	10800.	E	7.15	0.01	67.267	1.206E-06
NW	10800.	D	4.70	0.25	70.021	7.429E-07
NW	10800.	C	0.89	0.06	73.305	7.315E-07
NW	10800.	D	7.15	0.03	74.258	4.961E-07
NW	10800.	B	0.89	0.07	75.318	3.711E-07
NW	10800.	A	0.89	0.17	77.860	2.791E-07
NW	10800.	C	2.65	0.19	81.674	2.457E-07
NW	10800.	C	4.70	0.04	84.110	1.385E-07
NW	10800.	B	2.65	0.13	85.911	1.246E-07
NW	10800.	A	2.65	0.45	92.055	9.372E-08
NW	10800.	B	4.70	0.04	97.246	7.026E-08
NW	10800.	A	4.70	0.10	98.729	5.284E-08
NW	10800.	A	7.15	0.01	99.894	3.474E-08
NW	10800.	B	7.15	0.00	100.000	0.000E+00
NW	10800.	G	19.00	0.00	100.000	0.000E+00

NNW	8690.	G	0.89	0.14	1.528	4.974E-05
NNW	8690.	F	0.89	0.26	5.895	2.327E-05
NNW	8690.	G	2.65	0.23	11.245	1.994E-05
NNW	8690.	G	4.70	0.09	14.738	1.408E-05
NNW	8690.	E	0.89	0.30	18.996	1.053E-05
NNW	8690.	G	7.15	0.01	22.380	9.783E-06
NNW	8690.	F	2.65	0.44	27.293	8.711E-06
NNW	8690.	F	4.70	0.17	33.952	5.701E-06
NNW	8690.	D	0.89	0.32	39.301	4.916E-06
NNW	8690.	F	7.15	0.01	42.904	3.904E-06
NNW	8690.	E	2.65	0.52	48.690	3.801E-06
NNW	8690.	E	4.70	0.25	57.096	2.381E-06
NNW	8690.	D	2.65	0.53	65.611	1.709E-06
NNW	8690.	E	7.15	0.05	71.943	1.616E-06
NNW	8690.	C	0.89	0.04	72.926	1.083E-06
NNW	8690.	D	4.70	0.27	76.310	1.019E-06
NNW	8690.	D	7.15	0.07	80.022	6.830E-07
NNW	8690.	B	0.89	0.03	81.114	4.527E-07
NNW	8690.	C	2.65	0.10	82.533	3.638E-07
NNW	8690.	A	0.89	0.10	84.716	3.396E-07
NNW	8690.	C	4.70	0.04	86.245	2.051E-07
NNW	8690.	B	2.65	0.09	87.664	1.520E-07
NNW	8690.	C	7.15	0.01	88.755	1.348E-07
NNW	8690.	A	2.65	0.29	92.031	1.140E-07
NNW	8690.	B	4.70	0.05	95.742	8.572E-08
NNW	8690.	A	4.70	0.13	97.707	6.430E-08
NNW	8690.	B	7.15	0.01	99.236	5.635E-08
NNW	8690.	A	7.15	0.03	99.672	4.227E-08
NNW	8690.	A	9.80	0.00	100.000	0.000E+00
NNW	8690.	G	19.00	0.00	100.000	0.000E+00

N	8690.	G	0.89	0.17	1.950	4.974E-05
N	8690.	F	0.89	0.35	7.913	2.327E-05
N	8690.	G	2.65	0.20	14.220	1.994E-05
N	8690.	G	4.70	0.07	17.317	1.408E-05
N	8690.	E	0.89	0.34	22.018	1.053E-05
N	8690.	F	2.65	0.45	31.078	8.711E-06
N	8690.	F	4.70	0.14	37.844	5.701E-06
N	8690.	D	0.89	0.27	42.546	4.916E-06
N	8690.	F	7.15	0.02	45.872	3.904E-06
N	8690.	E	2.65	0.46	51.376	3.801E-06

RPP-13482 REV 7

N	8690.	F	9.80	0.01	56.766	2.849E-06
N	8690.	E	4.70	0.22	59.404	2.381E-06
N	8690.	D	2.65	0.35	65.940	1.709E-06
N	8690.	E	7.15	0.07	70.757	1.616E-06
N	8690.	E	9.80	0.01	71.674	1.179E-06
N	8690.	C	0.89	0.04	72.248	1.083E-06
N	8690.	D	4.70	0.24	75.459	1.019E-06
N	8690.	D	7.15	0.10	79.358	6.830E-07
N	8690.	D	9.80	0.02	80.734	4.983E-07
N	8690.	B	0.89	0.05	81.537	4.527E-07
N	8690.	C	2.65	0.06	82.798	3.638E-07
N	8690.	A	0.89	0.10	84.633	3.396E-07
N	8690.	C	4.70	0.05	86.353	2.051E-07
N	8690.	B	2.65	0.08	87.844	1.520E-07
N	8690.	C	7.15	0.02	88.991	1.348E-07
N	8690.	A	2.65	0.24	91.972	1.140E-07
N	8690.	C	9.80	0.01	94.839	9.837E-08
N	8690.	B	4.70	0.03	95.298	8.572E-08
N	8690.	A	4.70	0.12	97.018	6.430E-08
N	8690.	B	7.15	0.02	98.624	5.635E-08
N	8690.	A	7.15	0.04	99.312	4.227E-08
N	8690.	A	9.80	0.01	99.885	3.084E-08
N	8690.	G	7.15	0.00	100.000	0.000E+00
N	8690.	G	19.00	0.00	100.000	0.000E+00
NNE	8970.	G	0.89	0.09	1.807	4.826E-05
NNE	8970.	F	0.89	0.23	8.233	2.251E-05
NNE	8970.	G	2.65	0.08	14.458	1.928E-05
NNE	8970.	G	4.70	0.01	16.265	1.354E-05
NNE	8970.	E	0.89	0.21	20.683	1.015E-05
NNE	8970.	F	2.65	0.21	29.116	8.405E-06
NNE	8970.	F	4.70	0.03	33.936	5.480E-06
NNE	8970.	D	0.89	0.19	38.353	4.706E-06
NNE	8970.	E	2.65	0.21	46.386	3.655E-06
NNE	8970.	E	4.70	0.12	53.012	2.284E-06
NNE	8970.	D	2.65	0.18	59.036	1.634E-06
NNE	8970.	E	7.15	0.08	64.257	1.548E-06
NNE	8970.	E	9.80	0.05	66.867	1.129E-06
NNE	8970.	C	0.89	0.02	68.273	1.023E-06
NNE	8970.	D	4.70	0.13	71.285	9.733E-07
NNE	8970.	E	12.70	0.01	74.096	8.714E-07
NNE	8970.	D	7.15	0.11	76.506	6.518E-07
NNE	8970.	D	9.80	0.07	80.120	4.755E-07
NNE	8970.	B	0.89	0.02	81.928	4.388E-07
NNE	8970.	D	12.70	0.02	82.731	3.670E-07
NNE	8970.	C	2.65	0.02	83.534	3.435E-07
NNE	8970.	A	0.89	0.06	85.141	3.300E-07
NNE	8970.	C	4.70	0.02	86.747	1.937E-07
NNE	8970.	B	2.65	0.04	87.952	1.474E-07
NNE	8970.	C	7.15	0.01	88.956	1.273E-07
NNE	8970.	A	2.65	0.12	91.566	1.108E-07
NNE	8970.	B	4.70	0.02	94.377	8.309E-08
NNE	8970.	A	4.70	0.07	96.185	6.249E-08
NNE	8970.	B	7.15	0.01	97.791	5.462E-08
NNE	8970.	A	7.15	0.04	98.795	4.108E-08
NNE	8970.	A	9.80	0.01	99.799	2.997E-08
NNE	8970.	G	7.15	0.00	100.000	0.000E+00
NNE	8970.	G	19.00	0.00	100.000	0.000E+00
NE	10430.	G	0.89	0.10	1.282	4.173E-05
NE	10430.	F	0.89	0.22	5.385	1.919E-05
NE	10430.	G	2.65	0.10	9.487	1.640E-05
NE	10430.	G	4.70	0.02	11.026	1.125E-05

RPP-13482 REV 7

NE	10430.	E	0.89	0.25	14.487	8.485E-06
NE	10430.	F	2.65	0.27	21.154	7.088E-06
NE	10430.	F	4.70	0.07	25.513	4.544E-06
NE	10430.	D	0.89	0.21	29.103	3.819E-06
NE	10430.	F	7.15	0.01	31.923	3.093E-06
NE	10430.	E	2.65	0.29	35.769	3.033E-06
NE	10430.	E	4.70	0.18	41.795	1.872E-06
NE	10430.	D	2.65	0.24	47.179	1.321E-06
NE	10430.	E	7.15	0.17	52.436	1.264E-06
NE	10430.	E	9.80	0.11	56.026	9.222E-07
NE	10430.	D	4.70	0.23	60.385	7.815E-07
NE	10430.	C	0.89	0.02	63.590	7.787E-07
NE	10430.	E	12.70	0.04	64.359	7.116E-07
NE	10430.	E	15.60	0.01	65.000	5.793E-07
NE	10430.	D	7.15	0.25	68.333	5.222E-07
NE	10430.	B	0.89	0.01	71.667	3.829E-07
NE	10430.	D	9.80	0.16	73.846	3.810E-07
NE	10430.	D	12.70	0.09	77.051	2.940E-07
NE	10430.	A	0.89	0.06	78.974	2.880E-07
NE	10430.	C	2.65	0.03	80.128	2.615E-07
NE	10430.	D	15.60	0.03	80.897	2.393E-07
NE	10430.	C	4.70	0.03	81.667	1.475E-07
NE	10430.	B	2.65	0.03	82.436	1.286E-07
NE	10430.	C	7.15	0.02	83.077	9.693E-08
NE	10430.	A	2.65	0.17	85.513	9.672E-08
NE	10430.	B	4.70	0.05	88.333	7.251E-08
NE	10430.	C	9.80	0.02	89.231	7.072E-08
NE	10430.	C	12.70	0.02	89.744	5.457E-08
NE	10430.	A	4.70	0.14	91.795	5.453E-08
NE	10430.	B	7.15	0.04	94.103	4.766E-08
NE	10430.	A	7.15	0.11	96.026	3.585E-08
NE	10430.	B	9.80	0.02	97.692	3.478E-08
NE	10430.	B	12.70	0.01	98.077	2.683E-08
NE	10430.	A	9.80	0.05	98.846	2.615E-08
NE	10430.	A	12.70	0.02	99.744	2.018E-08
NE	10430.	F	9.80	0.00	100.000	0.000E+00
NE	10430.	G	19.00	0.00	100.000	0.000E+00
ENE	10530.	G	0.89	0.09	0.729	4.134E-05
ENE	10530.	F	0.89	0.27	3.647	1.899E-05
ENE	10530.	G	2.65	0.20	7.455	1.624E-05
ENE	10530.	G	4.70	0.09	9.806	1.112E-05
ENE	10530.	E	0.89	0.29	12.885	8.389E-06
ENE	10530.	F	2.65	0.46	18.963	7.011E-06
ENE	10530.	F	4.70	0.20	24.311	4.491E-06
ENE	10530.	D	0.89	0.17	27.310	3.769E-06
ENE	10530.	F	7.15	0.02	28.849	3.056E-06
ENE	10530.	E	2.65	0.48	32.901	2.997E-06
ENE	10530.	E	4.70	0.39	39.951	1.849E-06
ENE	10530.	D	2.65	0.28	45.381	1.303E-06
ENE	10530.	E	7.15	0.30	50.081	1.248E-06
ENE	10530.	E	9.80	0.15	53.728	9.105E-07
ENE	10530.	D	4.70	0.39	58.104	7.708E-07
ENE	10530.	C	0.89	0.02	61.426	7.654E-07
ENE	10530.	E	12.70	0.02	61.750	7.026E-07
ENE	10530.	D	7.15	0.38	64.992	5.149E-07
ENE	10530.	B	0.89	0.03	68.314	3.796E-07
ENE	10530.	D	9.80	0.24	70.502	3.757E-07
ENE	10530.	D	12.70	0.09	73.177	2.899E-07
ENE	10530.	A	0.89	0.06	74.392	2.855E-07
ENE	10530.	C	2.65	0.05	75.284	2.571E-07
ENE	10530.	D	15.60	0.03	75.932	2.360E-07
ENE	10530.	C	4.70	0.06	76.661	1.449E-07

RPP-13482 REV 7

ENE	10530.	B	2.65	0.05	77.553	1.275E-07
ENE	10530.	A	2.65	0.19	79.498	9.589E-08
ENE	10530.	C	7.15	0.07	81.605	9.528E-08
ENE	10530.	B	4.70	0.07	82.739	7.189E-08
ENE	10530.	C	9.80	0.05	83.711	6.952E-08
ENE	10530.	A	4.70	0.34	86.872	5.406E-08
ENE	10530.	C	12.70	0.01	89.708	5.364E-08
ENE	10530.	B	7.15	0.08	90.438	4.726E-08
ENE	10530.	C	15.60	0.01	91.167	4.367E-08
ENE	10530.	A	7.15	0.25	93.274	3.554E-08
ENE	10530.	B	9.80	0.04	95.624	3.448E-08
ENE	10530.	B	12.70	0.02	96.110	2.660E-08
ENE	10530.	A	9.80	0.16	97.569	2.593E-08
ENE	10530.	A	12.70	0.06	99.352	2.001E-08
ENE	10530.	A	15.60	0.01	99.919	1.629E-08
ENE	10530.	F	12.70	0.00	100.000	0.000E+00
ENE	10530.	G	19.00	0.00	100.000	0.000E+00

E	11160.	G	0.89	0.22	0.783	3.906E-05
E	11160.	F	0.89	0.48	3.274	1.785E-05
E	11160.	G	2.65	0.82	7.900	1.525E-05
E	11160.	G	4.70	0.56	12.811	1.035E-05
E	11160.	E	0.89	0.49	16.548	7.827E-06
E	11160.	F	2.65	1.60	23.986	6.564E-06
E	11160.	F	4.70	1.19	33.915	4.179E-06
E	11160.	D	0.89	0.40	39.573	3.477E-06
E	11160.	F	7.15	0.07	41.246	2.839E-06
E	11160.	E	2.65	1.58	47.117	2.789E-06
E	11160.	E	4.70	1.98	59.786	1.713E-06
E	11160.	D	2.65	0.69	69.288	1.201E-06
E	11160.	E	7.15	0.65	74.057	1.155E-06
E	11160.	E	9.80	0.06	76.584	8.424E-07
E	11160.	D	4.70	0.83	79.751	7.084E-07
E	11160.	C	0.89	0.04	82.847	6.898E-07
E	11160.	E	12.70	0.01	83.025	6.501E-07
E	11160.	D	7.15	0.58	85.125	4.728E-07
E	11160.	B	0.89	0.04	87.331	3.602E-07
E	11160.	D	9.80	0.13	87.936	3.450E-07
E	11160.	A	0.89	0.10	88.754	2.709E-07
E	11160.	D	12.70	0.03	89.217	2.662E-07
E	11160.	C	2.65	0.08	89.609	2.317E-07
E	11160.	D	15.60	0.02	89.964	2.167E-07
E	11160.	C	4.70	0.09	90.356	1.306E-07
E	11160.	B	2.65	0.07	90.925	1.210E-07
E	11160.	A	2.65	0.25	92.064	9.098E-08
E	11160.	C	7.15	0.06	93.167	8.587E-08
E	11160.	B	4.70	0.10	93.737	6.821E-08
E	11160.	C	9.80	0.02	94.164	6.265E-08
E	11160.	A	4.70	0.35	95.480	5.130E-08
E	11160.	B	7.15	0.06	96.939	4.484E-08
E	11160.	A	7.15	0.25	98.043	3.372E-08
E	11160.	B	9.80	0.02	99.004	3.271E-08
E	11160.	B	12.70	0.01	99.110	2.524E-08
E	11160.	A	9.80	0.10	99.502	2.460E-08
E	11160.	A	12.70	0.02	99.929	1.899E-08
E	11160.	C	12.70	0.00	100.000	0.000E+00
E	11160.	G	19.00	0.00	100.000	0.000E+00

ESE	15190.	G	0.89	0.14	0.372	2.873E-05
ESE	15190.	F	0.89	0.36	1.702	1.280E-05
ESE	15190.	G	2.65	0.69	4.495	1.090E-05
ESE	15190.	G	4.70	0.84	8.564	7.102E-06
ESE	15190.	E	0.89	0.44	11.968	5.404E-06

RPP-13482 REV 7

ESE	15190.	G	7.15	0.01	13.165	4.829E-06
ESE	15190.	F	2.65	1.69	17.686	4.617E-06
ESE	15190.	F	4.70	1.60	26.436	2.860E-06
ESE	15190.	D	0.89	0.44	31.862	2.261E-06
ESE	15190.	F	7.15	0.08	33.245	1.928E-06
ESE	15190.	E	2.65	1.68	37.926	1.901E-06
ESE	15190.	E	4.70	2.50	49.043	1.144E-06
ESE	15190.	D	2.65	1.09	58.590	7.760E-07
ESE	15190.	E	7.15	1.75	66.144	7.669E-07
ESE	15190.	E	9.80	0.38	71.809	5.595E-07
ESE	15190.	D	4.70	1.46	76.702	4.529E-07
ESE	15190.	E	12.70	0.05	80.718	4.317E-07
ESE	15190.	C	0.89	0.04	80.957	4.114E-07
ESE	15190.	D	7.15	1.14	84.096	3.012E-07
ESE	15190.	B	0.89	0.05	87.261	2.727E-07
ESE	15190.	D	9.80	0.50	88.723	2.198E-07
ESE	15190.	A	0.89	0.10	90.319	2.051E-07
ESE	15190.	D	12.70	0.07	90.771	1.696E-07
ESE	15190.	C	2.65	0.10	91.223	1.382E-07
ESE	15190.	B	2.65	0.09	91.729	9.158E-08
ESE	15190.	C	4.70	0.13	92.314	7.791E-08
ESE	15190.	A	2.65	0.30	93.457	6.887E-08
ESE	15190.	B	4.70	0.14	94.628	5.164E-08
ESE	15190.	C	7.15	0.07	95.186	5.121E-08
ESE	15190.	A	4.70	0.35	96.303	3.883E-08
ESE	15190.	C	9.80	0.03	97.314	3.736E-08
ESE	15190.	B	7.15	0.07	97.580	3.394E-08
ESE	15190.	C	12.70	0.01	97.793	2.883E-08
ESE	15190.	A	7.15	0.25	98.484	2.553E-08
ESE	15190.	B	9.80	0.03	99.229	2.476E-08
ESE	15190.	A	9.80	0.11	99.601	1.862E-08
ESE	15190.	A	12.70	0.02	99.947	1.437E-08
ESE	15190.	G	9.80	0.00	100.000	0.000E+00
ESE	15190.	G	19.00	0.00	100.000	0.000E+00
SE	21050.	G	0.89	0.14	0.646	2.054E-05
SE	21050.	F	0.89	0.32	2.770	8.941E-06
SE	21050.	G	2.65	0.30	5.633	7.592E-06
SE	21050.	G	4.70	0.13	7.618	4.782E-06
SE	21050.	E	0.89	0.45	10.295	3.635E-06
SE	21050.	F	2.65	0.82	16.159	3.174E-06
SE	21050.	F	4.70	0.32	21.422	1.922E-06
SE	21050.	D	0.89	0.54	25.392	1.430E-06
SE	21050.	F	7.15	0.03	28.024	1.287E-06
SE	21050.	E	2.65	1.11	33.287	1.265E-06
SE	21050.	E	4.70	0.75	41.874	7.494E-07
SE	21050.	E	7.15	0.41	47.230	4.997E-07
SE	21050.	D	2.65	1.05	53.970	4.882E-07
SE	21050.	E	9.80	0.11	59.326	3.646E-07
SE	21050.	D	4.70	0.84	63.712	2.825E-07
SE	21050.	E	12.70	0.03	67.729	2.813E-07
SE	21050.	C	0.89	0.10	68.329	2.721E-07
SE	21050.	B	0.89	0.07	69.114	2.031E-07
SE	21050.	D	7.15	0.50	71.745	1.873E-07
SE	21050.	A	0.89	0.14	74.700	1.527E-07
SE	21050.	D	9.80	0.29	76.685	1.367E-07
SE	21050.	D	12.70	0.08	78.393	1.055E-07
SE	21050.	C	2.65	0.19	79.640	9.138E-08
SE	21050.	B	2.65	0.16	81.256	6.821E-08
SE	21050.	C	4.70	0.12	82.548	5.153E-08
SE	21050.	A	2.65	0.42	85.042	5.130E-08
SE	21050.	B	4.70	0.12	87.535	3.846E-08
SE	21050.	C	7.15	0.06	88.366	3.387E-08

RPP-13482 REV 7

SE	21050.	A	4.70	0.40	90.489	2.892E-08
SE	21050.	B	7.15	0.09	92.752	2.528E-08
SE	21050.	C	9.80	0.05	93.398	2.471E-08
SE	21050.	C	12.70	0.01	93.675	1.907E-08
SE	21050.	A	7.15	0.33	95.245	1.901E-08
SE	21050.	B	9.80	0.06	97.045	1.844E-08
SE	21050.	B	12.70	0.01	97.368	1.423E-08
SE	21050.	A	9.80	0.24	98.523	1.387E-08
SE	21050.	A	12.70	0.03	99.769	1.070E-08
SE	21050.	A	15.60	0.01	99.954	8.714E-09
SE	21050.	G	9.80	0.00	100.000	0.000E+00
SE	21050.	G	19.00	0.00	100.000	0.000E+00
SSE	15360.	G	0.89	0.09	0.941	2.841E-05
SSE	15360.	F	0.89	0.23	4.289	1.264E-05
SSE	15360.	G	2.65	0.08	7.531	1.076E-05
SSE	15360.	G	4.70	0.01	8.473	7.007E-06
SSE	15360.	E	0.89	0.39	12.657	5.332E-06
SSE	15360.	F	2.65	0.25	19.351	4.559E-06
SSE	15360.	F	4.70	0.06	22.594	2.822E-06
SSE	15360.	D	0.89	0.55	28.975	2.226E-06
SSE	15360.	E	2.65	0.39	38.808	1.875E-06
SSE	15360.	E	4.70	0.13	44.247	1.128E-06
SSE	15360.	D	2.65	0.77	53.661	7.638E-07
SSE	15360.	E	7.15	0.02	61.925	7.557E-07
SSE	15360.	D	4.70	0.21	64.331	4.457E-07
SSE	15360.	C	0.89	0.10	67.573	4.046E-07
SSE	15360.	D	7.15	0.05	69.142	2.963E-07
SSE	15360.	B	0.89	0.10	70.711	2.700E-07
SSE	15360.	D	9.80	0.01	71.862	2.162E-07
SSE	15360.	A	0.89	0.22	74.268	2.030E-07
SSE	15360.	C	2.65	0.15	78.138	1.359E-07
SSE	15360.	B	2.65	0.16	81.381	9.066E-08
SSE	15360.	C	4.70	0.03	83.368	7.662E-08
SSE	15360.	A	2.65	0.48	88.703	6.818E-08
SSE	15360.	B	4.70	0.06	94.351	5.112E-08
SSE	15360.	C	7.15	0.01	95.084	5.036E-08
SSE	15360.	A	4.70	0.17	96.967	3.844E-08
SSE	15360.	B	7.15	0.01	98.849	3.360E-08
SSE	15360.	A	7.15	0.05	99.477	2.527E-08
SSE	15360.	G	7.15	0.00	100.000	0.000E+00
SSE	15360.	G	19.00	0.00	100.000	0.000E+00

This page intentionally left blank.

APPENDIX F

GXQ CDF OUTPUT FOR PUFF RELEASE

This page intentionally left blank.

APPENDIX F

GXQ CDF OUTPUT FOR PUFF RELEASE

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/24/02
Run Time = 14:03:40.54

Ground Level, Puff, 95th Percentile

CUMULATIVE DISTRIBUTION

SECTOR	DISTANCE (m)	ATM. STAB. CLASS	WIND SPEED (m/s)	SECTR FREQ (%)	CUM. FREQ. (%)	SCALED X/Q (1/m3)
S	100.	G	0.89	6.95	3.475	9.849E-03
S	100.	F	15.60	15.79	14.845	2.646E-03
SW	100.	E	0.89	26.22	35.850	8.120E-04
W	100.	D	0.89	27.96	62.940	3.144E-04
WNW	100.	C	2.65	4.39	79.115	9.471E-05
NNW	100.	B	0.89	4.56	83.590	3.762E-05
N	100.	A	0.89	14.07	92.905	1.620E-05
SW	100.	C	12.70	0.00	99.940	0.000E+00
SSE	100.	G	19.00	0.00	99.940	0.000E+00
NNW	8690.	G	0.89	0.91	0.455	1.608E-07
NNE	8970.	G	0.89	0.18	1.000	1.500E-07
NE	10430.	G	0.89	0.22	1.200	1.080E-07
ENE	10530.	G	0.89	0.38	1.500	1.058E-07
NW	10800.	G	0.89	0.34	1.860	1.001E-07
WSW	11100.	G	0.89	0.57	2.315	9.434E-08
E	11160.	G	0.89	1.60	3.400	9.324E-08
SW	13200.	G	0.89	0.10	4.250	6.485E-08
ESE	15190.	G	0.89	1.68	5.140	4.792E-08
SSW	15360.	G	0.89	0.40	6.180	4.679E-08
NNW	8690.	F	0.89	1.85	7.305	4.275E-08
NNE	8970.	F	0.89	0.47	8.465	3.989E-08
NE	10430.	F	0.89	0.57	8.985	2.872E-08
ENE	10530.	F	0.89	0.95	9.745	2.813E-08
NW	10800.	F	0.89	0.72	10.580	2.662E-08
WSW	11100.	F	0.89	1.14	11.510	2.509E-08
E	11160.	F	0.89	3.34	13.750	2.480E-08
SE	21050.	G	0.89	0.57	15.705	2.383E-08
SW	13200.	F	0.89	0.18	16.080	1.725E-08

RPP-13482 REV 7

ESE	15190.	F	0.89	3.73	18.035	1.275E-08
SSW	15360.	F	15.60	1.35	20.575	1.244E-08
NNW	8690.	E	0.89	2.22	22.360	1.221E-08
NNE	8970.	E	0.89	0.68	23.810	1.137E-08
NE	10430.	E	0.89	1.05	24.675	8.100E-09
ENE	10530.	E	0.89	1.63	26.015	7.929E-09
NW	10800.	E	0.89	0.94	27.300	7.491E-09
WSW	11100.	E	0.89	1.96	28.750	7.046E-09
E	11160.	E	0.89	4.77	32.115	6.961E-09
SE	21050.	F	0.89	1.49	35.245	6.338E-09
SW	13200.	E	9.80	0.46	36.220	4.784E-09
NNW	8690.	D	0.89	2.17	37.535	3.670E-09
ESE	15190.	E	0.89	6.80	42.020	3.500E-09
SSW	15360.	E	4.70	2.85	46.845	3.414E-09
NNE	8970.	D	0.89	0.70	48.620	3.404E-09
NE	10430.	D	0.89	1.21	49.575	2.379E-09
ENE	10530.	D	0.89	1.58	50.970	2.326E-09
NW	10800.	D	0.89	1.46	52.490	2.191E-09
W	11100.	D	0.89	3.71	55.075	2.053E-09
E	11160.	D	0.89	2.68	58.270	2.027E-09
SE	21050.	E	0.89	2.86	61.040	1.699E-09
SW	13200.	D	7.15	1.12	63.030	1.362E-09
ESE	15190.	D	0.89	4.70	65.940	9.774E-10
SSW	15360.	D	4.70	5.33	70.955	9.521E-10
NNW	8690.	C	0.89	0.37	73.805	5.102E-10
NNE	8970.	C	0.89	0.07	74.025	4.681E-10
SE	21050.	D	0.89	3.30	75.710	4.528E-10
NE	10430.	C	0.89	0.14	77.430	3.110E-10
ENE	10530.	C	0.89	0.27	77.635	3.031E-10
NW	10800.	C	0.89	0.29	77.915	2.831E-10
WNW	11100.	C	0.89	0.76	78.440	2.630E-10
E	11160.	C	0.89	0.29	78.965	2.592E-10
SW	13200.	C	7.15	0.19	79.205	1.663E-10
NNW	8690.	B	0.89	0.36	79.480	1.619E-10
NNE	8970.	B	0.89	0.09	79.705	1.525E-10
ESE	15190.	C	0.89	0.38	79.940	1.170E-10
NE	10430.	B	0.89	0.16	80.210	1.161E-10
ENE	10530.	B	0.89	0.29	80.435	1.142E-10
SSW	15360.	C	19.00	1.10	81.130	1.139E-10
NW	10800.	B	0.89	0.24	81.800	1.091E-10
WNW	11100.	B	0.89	0.81	82.325	1.038E-10
E	11160.	B	0.89	0.30	82.880	1.028E-10
NNW	8690.	A	4.70	1.06	83.560	9.134E-11
NNE	8970.	A	0.89	0.30	84.240	8.625E-11
SW	13200.	B	0.89	0.20	84.490	7.590E-11
NE	10430.	A	0.89	0.55	84.865	6.569E-11
ENE	10530.	A	0.89	1.07	85.675	6.457E-11
NW	10800.	A	0.89	0.73	86.575	6.168E-11
ESE	15190.	B	0.89	0.38	87.130	5.890E-11
WSW	11100.	A	0.89	2.55	88.595	5.870E-11
E	11160.	A	0.89	1.07	90.405	5.813E-11
S	15360.	B	19.00	1.22	91.550	5.772E-11
SE	21050.	C	0.89	0.53	92.425	5.764E-11
SW	13200.	A	0.89	0.68	93.030	4.293E-11
ESE	15190.	A	0.89	1.13	93.935	3.331E-11
SE	21050.	B	0.89	0.51	94.755	3.267E-11
S	15360.	A	2.65	3.36	96.690	3.265E-11
SE	21050.	A	0.89	1.57	99.155	1.848E-11
N	8690.	A	19.00	0.00	99.940	0.000E+00
SSE	15360.	G	19.00	0.00	99.940	0.000E+00

APPENDIX G

**SPECIAL χ /Q'S FOR THERMALLY LOFTED RELEASES
AND DISPLACED VOLUMES**

This page intentionally left blank.

APPENDIX G

SPECIAL χ/Q 'S FOR THERMALLY LOFTED RELEASES
AND DISPLACED VOLUMESG.1 SPECIAL THERMALLY LOFTED RELEASE χ/Q 'S FOR FIRE IN PIT

A series of thermally lofted release χ/Q 's were calculated for a fire in a pit. These scenarios were developed in RPP-13354, *Technical Basis for the Release from Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions*, and are summarized here. The pit cover was assumed to be removed (otherwise the fire would self-extinguish). Two cases were required: (1) a gasoline spill into the pit, and (2) a fire involving wood and miscellaneous flammable solids. The gasoline fires have defined areas (1 and 2 m radii) with a specified sensible heat rate per unit area. The wood/miscellaneous fire was assumed to cover the bottom of the pit. The pit area is 10 ft by 12 ft with an equivalent diameter of 3.77 m (circle with same area). A range of total heat rates was specified for the wood/miscellaneous fire. Wind speed was adjusted for plume height. Initial air entrainment due to plume turbulence including ground effect was included. The release was assumed to be from ground level with thermal lofting depending on the fire heat rate. Receptor height was set at 2 m. The fires were conservatively assumed to be of short duration (< 1 hr) so 1-hr χ/Q 's (i.e., without plume meander effects) were used. The results follow; a corresponding sample GXQ run file is included as Attachment G1.

Table G-1. 1-hr χ/Q 's for Ground Level Releases From Fire In Pit with Thermal Lofting.

Fuel type	Heat rate (MW)	Fire diameter (m)	χ/Q' (s/m ³)	
			Onsite	Offsite
Gasoline	6.8	2.0	6.55 E-5	3.74 E-6
	27.1	4.0	2.27 E-5	1.18 E-6
Wood/ miscellaneous	1.0	3.77	6.32 E-4	1.03 E-5
	4.0	3.77	1.08 E-4	5.51 E-6

Note:

MW = Mega Watt.

G.2 SPECIAL χ/Q 'S FOR DISPLACED VOLUME RATES OUT OF PIT

A series of χ/Q 's were calculated for a flammable gas deflagration in a pit and a load drop into a pit. These scenarios were developed in RPP-13354 and are summarized here. Both of these cases involved a fast (< 60 sec) displacement of air out of the pit. These were considered to be ground level releases with no thermal lofting, but with credit taken for the initial dilution caused by the expulsion of air out of the pit. The pit volume was specified to be 10 ft by 12 ft by 6 ft deep = 720 ft³ (20.4 m³). In addition, volumes of 500 ft³ (14.2 m³) and 1,000 ft³ (28.3 m³) were evaluated as a sensitivity study. One pit volume was assumed to be pushed out of the pit in 60 sec. This release time is conservative if the actual release time is less than 60 sec. No credit was taken for any momentum rise effects. These are short duration (< 60 sec) releases so

1-hr χ/Q 's (i.e., without plume meander effects) were used. The results follow; a corresponding sample GXQ run file is included as Attachment G2.

Table G-2. 1-hr χ/Q 's for Ground Level Initial Volume Displaced Releases From Pit.

Displaced volume		Volume rate (m ³ /s)	χ/Q ' (s/m ³)	
(ft ³)	(m ³)		Onsite	Offsite
500	14.2	0.237	2.95 E-2	2.22 E-5
720	20.4	0.340	2.89 E-2	2.22 E-5
1000	28.3	0.472	2.81 E-2	2.22 E-5

G.3 SPECIAL χ/Q 'S FOR DISPLACED VOLUME RATES OUT OF TANK DUE TO DOME COLLAPSE

A series of χ/Q 's were calculated for the tank dome collapse scenario for both single-shell tanks (SST) and double-shell tanks (DST). These scenarios were developed in RPP-12444, *Technical Basis for the Tank Failure Due to Excessive Loads Representative Accident and Associated Represented Hazardous Conditions*, and are summarized here. Both cases involved a fast (< 60 sec) displacement of air out of the tank headspace. These were considered to be ground level releases, but with credit taken for the initial dilution caused by the expulsion of air out of the tank.

SST dome collapse. Displaced volume of air from tank headspace was specified to be 52,000 gal (197 m³) corresponding to the volume of material falling into tank. Twice this displaced volume (394 m³) was also evaluated as a sensitivity study. The displaced volume was assumed to be pushed out of the tank through an opening with a 10-ft radius (6.10-m diameter) in 60 sec. This release time is conservative if the actual release time is less than 60 sec. Initial plume width was set at 6.10 m. No credit was taken for any momentum rise effects.

DST dome collapse. Displaced volume of air from tank headspace was specified to be 62,000 gal (235 m³) corresponding to the volume of material falling into tank. Twice this displaced volume (469 m³) was also evaluated as a sensitivity study. The displaced volume was assumed to be pushed out of the tank through an opening with a 10-ft radius (6.10-m diameter) in 60 sec. This release time is conservative if the actual release time is less than 60 sec. Initial plume width was set at 6.10 m. No credit was taken for any momentum rise effects.

These are short duration (< 60 sec) releases so 1-hr χ/Q 's (i.e., without plume meander effects) were used. The results for both the SST and DST cases follow; a corresponding sample GXQ run file is included as Attachment G3.

Table G-3. 1-hr χ/Q 's for Ground Level Initial Volume Displaced Releases
From Tank Dome Collapse.

Tank type	Displaced volume (m ³)	Volume rate (m ³ /s)	χ/Q' (s/m ³)	
			Onsite	Offsite
SST	197	3.28	1.98 E-2	2.21 E-5
	394	6.56	1.79 E-2	2.21 E-5
DST	235	3.91	1.94 E-2	2.21 E-5
	469	7.82	1.68 E-2	2.21 E-5

Notes:

DST = double-shell tank.

SST = single-shell tank.

References

RPP-12444, 2003, *Technical Basis for the Tank Failure Due to Excessive Loads Representative Accident and Associated Represented Hazardous Conditions*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13354, 2003, *Technical Basis for the Release from Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

ATTACHMENT G1

SAMPLE GXQ RUN FILE FOR RESULTS IN TABLE G-1

LOFTED RELEASE FROM FIRE IN PIT

- Wood/Miscellaneous fire (heat rate 4.0 MW – fire diameter 3.77 m)

RPP-13482 REV 7

Current Input File Name: oberg1.IN

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 12/26/02
Run Time = 14:45:39.92

INPUT ECHO:

Tank Farms - 95% all sectors - 1 hour - Case 1 - fire in pit
c GXQ Version 4.0 Input File

c mode
1

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T F F F T F

c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 1

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 1

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd)iwash igrav
1 1 0 0

c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on

RPP-13482 REV 7

```

c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on
c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height     to
c      hs(m)       ha(m)          hm(m)      exceed
c                                     Cx(%)
c
c      0.00000E+00  1.00000E+01    1.00000E+03  5.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height       trd(hr)      vd(m/s)         velocity
c      Wb(m)        Hb(m)                                     vg(m/s)
c
c      0.00000E+00  0.00000E+00    1.00000E+00  0.00000E+00    0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        V0(m3/s)     d(m)         rate(1)
c                                     qh(w)
c
c      2.00000E+01  2.00000E+01    0.00000E+00  3.77000E+00    4.00000E+06
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c
c      1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
Plume rise air entrainment model selected.
MACCS buoyancy plume rise model based on convective heat.

```

RPP-13482 REV 7

Mills buoyant rise modification for pool fire selected.
Wind velocity corrected for average plume height.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

Created 8/26/92 KR

Tank Farms - 95% all sectors - 1 hour - Case 1 - fire in pit

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	2	99.94	1	1.08E-04	1.08E-04	B	15.60
ALL	15360	2	99.94	1	5.51E-06	5.51E-06	G	0.89

ATTACHMENT G2

SAMPLE GXQ RUN FILE FOR RESULTS IN TABLE G-2

DISPLACED VOLUME RELEASES FROM PIT

- Flammable Gas Deflagration or Load Drop (displaced volume rate $20.4 \text{ m}^3/60 \text{ sec}$)

RPP-13482 REV 7

Current Input File Name: oberg2.IN

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 02/20/03
Run Time = 10:49:52.10

INPUT ECHO:

Tank Farms - 95% all sectors - 1 hour - release from pit
c GXQ Version 4.0 Input File

c mode
1

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T F F F T F

c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 1 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd)iwash igrav
0 0 0 0

c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on

RPP-13482 REV 7

```

c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on
c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height     to
c      hs(m)       ha(m)          hm(m)      exceed
c                                     Cx(%)
c
c      0.00000E+00  1.00000E+01    1.00000E+03  5.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height      trd(hr)      velocity        velocity
c      Wb(m)        Hb(m)          vd(m/s)      vg(m/s)
c
c      0.00000E+00  0.00000E+00    0.00000E+00  0.00000E+00    0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        V0(m3/s)     d(m)         rate(1)
c                                     qh(w)
c
c      2.00000E+01  2.00000E+01    3.40000E-01  1.00000E+00    0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c
c      1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
c MODE:
c Site specific X/Q calculated.
c
c LOGICAL CHOICES:
c Joint frequency used to calculate X/Q based on frequency of exceedance.
c No normalization of joint frequency.
c X/Q calculated for overall site.
c
c MODELS SELECTED:
c Time-integrated air concentration calculated (s/m3).
c Flow rate adjustment model.

```

RPP-13482 REV 7

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

Created 8/26/92 KR

Tank Farms - 95% all sectors - 1 hour - release from pit

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	2.89E-02	2.89E-02	F	0.89
ALL	15360	0	99.94	1	2.22E-05	2.22E-05	F	0.89

ATTACHMENT G3

SAMPLE GXQ RUN FILE FOR RESULTS IN TABLE G-3

**DISPLACED VOLUME RELEASES FROM TANK
DUE TO DOME COLLAPSE**

- DST Dome Collapse (displaced volume rate $469 \text{ m}^3/60 \text{ sec}$)

RPP-13482 REV 7

Current Input File Name: oberg3.IN

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 12/27/02
Run Time = 10:15:17.56

INPUT ECHO:

Tank Farms - 95% all sectors - 1 hour - tank dome collapse

c GXQ Version 4.0 Input File

c mode
1

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology

c mode = 2 then X/Q based on atmospheric stability class and wind speed

c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T F F F T F

c ifox = t then joint frequency used to compute frequency to exceed X/Q

c = f then joint frequency used to compute annual average X/Q

c inorm = t then joint frequency data is normalized (as in GENII)

c = f then joint frequency data is un-normalized

c icdf = t then cumulative distribution file created (CDF.OUT)

c = f then no cumulative distribution file created

c ichk = t then X/Q parameter print option turned on

c = f then no parameter print

c isite = t then X/Q based on joint frequency data for all 16 sectors

c = f then X/Q based on joint frequency data of individual sectors

c ipop = t then X/Q is population weighted

c = f then no population weighting

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 1 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd)iwash igrav
0 0 0 0

c ipuff = 1 then X/Q calculated using puff model

c = 0 then X/Q calculated using default continuous plume model

c idep = 1 then plume depletion model turned on (Chamberlain model)

c isrc = 1 then X/Q multiplied by scalar

c = 2 then X/Q adjusted by wind speed function

c iwind = 1 then wind speed corrected for plume height

c iwake = 1 then NRC RG 1.145 building wake model turned on

c = 2 then MACCS virtual distance building wake model turned on

c ipm = 1 then NRC RG 1.145 plume meander model turned on

c = 2 then 5th Power Law plume meander model turned on

c = 3 then sector average model turned on

RPP-13482 REV 7

```

c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on
c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height     to
c      hs(m)       ha(m)          hm(m)      exceed
c                                     Cx(%)
c
c      0.00000E+00  1.00000E+01  1.00000E+03  5.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height       trd(hr)      vd(m/s)         velocity
c      Wb(m)        Hb(m)                                     vg(m/s)
c
c      0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        flow rate   d(m)         rate(1)
c                                     V0(m3/s)
c                                     qh(w)
c
c      2.00000E+01  2.00000E+01  7.82000E+00  6.10000E+00  0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c
c      1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
Flow rate adjustment model.

```

RPP-13482 REV 7

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

Created 8/26/92 KR

Tank Farms - 95% all sectors - 1 hour - tank dome collapse

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	1.68E-02	1.68E-02	F	0.89
ALL	15360	0	99.94	1	2.21E-05	2.21E-05	F	0.89

This page intentionally left blank.

APPENDIX H

**SPECIAL χ/Q s AND χ/Q 's FOR PUFF RELEASES DUE TO
RAPID VENTING OF UNDERGROUND TANK**

This page intentionally left blank.

APPENDIX H

**SPECIAL χ/Q S AND χ/Q 'S FOR PUFF RELEASES DUE TO
RAPID VENTING OF UNDERGROUND TANK**

A series of χ/Q s and χ/Q 's were calculated for a rapid venting of a large underground waste tank where the tank dome is assumed to fail during a flammable gas deflagration/detonation. These scenarios were developed in RPP-13510, *Flammable Gas Technical Basis Document*, and relevant parameters are summarized here. The release is modeled as a semi-ellipsoidal puff on the ground above the tank arising from several vent paths out of the tank. Two cases were analyzed:

1. A double-shell tank (DST) with a headspace volume of 961 m³ with initial pressures up to 60 lb/in² gauge.
2. A single-shell tank (SST) with a headspace volume of 1,987 m³ with initial pressures up to 44 lb/in² gauge.

The DST and SST headspace volumes are assumptions supported by information contained in RPP-13019, *Determination of Hanford Waste Tank Volumes*. The DST headspace volume of 961 m³ is based on the fact that the majority of DSTs are essentially full. When filled to an operating level of 420 in., a DST with a total volume of 5,324 m³ will have a headspace volume of 953 m³. For an SST, the assumption is that the tank is essentially one-half full. The total volume of SSTs varies due to differences in design. The "one-half full" assumption leads to volumes roughly equivalent to 1,600 m³ for the 0.5 Mgal tanks, 2,000 m³ for the 0.75 Mgal tanks, and 2,500 m³ for the 1 Mgal tanks. The analyzed SST headspace volume of 1,987 m³ is thus approximately equivalent to a 0.75 Mgal SST that is one-half full. Note that the larger the assumed headspace volume, the bigger the "puff" which reduces the initial concentration which in turn results in lower onsite consequences.

Both tanks have a diameter of 75 ft (22.9 m). The initial puff at ground level is assumed to be the same diameter as the tank. The height of the puff depends on the volume vented. The resulting puff χ/Q s are shown in Table H-1 for the ranges of initial pressures required.

Table H-1. Puff χ/Q s for Rapid Venting of Underground Tanks.

Tank type	Initial pressure (lb/in ² gauge)	Initial puff volume (m ³)	χ/Q (1/m ³)	
			Onsite	Offsite
DST	5	320	6.49 E-4	4.89 E-8
	15	961	3.89 E-4	4.88 E-8
	45	2883	1.69 E-4	4.82 E-8
	60	3844	1.31 E-4	4.78 E-8
SST	15	1987	2.31 E-4	4.85 E-8
	44	5829	8.98 E-5	4.68 E-8

Notes:

DST = double-shell tank.

SST = single-shell tank.

The puff χ/Q s shown above will yield peak air concentrations and can be used to estimate toxicological consequences. To estimate radiological consequences, the time-integrated air concentration is needed. The corresponding 1-hr χ/Q 's that will yield the required time-integrated air concentrations are shown in Table H-2.

Table H-2. Continuous Release 1-hr χ/Q 's for Rapid Venting of Underground Tanks.

Tank type	Initial pressure (lb/in ² gauge)	Initial puff volume (m ³)	χ/Q' (s/m ³)	
			Onsite	Offsite
DST	5	320	1.06 E-2	2.18 E-5
	15	961	7.35 E-3	2.18 E-5
	45	2883	3.73 E-3	2.15 E-5
	60	3844	2.97 E-3	2.14 E-5
SST	15	1987	4.88 E-3	2.16 E-5
	44	5829	2.06 E-3	2.10 E-5

Notes:

DST = double-shell tank.

SST = single-shell tank.

The theory and calculations documenting these χ/Q s and χ/Q' s are shown in Attachment H1. A sample GXQ input file and run file are included in the attachment.

Reference

RPP-13019, 2003, *Determination of Hanford Waste Tank Volumes*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13510, 2003, *Flammable Gas Technical Basis Document*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

ATTACHMENT H1**Application of the MACCS Puff Model to Rapid Venting of Tank Headspace**

by Paul D. Rittmann PhD CHP

October 10, 2002

Attachment H1A describes the general methodology of using GXQ Version 4.0F to model puff releases with various initial shapes. The following is a specific application of that methodology to the rapid venting of a large underground tank into the air. The vented gas is assumed to be released at multiple locations over the top of the tank so as to form an initial cloud above the tank.

Two tank venting cases are evaluated. The first is a DST with a headspace volume of 961 m³ and the second is a SST with a headspace volume of 1,987 m³. The DST pressures range up to 60 psig. The SST pressures range up to 44 lb/in² gauge. Both tanks have a diameter of 75 ft (22.9 m). The initial puff is assumed to also have this diameter on the ground above the tank. The height of the puff depends on the volume vented. The height (vertical radius) of the semi-ellipsoid that has a given diameter and a given volume is calculated as shown in the equation below.

$$V_{\text{PUFF}} = \frac{\pi}{6} D_H^2 R_V \quad \text{or} \quad R_V = \frac{6 V_{\text{PUFF}}}{\pi D_H^2}$$

where:

- V_{PUFF} = initial volume of the semi-ellipsoidal puff (m³)
- D_H = horizontal diameter of the puff (m)
- R_V = vertical radius of the puff (m).

From Attachment H1A, the formula used to calculate the width and height inputs for the MACCS model are shown below.

$$W_B = \frac{2.15 D_H}{(4.5 \pi)^{1/6}} \quad \text{and} \quad H_B = \frac{2.15 R_V}{(4.5 \pi)^{1/6}}$$

where:

- D_H = horizontal diameter of the puff (m)
- R_V = vertical radius of the puff (m)
- W_B = building width in the MACCS building wake model (m)
- H_B = building height in the MACCS building wake model (m).

These calculations are readily carried out. The specific pressure and volume assumptions are listed in Table H1-1. The initial puff volume is calculated using the formula below.

$$V_{\text{PUFF}} = \frac{P_{\text{HEAD}}}{15 \text{ psi}_a} V_{\text{HEAD}}$$

where:

- V_{PUFF} = initial volume of the semi-ellipsoidal puff (m^3)
 P_{HEAD} = headspace pressure before venting (psig)
 V_{HEAD} = volume of the headspace in the underground tank (m^3).

The initial puff dimensions (width = 22.9 m and heights shown in Table H1-1) were input to GXQ Version 4.0F. A sample code input is shown in Attachment H1B. The results of the GXQ calculations using 200 area wind data collected from 1982 to 1991 are shown in the last columns of Table H1-1. Note that all χ/Q values are for the 95th percentile (overall site χ/Q). For comparison, the 95th percentile puff X/Q s for a point source are $8.88\text{E-}3 \text{ m}^{-3}$ at 100 m and $5.06\text{E-}8 \text{ m}^{-3}$ at the worst site boundary location (see Tables 2-4 and 2-5 in main document).

A sample output (for the $5,829\text{-m}^3$ puff) is included as Attachment H1C. Besides the 100-m (onsite) and the Hanford Site boundary χ/Q s, the value at a distance of 1 m was calculated to verify that the initial concentration matches the inverse of the initial puff volume, shown in Table H1-1 as the "Initial χ/Q (at 0 m)".

The initial χ/Q at zero distance is simply the inverse of the initial puff volume and is equal to the initial concentration that results from a unit amount released. It also was used as a check on the computed results. At 1 m (the GXQ code will not accept a 0-m distance), the GXQ value for χ/Q is $1.70\text{E-}04 \text{ m}^{-3}$ in good agreement with the expected value of $1.72\text{E-}04 \text{ m}^{-3}$ in Table H1-1 based on the initial puff volume.

Table H1-1. Input Values and χ/Q Results for a Puff Release.

Scenario	Initial Puff Volume (m^3)	Puff Height for Input to GXQ 4.0F (m)	Initial χ/Q (at 0 m) (m^{-3})	χ/Q from GXQ 4.0F (m^{-3})	
				Onsite (100 m)	Hanford Site Boundary
DST, 5 psig	320	1.62	$3.12\text{E-}03$	$6.49\text{E-}04$	$4.89\text{E-}08$
DST, 15 psig	961	4.86	$1.04\text{E-}03$	$3.89\text{E-}04$	$4.88\text{E-}08$
SST, 15 psig	1,987	10.04	$5.03\text{E-}04$	$2.31\text{E-}04$	$4.85\text{E-}08$
DST, 45 psig	2,883	14.57	$3.47\text{E-}04$	$1.69\text{E-}04$	$4.82\text{E-}08$
DST, 60 psig	3,844	19.42	$2.60\text{E-}04$	$1.31\text{E-}04$	$4.78\text{E-}08$
SST, 44 psig	5,829	29.45	$1.72\text{E-}04$	$8.98\text{E-}05$	$4.68\text{E-}08$

Notes:

Puff (building) width is 31.6 m for input to MACCS Building Wake Model in GXQ Version 4.0F.

The GXQ Version 4.0F values for χ/Q are the 95th percentile overall site numbers.

To estimate radiological consequences, the time-integral of the air concentration is needed. In a Gaussian model of a 3-dimension cloud that is moving along the x-axis at a speed μ (m/s), the time integral introduces a factor of the square root of 2π times the standard deviation (sigma parameter) divided by the wind speed. This factor is the effective time of exposure. Since the standard deviation increases with distance, the effective time of exposure also increases with distance.

Using the puff model dimensions derived above, the calculation of time-integrated exposures in GXQ only requires changing the IPUFF=1 flag to IPUFF=0. The puff (building) width and height remain the same. The GXQ results for the time-integrated χ/Q 's are shown in Table H1-2. A sample output is shown in Attachment H1D.

Table H1-2. Input Values and χ/Q ' Results for a Puff Release.

Scenario	Initial Puff Volume (m ³)	Puff Height for Input to GXQ (m)	χ/Q ' from GXQ 4.0F (s/m ³)	
			Onsite (100 m)	Hanford Site Boundary
DST, 5 psig	320	1.62	1.06E-02	2.18E-05
DST, 15 psig	961	4.86	7.35E-03	2.18E-05
SST, 15 psig	1,987	10.04	4.88E-03	2.16E-05
DST, 45 psig	2,883	14.57	3.73E-03	2.15E-05
DST, 60 psig	3,844	19.42	2.97E-03	2.14E-05
SST, 44 psig	5,829	29.45	2.06E-03	2.10E-05

Notes:

Puff (building) width is 31.6 m for input to MACCS Building Wake Model in GXQ Version 4.0F.

The GXQ Version 4.0F values for χ/Q ' are the 95th percentile overall site numbers.

The virtual distances used in GXQ depend on the atmospheric stability class. A complete listing is shown in Table H1-3. The 95th percentile results are usually stability class F.

Table H1-3. Virtual Distances Used in the Building Wake Calculation.

Stability Class	Horizontal 31.6 m	Vertical Dimension (Height)					
		1.62 m	4.86 m	10.0 m	14.6 m	19.4 m	29.5 m
A	27.7	4.3	13.9	30.3	45.0	61.2	95.5
B	38.0	5.5	18.2	39.9	59.8	81.6	132
C	51.6	7.9	26.6	59.3	89.5	123	194
D	76.0	12.9	45.0	103	152	211	346
E	111	17.3	60.9	138	216	311	539
F	167	26.1	101	244	391	567	979
G	262	48.4	184	463	752	1,105	2,095

Notes:

All virtual distances are in meters.

Column labeled "Horizontal" shows the virtual distances needed to give a horizontal spread (σ_y) of 31.6 m.

Columns labeled "Vertical Dimension (Height)" show the virtual distances needed to give the vertical spreads (σ_z) shown in the header row.

ATTACHMENT H1A:

How to Model Finite Size Puff Releases in GXQ Version 4.0F

by Paul D. Rittmann PhD CHP

August 12, 2002

The GXQ software Version 4.0F can be used to model the transport of a puff of toxic material. This essay summarizes the specific inputs for GXQ Version 4.0F to carry out a puff calculation.

The puff forms nearly instantaneously so that any spreading along the direction of wind travel during its formation is small. The puff is assumed to have a length equal to its width in this model. Three initial puff shapes were considered: box, cylinder, and sphere. In all three cases, the formulas were derived for a ground level release ($H=0$), with a receptor also located at ground level ($Z=0$).

In all three cases, the initial concentration in the puff is the amount initially airborne divided by the initial puff volume. The normalized air concentration is shown in the equations below. The factor of 2.0 in the numerator is the plume reflection factor for a ground level release.

$$\frac{1}{V_{\text{PUFF}}} = \left(\frac{X}{Q} \right)_0 = \frac{(2.0)(4.3)^2(2.15)}{(2\pi)^{1.5} W_B^2 H_B} \quad \text{or} \quad V_{\text{PUFF}} = \frac{(2\pi)^{1.5}}{8(2.15)^3} W_B^2 H_B$$

where:

- V_{PUFF} = initial volume of the puff (m^3)
- $(X/Q)_0$ = normalized air concentration (m^{-3}) at zero distance. This is the air concentration in the center of the puff divided by the amount initially airborne in the puff. Note that the release height is zero.
- W_B = building width (m) in the MACCS building wake model (input to GXQ Version 4.0F)
- H_B = building height (m) in the MACCS building wake model (input to GXQ Version 4.0F).

An instantaneous puff at ground level can then be modeled in GXQ Version 4.0F using the following inputs:

- (1) puff model calculations are selected (IPUFF=1)
- (2) MACCS building wake model selected (IWAKE=2)
- (3) release height is set to zero
- (4) release duration is set to zero
- (5) building width and height are input according to the equations derived below.

The influence of the ground is taken into account by GXQ through the plume reflection factor. If the puff is well above ground level initially, then the reflection factor is 1. However, in this case the puff volume should be twice as great since the puff extends both upward and downward from the point of release. This doubling restores the factor of 2. Thus, the equations derived below apply to elevated puffs as well as ground level puffs. Intermediate elevations may have small

differences between the volume correction and the plume reflection factor, so the formulas are not exact in those cases.

INITIAL PUFF AS A BOX

Assuming the initial puff has a rectangular shape, the volume of the puff is the product of the width squared and the height, as shown in the equation below. The puff is assumed to have a square base (length equal to width), because isotropic conditions in the x-y (horizontal) plane are assumed in this model.

$$V_{\text{PUFF}} = W_p^2 H_p$$

where:

V_{PUFF} = initial volume of the rectangular puff (m^3)

W_p = initial width of the puff (m)

H_p = initial height of the puff (m).

Inserting the volume of the box shown above into the first equation for V_{PUFF} leads to the equation shown below.

$$W_p^2 H_p = \frac{(2\pi)^{1.5}}{8(2.15)^3} W_B^2 H_B$$

The natural solution for W_B and H_B is to associate the building height with the initial height of the puff, and the building width with the initial width of the puff. The constant is distributed evenly between the two by taking its cube root. The results of this decomposition are shown below.

$$W_B = \frac{4.3 W_p}{\sqrt{2\pi}} \quad \text{and} \quad H_B = \frac{4.3 H_p}{\sqrt{2\pi}}$$

Using these calculated values for building width and height as input to GXQ, the initial concentration in the puff will be the initial amount airborne divided by the initial volume of the puff.

INITIAL PUFF AS A VERTICAL CYLINDER

Assuming the initial puff has the shape of a vertical cylinder, the volume of the puff is the product of the base area and the height, as shown in the equation below. The puff is assumed to have a circular base because of the assumed isotropy in the x-y plane in this model.

$$V_{\text{PUFF}} = \frac{\pi}{4} D_P^2 H_P$$

where:

- V_{PUFF} = initial volume of the cylindrical puff (m^3)
- D_P = initial diameter of the puff (m)
- H_P = initial height of the puff (m).

Inserting the volume of the cylinder into the first equation for V_{PUFF} leads to the equation shown below.

$$\frac{\pi}{4} D_P^2 H_P = \frac{(2\pi)^{1.5}}{8(2.15)^3} W_B^2 H_B$$

The natural solution for W_B and H_B is to associate the building height with the initial height of the puff, and the building width with the initial diameter of the puff. The constant is distributed evenly between the two by taking its cube root. The results of this decomposition are shown below.

$$W_B = \frac{2.15 D_P}{(2\pi)^{1/6}} \quad \text{and} \quad H_B = \frac{2.15 H_P}{(2\pi)^{1/6}}$$

Using these calculated values for building width and height as input to GXQ, the initial concentration in the puff will be the initial amount airborne divided by the initial volume of the puff.

INITIAL PUFF AS A HALF-ELLIPSOID

Assuming the initial puff has the shape of an ellipsoid whose center is at ground level, the volume of the puff is shown in the equation below. As before, the puff is assumed to have a circular base because of the assumed isotropy in the x-y plane.

$$V_{\text{PUFF}} = \frac{\pi}{6} D_H^2 R_V$$

where:

- V_{PUFF} = initial volume of the half-ellipsoidal puff (m^3)
- D_H = initial horizontal diameter of the puff (m)
- R_V = initial vertical radius of the puff (m).

Inserting the volume of the half-ellipsoid into the first equation for V_{PUFF} leads to the equation shown below.

$$\frac{\pi}{6} D_H^2 R_v = \frac{(2\pi)^{1.5}}{8(2.15)^3} W_B^2 H_B$$

The natural solution for W_B and H_B is to associate the building height with the initial vertical radius of the puff, and the building width with the initial diameter of the puff. The constant is distributed evenly between the two by taking its cube root. The results of this decomposition are shown below.

$$W_B = \frac{2.15 D_H}{(4.5 \pi)^{1/6}} \quad \text{and} \quad H_B = \frac{2.15 R_v}{(4.5 \pi)^{1/6}}$$

Using these calculated values for building width and height as input to GXQ, the initial concentration in the puff will be the initial amount airborne divided by the initial volume of the puff.

ATTACHMENT H1B

Sample Input File (5,829-m³ Puff)

```

5,829 cu.m Half-Spheroid Source, No Ground Deposition
  1 = mode -- GXQ Version 4.0 Input File
c ifox inorm icdf ichk isite ipop
  t      f      f      f      t      f
c ipuff idep isrc iwind
  1      0      0      0
c iwake ipm iflow ientr
  2      0      0      0
c irise igrnd iwash igrav
  0      0      0      0
c release          anemometer      mixing      frequency
c height,m         height,m         height,m     to exceed
  0                10              1000         5.0
c building         building         release      deposition      gravitational
c width,m          height,m         duration,h   speed,m/s      settling,m/s
  31.61           29.45              0           0           0
c ambient          stack gas        stack flow   stack(pool)    heat release
c temp, C          temp, C          rate,m3/s    diameter,m     rate,W
  0                0                1           1           0
c scaling          Speed
c factor           Exponent
  1                .78
c receptor specified using
c sector distance elevation
  0          100          0      onsite location
  1          15360         0      Hanford Site Boundary
  2          15360         0
  3          13200         0
  4          11100         0
  5          11100         0
  6          11100         0
  7          10800         0
  8          8690          0
  9          8690          0
 10          8970          0
 11          10430         0
 12          10530         0
 13          11160         0
 14          15190         0
 15          21050         0
 16          15360         0
  0           1           0

```

ATTACHMENT H1C

Sample Output File (5,829-m³ Puff)

Maximum Concentration

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/10/02
Run Time = 16:33:47.66

INPUT ECHO:

5,829 cu.m Half-Spheroid Source, No Ground Deposition

c	ifox	inorm	icdf	ichk	isite	ipop			
	T	F	F	F	T	F			
c	ipuff	idep	isrc	iwind					
	1	0	0	0					
c	iwake	ipm	iflow	ientr					
	2	0	0	0					
c	irise	igrnd	iwash	igrav					
	0	0	0	0					
c	release		anemometer		mixing		frequency		
c	height,m		height,m		height,m		to exceed		
	0.00000E+00		1.00000E+01		1.00000E+03		5.00000E+00		
c	building		building		release		deposition		gravitational
c	width,m		height,m		duration,h		speed,m/s		settling,m/s
	3.16100E+01		2.94500E+01		0.00000E+00		0.00000E+00		0.00000E+00
c	ambient		stack gas		stack flow		stack(pool)		heat release
c	temp, C		temp, C		rate,m3/s		diameter,m		rate,W
	0.00000E+00		0.00000E+00		1.00000E+00		1.00000E+00		0.00000E+00
c	scaling		Speed						
c	factor		Exponent						
	1.00000E+00		7.80000E-01						
c	receptor specified using								
c	sector	distance	elevation						

MODE:

Site specific X/Q calculated.

RPP-13482 REV 7

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.

No normalization of joint frequency.

X/Q calculated for overall site.

MODELS SELECTED:

Air concentrations will be calculated (1/m3).

MACCS Virtual source building wake model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

Created 8/26/92 KR

5,829 cu.m Half-Spheroid Source, No Ground Deposition

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL	AVERAGE	ATM. STAB. CLASS	WIND SPEED (m/s)
					POPULATION	INDIVIDUAL		
					SCALED X/Q (1/m3)	SCALED X/Q (1/m3)		
ALL	100	0	99.94	1	8.98E-05	8.98E-05	G	0.89
ALL	15360	0	99.94	1	4.68E-08	4.68E-08	G	0.89
ALL	1	0	99.94	1	1.70E-04	1.70E-04	G	0.89

ATTACHMENT H1D

Example Output File (5,829-m³ Puff)

Time-Integrated Concentration

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 10/10/02
Run Time = 16:33:26.02

INPUT ECHO:

5,829 cu.m Half-Spheroid Source, No Ground Deposition

```

1
c ifox inorm icdf ichk isite ipop
  T   F   F   F   T   F
c ipuff idep isrc iwind
  0   0   0   0
c iwake ipm iflow ientr
  2   0   0   0
c irise igrnd iwash igrav
  0   0   0   0
c release          anemometer      mixing      frequency
c height,m         height,m         height,m    to exceed
  0.00000E+00      1.00000E+01      1.00000E+03  5.00000E+00
c building         building         release      deposition      gravitational
c width,m          height,m         duration,h   speed,m/s       settling,m/s
  3.16100E+01      2.94500E+01      0.00000E+00  0.00000E+00    0.00000E+00
c ambient          stack gas        stack flow   stack(pool)     heat release
c temp, C          temp, C          rate,m3/s    diameter,m      rate,W
  0.00000E+00      0.00000E+00      1.00000E+00  1.00000E+00    0.00000E+00
c scaling          Speed
c factor           Exponent
  1.00000E+00      7.80000E-01
c receptor specified using
c sector distance elevation

```

MODE:

Site specific X/Q calculated.

RPP-13482 REV 7

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:

Time-integrated air concentration calculated (s/m3).
MACCS Virtual source building wake model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

5,829 cu.m Half-Spheroid Source, No Ground Deposition

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	2.06E-03	2.06E-03	F	0.89
ALL	15360	0	99.94	1	2.10E-05	2.10E-05	F	0.89
ALL	1	0	99.94	1	3.53E-03	3.53E-03	F	0.89

APPENDIX I

SPECIAL GROUND LEVEL RELEASE χ /Q'S WITH PLUME DEPLETION

This page intentionally left blank.

APPENDIX I

SPECIAL GROUND LEVEL RELEASE χ/Q 'S WITH PLUME DEPLETION

The effects of particle fallout and resulting plume depletion on 100-m onsite and site boundary continuous-release χ/Q 's and puff-release χ/Q 's were calculated for a series of particle sizes for application to analysis of toxicological consequences for accidental spray releases. These scenarios were developed in RPP-13750, *Waste Transfer Leaks Technical Basis Document*, and relevant parameters are summarized here. The particles in this case are liquid aerosol droplets with specified sizes of 2, 10, 20, 50, 100, and 200 μm (aerodynamic equivalent diameter [AED]), and densities ranging from 1 to 1.5 g/cm^3 .

Each particle size is associated with a gravitational deposition velocity, which is just the terminal fall velocity in still air. For deposition velocities above about 1 cm/s, this is the actual average fall velocity observed. It turns out, however, that the average random vorticity in air is about 1 cm/s, so that particles with a gravitational fall velocity less than this tend to stay mixed in the air and move where the air moves. Particles in the smaller size range with fall velocities less than about 1 cm/s still plate out on the ground and vegetation, but the rate depends more on the nature of the surface and other parameters than on the fall velocity. The deposition rate is characterized by a surface flux per unit air concentration (e.g., $\text{g/m}^2\text{s}$ per g/m^3). This normalized surface flux has the dimensions of velocity and so is called the deposition "velocity." It is easily seen that, for larger particles actually falling through the air, the deposition velocity is the same as the gravitational fall velocity.

The behavior of the deposition velocity as a function of particle size and other parameters is discussed in the main document, Section 2.3.1. It is evident from Figure 2-1 in that section that the variation in deposition velocity over the density range from 1 to 1.5 g/cm^3 is not significant and will be neglected.

Based on Table 2-8 in the main document, the deposition velocities shown in Table I-1 were assumed for the required aerosol particle sizes through 50 μm . For the larger droplets (100 μm and 200 μm), the fall velocities were taken from Table 3.3 in *Aerosol Technology – Properties, Behavior, and Measurement of Airborne Particles* (Hinds 1982). The theoretical terminal gravitational fall velocities are shown for comparison.

Table I-1. Terminal Fall Velocities and Deposition Velocities.

Particle size (AED) (μm)	Terminal fall velocity (cm/s)	Deposition velocity (cm/s)
2	0.01	0.2
10	0.3	0.5
20	1	1
50	7	7
100	25	25
200	71	71

Note:

AED = aerodynamic equivalent diameter.

For this study, the continuous release was assumed to take place over a period of less than 1 hr (i.e., no credit was taken for plume meander). Continuous release χ/Q 's and puff release χ/Q s with deposition effects were calculated for all sectors (95th percentile) at a 100-m radius, and for all sectors around the site boundary at distances defined in Table 2-3 of the main document. A sample GXQ input file and sample run files for continuous and puff releases are shown in Attachment I1.

The resulting continuous-release χ/Q 's are shown in Tables I-2 and I-3 for onsite and site boundary receptors, respectively. The reduction factors relative to the χ/Q 's with no plume depletion are also shown for information. The values for χ/Q ' with no plume depletion were taken from Tables 2-4 and 2-5 of the main document.

Table I-2. 95th Percentile Continuous Release 1-hr χ/Q 's for Onsite Receptor at 100 m.

Particle size (AED) (μm)	χ/Q ' with no depletion (s/m^3)	χ/Q ' with depletion (s/m^3)	Reduction factor
2	3.28 E-2	2.71 E-2	8.3 E-1
10		2.11 E-2	6.4 E-1
20		1.38 E-2	4.2 E-1
50		1.43 E-3	4.4 E-2
100		1.51 E-4	4.6 E-3
200		1.04 E-5	3.2 E-4

Note:

AED = aerodynamic equivalent diameter.

Table I-3. 95th Percentile Continuous Release 1-hr χ/Q 's for Site Boundary Receptor.

Particle size (AED) (μm)	χ/Q with no depletion (s/m^3)	χ/Q with depletion (s/m^3)	Reduction factor
2	2.22 E-5	8.86 E-6	4.0 E-1
10		3.62 E-6	1.6 E-1
20		1.61 E-6	7.3 E-2
50		6.28 E-8	2.8 E-3
100		3.40 E-9	1.5 E-4
200		2.67 E-11	-1.2 E-6

Note:

AED = aerodynamic equivalent diameter.

Puff-release χ/Q s are shown in Tables I-4 and I-5 for onsite and site boundary, respectively. The reduction factors relative to the χ/Q s with no plume depletion are also shown for information. The values for puff release χ/Q with no plume depletion were taken from Tables 2-4 and 2-5 of the main document.

Table I-4. 95th Percentile Puff Release χ/Q s for Onsite Receptor at 100 m.

Particle size (AED) (μm)	χ/Q with no depletion ($1/\text{m}^3$)	χ/Q with depletion ($1/\text{m}^3$)	Reduction factor
2	8.88 E-3	7.83 E-3	8.8 E-1
10		5.67 E-3	6.4 E-1
20		2.75 E-3	3.1 E-1
50		6.21 E-4	7.0 E-2
100		6.53 E-5	7.4 E-3
200		2.46 E-6	2.8 E-4

Note:

AED = aerodynamic equivalent diameter.

Table I-5. 95th Percentile Puff Release χ/Q s for Site Boundary Receptor.

Particle size (AED) (μm)	χ/Q with no depletion ($1/\text{m}^3$)	χ/Q with depletion ($1/\text{m}^3$)	Reduction factor
2	5.06 E-8	3.17 E-8	6.3 E-1
10		1.95 E-8	3.9 E-1
20		8.35 E-9	1.7 E-1
50		2.81 E-10	5.6 E-3
100		5.93 E-12	1.2 E-4
200		5.48 E-14	1.1 E-6

Note:

AED = aerodynamic equivalent diameter.

References

Hinds, W. C., 1982, *Aerosol Technology – Properties, Behavior, and Measurement of Airborne Particles*, John Wiley & Sons, New York, New York.

RPP-13750, 2003, *Waste Transfer Leaks Technical Basis Document*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

ATTACHMENT I1

**SAMPLE GXQ INPUT AND RUN FILES GROUND LEVEL RELEASES
WITH PLUME DEPLETION DUE TO PARTICLE DEPOSITION**

- Input File
- Sample Run File for Continuous Release (deposition velocity = 0.2 cm/s)
- Sample Run File for Puff Release (deposition velocity = 25 cm/s)

RPP-13482 REV 7

```

Caustic Spray transport - dep. vel. = 0.2 cm/s - No PM
c GXQ Version 4.0 Input File
c mode
  1
c
c MODE CHOICE:
c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created
c
c LOGICAL CHOICES:
c   ifox   inorm   icdf   ichk   isite   ipop
c   T       f       f       f       T       f
c ifox = t then joint frequency used to compute frequency to exceed X/Q
c       = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c       = f then joint frequency data is un-normalized
c icdf  = t then cumulative distribution file created (CDF.OUT)
c       = f then no cumulative distribution file created
c ichk  = t then X/Q parameter print option turned on
c       = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c       = f then X/Q based on joint frequency data of individual sectors
c ipop  = t then X/Q is population weighted
c       = f then no population weighting
c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:
c   ipuff   idep   isrc   iwind
c   0       1       0       0
c
c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:
c   iwake   ipm   iflow   ientr
c   0       0       0       0
c
c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:
c   (irise   igrnd)iwash   igrav
c   0       0       0       0
c
c ipuff = 1 then X/Q calculated using puff model
c       = 0 then X/Q calculated using default continuous plume model
c idep  = 1 then plume depletion model turned on (Chamberlain model)
c isrc  = 1 then X/Q multiplied by scalar
c       = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c       = 2 then MACCS virtual distance building wake model turned on
c ipm   = 1 then NRC RG 1.145 plume meander model turned on
c       = 2 then 5th Power Law plume meander model turned on
c       = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on
c       = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c       = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c   release      reference      frequency
c   height       anemometer     to
c   hs(m)        height         exceed
c               ha(m)          hm(m)   Cx(%)
c
c   0.0          10.0          1000    5.0
c
c   initial      initial
c   plume        plume
c   width        height
c   Wb(m)        Hb(m)
c               trd(hr)
c
c   0.0          0.0          0.0      0.002    0.00
c
c   ambient      initial
c               plume
c               plume
c               release
c               convective
c               heat release

```

RPP-13482 REV 7

```

c   temperature      temperature      flow rate      diameter      rate(1)
c   Tamb(C)          T0(C)            V0(m3/s)       d(m)           qh(w)
c   _____      _____      _____      _____      _____
c   20                38                1.0            1.0            0
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c   X/Q              Wind
c   scaling          Speed
c   factor           Exponent
c   c(?)            a(?)
c   _____      _____
c   1                .78
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)      class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
0   100   0
1   15360 0
2   15360 0
3   13200 0
4   11100 0
5   11100 0
6   11100 0
7   10800 0
8   8690  0
9   8690  0
10  8970  0
11  10430 0
12  10530 0
13  11160 0
14  15190 0
15  21050 0
16  15360 0

```

RPP-13482 REV 7

Current Input File Name: zimm2a.IN

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 05/22/03
Run Time = 11:02:43.20

INPUT ECHO:

Caustic Spray transport - dep. vel. = 0.2 cm/s - No PM

c GXQ Version 4.0 Input File

c mode
1

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T F F F T F

c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 1 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd)iwash igrav

```

      0      0      0      0
c  ipuff = 1 then X/Q calculated using puff model
c      = 0 then X/Q calculated using default continuous plume model
c  idep = 1 then plume depletion model turned on (Chamberlain model)
c  isrc = 1 then X/Q multiplied by scalar
c      = 2 then X/Q adjusted by wind speed function
c  iwind = 1 then wind speed corrected for plume height
c  iwake = 1 then NRC RG 1.145 building wake model turned on
c      = 2 then MACCS virtual distance building wake model turned on
c  ipm = 1 then NRC RG 1.145 plume meander model turned on
c      = 2 then 5th Power Law plume meander model turned on
c      = 3 then sector average model turned on
c  iflow = 1 then sigmas adjusted for volume flow rate
c  ientr = 1 then method of Pasquill used to account for entrainment
c  irise = 1 then MACCS buoyant plume rise model turned on
c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c  igrnd = 1 then Mills buoyant plume rise modification for ground effects
c  iwash = 1 then stack downwash model turned on
c  igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c  PARAMETER INPUT:
c
c      release      reference      frequency
c      height      anemometer      to
c      hs(m)      height      exceed
c                  ha(m)      hm(m)      Cx(%)
c
c      0.00000E+00  1.00000E+01  1.00000E+03  5.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume      plume      duration      velocity      settling
c      width      height      trd(hr)      vd(m/s)      velocity
c      Wb(m)      Hb(m)
c
c      0.00000E+00  0.00000E+00  0.00000E+00  2.00000E-03  0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume      plume      diameter      heat release
c      Tamb(C)      TO(C)      flow rate      d(m)      rate(1)
c                  V0(m3/s)
c
c      2.00000E+01  3.80000E+01  1.00000E+00  1.00000E+00  0.00000E+00
c
c  (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q      Wind
c      scaling  Speed
c      factor   Exponent
c      c(?)     a(?)
c
c      1.00000E+00  7.80000E-01
c
c  RECEPTOR DEPENDENT DATA (no line limit)
c  FOR MODE make RECEPTOR DEPENDENT DATA
c  1 (site specific) sector distance receptor-height
c  2 (by class & wind speed) class windspeed distance offset receptor-height
c  3 (create plot file) class windspeed xmax imax ymax jmax xmin power
c
c  RECEPTOR PARAMETER DESCRIPTION
c  sector = 0, 1, 2... (all, S, SSW, etc.)

```


c distance = receptor distance (m)
 c receptor height = height of receptor (m)
 c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
 c windspeed = anemometer wind speed (m/s)
 c offset = offset from plume centerline (m)
 c xmax = maximum distance to plot or calculate to (m)
 c imax = distance intervals
 c ymax = maximum offset to plot (m)
 c jmax = offset intervals
 c xqmin = minimum scaled X/Q to calculate
 c power = exponent in power function step size

MODE:

Site specific X/Q calculated.

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.
 No normalization of joint frequency.
 X/Q calculated for overall site.

MODELS SELECTED:

Time-integrated air concentration calculated (s/m3).
 Source depletion model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
 Created 8/26/92 KR

Caustic Spray transport - dep. vel. = 0.2 cm/s - No PM

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	2.71E-02	2.71E-02	F	0.89
ALL	15360	0	99.94	1	8.86E-06	8.86E-06	F	0.89

RPP-13482 REV 7

Current Input File Name: zimm2e.IN

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 05/22/03
Run Time = 13:33:58.43

INPUT ECHO:

caustic Spray transport - dep. vel. = 25 cm/s - Puff
GXQ Version 4.0 Input File

c mode
1

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T F F F T F

c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
1 1 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd)iwash igrav

```

0      0      0      0
c ipuff = 1 then X/Q calculated using puff model
c       = 0 then X/Q calculated using default continuous plume model
c idep  = 1 then plume depletion model turned on (Chamberlain model)
c isrc  = 1 then X/Q multiplied by scalar
c       = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c       = 2 then MACCS virtual distance building wake model turned on
c ipm   = 1 then NRC RG 1.145 plume meander model turned on
c       = 2 then 5th Power Law plume meander model turned on
c       = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on
c       = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c       = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c   release      reference      mixing      frequency
c   height      anemometer     height     to
c   hs(m)       ha(m)          hm(m)      exceed
c                                     Cx(%)
c
c   0.00000E+00  1.00000E+01  1.00000E+03  5.00000E+00
c
c   initial      initial      release      deposition      gravitational
c   plume        plume        duration     velocity        settling
c   width        height      trd(hr)      vd(m/s)         velocity
c   Wb(m)        Hb(m)                                     vg(m/s)
c
c   0.00000E+00  0.00000E+00  0.00000E+00  2.50000E-01  0.00000E+00
c
c   ambient      initial      initial      release      convective
c   temperature  plume        plume        diameter    heat release
c   Tamb(C)      T0(C)        flow rate   d(m)         rate(1)
c                                     V0(m3/s)    qh(w)
c
c   2.00000E+01  3.80000E+01  1.00000E+00  1.00000E+00  0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c   X/Q          Wind
c   scaling      Speed
c   factor       Exponent
c   c(?)         a(?)
c
c   1.00000E+00  7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)

```

c distance = receptor distance (m)
 c receptor height = height of receptor (m)
 c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
 c windspeed = anemometer wind speed (m/s)
 c offset = offset from plume centerline (m)
 c xmax = maximum distance to plot or calculate to (m)
 c imax = distance intervals
 c ymax = maximum offset to plot (m)
 c jmax = offset intervals
 c xqmin = minimum scaled X/Q to calculate
 c power = exponent in power function step size

MODE:

Site specific X/Q calculated.

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.
 No normalization of joint frequency.
 X/Q calculated for overall site.

MODELS SELECTED:

Air concentrations will be calculated (1/m3).
 Source depletion model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
 Created 8/26/92 KR

caustic Spray transport - dep. vel. = 25 cm/s - Puff

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (1/m3)	AVERAGE INDIVIDUAL SCALED X/Q (1/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	6.53E-05	6.53E-05	E	7.15
ALL	15360	0	99.94	1	5.93E-12	5.93E-12	A	7.15

This page intentionally left blank.

APPENDIX J

SPECIAL χ/Q 'S FOR GASOLINE POOL FIRES

This page intentionally left blank.

APPENDIX J

SPECIAL χ/Q 'S FOR GASOLINE POOL FIRES

A series of χ/Q 's were calculated for gasoline fires of various sizes and areal heat rates associated with transportation accidents. These scenarios were developed in RPP-13978, *Technical Basis for the Transportation-Related Handling Accidents and Associated Representative Hazardous Conditions*, and relevant parameters are summarized here. The fires were assumed to be circular pools with diameters of 2, 3, and 4 m with areal heat rates of 50, 70, and 90 kW/m². The corresponding total heat rates (kW) for the various pool sizes are shown in Table J-1. The dispersion coefficients were calculated using the MACCS buoyant plume rise model as discussed in Section 2.3.2 of the main document. The amount of buoyant plume rise can be based on either the plume ambient temperature difference or on the fire heat rate. If a non-zero fire heat rate is entered (the case here) then it overrides the plume temperature entry which becomes inoperative. The plume temperature is operative only when a thermal plume rise model is turned on (irise = 1 or 2) and the thermal heat rate is entered as zero. Corrections were also included for the increase in wind speed with plume height and for initial air entrainment due to plume turbulence, including ground effects. Source width correction is included as part of the plume rise model. All receptors were assumed to have a height of 2 m above the ground in order to maximize exposure to the elevated plume. The resulting 1-hr χ/Q 's (i.e., without plume meander) are shown in Tables J-2 and J-3. As discussed in Section 2.3.3 of the main document, plume meander effects cannot be applied to a large source-corrected χ/Q '.

Table J-1. Total Fire Heat Rates.

Pool diameter (m)	Total fire heat rate (kW)		
	50 kW/m ²	70 kW/m ²	90 kW/m ²
2.0	157	220	283
3.0	353	495	636
4.0	628	880	1130

Table J-2. 95th Percentile Onsite 1-hr χ/Q 's (100 m).

Pool diameter (m)	Onsite χ/Q ' (s/m ³)		
	50 kW/m ²	70 kW/m ²	90 kW/m ²
2.0	1.15 E-3	1.00 E-3	8.54 E-4
3.0	9.09 E-4	7.82 E-4	7.23 E-4
4.0	8.08 E-4	6.98 E-4	5.64 E-4

Table J-3. 95th Percentile Offsite 1-hr χ/Q 's (Site Boundary).

Pool diameter (m)	Offsite χ/Q' (s/m ³)		
	50 kW/m ²	70 kW/m ²	90 kW/m ²
2.0	1.56 E-5	1.46 E-5	1.38 E-5
3.0	1.35 E-5	1.24 E-5	1.16 E-5
4.0	1.20 E-5	1.08 E-5	9.93 E-6

A sample GXQ run file is included as Attachment J1. Note that the onsite χ/Q' was evaluated at 10-m intervals from 10 m to 110 m to investigate the elevated plume behavior as it passed the onsite receptor at 100 m.

References

RPP-13978, 2003, *Technical Basis for the Transportation-Related Handling Accidents and Associated Representative Hazardous Conditions*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13482 REV 7

ATTACHMENT J1

SAMPLE GXQ RUN FILE (Fire diameter = 4 m, Heat rate = 90 kW/m²)

RPP-13482 REV 7

Current Input File Name: tomas1.IN

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 01/10/03
Run Time = 09:32:47.70

INPUT ECHO:

Tank Farms - 95% all sectors - 1 hour - fire - 4 m dia. - 90 kW/m2
c GXQ Version 4.0 Input File
c mode
1
c
c MODE CHOICE:
c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created
c
c LOGICAL CHOICES:
c ifox inorm icdf ichk isite ipop
T F F F T F
c ifox = t then joint frequency used to compute frequency to exceed X/Q
c = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c = f then joint frequency data is un-normalized
c icdf = t then cumulative distribution file created (CDF.OUT)
c = f then no cumulative distribution file created
c ichk = t then X/Q parameter print option turned on
c = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c = f then X/Q based on joint frequency data of individual sectors
c ipop = t then X/Q is population weighted
c = f then no population weighting
c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:
c ipuff idep isrc iwind
0 0 0 1
c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:
c iwake ipm iflow ientr
0 0 0 1
c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:
c (irise igrnd) iwash igrav
1 1 0 0
c ipuff = 1 then X/Q calculated using puff model
c = 0 then X/Q calculated using default continuous plume model
c idep = 1 then plume depletion model turned on (Chamberlain model)
c isrc = 1 then X/Q multiplied by scalar
c = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c = 2 then MACCS virtual distance building wake model turned on
c ipm = 1 then NRC RG 1.145 plume meander model turned on
c = 2 then 5th Power Law plume meander model turned on
c = 3 then sector average model turned on

RPP-13482 REV 7

```

c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on
c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer     height     to
c      hs(m)       ha(m)          hm(m)      exceed
c                                     Cx(%)
c
c      0.00000E+00   1.00000E+01   1.00000E+03   5.00000E+00
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration     velocity        settling
c      width        height       trd(hr)      vd(m/s)         velocity
c      Wb(m)        Hb(m)                                     vg(m/s)
c
c      0.00000E+00   0.00000E+00   1.00000E+00   0.00000E+00   0.00000E+00
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      T0(C)        flow rate   d(m)         rate(1)
c                                     V0(m3/s)
c                                     qh(w)
c
c      2.00000E+01   2.00000E+01   0.00000E+00   4.00000E+00   1.13000E+06
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)
c
c      1.00000E+00   7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
c MODE:
c Site specific X/Q calculated.
c
c LOGICAL CHOICES:
c Joint frequency used to calculate X/Q based on frequency of exceedance.
c No normalization of joint frequency.
c X/Q calculated for overall site.
c
c MODELS SELECTED:
c Time-integrated air concentration calculated (s/m3).
c Plume rise air entrainment model selected.
c MACCS buoyancy plume rise model based on convective heat.

```

RPP-13482 REV 7

Mills buoyant rise modification for pool fire selected.
Wind velocity corrected for average plume height.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

Tank Farms - 95% all sectors - 1 hour - fire - 4 m dia. - 90 kW/m2

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL	AVERAGE	ATM. STAB. CLASS	WIND SPEED (m/s)
					POPULATION SCALED X/Q (s/m3)	INDIVIDUAL SCALED X/Q (s/m3)		
ALL	10	2	99.94	1	3.54E-02	3.54E-02	F	2.65
ALL	20	2	99.94	1	2.33E-02	2.33E-02	F	4.70
ALL	30	2	99.94	1	5.04E-03	5.04E-03	G	4.70
ALL	40	2	99.94	1	3.34E-03	3.34E-03	E	9.80
ALL	50	2	99.94	1	2.25E-03	2.25E-03	F	15.60
ALL	60	2	99.94	1	1.44E-03	1.44E-03	E	7.15
ALL	70	2	99.94	1	9.69E-04	9.69E-04	E	7.15
ALL	80	2	99.94	1	7.01E-04	7.01E-04	E	7.15
ALL	90	2	99.94	1	6.27E-04	6.27E-04	D	7.15
ALL	100	2	99.94	1	5.64E-04	5.64E-04	D	7.15
ALL	110	2	99.94	1	5.12E-04	5.12E-04	D	7.15
ALL	15360	2	99.94	1	9.93E-06	9.93E-06	G	2.65

RPP-13482 REV 7

APPENDIX K

SPECIAL χ /Q'S FOR RELEASES FROM THE 242-A EVAPORATOR

This page intentionally left blank.

APPENDIX K

SPECIAL χ/Q 'S FOR RELEASES FROM THE 242-A EVAPORATOR

A special set of χ/Q 's were calculated for releases from the 242-A Evaporator. This facility is located at the east end of the 200 East Area between the 241-AX and 241-AW Tank Farms, and is within the tank farms area with regard to sector distances to the Hanford Site boundary. The Hanford Site boundary distances shown in Table 2-3 of the main document were used to determine the χ/Q ' for the site boundary receptor (maximum offsite individual [MOI]). In addition, χ/Q 's are required for the onsite receptor (collocated worker [CW]) at 100 m and an onsite public receptor at 8 km (Highway 240).

These χ/Q 's are to be applied to the two bounding accidents (a spill and a fire) in HNF-14755, *Documented Safety Analysis for the 242-A Evaporator*. No credit was taken for thermal lofting from the fire due to the fact that the fire is assumed to occur within the intact building and to cool before entering the environment. However, mixing of the release plume with the building wake was assumed. Minimum dimensions of the facility are given as 23 m wide by 19 m high in Section 3.4.2.2.2 of HNF-14755. The resulting building wake-corrected 95th percentile χ/Q 's over all sectors were calculated using the methodology described in Section 2.3.5 of the main document and are shown in Table K-1 below.

Table K-1. 95th percentile χ/Q 's for 242-A Evaporator.

Receptor	χ/Q' (s/m ³)
CW at 100 m	1.09 E-2
Onsite public at 8 km	3.30 E-5
MOI at site boundary	2.21 E-5

Notes:

CW = collocated worker.

MOI = maximum offsite individual.

The GXQ input and run file with these results is attached.

Reference

HNF-14755, 2004, *Documented Safety Analysis for the 242-A Evaporator*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland Washington.

RPP-13482 REV 7

ATTACHMENT K1

**GXQ INPUT AND RUN FILES FOR RELEASES FROM 242-A EVAPORATOR
WITH BUILDING WAKE CORRECTION**

RPP-13482 REV 7

```

242-A Evaporator X/Q update for DSA
c GXQ Version 4.0 Input File
  1 = mode
c MODE SELECTION:
c 1 - X/Q based on site-specific wind data from JOINTFRE.IN
c 2 - X/Q based on input stability class and wind speed
c 3 - X/Q plot file table is created
c
c SITE WIND & POPULATION OPTIONS:
c ifox inorm icdf ichk isite ipop
  T      f      f      f      T      f
c ifox = T compute probabilistic X/Q from a cumulative distribution
c       = F compute annual average X/Q (usually sector average with ipm=3)
c inorm = T normalize joint frequency data in a sector (as in GENII)
c       = F use joint frequency data as is
c icdf  = T put cumulative distributions in the CDF.OUT file
c       = F no cumulative distribution file created
c ichk  = T show details for each X/Q (long output)
c       = F standard length output
c isite = T compute overall site X/Q (need groups of 16 sectors)
c       = F compute X/Q for individual sectors
c ipop  = T population-weighted using the file POP.IN (use ipm=3)
c       = F no population weighting
c
c GAUSSIAN PLUME/PUFF MODEL OPTIONS: (enter 0 to inactivate option)
c ipuff idep isrc iwind
  0      0      0      0
c iwake ipm iflow ientr
  1      0      0      0
c irise igrnd iwash igrav
  0      0      0      0
c ipuff = 0 compute time-integrated air concentrations (s/m3)
c       = 1 compute air concentrations (1/m3) (need release duration)
c idep  = 1 plume depletion model (source depletion)
c isrc  = 1 multiply X/Q by scale factor (input below)
c       = 2 multiply by wind speed function: (factor)*[speed**(exponent)]
c       = 3 multiply by wind speed function: (factor)*[10**(speed*exponent)]
c iwind = 1 wind speed corrected for plume height using power law
c iwake = 1 NRC Reg Guide 1.145 building wake model
c       = 2 MACCS virtual source building wake model
c ipm    = 1 NRC Reg Guide 1.145 plume meander model
c       = 2 MACCS time-dependent plume meander model
c       = 3 sector average X/Q computed
c iflow  = 1 exhaust flow rate adjustment using virtual source method
c ientr  = 1 entrainment method of Pasquill
c irise  = 1 MACCS buoyant plume rise (uses building height)
c       = 2 ISC momentum/buoyancy plume rise
c igrnd  = 1 modifies buoyant plume rise for ground-level effects
c iwash  = 1 stack downwash
c igrav  = 1 gravitational settling
c
c PARAMETER INPUT:
c release      anemometer      mixing      % of X/Q
c height,m     height,m (*)    height,m   larger
c 0            10             1000        5.0
c (* In MODE=1 this input is superceded by the value read from JOINTFRE.IN)
c
c building      building      release      deposition      gravitational
c width,m       height,m     duration,h   speed,m/s       settling,m/s
c 23.0          19.0         0           0               0
c
c ambient      stack gas      stack flow   stack(pool)     heat exhaust
c temp,C       temp,C        rate,m3/s    diameter,m      rate,W (**)
c 20           20            0           0               0
c (** If this is 0 then buoyant flux computed from temps & flow rate)
c
c scale        speed
c factor       exponent
c 1            0.78
c
c RECEPTOR LOCATIONS (no line limit, 3 kinds)
c MODE = 1 wind data read from JOINTFRE.IN

```

RPP-13482 REV 7

```

c      input:  sector, distance, elevation
c      MODE = 2  user supplies stability class, wind speed and receptor X,Y,Z
c      input:  class, windspeed, distance, offset, elevation
c      MODE = 3  output file has X/Q table for plotting isopleths (note Z=0)
c      input:  class, windspeed, xmax, xint, ymax, yint, xqmin, power
c
c RECEPTOR PARAMETERS
c      sector = 0, 1, 2, . . . (all, S, SSW, SW, WSW, etc.)
c      distance (X) = receptor distance from point of release (m)
c      offset (Y) = offset from plume centerline (m)
c      elevation (Z) = height of receptor above grade (m)
c      class = 1,2,3,4,5,6,7 (Pasquill stability A,B,C,D,E,F,G)
c      windspeed = anemometer wind speed (m/s)
c      xmax,xint = maximum distance (m) and number of distance intervals
c      ymax,yint = maximum offset distance (m) and number of distance intervals
c      xqmin = minimum value of X/Q to show on table (s/m3 or 1/m3)
c      power = exponent in power function step size (1 or 2)
c
c sector  distance  elevation
0         100       0      collocated worker
0         8000      0      HW-240 (onsite public)
1        15360      0      MOI (site boundary)
2        15360      0
3        13200      0
4        11100      0
5        11100      0
6        11100      0
7        10800      0
8         8690      0
9         8690      0
10        8670      0
11        10430     0
12        10530     0
13        11160     0
14        15190     0
15        21050     0
16        15360     0

```

RPP-13482 REV 7

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 09/27/04
Run Time = 13:56:05.32

INPUT ECHO:

```
242-A Evaporator X/Q update for DSA
c GXQ Version 4.0 Input File
  1
c MODE SELECTION:
c   1 - X/Q based on site-specific wind data from JOINTFRE.IN
c   2 - X/Q based on input stability class and wind speed
c   3 - X/Q plot file table is created
c
c SITE WIND & POPULATION OPTIONS:
c   ifox inorm icdf ichk isite ipop
c     T   F   F   F   T   F
c   ifox = T compute probabilistic X/Q from a cumulative distribution
c     = F compute annual average X/Q (usually sector average with ipm=3)
c   inorm = T normalize joint frequency data in a sector (as in GENII)
c     = F use joint frequency data as is
c   icdf = T put cumulative distributions in the CDF.OUT file
c     = F no cumulative distribution file created
c   ichk = T show details for each X/Q (long output)
c     = F standard length output
c   isite = T compute overall site X/Q (need groups of 16 sectors)
c     = F compute X/Q for individual sectors
c   ipop = T population-weighted using the file POP.IN (use ipm=3)
c     = F no population weighting
c
c GAUSSIAN PLUME/PUFF MODEL OPTIONS: (enter 0 to inactivate option)
c   ipuff idep isrc iwind
c     0   0   0   0
c   iwake ipm iflow ientr
c     1   0   0   0
c   irise igrnd iwash igrav
c     0   0   0   0
c   ipuff = 0 compute time-integrated air concentrations (s/m3)
c     = 1 compute air concentrations (1/m3) (need release duration)
c   idep = 1 plume depletion model (source depletion)
c   isrc = 1 multiply X/Q by scale factor (input below)
c     = 2 multiply by wind speed function: (factor)*[speed**(exponent)]
c     = 3 multiply by wind speed function: (factor)*[10**(speed*exponent)]
c   iwind = 1 wind speed corrected for plume height using power law
c   iwake = 1 NRC Reg Guide 1.145 building wake model
c     = 2 MACCS virtual source building wake model
c   ipm = 1 NRC Reg Guide 1.145 plume meander model
c     = 2 MACCS time-dependent plume meander model
c     = 3 sector average X/Q computed
c   iflow = 1 exhaust flow rate adjustment using virtual source method
c   ientr = 1 entrainment method of Pasquill
c   irise = 1 MACCS buoyant plume rise (uses building height)
c     = 2 ISC momentum/buoyancy plume rise
```

RPP-13482 REV 7

```

c igrnd = 1  modifies buoyant plume rise for ground-level effects
c iwash = 1  stack downwash
c igrav = 1  gravitational settling
c
c PARAMETER INPUT:
c   release      anemometer      mixing      % of X/Q
c   height,m     height,m (*)    height,m    larger
c   0.00000E+00  1.00000E+01     1.00000E+03 5.00000E+00
c (* In MODE=1 this input is superceded by the value read from JOINTFRE.IN)
c
c   building      building      release      deposition      gravitational
c   width,m       height,m     duration,h   speed,m/s       settling,m/s
c   2.30000E+01   1.90000E+01     0.00000E+00 0.00000E+00     0.00000E+00
c
c   ambient      stack gas      stack flow   stack(pool)     heat exhaust
c   temp,C       temp,C         rate,m3/s    diameter,m       rate,W (**)
c   2.00000E+01  2.00000E+01     0.00000E+00 0.00000E+00     0.00000E+00
c (** If this is 0 then buoyant flux computed from temps & flow rate)
c
c   scale        speed
c   factor       exponent
c   1.00000E+00  7.80000E-01
c
c RECEPTOR LOCATIONS (no line limit, 3 kinds)
c   MODE = 1  wind data read from JOINTFRE.IN
c   input:    sector, distance, elevation
c   MODE = 2  user supplies stability class, wind speed and receptor X,Y,Z
c   input:    class, windspeed, distance, offset, elevation
c   MODE = 3  output file has X/Q table for plotting isopleths (note Z=0)
c   input:    class, windspeed, xmax, xint, ymax, yint, xqmin, power
c
c RECEPTOR PARAMETERS
c   sector = 0, 1, 2, . . . (all, S, SSW, SW, WSW, etc.)
c   distance (X) = receptor distance from point of release (m)
c   offset (Y) = offset from plume centerline (m)
c   elevation (Z) = height of receptor above grade (m)
c   class = 1,2,3,4,5,6,7 (Pasquill stability A,B,C,D,E,F,G)
c   windspeed = anemometer wind speed (m/s)
c   xmax,xint = maximum distance (m) and number of distance intervals
c   ymax,yint = maximum offset distance (m) and number of distance intervals
c   xqmin = minimum value of X/Q to show on table (s/m3 or 1/m3)
c   power = exponent in power function step size (1 or 2)
c
c sector distance elevation
c
MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
NRC RG 1.145 building wake model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:
200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

```

242-A Evaporator X/Q update for DSA

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL	AVERAGE	ATM. STAB. CLASS	WIND SPEED (m/s)
					POPULATION SCALED X/Q (s/m3)	INDIVIDUAL SCALED X/Q (s/m3)		

RPP-13482 REV 7

ALL	100	0	99.94	1	1.09E-02	1.09E-02 F	0.89
ALL	8000	0	99.94	1	3.30E-05	3.30E-05 F	0.89
ALL	15360	0	99.94	1	2.21E-05	2.21E-05 F	0.89

This page intentionally left blank.

APPENDIX L

SPECIAL χ /Q'S FOR RELEASES FROM THE 222-S LABORATORY

This page intentionally left blank.

APPENDIX L

SPECIAL χ/Q 'S FOR RELEASES FROM THE 222-S LABORATORY

A special set of χ/Q 's were calculated for releases from the 222-S Laboratory. This facility is located at the south end of the 200 West Area, and is slightly outside the tank farms area with regard to sector distances to the Hanford Site boundary. The Hanford Site boundary distances shown in Table 2-3 of the main document therefore cannot be used to determine the χ/Q ' for the site boundary receptor (maximum offsite individual [MOI]). The site boundary distances used to calculate the site boundary χ/Q ' are shown below in Table L-1. These site boundary distances were generated in the same way as the distances shown in Table 2-3, i.e. the distance in each 22.5° sector was based on the minimum distance within a 45° sector centered on the same direction. In addition, χ/Q 's are required for the onsite receptor (collocated worker [CW]) at 100 m and an onsite public receptor at 3.4 km (Highway 240).

Table L-1. Site Boundary Distances for the
222-S Laboratory.

Sector	Minimum distance within a 45° sector (m)
S	12,580
SSW	12,580
SW	13,620
WSW	12,950
W	12,950
WNW	12,950
NW	14,110
NNW	17,130
N	19,070
NNE	24,170
NE	24,530
ENE	23,160
E	23,160
ESE	26,540
SE	19,400
SSE	14,570

The following χ/Q 's are to be applied to the bounding accident (a building-wide fire) in HNF-12125, *222-S Laboratory Documented Safety Analysis*. No credit was taken for thermal lofting from the fire due to the fact that the fire is assumed to occur within the intact building and to cool before entering the environment. However, mixing of the release plume with the building wake was assumed. Minimum dimensions of the facility are 32.6 m wide by 9.1 m high. The resulting building wake-corrected 95th percentile χ/Q 's over all sectors were calculated

using the methodology described in Section 2.3.5 of the main document and are shown in Table L-2.

Table L-2. 95th percentile χ/Q 's for 222-S Laboratory.

Receptor	χ/Q' (s/m ³)
CW at 100 m	1.09 E-2
Onsite public at 3.4 km	1.02 E-4
MOI at site boundary	1.13 E-5

Notes:

CW = collocated worker.

MOI = maximum offsite individual.

The GXQ input and run file with these results is attached.

Reference

HNF-12125, 2004, *222-S Laboratory Documented Safety Analysis*, Rev. 1, CH2M HILL
Hanford Group, Inc., Richland Washington.

RPP-13482 REV 7

ATTACHMENT L1

**GXQ INPUT AND RUN FILES FOR RELEASES FROM 222-S LABORATORY
WITH BUILDING WAKE CORRECTION**

RPP-13482 REV 7

```

222-S Lab X/Q update for DSA
c GXQ Version 4.0 Input File
  1 = mode
c MODE SELECTION:
c 1 - X/Q based on site-specific wind data from JOINTFRE.IN
c 2 - X/Q based on input stability class and wind speed
c 3 - X/Q plot file table is created
c
c SITE WIND & POPULATION OPTIONS:
c ifox inorm icdf ichk isite ipop
  T   f   f   f   T   f
c ifox = T compute probabilistic X/Q from a cumulative distribution
c       = F compute annual average X/Q (usually sector average with ipm=3)
c inorm = T normalize joint frequency data in a sector (as in GENII)
c       = F use joint frequency data as is
c icdf  = T put cumulative distributions in the CDF.OUT file
c       = F no cumulative distribution file created
c ichk  = T show details for each X/Q (long output)
c       = F standard length output
c isite = T compute overall site X/Q (need groups of 16 sectors)
c       = F compute X/Q for individual sectors
c ipop  = T population-weighted using the file POP.IN (use ipm=3)
c       = F no population weighting
c
c GAUSSIAN PLUME/PUFF MODEL OPTIONS: (enter 0 to inactivate option)
c ipuff idep isrc iwind
  0     0     0     0
c iwake ipm iflow ientr
  1     0     0     0
c irise igrnd iwash igrav
  0     0     0     0
c ipuff = 0 compute time-integrated air concentrations (s/m3)
c       = 1 compute air concentrations (1/m3) (need release duration)
c idep  = 1 plume depletion model (source depletion)
c isrc  = 1 multiply X/Q by scale factor (input below)
c       = 2 multiply by wind speed function: (factor)*[speed**(exponent)]
c       = 3 multiply by wind speed function: (factor)*[10**(speed*exponent)]
c iwind = 1 wind speed corrected for plume height using power law
c iwake = 1 NRC Reg Guide 1.145 building wake model
c       = 2 MACCS virtual source building wake model
c ipm   = 1 NRC Reg Guide 1.145 plume meander model
c       = 2 MACCS time-dependent plume meander model
c       = 3 sector average X/Q computed
c iflow = 1 exhaust flow rate adjustment using virtual source method
c ientr = 1 entrainment method of Pasquill
c irise = 1 MACCS buoyant plume rise (uses building height)
c       = 2 ISC momentum/buoyancy plume rise
c igrnd = 1 modifies buoyant plume rise for ground-level effects
c iwash = 1 stack downwash
c igrav = 1 gravitational settling
c
c PARAMETER INPUT:
c release      anemometer      mixing      % of X/Q
c height,m     height,m (*)    height,m    larger
c 0            10             1000         5.0
c (* In MODE=1 this input is superceded by the value read from JOINTFRE.IN)
c
c building     building      release      deposition      gravitational
c width,m      height,m      duration,h   speed,m/s       settling,m/s
c 32.6         9.1          0           0              0
c
c ambient      stack gas      stack flow   stack(pool)     heat exhaust
c temp,C       temp,C        rate,m3/s    diameter,m       rate,W (**)
c 20           20            0           0              0
c (** If this is 0 then buoyant flux computed from temps & flow rate)
c
c scale        speed
c factor       exponent
c 1            0.78
c
c RECEPTOR LOCATIONS (no line limit, 3 kinds)
c MODE = 1 wind data read from JOINTFRE.IN

```

RPP-13482 REV 7

```

c   input:  sector, distance, elevation
c   MODE = 2  user supplies stability class, wind speed and receptor X,Y,Z
c   input:  class, windspeed, distance, offset, elevation
c   MODE = 3  output file has X/Q table for plotting isopleths (note Z=0)
c   input:  class, windspeed, xmax, xint, ymax, yint, xmin, power
c
c RECEPTOR PARAMETERS
c   sector = 0, 1, 2, . . . (all, S, SSW, SW, WSW, etc.)
c   distance (X) = receptor distance from point of release (m)
c   offset (Y) = offset from plume centerline (m)
c   elevation (Z) = height of receptor above grade (m)
c   class = 1,2,3,4,5,6,7 (Pasquill stability A,B,C,D,E,F,G)
c   windspeed = anemometer wind speed (m/s)
c   xmax,xint = maximum distance (m) and number of distance intervals
c   ymax,yint = maximum offset distance (m) and number of distance intervals
c   xmin    = minimum value of X/Q to show on table (s/m3 or 1/m3)
c   power   = exponent in power function step size (1 or 2)
c
c sector  distance  elevation
0         100        0      collocated worker
0         3400        0      HW-240 (onsite public)
1        12580        0      MOI (site boundary)
2        12580        0
3        13620        0
4        12950        0
5        12950        0
6        12950        0
7        14110        0
8        17130        0
9        19070        0
10       24170        0
11       24530        0
12       23160        0
13       23160        0
14       26540        0
15       19400        0
16       14570        0

```

RPP-13482 REV 7

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 09/27/04
Run Time = 13:51:29.92

INPUT ECHO:

```
222-S Lab X/Q update for DSA
c GXQ Version 4.0 Input File
  1
c MODE SELECTION:
c   1 - X/Q based on site-specific wind data from JOINTFRE.IN
c   2 - X/Q based on input stability class and wind speed
c   3 - X/Q plot file table is created
c
c SITE WIND & POPULATION OPTIONS:
c   ifox inorm icdf ichk isite ipop
c     T   F   F   F   T   F
c   ifox = T compute probabilistic X/Q from a cumulative distribution
c     = F compute annual average X/Q (usually sector average with ipm=3)
c   inorm = T normalize joint frequency data in a sector (as in GENII)
c     = F use joint frequency data as is
c   icdf = T put cumulative distributions in the CDF.OUT file
c     = F no cumulative distribution file created
c   ichk = T show details for each X/Q (long output)
c     = F standard length output
c   isite = T compute overall site X/Q (need groups of 16 sectors)
c     = F compute X/Q for individual sectors
c   ipop = T population-weighted using the file POP.IN (use ipm=3)
c     = F no population weighting
c
c GAUSSIAN PLUME/PUFF MODEL OPTIONS: (enter 0 to inactivate option)
c   ipuff idep isrc iwind
c     0   0   0   0
c   iwake ipm iflow ientr
c     1   0   0   0
c   irise igrnd iwash igrav
c     0   0   0   0
c   ipuff = 0 compute time-integrated air concentrations (s/m3)
c     = 1 compute air concentrations (1/m3) (need release duration)
c   idep = 1 plume depletion model (source depletion)
c   isrc = 1 multiply X/Q by scale factor (input below)
c     = 2 multiply by wind speed function: (factor)*[speed**(exponent)]
c     = 3 multiply by wind speed function: (factor)*[10**(speed*exponent)]
c   iwind = 1 wind speed corrected for plume height using power law
c   iwake = 1 NRC Reg Guide 1.145 building wake model
c     = 2 MACCS virtual source building wake model
c   ipm = 1 NRC Reg Guide 1.145 plume meander model
c     = 2 MACCS time-dependent plume meander model
c     = 3 sector average X/Q computed
c   iflow = 1 exhaust flow rate adjustment using virtual source method
c   ientr = 1 entrainment method of Pasquill
c   irise = 1 MACCS buoyant plume rise (uses building height)
c     = 2 ISC momentum/buoyancy plume rise
```

RPP-13482 REV 7

```

c igrnd = 1 modifies buoyant plume rise for ground-level effects
c iwash = 1 stack downwash
c igrav = 1 gravitational settling
c
c PARAMETER INPUT:
c release anemometer mixing % of X/Q
c height,m height,m (*) height,m larger
c 0.00000E+00 1.00000E+01 1.00000E+03 5.00000E+00
c (* In MODE=1 this input is superceded by the value read from JOINTFRE.IN)
c
c building building release deposition gravitational
c width,m height,m duration,h speed,m/s settling,m/s
c 3.26000E+01 9.10000E+00 0.00000E+00 0.00000E+00 0.00000E+00
c
c ambient stack gas stack flow stack(pool) heat exhaust
c temp,C temp,C rate,m3/s diameter,m rate,W (**)
c 2.00000E+01 2.00000E+01 0.00000E+00 0.00000E+00 0.00000E+00
c (** If this is 0 then buoyant flux computed from temps & flow rate)
c
c scale speed
c factor exponent
c 1.00000E+00 7.80000E-01
c
c RECEPTOR LOCATIONS (no line limit, 3 kinds)
c MODE = 1 wind data read from JOINTFRE.IN
c input: sector, distance, elevation
c MODE = 2 user supplies stability class, wind speed and receptor X,Y,Z
c input: class, windspeed, distance, offset, elevation
c MODE = 3 output file has X/Q table for plotting isopleths (note Z=0)
c input: class, windspeed, xmax, xint, ymax, yint, xqmin, power
c
c RECEPTOR PARAMETERS
c sector = 0, 1, 2, . . . (all, S, SSW, SW, WSW, etc.)
c distance (X) = receptor distance from point of release (m)
c offset (Y) = offset from plume centerline (m)
c elevation (Z) = height of receptor above grade (m)
c class = 1,2,3,4,5,6,7 (Pasquill stability A,B,C,D,E,F,G)
c windspeed = anemometer wind speed (m/s)
c xmax,xint = maximum distance (m) and number of distance intervals
c ymax,yint = maximum offset distance (m) and number of distance intervals
c xqmin = minimum value of X/Q to show on table (s/m3 or 1/m3)
c power = exponent in power function step size (1 or 2)
c
c sector distance elevation

```

MODE:

Site specific X/Q calculated.

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.

X/Q calculated for overall site.

MODELS SELECTED:

Time-integrated air concentration calculated (s/m3).
NRC RG 1.145 building wake model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

222-S Lab X/Q update for DSA

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)

RPP-13482 REV 7

ALL	100	0	99.94	1	1.09E-02	1.09E-02	F	0.89
ALL	3400	0	99.94	1	1.02E-04	1.02E-04	F	0.89
ALL	14570	0	99.94	1	1.13E-05	1.13E-05	F	0.89

RPP-13482 REV 7

APPENDIX M

**SPECIAL χ /Q'S FOR POOL FIRES AT THE
DEMONSTRATION BULK VITRIFICATION SYSTEM**

This page intentionally left blank.

APPENDIX M

**SPECIAL χ/Q 'S FOR POOL FIRES AT THE
DEMONSTRATION BULK VITRIFICATION SYSTEM**

A set of χ/Q 's was calculated for several postulated liquid fuel pool fires at the Demonstration Bulk Vitrification System (DBVS) using GXQ version 4.0F. These fires, corresponding to 100 gal, 800 gal, and 10,000 gal spills are shown with their specified convective heat rates and fire diameters in Table M-1. The resulting χ/Q ' values are shown for the collocated worker (CW) and the maximum offsite individual (MOI). The χ/Q 's for the MOI were calculated assuming the site boundary distances shown in Table 2-3 of the main document. The convective heat rates shown are the heat rates applied to the gases issuing from the fire. They do not include radiation or other losses.

Table M-1. 95th Percentile 1-hr χ/Q 's for Pool Fires at the Demonstration Bulk Vitrification System.

Spill Size (gal)	Convective Heat Rate (MW)	Pool Diameter (m)	χ/Q ' (s/m ³)	
			CW	MOI
100	24.3	5.25	3.04E-5	1.36E-6
800	128.2	13	6.28E-6	2.95E-7
10,000	1880	43	6.04E-7	1.47E-7

Notes:

CW = collocated worker.

MOI = maximum offsite individual.

These χ/Q 's were calculated using the MACCS buoyant plume model for ground fires as discussed in Section 2.3 of the main document. Corrections were included for the increase in wind speed with plume height and for initial air entrainment due to plume turbulence, including ground effects. Source width correction is included as part of the plume rise model. Plume meander effects cannot be applied to elevated plumes, so the 2-hr χ/Q 's are the same as the 1-hr χ/Q 's in this case.

A sample GXQ run file is included as Attachment X1. Note that the onsite χ/Q 's were calculated at 10-m intervals from 100 m to 150 m and for receptor heights of 0, 1, and 2 m to establish the worst cases. For all the cases shown in Table M-1 the maximum onsite χ/Q ' occurred at 100 m with a receptor height of 2 m. The site boundary is far enough from the release point that receptor height is not a factor.

RPP-13482 REV 7

ATTACHMENT M1

SAMPLE GXQ RUN FILE (Fire diameter = 13 m, Heat rate = 128.2 MW)

RPP-13482 REV 7

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 12/30/04
Run Time = 14:42:04.06

INPUT ECHO:

Bulk Vit pool fire 13.0 m diameter, 128.2 MW
c GXQ Version 4.0 Input File

1

c MODE SELECTION:

- c 1 - X/Q based on site-specific wind data from JOINTFRE.IN
- c 2 - X/Q based on input stability class and wind speed
- c 3 - X/Q plot file table is created

c

c SITE WIND & POPULATION OPTIONS:

- | | T | F | F | F | T | F |
|-----------------------------------|--|---|---|---|---|---|
| c ifox inorm icdf ichk isite ipop | | | | | | |
| c ifox = T | compute probabilistic X/Q from a cumulative distribution | | | | | |
| c = F | compute annual average X/Q (usually sector average with ipm=3) | | | | | |
| c inorm = T | normalize joint frequency data in a sector (as in GENII) | | | | | |
| c = F | use joint frequency data as is | | | | | |
| c icdf = T | put cumulative distributions in the CDF.OUT file | | | | | |
| c = F | no cumulative distribution file created | | | | | |
| c ichk = T | show details for each X/Q (long output) | | | | | |
| c = F | standard length output | | | | | |
| c isite = T | compute overall site X/Q (need groups of 16 sectors) | | | | | |
| c = F | compute X/Q for individual sectors | | | | | |
| c ipop = T | population-weighted using the file POP.IN (use ipm=3) | | | | | |
| c = F | no population weighting | | | | | |

c

c GAUSSIAN PLUME/PUFF MODEL OPTIONS: (enter 0 to inactivate option)

- | | | | | |
|---------------------------|--|--|--|--|
| c ipuff idep isrc iwind | | | | |
| 0 0 0 1 | | | | |
| c iwake ipm iflow ientr | | | | |
| 0 0 0 1 | | | | |
| c irise igrnd iwash igrav | | | | |
| 1 1 0 0 | | | | |
| c ipuff = 0 | compute time-integrated air concentrations (s/m3) | | | |
| c = 1 | compute air concentrations (1/m3) (need release duration) | | | |
| c idep = 1 | plume depletion model (source depletion) | | | |
| c isrc = 1 | multiply X/Q by scale factor (input below) | | | |
| c = 2 | multiply by wind speed function: (factor)*[speed**(exponent)] | | | |
| c = 3 | multiply by wind speed function: (factor)*[10**(speed*exponent)] | | | |
| c iwind = 1 | wind speed corrected for plume height using power law | | | |
| c iwake = 1 | NRC Reg Guide 1.145 building wake model | | | |
| c = 2 | MACCS virtual source building wake model | | | |
| c ipm = 1 | NRC Reg Guide 1.145 plume meander model | | | |
| c = 2 | MACCS time-dependent plume meander model | | | |
| c = 3 | sector average X/Q computed | | | |
| c iflow = 1 | exhaust flow rate adjustment using virtual source method | | | |
| c ientr = 1 | entrainment method of Pasquill | | | |
| c irise = 1 | MACCS buoyant plume rise (uses building height) | | | |
| c = 2 | ISC momentum/buoyancy plume rise | | | |

RPP-13482 REV 7

```

c igrnd = 1 modifies buoyant plume rise for ground-level effects
c iwash = 1 stack downwash
c igrav = 1 gravitational settling
c
c PARAMETER INPUT:
c release      anemometer      mixing      % of X/Q
c height,m     height,m (*)    height,m     larger
c 0.00000E+00  1.00000E+01      1.00000E+03  5.00000E+00
c (* In MODE=1 this input is superseded by the value read from JOINTFRE.IN)
c
c building      building      release      deposition      gravitational
c width,m       height,m     duration,h   speed,m/s       settling,m/s
c 0.00000E+00   0.00000E+00   0.00000E+00 0.00000E+00     0.00000E+00
c
c ambient      stack gas      stack flow   stack(pool)     heat exhaust
c temp,C       temp,C        rate,m3/s    diameter,m      rate,W (**)
c 2.00000E+01  2.00000E+01      0.00000E+00 1.30000E+01     1.28200E+08
c (** If this is 0 then buoyant flux computed from temps & flow rate)
c
c scale        speed
c factor       exponent
c 1.00000E+00  7.80000E-01
c
c RECEPTOR LOCATIONS (no line limit, 3 kinds)
c MODE = 1 wind data read from JOINTFRE.IN
c input: sector, distance, elevation
c MODE = 2 user supplies stability class, wind speed and receptor X,Y,Z
c input: class, windspeed, distance, offset, elevation
c MODE = 3 output file has X/Q table for plotting isopleths (note Z=0)
c input: class, windspeed, xmax, xint, ymax, yint, xmin, power
c
c RECEPTOR PARAMETERS
c sector = 0, 1, 2, . . . (all, S, SSW, SW, WSW, etc.)
c distance (X) = receptor distance from point of release (m)
c offset (Y) = offset from plume centerline (m)
c elevation (Z) = height of receptor above grade (m)
c class = 1,2,3,4,5,6,7 (Pasquill stability A,B,C,D,E,F,G)
c windspeed = anemometer wind speed (m/s)
c xmax,xint = maximum distance (m) and number of distance intervals
c ymax,yint = maximum offset distance (m) and number of distance intervals
c xmin = minimum value of X/Q to show on table (s/m3 or 1/m3)
c power = exponent in power function step size (1 or 2)
c
c sector distance elevation

MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
Plume rise air entrainment model selected.
MACCS buoyancy plume rise model based on convective heat.
Mills buoyant rise modification for pool fire selected.
Wind velocity corrected for average plume height.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:
200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

```

Bulk Vit pool fire 13.0 m diameter, 128.2 MW

RECEPT	SECT.	TOTAL POPULATION SCALED	AVERAGE INDIVIDUAL SCALED	ATM.	WIND
--------	-------	-------------------------------	---------------------------------	------	------

RPP-13482 REV 7

SECTOR	DISTANCE (m)	HEIGHT (m)	FREQ. (%)	POPULATION	X/Q (s/m3)	X/Q (s/m3)	STAB. CLASS	SPEED (m/s)
ALL	100	0	99.94	1	5.80E-06	5.80E-06	B	7.15
ALL	110	0	99.94	1	4.98E-06	4.98E-06	B	7.15
ALL	120	0	99.94	1	4.36E-06	4.36E-06	B	7.15
ALL	130	0	99.94	1	3.87E-06	3.87E-06	B	7.15
ALL	140	0	99.94	1	3.48E-06	3.48E-06	B	7.15
ALL	150	0	99.94	1	3.16E-06	3.16E-06	B	7.15
ALL	100	1	99.94	1	5.97E-06	5.97E-06	B	7.15
ALL	110	1	99.94	1	5.10E-06	5.10E-06	B	7.15
ALL	120	1	99.94	1	4.45E-06	4.45E-06	B	7.15
ALL	130	1	99.94	1	3.94E-06	3.94E-06	B	7.15
ALL	140	1	99.94	1	3.54E-06	3.54E-06	B	7.15
ALL	150	1	99.94	1	3.21E-06	3.21E-06	B	7.15
ALL	100	2	99.94	1	6.28E-06	6.28E-06	E	9.80
ALL	110	2	99.94	1	5.30E-06	5.30E-06	E	9.80
ALL	120	2	99.94	1	4.57E-06	4.57E-06	E	9.80
ALL	130	2	99.94	1	4.01E-06	4.01E-06	E	9.80
ALL	140	2	99.94	1	3.57E-06	3.57E-06	E	9.80
ALL	150	2	99.94	1	3.22E-06	3.22E-06	E	9.80
ALL	15360	0	99.94	1	2.95E-07	2.95E-07	F	2.65

This page intentionally left blank.

APPENDIX N

**SPECIAL χ /Q'S FOR POOL FIRES AT THE CONTACT-HANDLED TRANSURANIC
MIXED WASTE PACKAGING UNIT**

RPP-13482 REV 7

This page intentionally left blank.

APPENDIX N

SPECIAL χ/Q 'S FOR POOL FIRES AT THE CONTACT-HANDLED TRANSURANIC MIXED WASTE PACKAGING UNIT

A set of χ/Q 's was calculated for two postulated liquid fuel pool fires at the Contact-Handled Transuranic Mixed (CH-TRUM) Waste Packaging Unit using GXQ version 4.0F. These fires are shown with their specified convective heat rates and fire diameters in Table N-1. The resulting χ/Q ' values are shown for the collocated worker (CW) and the maximum offsite individual (MOI). The χ/Q 's for the MOI were calculated assuming the site boundary distances shown in Table 2-3 of the main document. The convective heat rates shown are the heat rates applied to the gases issuing from the fire. They do not include radiation or other losses.

Table N-1. 95th Percentile 1-hr χ/Q 's for Pool Fires at the Contact-Handled Transuranic Mixed Waste Packaging Unit.

Convective Heat Rate (MW)	Pool Diameter (m)	χ/Q ' (s/m ³)	
		CW	MOI
24.2	4.8	2.89E-5	1.35E-6
289	16.9	2.59E-6	1.71E-7

These χ/Q 's were calculated using the MACCS buoyant plume model for ground fires as discussed in Section 2.3 of the main document. Corrections were included for the increase in wind speed with plume height and for initial air entrainment due to plume turbulence, including ground effects. Source width correction is included as part of the plume rise model. Plume meander effects cannot be applied to elevated plumes, so the 2-hr χ/Q 's are the same as the 1-hr χ/Q 's in this case.

A sample GXQ run file is included as Attachment N1. Note that the onsite χ/Q 's were calculated at 10-m intervals from 100 m to 150 m and for receptor heights of 0, 1, and 2 m to establish the worst cases. For all the cases shown in Table N-1 the maximum onsite χ/Q ' occurred at 100 m with a receptor height of 2 m. The site boundary is far enough from the release point that receptor height is not a factor.

RPP-13482 REV 7

ATTACHMENT N1

SAMPLE GXQ RUN FILE (Fire diameter = 4.8 m, Heat rate = 24.2 MW)

RPP-13482 REV 7

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 02/09/05
Run Time = 15:34:49.80

INPUT ECHO:

CH-TRUM pool fire 4.8 m diameter, 24.2 MW

c GXQ Version 4.0 Input File

1

c MODE SELECTION:

c 1 - X/Q based on site-specific wind data from JOINTFRE.IN

c 2 - X/Q based on input stability class and wind speed

c 3 - X/Q plot file table is created

c

c SITE WIND & POPULATION OPTIONS:

c ifox inorm icdf ichk isite ipop

T F F F T F

c ifox = T compute probabilistic X/Q from a cumulative distribution

c = F compute annual average X/Q (usually sector average with ipm=3)

c inorm = T normalize joint frequency data in a sector (as in GENII)

c = F use joint frequency data as is

c icdf = T put cumulative distributions in the CDF.OUT file

c = F no cumulative distribution file created

c ichk = T show details for each X/Q (long output)

c = F standard length output

c isite = T compute overall site X/Q (need groups of 16 sectors)

c = F compute X/Q for individual sectors

c ipop = T population-weighted using the file POP.IN (use ipm=3)

c = F no population weighting

c

c GAUSSIAN PLUME/PUFF MODEL OPTIONS: (enter 0 to inactivate option)

c ipuff idep isrc iwind

0 0 0 1

c iwake ipm iflow ientr

0 0 0 1

c irise igrnd iwash igrav

1 1 0 0

c ipuff = 0 compute time-integrated air concentrations (s/m3)

c = 1 compute air concentrations (1/m3) (need release duration)

c idep = 1 plume depletion model (source depletion)

c isrc = 1 multiply X/Q by scale factor (input below)

c = 2 multiply by wind speed function: (factor)*[speed**(exponent)]

c = 3 multiply by wind speed function: (factor)*[10**(speed*exponent)]

c iwind = 1 wind speed corrected for plume height using power law

c iwake = 1 NRC Reg Guide 1.145 building wake model

c = 2 MACCS virtual source building wake model

c ipm = 1 NRC Reg Guide 1.145 plume meander model

c = 2 MACCS time-dependent plume meander model

c = 3 sector average X/Q computed

c iflow = 1 exhaust flow rate adjustment using virtual source method

c ientr = 1 entrainment method of Pasquill

RPP-13482 REV 7

```

c  irise = 1  MACCS buoyant plume rise (uses building height)
c           = 2  ISC momentum/buoyancy plume rise
c  igrnd = 1  modifies buoyant plume rise for ground-level effects
c  iwash = 1  stack downwash
c  igrav = 1  gravitational settling
c
c  PARAMETER INPUT:
c  release      anemometer      mixing      % of X/Q
c  height,m     height,m (*)    height,m    larger
c  0.00000E+00  1.00000E+01    1.00000E+03  5.00000E+00
c  (* In MODE=1 this input is superceded by the value read from JOINTFRE.IN)
c
c  building      building      release      deposition      gravitational
c  width,m       height,m     duration,h   speed,m/s       settling,m/s
c  0.00000E+00   0.00000E+00   0.00000E+00  0.00000E+00    0.00000E+00
c
c  ambient      stack gas      stack flow   stack(pool)     heat exhaust
c  temp,C       temp,C        rate,m3/s    diameter,m       rate,W (**)
c  2.00000E+01  2.00000E+01    0.00000E+00  4.80000E+00     2.42000E+07
c  (** If this is 0 then buoyant flux computed from temps & flow rate)
c
c  scale        speed
c  factor        exponent
c  1.00000E+00  7.80000E-01
c
c  RECEPTOR LOCATIONS (no line limit, 3 kinds)
c  MODE = 1  wind data read from JOINTFRE.IN
c  input:    sector, distance, elevation
c  MODE = 2  user supplies stability class, wind speed and receptor X,Y,Z
c  input:    class, windspeed, distance, offset, elevation
c  MODE = 3  output file has X/Q table for plotting isopleths (note Z=0)
c  input:    class, windspeed, xmax, xint, ymax, yint, xqmin, power
c
c  RECEPTOR PARAMETERS
c  sector = 0, 1, 2, . . . (all, S, SSW, SW, WSW, etc.)
c  distance (X) = receptor distance from point of release (m)
c  offset (Y) = offset from plume centerline (m)
c  elevation (Z) = height of receptor above grade (m)
c  class = 1,2,3,4,5,6,7 (Pasquill stability A,B,C,D,E,F,G)
c  windspeed = anemometer wind speed (m/s)
c  xmax,xint = maximum distance (m) and number of distance intervals
c  ymax,yint = maximum offset distance (m) and number of distance intervals
c  xqmin = minimum value of X/Q to show on table (s/m3 or 1/m3)
c  power = exponent in power function step size (1 or 2)
c
c  sector distance elevation

MODE:
Site specific X/Q calculated.

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for overall site.

MODELS SELECTED:
Time-integrated air concentration calculated (s/m3).
Plume rise air entrainment model selected.
MACCS buoyancy plume rise model based on convective heat.
Mills buoyant rise modification for pool fire selected.
Wind velocity corrected for average plume height.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:
200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

```

CH-TRUM pool fire 4.8 m diameter, 24.2 MW

RPP-13482 REV 7

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	2.58E-05	2.58E-05	G	19.00
ALL	110	0	99.94	1	2.14E-05	2.14E-05	G	19.00
ALL	120	0	99.94	1	1.83E-05	1.83E-05	G	19.00
ALL	130	0	99.94	1	1.58E-05	1.58E-05	G	19.00
ALL	140	0	99.94	1	1.39E-05	1.39E-05	G	19.00
ALL	150	0	99.94	1	1.52E-05	1.52E-05	B	7.15
ALL	100	1	99.94	1	2.67E-05	2.67E-05	B	7.15
ALL	110	1	99.94	1	2.34E-05	2.34E-05	B	7.15
ALL	120	1	99.94	1	2.08E-05	2.08E-05	B	7.15
ALL	130	1	99.94	1	1.87E-05	1.87E-05	B	7.15
ALL	140	1	99.94	1	1.73E-05	1.73E-05	G	19.00
ALL	150	1	99.94	1	1.52E-05	1.52E-05	G	19.00
ALL	100	2	99.94	1	2.89E-05	2.89E-05	B	7.15
ALL	110	2	99.94	1	2.50E-05	2.50E-05	B	7.15
ALL	120	2	99.94	1	2.20E-05	2.20E-05	B	7.15
ALL	130	2	99.94	1	1.96E-05	1.96E-05	B	7.15
ALL	140	2	99.94	1	1.77E-05	1.77E-05	B	7.15
ALL	150	2	99.94	1	1.61E-05	1.61E-05	B	7.15
ALL	15360	0	99.94	1	1.35E-06	1.35E-06	G	0.89

APPENDIX O

SPECIAL γ/Q' FOR A 155-FT STACK

This page intentionally left blank.

APPENDIX O**SPECIAL χ/Q' FOR A 155-FT STACK**

The Demonstration Bulk Vitrification System (DBVS) is likely to have a stack approximately 155 ft tall and with an outside diameter at the top of 24 in. For the purposes of evaluating proposed designs, air transport factors were calculated for various flow rates using an inside diameter of 24 in. This assumption removes the stack wall thickness from consideration. It also adds a small conservatism because increasing the diameter lowers the vertical exit speed from the top of the stack (for a given flow rate). Thus, there is less plume rise, larger air concentrations, and greater doses.

Air transport factors (χ/Q') were calculated using GXQ Version 4.0F (WHC-SD-GN-SWD-30002) for stack flow rates ranging from 10 ft³/min to 30,000 ft³/min (0.00472 to 14.16 m³/s). The low number represents essentially no flow from the stack, while the larger number exceeds the current theoretical maximum flow rate. In addition, various distances downwind and receptor elevations (0 m, 1 m, and 2 m) were used to determine the worst onsite and offsite (Hanford Site boundary) locations.

Modeling assumptions used as input to GXQ include momentum plume rise using the ISC method, wind speed adjustment with elevations above 10 m using the GXQ method, source flow rate adjustment, air entrainment effects at the point of release, and stack downwash effects. In addition, the stack gas and ambient temperature are both assumed to be 20 °C, so there is not thermal rise. The stack height was input as 155 ft (47.244 m) with a diameter of 2 ft (0.6096 m). The overall site 95th percentile χ/Q' were calculated using wind data collected at the Hanford Meteorological Station (HMS) from 1983 to 1991.

Numeric values for χ/Q' from a 155-ft stack are listed in Table O-1. The table also includes information about the distance to the worst-case onsite receptor. During an accident, the stack flow rate cannot be guaranteed (if the stack remains upright). The worst case is to use the minimum flow rate of 10 ft³/min.

The χ/Q' results are also shown graphically in Figure O-1. The method of interpolation to other stack flow rates described in Section 2.3.2 for short stacks is also suitable for 155-ft stacks also. Sample input and output files are included at the end of this appendix.

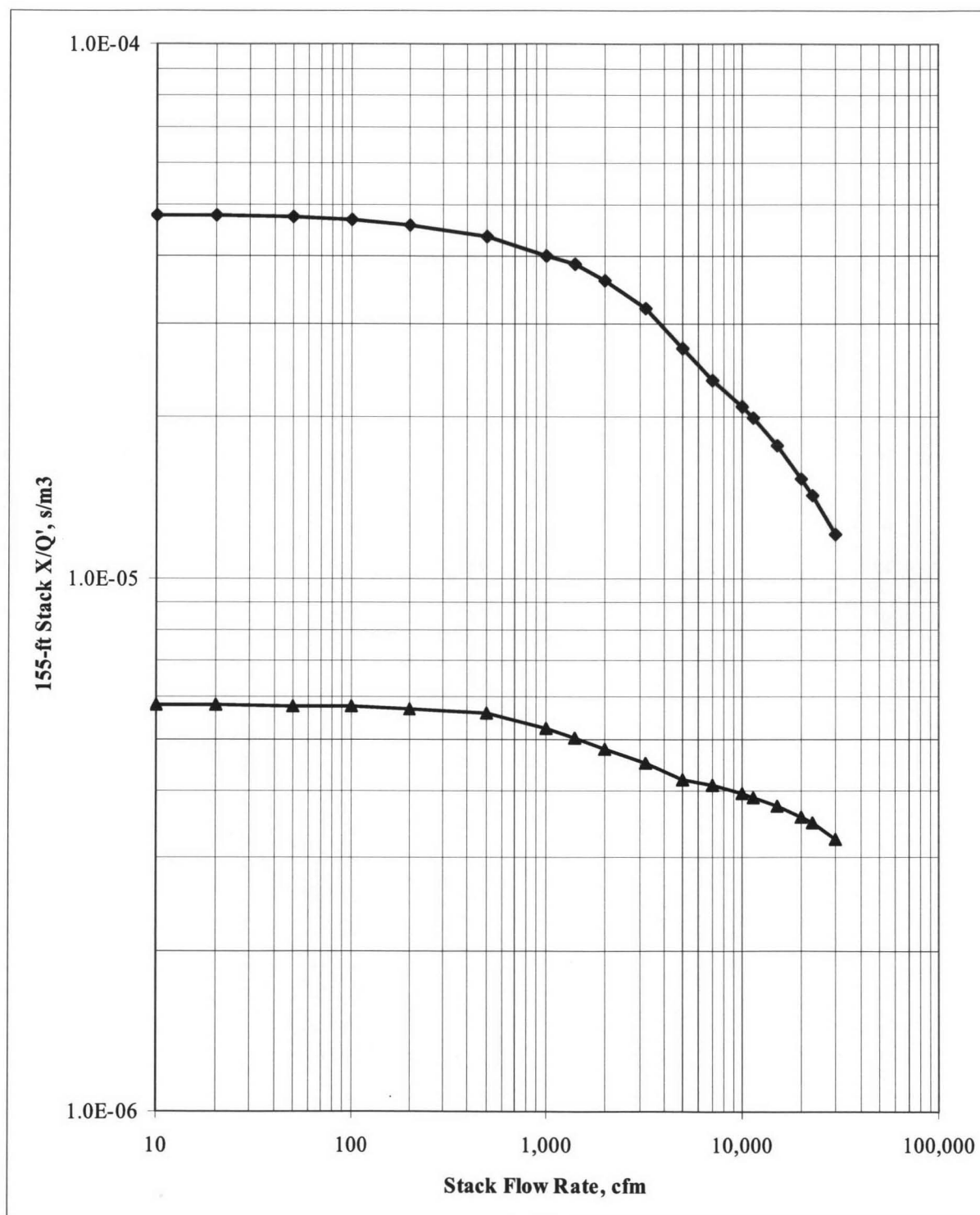
Table O-1. All-Sector 95th Percentile, 1-hr χ/Q' for 155-ft Stacks for Various Exhaust Flow Rates.

Stack Flow Rate		Worst-Case Onsite Receptor		Hanford Site Boundary
Conventional	SI Units	χ/Q' , s/m ³	Distance	χ/Q' , s/m ³
10 ft ³ /min	0.00472 m ³ /s	4.77E-05	270 m	5.78E-06
20 ft ³ /min	0.00944 m ³ /s	4.76E-05	270 m	5.78E-06
50 ft ³ /min	0.0236 m ³ /s	4.73E-05	270 m	5.76E-06
100 ft ³ /min	0.0472 m ³ /s	4.68E-05	270 m	5.74E-06
200 ft ³ /min	0.0944 m ³ /s	4.57E-05	270 m	5.70E-06
500 ft ³ /min	0.236 m ³ /s	4.35E-05	280 m	5.58E-06
1,000 ft ³ /min	0.472 m ³ /s	4.00E-05	290 m	5.24E-06
1,400 ft ³ /min	0.661 m ³ /s	3.86E-05	300 m	5.02E-06
2,000 ft ³ /min	0.944 m ³ /s	3.60E-05	300 m	4.78E-06
3,200 ft ³ /min	1.51 m ³ /s	3.19E-05	310 m	4.50E-06
5,000 ft ³ /min	2.36 m ³ /s	2.68E-05	320 m	4.19E-06
7,000 ft ³ /min	3.30 m ³ /s	2.34E-05	270 m	4.09E-06
10,000 ft ³ /min	4.72 m ³ /s	2.09E-05	280 m	3.94E-06
11,400 ft ³ /min	5.38 m ³ /s	1.99E-05	280 m	3.88E-06
15,000 ft ³ /min	7.08 m ³ /s	1.77E-05	290 m	3.74E-06
20,000 ft ³ /min	9.44 m ³ /s	1.53E-05	300 m	3.57E-06
22,800 ft ³ /min	10.76 m ³ /s	1.43E-05	310 m	3.49E-06
30,000 ft ³ /min	14.16 m ³ /s	1.21E-05	330 m	3.25E-06

Note:

The stack diameter is 24 in. Ambient temperature is 20 °C.

SI = Standard international system of units.

Figure O-1. Onsite and Offsite χ/Q' as a Function of Stack Flow Rate.

GXQ Input and Output Files for a 11,400 ft³/min Stack

```

Stack: 155 ft Height, 2 ft Diameter, 11,400 cfm, ISC Rise
1 = mode -- GXQ Version 4.0 Input File
c ifox inorm icdf ichk isite ipop
  t      f      f      f      t      f
c ipuff idep isrc iwind
  0      0      0      1
c iwake ipm  iflow ientr
  0      0      1      1
c irise igrnd iwash igrav
  2      0      1      0
c release          anemometer      mixing      frequency
c height,m        height,m        height,m    to exceed
  47.244          10              1000         5
c building        building          release      deposition      gravitational
c width,m         height,m         duration,h  speed,m/s        settling,m/s
  0              0                0           0             0
c ambient         stack gas         stack flow  stack(pool)      heat release
c temp, C         temp, C          rate,m3/s   diameter,m       rate,W
  20             20              5.380       0.6096          0
c scaling         Speed
c factor          Exponent
  1              0
c receptor specified using
c sector pop.dist elevation
  0          100      0      Onsite Worker at 0 m
  0          110      0
  0          120      0
  0          130      0
  0          140      0
  0          150      0
  0          160      0
  0          170      0
  0          180      0
  0          190      0
  0          200      0
  0          210      0
  0          220      0
  0          230      0
  0          240      0
  0          250      0
  0          260      0
  0          270      0
  0          280      0
  0          290      0
  0          300      0
  0          310      0
  0          320      0
  0          330      0
  0          340      0
  0          350      0
  0          360      0
  0          370      0
  0          380      0
  0          390      0
  0          400      0
  0          410      0
  0          420      0
  0          430      0

```

RPP-13482 REV 7

0	440	0	
0	450	0	
0	460	0	
0	470	0	
0	480	0	
0	490	0	
0	500	0	
0	520	0	
0	540	0	
0	560	0	
0	580	0	
0	600	0	
0	620	0	
0	640	0	
0	660	0	
0	680	0	
0	700	0	
0	720	0	
0	740	0	
0	760	0	
0	780	0	
0	800	0	
0	820	0	
0	840	0	
0	860	0	
0	880	0	
0	900	0	
0	920	0	
0	940	0	
0	960	0	
0	980	0	
0	1000	0	
1	15360	0	Hanford Site Boundary
2	15360	0	
3	13200	0	
4	11100	0	
5	11100	0	
6	11100	0	
7	10800	0	
8	8690	0	
9	8690	0	
10	8970	0	
11	10430	0	
12	10530	0	
13	11160	0	
14	15190	0	
15	21050	0	
16	15360	0	
0	100	1	Onsite Worker at 1 m
0	110	1	
0	120	1	
0	130	1	
0	140	1	
0	150	1	
0	160	1	
0	170	1	
0	180	1	
0	190	1	
0	200	1	
0	210	1	
0	220	1	
0	230	1	
0	240	1	

RPP-13482 REV 7

0	250	1	
0	260	1	
0	270	1	
0	280	1	
0	290	1	
0	300	1	
0	310	1	
0	320	1	
0	330	1	
0	340	1	
0	350	1	
0	360	1	
0	370	1	
0	380	1	
0	390	1	
0	400	1	
0	410	1	
0	420	1	
0	430	1	
0	440	1	
0	450	1	
0	460	1	
0	470	1	
0	480	1	
0	490	1	
0	500	1	
0	520	1	
0	540	1	
0	560	1	
0	580	1	
0	600	1	
0	620	1	
0	640	1	
0	660	1	
0	680	1	
0	700	1	
0	720	1	
0	740	1	
0	760	1	
0	780	1	
0	800	1	
0	820	1	
0	840	1	
0	860	1	
0	880	1	
0	900	1	
0	920	1	
0	940	1	
0	960	1	
0	980	1	
0	1000	1	
1	15360	1	Hanford Site Boundary
2	15360	1	
3	13200	1	
4	11100	1	
5	11100	1	
6	11100	1	
7	10800	1	
8	8690	1	
9	8690	1	
10	8970	1	
11	10430	1	
12	10530	1	

RPP-13482 REV 7

13	11160	1	
14	15190	1	
15	21050	1	
16	15360	1	
0	100	2	Onsite Worker at 2 m
0	110	2	
0	120	2	
0	130	2	
0	140	2	
0	150	2	
0	160	2	
0	170	2	
0	180	2	
0	190	2	
0	200	2	
0	210	2	
0	220	2	
0	230	2	
0	240	2	
0	250	2	
0	260	2	
0	270	2	
0	280	2	
0	290	2	
0	300	2	
0	310	2	
0	320	2	
0	330	2	
0	340	2	
0	350	2	
0	360	2	
0	370	2	
0	380	2	
0	390	2	
0	400	2	
0	410	2	
0	420	2	
0	430	2	
0	440	2	
0	450	2	
0	460	2	
0	470	2	
0	480	2	
0	490	2	
0	500	2	
0	520	2	
0	540	2	
0	560	2	
0	580	2	
0	600	2	
0	620	2	
0	640	2	
0	660	2	
0	680	2	
0	700	2	
0	720	2	
0	740	2	
0	760	2	
0	780	2	
0	800	2	
0	820	2	
0	840	2	
0	860	2	

RPP-13482 REV 7

0	880	2	
0	900	2	
0	920	2	
0	940	2	
0	960	2	
0	980	2	
0	1000	2	
1	15360	2	Hanford Site Boundary
2	15360	2	
3	13200	2	
4	11100	2	
5	11100	2	
6	11100	2	
7	10800	2	
8	8690	2	
9	8690	2	
10	8970	2	
11	10430	2	
12	10530	2	
13	11160	2	
14	15190	2	
15	21050	2	
16	15360	2	

GXQ Version 4.0F
October 9, 2002

General Purpose Atmospheric Dispersion Code
Produced by Fluor Federal Services, Inc.

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Paul D. Rittmann, PhD CHP
Fluor Federal Services, Inc. E6-17
P.O. Box 1050
Richland, WA 99352-1050
(509) 376-8715

Run Date = 06/12/06
Run Time = 15:45:13.97

INPUT ECHO:

Stack: 155 ft Height, 2 ft Diameter, 11,400 cfm, ISC Rise

1					
c	ifox	inorm	icdf	ichk	isite ipop
	T	F	F	F	T F
c	ipuff	idep	isrc	iwind	
	0	0	0	1	
c	iwake	ipm	iflow	ientr	
	0	0	1	1	
c	irise	igrnd	iwash	igrav	

RPP-13482 REV 7

```

      2      0      1      0
c  release      anemometer      mixing      frequency
c  height,m      height,m      height,m      to exceed
      4.72440E+01      1.00000E+01      1.00000E+03      5.00000E+00
c  building      building      release      deposition      gravitational
c  width,m      height,m      duration,h      speed,m/s      settling,m/s
      0.00000E+00      0.00000E+00      0.00000E+00      0.00000E+00      0.00000E+00
c  ambient      stack gas      stack flow      stack(pool)      heat release
c  temp, C      temp, C      rate,m3/s      diameter,m      rate,W
      2.00000E+01      2.00000E+01      5.38000E+00      6.09600E-01      0.00000E+00
c  scaling      Speed
c  factor      Exponent
      1.00000E+00      0.00000E+00
c  receptor specified using
c  sector pop.dist elevation

```

MODE:

Site specific X/Q calculated.

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.

No normalization of joint frequency.

X/Q calculated for overall site.

MODELS SELECTED:

Time-integrated air concentration calculated (s/m3).

Flow rate adjustment model.

Plume rise air entrainment model selected.

ISC2 momentum/buoyancy plume model based on temperature difference.

Stack downwash model selected.

Wind velocity corrected for average plume height.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

Created 8/26/92 KR

Stack: 155 ft Height, 2 ft Diameter, 11,400 cfm, ISC Rise

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.94	1	1.99E-07	1.99E-07	A	9.80
ALL	110	0	99.94	1	3.71E-07	3.71E-07	A	9.80
ALL	120	0	99.94	1	7.38E-07	7.38E-07	A	7.15
ALL	130	0	99.94	1	1.33E-06	1.33E-06	A	2.65
ALL	140	0	99.94	1	2.20E-06	2.20E-06	A	2.65
ALL	150	0	99.94	1	3.29E-06	3.29E-06	A	2.65
ALL	160	0	99.94	1	4.59E-06	4.59E-06	A	2.65
ALL	170	0	99.94	1	6.05E-06	6.05E-06	A	2.65
ALL	180	0	99.94	1	7.56E-06	7.56E-06	A	2.65
ALL	190	0	99.94	1	9.18E-06	9.18E-06	A	2.65
ALL	200	0	99.94	1	1.14E-05	1.14E-05	A	2.65
ALL	210	0	99.94	1	1.36E-05	1.36E-05	A	2.65
ALL	220	0	99.94	1	1.52E-05	1.52E-05	A	2.65
ALL	230	0	99.94	1	1.66E-05	1.66E-05	A	2.65
ALL	240	0	99.94	1	1.77E-05	1.77E-05	A	2.65
ALL	250	0	99.94	1	1.86E-05	1.86E-05	A	2.65

RPP-13482 REV 7

ALL	260	0	99.94	1	1.93E-05	1.93E-05	A	2.65
ALL	270	0	99.94	1	1.97E-05	1.97E-05	A	2.65
ALL	280	0	99.94	1	1.99E-05	1.99E-05	A	2.65
ALL	290	0	99.94	1	1.99E-05	1.99E-05	A	2.65
ALL	300	0	99.94	1	1.98E-05	1.98E-05	A	2.65
ALL	310	0	99.94	1	1.95E-05	1.95E-05	A	2.65
ALL	320	0	99.94	1	1.91E-05	1.91E-05	A	2.65
ALL	330	0	99.94	1	1.87E-05	1.87E-05	A	2.65
ALL	340	0	99.94	1	1.82E-05	1.82E-05	A	2.65
ALL	350	0	99.94	1	1.57E-05	1.57E-05	B	0.89
ALL	360	0	99.94	1	1.49E-05	1.49E-05	B	2.65
ALL	370	0	99.94	1	1.51E-05	1.51E-05	B	2.65
ALL	380	0	99.94	1	1.52E-05	1.52E-05	B	2.65
ALL	390	0	99.94	1	1.53E-05	1.53E-05	B	2.65
ALL	400	0	99.94	1	1.53E-05	1.53E-05	B	2.65
ALL	410	0	99.94	1	1.53E-05	1.53E-05	B	2.65
ALL	420	0	99.94	1	1.53E-05	1.53E-05	B	2.65
ALL	430	0	99.94	1	1.52E-05	1.52E-05	B	2.65
ALL	440	0	99.94	1	1.51E-05	1.51E-05	B	2.65
ALL	450	0	99.94	1	1.48E-05	1.48E-05	B	2.65
ALL	460	0	99.94	1	1.47E-05	1.47E-05	B	2.65
ALL	470	0	99.94	1	1.46E-05	1.46E-05	B	2.65
ALL	480	0	99.94	1	1.45E-05	1.45E-05	B	2.65
ALL	490	0	99.94	1	1.44E-05	1.44E-05	B	2.65
ALL	500	0	99.94	1	1.42E-05	1.42E-05	B	2.65
ALL	520	0	99.94	1	1.40E-05	1.40E-05	B	2.65
ALL	540	0	99.94	1	1.38E-05	1.38E-05	C	0.89
ALL	560	0	99.94	1	1.44E-05	1.44E-05	C	0.89
ALL	580	0	99.94	1	1.34E-05	1.34E-05	B	2.65
ALL	600	0	99.94	1	1.29E-05	1.29E-05	C	2.65
ALL	620	0	99.94	1	1.23E-05	1.23E-05	A	0.89
ALL	640	0	99.94	1	1.15E-05	1.15E-05	B	2.65
ALL	660	0	99.94	1	1.11E-05	1.11E-05	B	2.65
ALL	680	0	99.94	1	1.06E-05	1.06E-05	B	2.65
ALL	700	0	99.94	1	1.02E-05	1.02E-05	B	2.65
ALL	720	0	99.94	1	9.83E-06	9.83E-06	B	2.65
ALL	740	0	99.94	1	9.41E-06	9.41E-06	B	2.65
ALL	760	0	99.94	1	9.07E-06	9.07E-06	B	2.65
ALL	780	0	99.94	1	8.74E-06	8.74E-06	B	2.65
ALL	800	0	99.94	1	8.42E-06	8.42E-06	B	2.65
ALL	820	0	99.94	1	8.12E-06	8.12E-06	B	2.65
ALL	840	0	99.94	1	7.84E-06	7.84E-06	B	2.65
ALL	860	0	99.94	1	7.56E-06	7.56E-06	B	2.65
ALL	880	0	99.94	1	7.32E-06	7.32E-06	B	2.65
ALL	900	0	99.94	1	9.68E-06	9.68E-06	C	2.65
ALL	920	0	99.94	1	9.60E-06	9.60E-06	C	2.65
ALL	940	0	99.94	1	9.51E-06	9.51E-06	C	2.65
ALL	960	0	99.94	1	9.42E-06	9.42E-06	C	2.65
ALL	980	0	99.94	1	9.33E-06	9.33E-06	C	2.65
ALL	1000	0	99.94	1	9.23E-06	9.23E-06	C	2.65
ALL	15360	0	99.94	1	3.88E-06	3.88E-06	E	0.89
ALL	100	1	99.94	1	2.04E-07	2.04E-07	A	9.80
ALL	110	1	99.94	1	3.85E-07	3.85E-07	A	9.80
ALL	120	1	99.94	1	7.50E-07	7.50E-07	A	7.15
ALL	130	1	99.94	1	1.35E-06	1.35E-06	A	2.65
ALL	140	1	99.94	1	2.22E-06	2.22E-06	A	2.65
ALL	150	1	99.94	1	3.31E-06	3.31E-06	A	2.65
ALL	160	1	99.94	1	4.62E-06	4.62E-06	A	2.65
ALL	170	1	99.94	1	6.07E-06	6.07E-06	A	2.65
ALL	180	1	99.94	1	7.58E-06	7.58E-06	A	2.65
ALL	190	1	99.94	1	9.20E-06	9.20E-06	A	2.65
ALL	200	1	99.94	1	1.14E-05	1.14E-05	A	2.65
ALL	210	1	99.94	1	1.36E-05	1.36E-05	A	2.65

RPP-13482 REV 7

ALL	220	1	99.94	1	1.52E-05	1.52E-05 A	2.65
ALL	230	1	99.94	1	1.66E-05	1.66E-05 A	2.65
ALL	240	1	99.94	1	1.77E-05	1.77E-05 A	2.65
ALL	250	1	99.94	1	1.86E-05	1.86E-05 A	2.65
ALL	260	1	99.94	1	1.93E-05	1.93E-05 A	2.65
ALL	270	1	99.94	1	1.97E-05	1.97E-05 A	2.65
ALL	280	1	99.94	1	1.99E-05	1.99E-05 A	2.65
ALL	290	1	99.94	1	1.99E-05	1.99E-05 A	2.65
ALL	300	1	99.94	1	1.98E-05	1.98E-05 A	2.65
ALL	310	1	99.94	1	1.95E-05	1.95E-05 A	2.65
ALL	320	1	99.94	1	1.91E-05	1.91E-05 A	2.65
ALL	330	1	99.94	1	1.87E-05	1.87E-05 A	2.65
ALL	340	1	99.94	1	1.82E-05	1.82E-05 A	2.65
ALL	350	1	99.94	1	1.57E-05	1.57E-05 B	0.89
ALL	360	1	99.94	1	1.49E-05	1.49E-05 B	2.65
ALL	370	1	99.94	1	1.51E-05	1.51E-05 B	2.65
ALL	380	1	99.94	1	1.52E-05	1.52E-05 B	2.65
ALL	390	1	99.94	1	1.53E-05	1.53E-05 B	2.65
ALL	400	1	99.94	1	1.53E-05	1.53E-05 B	2.65
ALL	410	1	99.94	1	1.53E-05	1.53E-05 B	2.65
ALL	420	1	99.94	1	1.53E-05	1.53E-05 B	2.65
ALL	430	1	99.94	1	1.52E-05	1.52E-05 B	2.65
ALL	440	1	99.94	1	1.51E-05	1.51E-05 B	2.65
ALL	450	1	99.94	1	1.48E-05	1.48E-05 B	2.65
ALL	460	1	99.94	1	1.48E-05	1.48E-05 B	2.65
ALL	470	1	99.94	1	1.46E-05	1.46E-05 B	2.65
ALL	480	1	99.94	1	1.45E-05	1.45E-05 B	2.65
ALL	490	1	99.94	1	1.44E-05	1.44E-05 B	2.65
ALL	500	1	99.94	1	1.42E-05	1.42E-05 B	2.65
ALL	520	1	99.94	1	1.40E-05	1.40E-05 B	2.65
ALL	540	1	99.94	1	1.38E-05	1.38E-05 C	0.89
ALL	560	1	99.94	1	1.44E-05	1.44E-05 C	0.89
ALL	580	1	99.94	1	1.34E-05	1.34E-05 B	2.65
ALL	600	1	99.94	1	1.29E-05	1.29E-05 C	2.65
ALL	620	1	99.94	1	1.23E-05	1.23E-05 A	0.89
ALL	640	1	99.94	1	1.15E-05	1.15E-05 B	2.65
ALL	660	1	99.94	1	1.11E-05	1.11E-05 B	2.65
ALL	680	1	99.94	1	1.06E-05	1.06E-05 B	2.65
ALL	700	1	99.94	1	1.02E-05	1.02E-05 B	2.65
ALL	720	1	99.94	1	9.83E-06	9.83E-06 B	2.65
ALL	740	1	99.94	1	9.40E-06	9.40E-06 B	2.65
ALL	760	1	99.94	1	9.06E-06	9.06E-06 B	2.65
ALL	780	1	99.94	1	8.74E-06	8.74E-06 B	2.65
ALL	800	1	99.94	1	8.42E-06	8.42E-06 B	2.65
ALL	820	1	99.94	1	8.12E-06	8.12E-06 B	2.65
ALL	840	1	99.94	1	7.84E-06	7.84E-06 B	2.65
ALL	860	1	99.94	1	7.56E-06	7.56E-06 B	2.65
ALL	880	1	99.94	1	7.32E-06	7.32E-06 B	2.65
ALL	900	1	99.94	1	9.68E-06	9.68E-06 C	2.65
ALL	920	1	99.94	1	9.60E-06	9.60E-06 C	2.65
ALL	940	1	99.94	1	9.51E-06	9.51E-06 C	2.65
ALL	960	1	99.94	1	9.42E-06	9.42E-06 C	2.65
ALL	980	1	99.94	1	9.33E-06	9.33E-06 C	2.65
ALL	1000	1	99.94	1	9.23E-06	9.23E-06 C	2.65
ALL	15360	1	99.94	1	3.88E-06	3.88E-06 E	0.89
ALL	100	2	99.94	1	2.20E-07	2.20E-07 A	9.80
ALL	110	2	99.94	1	4.07E-07	4.07E-07 A	9.80
ALL	120	2	99.94	1	7.86E-07	7.86E-07 A	7.15
ALL	130	2	99.94	1	1.40E-06	1.40E-06 A	2.65
ALL	140	2	99.94	1	2.28E-06	2.28E-06 A	2.65
ALL	150	2	99.94	1	3.38E-06	3.38E-06 A	2.65
ALL	160	2	99.94	1	4.69E-06	4.69E-06 A	2.65
ALL	170	2	99.94	1	6.14E-06	6.14E-06 A	2.65

RPP-13482 REV 7

ALL	180	2	99.94	1	7.65E-06	7.65E-06	A	2.65
ALL	190	2	99.94	1	9.27E-06	9.27E-06	A	2.65
ALL	200	2	99.94	1	1.15E-05	1.15E-05	A	2.65
ALL	210	2	99.94	1	1.37E-05	1.37E-05	A	2.65
ALL	220	2	99.94	1	1.53E-05	1.53E-05	A	2.65
ALL	230	2	99.94	1	1.66E-05	1.66E-05	A	2.65
ALL	240	2	99.94	1	1.78E-05	1.78E-05	A	2.65
ALL	250	2	99.94	1	1.87E-05	1.87E-05	A	2.65
ALL	260	2	99.94	1	1.93E-05	1.93E-05	A	2.65
ALL	270	2	99.94	1	1.97E-05	1.97E-05	A	2.65
ALL	280	2	99.94	1	1.99E-05	1.99E-05	A	2.65
ALL	290	2	99.94	1	1.99E-05	1.99E-05	A	2.65
ALL	300	2	99.94	1	1.98E-05	1.98E-05	A	2.65
ALL	310	2	99.94	1	1.95E-05	1.95E-05	A	2.65
ALL	320	2	99.94	1	1.91E-05	1.91E-05	A	2.65
ALL	330	2	99.94	1	1.87E-05	1.87E-05	A	2.65
ALL	340	2	99.94	1	1.82E-05	1.82E-05	A	2.65
ALL	350	2	99.94	1	1.58E-05	1.58E-05	B	0.89
ALL	360	2	99.94	1	1.49E-05	1.49E-05	B	2.65
ALL	370	2	99.94	1	1.51E-05	1.51E-05	B	2.65
ALL	380	2	99.94	1	1.52E-05	1.52E-05	B	2.65
ALL	390	2	99.94	1	1.53E-05	1.53E-05	B	2.65
ALL	400	2	99.94	1	1.53E-05	1.53E-05	B	2.65
ALL	410	2	99.94	1	1.53E-05	1.53E-05	B	2.65
ALL	420	2	99.94	1	1.53E-05	1.53E-05	B	2.65
ALL	430	2	99.94	1	1.52E-05	1.52E-05	B	2.65
ALL	440	2	99.94	1	1.52E-05	1.52E-05	B	2.65
ALL	450	2	99.94	1	1.48E-05	1.48E-05	B	2.65
ALL	460	2	99.94	1	1.48E-05	1.48E-05	B	2.65
ALL	470	2	99.94	1	1.47E-05	1.47E-05	B	2.65
ALL	480	2	99.94	1	1.45E-05	1.45E-05	B	2.65
ALL	490	2	99.94	1	1.44E-05	1.44E-05	B	2.65
ALL	500	2	99.94	1	1.43E-05	1.43E-05	B	2.65
ALL	520	2	99.94	1	1.40E-05	1.40E-05	B	2.65
ALL	540	2	99.94	1	1.38E-05	1.38E-05	C	0.89
ALL	560	2	99.94	1	1.44E-05	1.44E-05	C	0.89
ALL	580	2	99.94	1	1.34E-05	1.34E-05	B	2.65
ALL	600	2	99.94	1	1.30E-05	1.30E-05	C	2.65
ALL	620	2	99.94	1	1.23E-05	1.23E-05	A	0.89
ALL	640	2	99.94	1	1.15E-05	1.15E-05	B	2.65
ALL	660	2	99.94	1	1.11E-05	1.11E-05	B	2.65
ALL	680	2	99.94	1	1.06E-05	1.06E-05	B	2.65
ALL	700	2	99.94	1	1.02E-05	1.02E-05	B	2.65
ALL	720	2	99.94	1	9.83E-06	9.83E-06	B	2.65
ALL	740	2	99.94	1	9.40E-06	9.40E-06	B	2.65
ALL	760	2	99.94	1	9.06E-06	9.06E-06	B	2.65
ALL	780	2	99.94	1	8.74E-06	8.74E-06	B	2.65
ALL	800	2	99.94	1	8.42E-06	8.42E-06	B	2.65
ALL	820	2	99.94	1	8.12E-06	8.12E-06	B	2.65
ALL	840	2	99.94	1	7.83E-06	7.83E-06	B	2.65
ALL	860	2	99.94	1	7.56E-06	7.56E-06	B	2.65
ALL	880	2	99.94	1	7.32E-06	7.32E-06	B	2.65
ALL	900	2	99.94	1	9.69E-06	9.69E-06	C	2.65
ALL	920	2	99.94	1	9.61E-06	9.61E-06	C	2.65
ALL	940	2	99.94	1	9.52E-06	9.52E-06	C	2.65
ALL	960	2	99.94	1	9.43E-06	9.43E-06	C	2.65
ALL	980	2	99.94	1	9.34E-06	9.34E-06	C	2.65
ALL	1000	2	99.94	1	9.24E-06	9.24E-06	C	2.65
ALL	15360	2	99.94	1	3.88E-06	3.88E-06	E	0.89

APPENDIX P

CHEMICAL EXPOSURE TIMES FOR ACCIDENT ANALYSIS

This page intentionally left blank.

APPENDIX P

CHEMICAL EXPOSURE TIMES FOR ACCIDENT ANALYSIS

The U.S. Department of Energy (DOE) has provided guidance regarding exposure times to be used in evaluating chemical toxicity effects to the public and onsite workers. The guidance in DOE G 151.1-2, *Technical Planning Basis* (see Appendix F), and DOE-STD-1189-2008, *Integration of Safety into the Design Process* (see Appendix B) are similar.

“To determine whether a chemical consequence exceeds [Protective Action Criteria] PAC, the highest time-weighted average (TWA) concentration predicted or measured for any 15-minute period (i.e., the maximum or peak 15-minute TWA concentration) should be compared to the PAC. For exposure periods of less than 15 minutes, concentrations for comparison with the guidelines may be [emphasis added] calculated over a shorter time period (e.g., the exposure duration).”

Regarding the last sentence in this guidance, neither DOE G 151.1-2 nor DOE-STD-1189-2008 provides guidance regarding when concentrations for comparison with the guidelines should be calculated over a shorter time period.

Therefore, additional review of published guidance is provided in Attachment 1. In addition, an expert in the preparation of emergency preparedness hazard analyses was consulted. His evaluation is presented in Attachment 2. He concluded that the chemical properties of Hanford Tank waste do not represent the type and magnitude of toxic chemical hazard that is intended to form the technical basis for emergency management plans. This is supportive of the evaluation conclusion that exposure to chemicals in waste aerosols is not immediately toxic.

Based on the above published guidance and input from an expert in the preparation of emergency preparedness hazard analyses, it is concluded that the use of 15-minute TWA concentration is reasonably conservative for determining the toxicological consequences to the public and onsite workers for accidents involving tank farm wastes.

References

DOE G 151.1-2, 2007, *Technical Planning Basis*, U.S. Department of Energy, Washington D.C.

DOE-STD-1189-2008, 2008, *Integration of Safety into the Design Process*, U.S. Department of Energy, Washington D.C.

APPENDIX P

Attachment 1

**URS, INC.'S REVIEW OF PUBLISHED GUIDANCE REGARDING CHEMICAL
EXPOSURE TIMES AND EXPOSURE TIMES USED AT OTHER DOE SITES**



Memorandum

Date: September 30, 2010

URS-SMS-OPS-10-0013

To: Larry Eppler, WRPS, Richland, WA

From: M. K. Gupta, URS SMS, Aiken, SC, Technical Reviewer: John McAllister

Subject: **Review of Published Guidance Regarding Chemical Exposure Times Used at Other DOE Sites**

The U. S. Department of Energy (DOE) has provided guidance regarding exposure times to be used in evaluating chemical toxicity effects on the public and onsite workers. The guidance below from DOE G 151.1-2, *Technical Planning Basis* (see Appendix F), is similar to guidance in DOE-STD-1189-2008, *Integration of Safety into the Design Process* (see Appendix B).

"To determine whether a chemical consequence exceeds [Protective Action Criteria] PAC, the highest time-weighted average (TWA) concentration predicted or measured for any 15-minute period (i.e., the maximum or peak 15-minute TWA concentration) should be compared to the PAC. For exposure periods of less than 15 minutes, concentrations for comparison with the guidelines may be [emphasis added] calculated over a shorter time period (e.g., the exposure duration)."

Regarding the last sentence in this guidance, neither DOE G 151.1-2 or DOE-STD-1189-2008 provide guidance regarding when concentrations for comparison with the guidelines should be calculated over a shorter time period. Therefore, guidance provided on the Subcommittee on Consequence Assessment and Protective Actions (SCAPA) website, in published literature, and exposure times used at other DOE sites were reviewed.

Published Guidance

To define when a shorter exposure duration should be used, the Hanford tank farms used note B from *The User's Guide for the Chemical Mixture Methodology*, Table 1, "Chemical Categories Used in the Import Worksheet: Column P" (Reference 1).

Note B states, "For release durations less than 15 minutes, concentrations may be calculated over a shorter time period but for not less than 1 minute if the chemical is known to exert immediate toxic effects." However, for chemicals with concentration dependent limits (i.e., those with a Concentration-Limit Classification of 1A - Ceiling standard, 1B - Irritants, or 1C - Technologic feasibility), the recommended exposure duration treatment refers to Note D.

Note D states, "For concentration-dependent chemicals, the concentration at the receptor point of interest is calculated as the peak 15-minute time-weighted average (TWA) concentration."

There is no guidance in *The User's Guide for the Chemical Mixture Methodology*, for when Note B should be used as all concentration dependent chemical are Concentration-Limit Classification 1A, 1B, or 1C. Thus, Note D is applicable.



Alternative Guideline Limits for Chemicals Without (Emergency) Response Planning Guidelines (Reference 2) states:

"Exposure Time – In practice, observed atmospheric concentrations of chemicals downwind of a source, whether instantaneous or continuous, vary widely about the mean concentration over any period of time. Unless information to the contrary is available, published exposure-limit parameters or guidelines should be treated as ceiling or peak values. The concentration of interest, therefore, is the instantaneous value at the point of interest. For practical purposes the peak 15-minute average concentration may be treated as the instantaneous concentration. This peak concentration value is used for comparison with the primary concentration guidelines [(e.g., ERPG/AEGL values), or the alternative hierarchy guidelines (e.g., PAC values)], without regard to the length of time for which any particular exposure-limit parameter was developed. An exception is made for those chemicals whose toxic effects are known to be dose-dependent. For those chemicals only, the peak 1-hour average concentration may be used for comparison to the guideline value.

It is of interest to note that the Environmental Protection Agency (EPA) does not specify an exposure time for its levels of concern (LOC), stating only that they are concentrations in air above which there may be serious irreversible health effects or death as a result of a single exposure for a relatively short period of time (Reference 3). However, one quarter of the approximately 400 published LOC values are one-tenth of the IDLH (Immediately Dangerous to Life and Health) values, which are based on a 30-minute exposure time (Reference 4).

Use of the peak 15-minute average concentration introduces a measure of conservatism in using the exposure-limit parameters (LOC, IDLH). Additional reasons for using a 15-minute averaging time include lack of toxic-effects data for shorter time periods, physiological equilibration in relation to the breathing rate of humans, and better matching with hypothetical centerline plume concentrations than would be the case over a longer time period."

Derivation of Temporary Emergency Exposure Limits (TEELs) (Reference 5) states, "It is recommended that, for application of TEELs, concentration at the receptor point of interest be calculated as the peak 15-minute time-weighted average (TWA) concentration."

Recommended Default Methodology for Analysis of Airborne Exposures to Mixtures of Chemicals in Emergencies (Reference 6) states, "Calculate the peak 15-minute TWA concentration, and when applicable for dose dependent chemicals, the peak 60-minute TWA concentration for each chemical component at each receptor point."

Fifteen minutes is chosen because two of the hierarchy parameters used in deriving TEELs are short-term exposure limits (e.g., PEL-STEL, TLV-STEL, REL-STEL) and ceiling limits (e.g., PEL-C, TLV-C, WEEL-C). Both STEL and C ACGIH definitions (Reference 7) include reference to 15-minute time period. Use of ERPGs (Reference 8), defined in terms of exposures of up to 1 hour, would be conservative when used as PACs in emergencies. Use of the 60-minute AEGL (Reference 9) values, chosen as the primary PAC values, is similarly conservative. Choice of the one hour AEGL values was based on the best quality data available for deriving AEGL values, to minimize the uncertainty in time scale extrapolation. Toxicity studies used for AEGL derivations were analyzed and it was found that the most frequent exposure period used is one hour (Reference 10).

Precedent at Other DOE Sites.



The release duration of 15 minutes used for analyzing chemicals that are part of the waste stream at the Tank Farms of Savannah River Site (SRS) (Reference 11) is based on the guidance provided in Reference 2. The Saltstone Facility at SRS has also used release duration of 15 minutes for analyzing chemicals that are part of the waste stream (Reference 12) based on the guidance in Reference 2. The chemicals in the SRS Tank Farms and Saltstone Facility are similar to those in the Hanford Tank Farms. The Waste Treatment and Immobilization Plant (WTP) at Hanford used release duration of 15 minutes for analyzing chemicals that are part of the waste stream (Reference 13) based on the guidance in DOE-STD-1189 (Reference 16). The WTP processes waste from the Hanford Tank Farms, and thus similar chemicals. An evaluation completed by Los Alamos National Laboratory (LANL) recommends release duration of 15 minutes for quantitative analysis of chemicals present in a non-nuclear DOE Facility (Reference 14). DOE G 151.1-2, *Technical Planning Basis, Emergency Management System*, recommends that a peak 15-minute TWA chemical concentration be used for comparison with PAC values (Reference 15).

Conclusions

Based on the above published guidance and precedent at other DOE sites, it is concluded that the use of 15-minute TWA concentration for Hanford Tank Farms chemicals is reasonably conservative for determining the toxicological consequences to the public and onsite workers and exposures over a shorter period are not required to be calculated for comparison to the guidelines.

References

1. *The User's Guide for the Chemical Mixture Methodology*, U.S. Department of Energy, Washington, D. C., October 2009.
2. American Industrial Hygiene Association. *Alternative Guideline Limits for Chemicals without (Emergency) Response Planning Guidelines*, American Industrial Hygiene Association Journal. (56), 919-925, September 1995.
3. *Technical Guidance for Hazards Analysis. Emergency Planning for Extremely Hazardous Substances*, U. S. Environmental Protection Agency, Federal Emergency Management Agency, and U. S. Department of Transportation: EPA-OSWER-88-0001, Washington, DC, U.S. Government Printing Office, December 1987.
4. National Institute for Occupational Safety and Health, *NIOSH Pocket Guide to Chemical Hazards*, Department of Health and Human Services, Public Health Service, NIOSH, Washington, DC (1990).
5. *Derivation of Temporary Emergency Exposure Limits (TEELs)*, 2000, J. Applied Toxicology, 20, 11-20.
6. D. K. Craig, R. L. Baskett, J. S. Davis, L. Dukes, D. J. Hansen, A. J. Petrocchi, T. J. Powell, P. J. Sutherland, and T. E. Tuccinardi, Jr., "Recommended Default Methodology for Analysis of Airborne Exposures to Mixtures of Chemicals in Emergencies." *Applied Occupational and Environmental Hygiene* 14(9):609-617 (1999).



7. *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposures Indices*, 1993-1994, American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, OH, (updated annually).
8. American Industrial Hygiene Association, *The AIHA 2007 Emergency Response Planning Guidelines and Workplace Environmental Exposure Level Guides Handbook*, AIHA Press, Fairfax, VA (2007).
9. *Acute Exposure Guideline Levels for Selected Airborne Chemicals*, National Research Council of the National Academies, The National Academy Press, Washington DC (Volumes published periodically).
10. *The Development of Emergency Response Values*. Presented at: First Joint Emergency Preparedness and Response/Robotic and Remote Systems Topical Meeting, Salt Lake City, UT, February 11-16, 2006.
11. *SRS High Level Waste Chemical and Radiological Consequence Analysis Comparison*, 2002, S-CLC-G-00280, Rev. 0, Savannah River Site, Aiken, South Carolina.
12. *Saltstone Facility Vault Explosion Chemical Evaluation*, 2009, S-CLC-Z-00039, Rev. 3, Savannah River Site, Aiken, South Carolina.
13. *Assessment of the Toxicological Hazards of WTP Waste*. Andrew R. Larson and Richard I. Smith, BNI, Draft for Review and Comment.
14. *Perspectives on Chemical Hazard Characterization and Analysis Process at DOE*, Journal of Chemical Health and Safety, Volume 13, Number 4, July/August 2006.
15. DOE G 151.1-2, *Technical Planning Basis*, Emergency Management System, U.S. Department of Energy, Washington, D. C.
16. DOE-STD-1189-2008, *Integration of Safety into the Design Process*, U.S. Department of Energy, Washington, D. C.

APPENDIX P

Attachment 2

**DR. JAMISON'S EVALUATION OF THE TOXICITY
OF TANK FARM WASTE**

**DR. JAMISON'S EVALUATION OF THE TOXICITY
OF TANK FARM WASTE**

From: JAMES JAMISON [Jamisonjd@msn.com]
Sent: Friday, July 11, 2008 10:58 AM
To: Kozlowski, Stephen
Cc: Jim Jamison
Subject: Tank Waste & EPHAs

Steve:

Per our discussion on Thursday, the approach to screening chemicals recommended by the DOE Office of Emergency Management in DOE G 151.1-2 (Appendix A) allows and encourages the elimination from further consideration ("screening out") of certain chemicals that "...do not represent the type or magnitude of hazard that is intended to form the technical basis for emergency management programs." Experience has shown that indiscriminate use (use without some foreknowledge that a chemical is a bad actor) of concentration-at-distance calculations tends to give results that are misleading and not very useful as indications of actual health impact or risk.

The DOE G 151.1-2 screening guidelines include considerations of quantity, form, dispersibility and toxicity. They reflect a wide body of emergency management and hazardous materials response experience, both in the U.S. and elsewhere, which shows that some types of materials simply have very little potential to cause harm to people outside the immediate vicinity of the release. Chemicals with Health Hazard Ratings of 0, 1 or 2 according to the NFPA 704 method can be categorically excluded. Solids, liquids with low vapor pressures, and most solutions can also be excluded because they have little potential for dispersal into the atmosphere. The guidance states that in a few circumstances, the chemical toxicity of a radioactive substance may actually be of greater health concern than the potential radiation dose, but that *"For practical purposes, the concern is limited to uranium of low enrichment in the form of compounds that are relatively soluble in body fluids..."*.

The chemical properties of Hanford Tank waste do not represent the type and magnitude of toxic chemical hazard that is intended to form the technical basis for emergency management plans. Without its radioactive constituents, the liquids and solids would not be analyzed for emergency management purposes because the low chemical toxicity and limited inherent dispersibility. The Savannah River Site reached this same conclusion in 2002 and does not analyze the toxic chemical impacts of tank waste for purposes of either their DSAs or EPHAs. Their technical basis is documented in a calculation titled "SRS High Level Waste Chemical and Radiological Consequence Analysis".

Jim Jamison
SAIC
372-7736 (office)
438-5740 (cell)

APPENDIX Q

PEER REVIEW CHECKLISTS

This page intentionally left blank.

APPENDIX Q

PEER REVIEW CHECKLIST

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13482

Scope of Review (e.g., document section or portion of calculation): Reviewed entire document via spot check method.

Yes No NA*

- | | | | |
|-------------------------------------|--------------------------|-------------------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 2. Problem is completely defined. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 3. Accident scenarios are developed in a clear and logical manner. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 4. Analytical and technical approaches and results are reasonable and appropriate. (ORP QAPP criterion 2.8) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 5. Necessary assumptions are reasonable, explicitly stated, and supported. (ORP QAPP criterion 2.2) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 6. Computer codes and data files are documented. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 7. Data used in calculations are explicitly stated. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Final Safety Analysis Report). |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 9. Data were checked for consistency with original source information as applicable. (ORP QAPP criterion 2.9) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. (ORP QAPP criterion 2.17) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 11. Mathematical derivations were checked including dimensional consistency of results. (ORP QAPP criterion 2.16) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 13. Spreadsheet results and all hand calculations were verified. Spot check |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. (ORP QAPP criterion 2.5) Qualified meaning qualified in atmospheric dispersion methods. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 15. Software input is correct and consistent with the document reviewed. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 16. Software output is consistent with the input and with the results reported in the document reviewed. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 17. Software verification and validation are addressed adequately. (ORP QAPP criterion 2.6) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. (ORP QAPP criterion 2.9) |

- ☐ ☐ ☒ 19. Safety margins are consistent with good engineering practices.
☒ ☐ ☐ 20. Conclusions are consistent with analytical results and applicable limits.

☒ ☐ ☐ 21. Results and conclusions address all points in the purpose. (*ORP QPP criterion 2.3*)
☒ ☐ ☐ 22. All references cited in the text, figures, and tables are contained in the reference list. **Spot check**
☒ ☐ ☐ 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list. **Spot check**
☐ ☐ ☒ 24. Only released (i.e., not draft) references are cited. (*ORP QAPP criterion 2.1*) **Did not check**
☒ ☐ ☐ 25. Referenced documents are retrievable or otherwise available.
☐ ☐ ☒ 26. The most recent version of each reference is cited, as appropriate. (*ORP QAPP criterion 2.1*) **Did not check**
☐ ☐ ☒ 27. There are no duplicate citations in the reference list. **Did not check**
☐ ☐ ☒ 28. Referenced documents are spelled out (title and number) the first time they are cited. **Did not check**
☐ ☐ ☒ 29. All acronyms are spelled out the first time they are used. **Did not check**
☐ ☐ ☒ 30. The Table of Contents is correct. **Did not check**
☐ ☐ ☒ 31. All figure, table, and section callouts are correct. **Did not check**
☒ ☐ ☐ 32. Unit conversions are correct and consistent.
☒ ☐ ☐ 33. The number of significant digits is appropriate and consistent. **Focused on the final results.**
☐ ☐ ☒ 34. Chemical reactions are correct and balanced.
☐ ☐ ☒ 35. All tables are formatted consistently and are free of blank cells. **Did not check**
☐ ☐ ☒ 36. The document is complete (pages, attachments, and appendices) and in the proper order. **Did not check**
☐ ☐ ☒ 37. The document is free of typographical errors. **Did not check**
☒ ☐ ☐ 38. The tables are internally consistent.
☐ ☐ ☒ 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".
☒ ☐ ☐ **Concurrence**

Robert Marusich

Reviewer (Printed Name and Signature)

03/07/03

Date

- If No or NA is chosen, provide an explanation on this form. See the following.

All derivations were checked. Results were spot checked, typically by ratioing based on the important parameters. For those GXQ runs provided, the input and output were checked. Items 24, 26-31, and 35-37 are assumed to be picked up by the editor. Document contains no accident analysis, therefore no limits are necessary. There were no previous reviews. Software V&V is done within the document (Chapter 3)

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed:

Scope of Review (e.g., document section or portion of calculation):

<u>Yes</u>	<u>No</u>	<u>NA*</u>	
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	2. Problem is completely defined.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	3. Accident scenarios are developed in a clear and logical manner.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	4. Analytical and technical approaches and results are reasonable and appropriate. (<i>ORP QAPP criterion 2.8</i>)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	5. Necessary assumptions are reasonable, explicitly stated, and supported. (<i>ORP QAPP criterion 2.2</i>)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	6. Computer codes and data files are documented.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	7. Data used in calculations are explicitly stated.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Final Safety Analysis Report).
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	9. Data were checked for consistency with original source information as applicable. (<i>ORP QAPP criterion 2.9</i>)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. (<i>ORP QAPP criterion 2.17</i>)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	11. Mathematical derivations were checked including dimensional consistency of results. (<i>ORP QAPP criterion 2.16</i>)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	13. Spreadsheet results and all hand calculations were verified.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. (<i>ORP QAPP criterion 2.5</i>)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	15. Software input is correct and consistent with the document reviewed.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	16. Software output is consistent with the input and with the results reported in the document reviewed.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	17. Software verification and validation are addressed adequately. (<i>ORP QAPP criterion 2.6</i>)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. (<i>ORP QAPP criterion 2.9</i>)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	19. Safety margins are consistent with good engineering practices.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	20. Conclusions are consistent with analytical results and applicable limits.

- | | | | |
|-------------------------------------|--------------------------|-------------------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 21. Results and conclusions address all points in the purpose. (ORP QAPP criterion 2.3) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 22. All references cited in the text, figures, and tables are contained in the reference list. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 24. Only released (i.e., not draft) references are cited. (ORP QAPP criterion 2.1) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 25. Referenced documents are retrievable or otherwise available. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 26. The most recent version of each reference is cited, as appropriate. (ORP QAPP criterion 2.1) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 27. There are no duplicate citations in the reference list. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 28. Referenced documents are spelled out (title and number) the first time they are cited. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 29. All acronyms are spelled out the first time they are used. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 30. The Table of Contents is correct. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 31. All figure, table, and section callouts are correct. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 32. Unit conversions are correct and consistent. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 33. The number of significant digits is appropriate and consistent. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 34. Chemical reactions are correct and balanced. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 35. All tables are formatted consistently and are free of blank cells. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 36. The document is complete (pages, attachments, and appendices) and in the proper order. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 37. The document is free of typographical errors. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 38. The tables are internally consistent. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions". |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Concurrence |

NA check for those items not responsibility of tech editor.

Laurie L. Kroemer *Laurie L. Kroemer* 3/17/03
 Reviewer (Printed Name and Signature) Date

RPP-13482
 * If No or NA is chosen, provide an explanation on this form.

Calculation Review Checklist.

Calculation Reviewed: RPP-13482 Rev 1Scope of Review: Sections and Appendices changed by Rev 1
(e.g., document section or portion of calculation)Engineer/Analyst: D. Himes and P. Rittman, PFS Date: 7/25/03Organizational Mgr: L Johnson, PFS Date: 7/25/03This document consists of _____ pages and the following attachments (if applicable):

Yes No NA*

- | | | | |
|-------------------------------------|--------------------------|-------------------------------------|---|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 1. Analytical and technical approaches and results are reasonable and appropriate. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 2. Necessary assumptions are reasonable, explicitly stated, and supported. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 3. Ensure calculations that use software include a paper printout, microfiche, CD ROM, or other electronic file of the input data and identification to the computer codes and versions used, or provide alternate documentation to uniquely and clearly identify the exact coding and execution process. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 4. Input data were checked for consistency with original source information. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 5. For both qualitative and quantitative data, uncertainties are recognized and discussed. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 6. Mathematical derivations were checked including dimensional consistency of results. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 7. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 8. Software verification and validation are addressed adequately. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 9. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 10. Conclusions are consistent with analytical results and applicable limits. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 11. Results and conclusions address all points in the purpose. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 12. Referenced documents are retrievable or otherwise available. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 13. The version or revision of each reference is cited. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 14. The document was prepared in accordance with Attachment A, "Calculation Format and Preparation Instructions." Did not check |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 15. All checker comments have been dispositioned and the design media matches the calculations. |

Robert Marwick Robert Marwick
Checker (Printed Name and Signature)

Date 7/28/03

* If No or NA is chosen, an explanation must be provided on or attached to this form.

Subcontractor Calculation Review Checklist.

Page 1 of 1

Subject: Review of Document Prepared by Fluor Federal Services

The subject document has been reviewed by the undersigned.

The checker reviewed and verified the following items as applicable.

Documents Reviewed: RPP-13482, Atmospheric Dispersion Coefficients and Radiological and
Toxicological Exposure Methodology for Use in Tank Farms

Analysis Performed By: W.L. Cowley

- Design Input
- Basic Assumptions
- Approach/Design Methodology
- Consistency with item or document supported by the calculation
- Conclusion/Results Interpretation
- _____

Checker (printed name, signature, and date) _____

W.L. Cowley W.L. Cowley 7-28-03

Organizational Manager (printed name, signature and date) _____

R.J. Stevens R.J. Stevens 7/28/03

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13482, Rev. 2

Yes No NA*

- | | | | | |
|--------------------------|--------------------------|--------------------------|-------------------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 2. Problem is completely defined. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 3. Accident scenarios are developed in a clear and logical manner. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 4. Analytical and technical approaches and results are reasonable and appropriate. (ORP QAPP criterion 2.8) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 5. Necessary assumptions are reasonable, explicitly stated, and supported. (ORP QAPP criterion 2.2) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 6. Computer codes and data files are documented. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 7. Data used in calculations are explicitly stated. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Final Safety Analysis Report). |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 9. Data were checked for consistency with original source information as applicable. (ORP QAPP criterion 2.9) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. (ORP QAPP criterion 2.17) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 11. Mathematical derivations were checked including dimensional consistency of results. (ORP QAPP criterion 2.16) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 13. Spreadsheet results and all hand calculations were verified. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. (ORP QAPP criterion 2.5) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 15. Software input is correct and consistent with the document reviewed. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 16. Software output is consistent with the input and with the results reported in the document reviewed. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 17. Software verification and validation are addressed adequately. (ORP QAPP criterion 2.6) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. (ORP QAPP criterion 2.9) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 19. Safety margins are consistent with good engineering practices. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 20. Conclusions are consistent with analytical results and applicable limits. |

Checklist For Technical Peer Review

Document Reviewed - RPP-13482, Rev 3

Title: Atmospheric Dispersion Coefficients and Radiological/toxicological Exposure
Methodology for Use in Tank Farms

Scope of Review: Sections and Appendices changed by Rev 3.

Author: D. Himes, Paul Rittmann

Date: 12/07/04

<u>Yes</u>	<u>No*</u>	<u>NA</u>	
[X]	[]	[]	Referenced analyses appropriate.
[X]	[]	[]	Problem completely defined and all potential configurations considered.
[]	[]	[X]	Accident scenarios developed in a clear and logical manner.
[X]	[]	[]	Necessary assumptions explicitly stated and supported.
[X]	[]	[]	Computer codes and data files documented.
[X]	[]	[]	Data used in calculations explicitly stated in document.
[X]	[]	[]	Data checked for consistency with original source information as applicable.
[X]	[]	[]	Mathematical derivations checked including dimensional consistency of results.
[X]	[]	[]	Models appropriate and used within range of validity, or use outside range of established validity justified.
[X]	[]	[]	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
[X]	[]	[]	Software input correct and consistent with document reviewed.
[X]	[]	[]	Software output consistent with input and with results reported in document reviewed.
[]	[]	[X]	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
[X]	[]	[]	Safety margins consistent with good engineering practices.
[X]	[]	[]	Conclusions consistent with analytical results and applicable limits.
[X]	[]	[]	Results and conclusions address all points required in the problem statement.
[X]	[]	[]	Format consistent with applicable guides or other standards.
[]	[]	[X]	** Review calculations, comments, and/or notes are attached.
[X]	[]	[]	Document approved (for example, the reviewer affirms the technical accuracy of the document).

Robert Marusich

Technical Peer Reviewer (printed name and signature)

12/07/04

Date

* All "no" responses must be explained below or on an additional sheet.

** Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. The material should be labeled and recorded in such a manner as to be understandable to a technically qualified third party.

Subcontractor Calculation Review Checklist.

Page 1 of 1

Subject: Review of a Revision Prepared by Fluor Government Group

The subject document has been reviewed by the undersigned.
The checker reviewed and verified the following items as applicable.

Documents Reviewed: Rev. 3 of RPP-13482. Rev. 3 added additional material to the report.
This review covers only the new material added by Rev.3

Analysis Performed By: D.A. Himes and P.D. Rittman, Fluor Government Group

- Design Input
- Basic Assumptions
- Approach/Design Methodology
- Consistency with item or document supported by the calculation
- Conclusion/Results Interpretation – N/A
- Impact on existing requirements
- _____

Checker (printed name, signature, and date)

W.L. Cowley 1-31-05
W.L. Cowley

Organizational Manager (printed name, signature and date)

J.M. Griggsy JMG 1/31/05

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13482, Rev 3

Scope of Review (e.g. document section or portion of calculation): tech edit

Yes	No	NA*	
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	2. Problem is completely defined.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	3. Accident scenarios are developed in a clear and logical manner.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	4. Analytical and technical approaches and results are reasonable and appropriate. (ORP QAPP criterion 2.8)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	5. Necessary assumptions are reasonable, explicitly stated, and supported. (ORP QAPP criterion 2.2)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	6. Computer codes and data files are documented.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	7. Data used in calculations are explicitly stated.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Final Safety Analysis Report).
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	9. Data were checked for consistency with original source information as applicable. (ORP QAPP criterion 2.9)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. (ORP QAPP criterion 2.17)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	11. Mathematical derivations were checked including dimensional consistency of results. (ORP QAPP criterion 2.16)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	13. Spreadsheet results and all hand calculations were verified.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. (ORP QAPP criterion 2.5)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	15. Software input is correct and consistent with the document reviewed.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	16. Software output is consistent with the input and with the results reported in the document reviewed.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	17. Software verification and validation are addressed adequately. (ORP QAPP criterion 2.6)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. (ORP QAPP criterion 2.9)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	19. Safety margins are consistent with good engineering practices.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	20. Conclusions are consistent with analytical results and applicable limits.

- | | | | |
|-------------------------------------|--------------------------|-------------------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 21. Results and conclusions address all points in this purpose. (ORP QAPP criterion 2.3) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 22. All references cited in the text, figures, and tables are contained in the reference list. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 24. Only released (i.e., not draft) references are cited. (ORP QAPP criterion 2.1) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 25. Referenced documents are retrievable or otherwise available. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 26. The most recent version of each reference is cited, as appropriate. (ORP QAPP criterion 2.1) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 27. There are no duplicate citations in the reference list. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 28. Referenced documents are spelled out (title and number) the first time they are cited. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 29. All acronyms are spelled out the first time they are used. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 30. The Table of Contents is correct. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 31. All figure, table, and section callouts are correct. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 32. Unit conversions are correct and consistent. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 33. The number of significant digits is appropriate and consistent. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 34. Chemical reactions are correct and balanced. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 35. All tables are formatted consistently and are free of blank cells. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 36. The document is complete (pages, attachments, and appendices) and in the proper order. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 37. The document is free of typographical errors. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 38. The tables are internally consistent. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions". |

Comments:

Tech Edit


 Reviewer (Printed Name and Signature)
 Leona Annot

01/31/05
 Date

*If No or NA is chosen, an explanation must be provided on this form.

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed:

Appendix to RPP-13482

Scope of Review (e.g., document section or portion of calculation):

Special XG's for Pool Fires at the DBVS

Yes No NA*

- | | | | |
|-------------------------------------|--------------------------|-------------------------------------|---|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 2. Problem is completely defined. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 3. Accident scenarios are developed in a clear and logical manner. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 4. Analytical and technical approaches and results are reasonable and appropriate. (ORP QAPP criterion 2.8) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 5. Necessary assumptions are reasonable, explicitly stated, and supported. (ORP QAPP criterion 2.2) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 6. Computer codes and data files are documented. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 7. Data used in calculations are explicitly stated. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Final Safety Analysis Report). |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 9. Data were checked for consistency with original source information as applicable. (ORP QAPP criterion 2.9) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. (ORP QAPP criterion 2.17) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 11. Mathematical derivations were checked including dimensional consistency of results. (ORP QAPP criterion 2.16) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 13. Spreadsheet results and all hand calculations were verified. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. (ORP QAPP criterion 2.5) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 15. Software input is correct and consistent with the document reviewed. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 16. Software output is consistent with the input and with the results reported in the document reviewed. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 17. Software verification and validation are addressed adequately. (ORP QAPP criterion 2.6) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. (ORP QAPP criterion 2.9) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 19. Safety margins are consistent with good engineering practices. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 20. Conclusions are consistent with analytical results and applicable limits. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 21. Results and conclusions address all points in the purpose. (ORP QAPP criterion 2.3) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 22. All references cited in the text, figures, and tables are contained in the reference list. |

Effective Date: 2/12/2004

- ☐ ☐ ☒ 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list.
- ☒ ☐ ☐ 24. Only released (i.e., not draft) references are cited. (*ORP QAPP criterion 2.1*)
- ☒ ☐ ☐ 25. Referenced documents are retrievable or otherwise available.
- ☒ ☐ ☐ 26. The most recent version of each reference is cited, as appropriate. (*ORP QAPP criterion 2.1*)
- ☐ ☐ ☒ 27. There are no duplicate citations in the reference list.
- ☒ ☐ ☐ 28. Referenced documents are spelled out (title and number) the first time they are cited.
- ☒ ☐ ☐ 29. All acronyms are spelled out the first time they are used.
- ☐ ☐ ☒ 30. The Table of Contents is correct.
- ☒ ☐ ☐ 31. All figure, table, and section callouts are correct.
- ☒ ☐ ☐ 32. Unit conversions are correct and consistent.
- ☒ ☐ ☐ 33. The number of significant digits is appropriate and consistent.
- ☐ ☐ ☒ 34. Chemical reactions are correct and balanced.
- ☒ ☐ ☐ 35. All tables are formatted consistently and are free of blank cells.
- ☒ ☐ ☐ 36. The document is complete (pages, attachments, and appendices) and in the proper order.
- ☒ ☐ ☐ 37. The document is free of typographical errors.
- ☒ ☐ ☐ 38. The tables are internally consistent.
- ☐ ☐ ☒ 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".
- ☐ ☐ ☒ 40. Impacted documents are appropriately identified in Blocks 7 and 25 of the Engineering Change Notice (form A-6003-563.1).
- ☐ ☐ ☒ 41. If more than one Technical Peer Reviewer was designated for this document, an overall review of the entire document was performed after resolution of all Technical Peer Review comments and confirmed that the document is self-consistent and complete.
- ☒ ☐ ☐ **Concurrence**

Paul Rittmann PD Rittmann 1-6-05
 Reviewer (Printed Name and Signature) Date

* If No or NA is chosen, provide an explanation on this form.

All "NA" responses are for checklist items that do not apply to this document.

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13482 Rev 4

Scope of Review (e.g., document section or portion of calculation): Technical edit

Yes No NA*

- | Yes | No | NA* | |
|--------------------------|--------------------------|-------------------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 2. Problem is completely defined. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 3. Accident scenarios are developed in a clear and logical manner. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 4. Analytical and technical approaches and results are reasonable and appropriate. (ORP QAPP criterion 2.8) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 5. Necessary assumptions are reasonable, explicitly stated, and supported. (ORP QAPP criterion 2.2) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 6. Computer codes and data files are documented. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 7. Data used in calculations are explicitly stated. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Final Safety Analysis Report). |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 9. Data were checked for consistency with original source information as applicable. (ORP QAPP criterion 2.9) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. (ORP QAPP criterion 2.17) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 11. Mathematical derivations were checked including dimensional consistency of results. (ORP QAPP criterion 2.16) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 13. Spreadsheet results and all hand calculations were verified. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. (ORP QAPP criterion 2.5) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 15. Software input is correct and consistent with the document reviewed. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 16. Software output is consistent with the input and with the results reported in the document reviewed. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 17. Software verification and validation are addressed adequately. (ORP QAPP criterion 2.6) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. (ORP QAPP criterion 2.9) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 19. Safety margins are consistent with good engineering practices. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 20. Conclusions are consistent with analytical results and applicable limits. |

CHECKLIST FOR TECHNICAL PEER REVIEW

- ☐ ☐ ☒ 21. Results and conclusions address all points in the purpose. (*ORP QAPP criterion 2.3*)
- ☒ ☐ ☐ 22. All references cited in the text, figures, and tables are contained in the reference list.
- ☒ ☐ ☐ 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list.
- ☒ ☐ ☐ 24. Only released (i.e., not draft) references are cited. (*ORP QAPP criterion 2.1*)
- ☒ ☐ ☐ 25. Referenced documents are retrievable or otherwise available.
- ☒ ☐ ☐ 26. The most recent version of each reference is cited, as appropriate. (*ORP QAPP criterion 2.1*)
- ☒ ☐ ☐ 27. There are no duplicate citations in the reference list.
- ☒ ☐ ☐ 28. Referenced documents are spelled out (title and number) the first time they are cited.
- ☒ ☐ ☐ 29. All acronyms are spelled out the first time they are used.
- ☒ ☐ ☐ 30. The Table of Contents is correct.
- ☒ ☐ ☐ 31. All figure, table, and section callouts are correct.
- ☒ ☐ ☐ 32. Unit conversions are correct and consistent.
- ☒ ☐ ☐ 33. The number of significant digits is appropriate and consistent.
- ☐ ☐ ☒ 34. Chemical reactions are correct and balanced.
- ☒ ☐ ☐ 35. All tables are formatted consistently and are free of blank cells.
- ☒ ☐ ☐ 36. The document is complete (pages, attachments, and appendices) and in the proper order.
- ☒ ☐ ☐ 37. The document is free of typographical errors.
- ☒ ☐ ☐ 38. The tables are internally consistent.
- ☒ ☐ ☐ 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".
- ☐ ☐ ☒ 40. Impacted documents are appropriately identified in Blocks 7 and 25 of the Engineering Change Notice (form A-6003-563.1).
- ☐ ☐ ☒ 41. If more than one Technical Peer Reviewer was designated for this document, an overall review of the entire document was performed after resolution of all Technical Peer Review comments and confirmed that the document is self-consistent and complete.
- ☒ ☐ ☐ **Concurrence**

Leona Aamot
Reviewer (Printed Name and Signature)

3/1/05
Date

* If No or NA is chosen, provide an explanation on this form.

Technical Edit

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: Appendix to RPP-13482, *Special X/Q's for Pool Fires at the CH-TRUM Waste Packaging Unit*

Scope of Review (e.g., document section or portion of calculation): entire document

Yes No NA*

- | | | | |
|-------------------------------------|--------------------------|-------------------------------------|---|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 2. Problem is completely defined. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 3. Accident scenarios are developed in a clear and logical manner. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 4. Analytical and technical approaches and results are reasonable and appropriate. (ORP QAPP criterion 2.8) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 5. Necessary assumptions are reasonable, explicitly stated, and supported. (ORP QAPP criterion 2.2) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 6. Computer codes and data files are documented. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 7. Data used in calculations are explicitly stated. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Final Safety Analysis Report). |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 9. Data were checked for consistency with original source information as applicable. (ORP QAPP criterion 2.9) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. (ORP QAPP criterion 2.17) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 11. Mathematical derivations were checked including dimensional consistency of results. (ORP QAPP criterion 2.16) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 13. Spreadsheet results and all hand calculations were verified. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. (ORP QAPP criterion 2.5) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 15. Software input is correct and consistent with the document reviewed. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 16. Software output is consistent with the input and with the results reported in the document reviewed. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 17. Software verification and validation are addressed adequately. (ORP QAPP criterion 2.6) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. (ORP QAPP criterion 2.9) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 19. Safety margins are consistent with good engineering practices. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 20. Conclusions are consistent with analytical results and applicable limits. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 21. Results and conclusions address all points in the purpose. (ORP QAPP criterion 2.3) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 22. All references cited in the text, figures, and tables are contained in the |

Effective Date: 2/12/2004

- reference list.
- ☒ ☐ ☐ 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list.
- ☒ ☐ ☐ 24. Only released (i.e., not draft) references are cited. (ORP QAPP criterion 2.1)
- ☒ ☐ ☐ 25. Referenced documents are retrievable or otherwise available.
- ☒ ☐ ☐ 26. The most recent version of each reference is cited, as appropriate. (ORP QAPP criterion 2.1)
- ☒ ☐ ☐ 27. There are no duplicate citations in the reference list.
- ☒ ☐ ☐ 28. Referenced documents are spelled out (title and number) the first time they are cited.
- ☒ ☐ ☐ 29. All acronyms are spelled out the first time they are used.
- PAR ☒ ☐ ☒ 30. The Table of Contents is correct.
- ☒ ☐ ☐ 31. All figure, table, and section callouts are correct.
- ☐ ☐ ☒ 32. Unit conversions are correct and consistent.
- ☒ ☐ ☐ 33. The number of significant digits is appropriate and consistent.
- ☐ ☐ ☒ 34. Chemical reactions are correct and balanced.
- ☒ ☐ ☐ 35. All tables are formatted consistently and are free of blank cells.
- ☒ ☐ ☐ 36. The document is complete (pages, attachments, and appendices) and in the proper order.
- ☒ ☐ ☐ 37. The document is free of typographical errors.
- ☒ ☐ ☐ 38. The tables are internally consistent.
- ☒ ☐ ☐ 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".
- ☒ ☐ ☐ 40. Impacted documents are appropriately identified in Blocks 7 and 25 of the Engineering Change Notice (form A-6003-563.1).
- ☒ ☐ ☐ 41. If more than one Technical Peer Reviewer was designated for this document, an overall review of the entire document was performed after resolution of all Technical Peer Review comments and confirmed that the document is self-consistent and complete.
- ☒ ☐ ☐ Concurrence

P.D. Rittmann
Reviewer (Printed Name and Signature)

Paul Rittmann

3-28-05
Date

* If No or NA is chosen, provide an explanation on this form.

Items marked NA do not apply to this document.

Subcontractor Calculation Review Checklist.

Page 1 of 1

Subject: RPP-13482, Revision 5, prepared by the Fluor Government Group

The subject document has been reviewed by the undersigned.

The checker reviewed and verified the following items as applicable.

Documents Reviewed: RPP-13482, Appendix N

Analysis Performed By: DA Himes and PD Rittman of Fluor Government Group

- Design Input
- Basic Assumptions
- Approach/Design Methodology
- Consistency with item or document supported by the calculation
- Conclusion/Results Interpretation – N/A
- Impact on existing requirements
- _____

Checker (printed name, signature, and date)

EC Heubach II EC Heubach II 09/22/05

Organizational Manager (printed name, signature and date)

JM Grigsby JM Grigsby 9/22/05

Scope of Review (e.g., document section or portion of calculation): All changes

Yes No NA*

- | | | | |
|-------------------------------------|-------------------------------------|-------------------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 2. Problem is completely defined. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 3. Accident scenarios are developed in a clear and logical manner. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 4. Analytical and technical approaches and results are reasonable and appropriate. (ORP QAPP criterion 2.8) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 5. Necessary assumptions are reasonable, explicitly stated, and supported. (ORP QAPP criterion 2.2) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 6. Computer codes and data files are documented. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 7. Data used in calculations are explicitly stated. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Final Safety Analysis Report). |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 9. Data were checked for consistency with original source information as applicable. (ORP QAPP criterion 2.9) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. (ORP QAPP criterion 2.17) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 11. Mathematical derivations were checked including dimensional consistency of results. (ORP QAPP criterion 2.16) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity. |
| * | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 13. Spreadsheet results and all hand calculations were verified. |
| | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. (ORP QAPP criterion 2.5) |
| * | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 15. Software input is correct and consistent with the document reviewed. |
| * | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 16. Software output is consistent with the input and with the results reported in the document reviewed. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 17. Software verification and validation are addressed adequately. (ORP QAPP criterion 2.6) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. (ORP QAPP criterion 2.9) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 19. Safety margins are consistent with good engineering practices. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 20. Conclusions are consistent with analytical results and applicable limits. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 21. Results and conclusions address all points in the purpose. (ORP QAPP criterion 2.3) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 22. All references cited in the text, figures, and tables are contained in the reference list. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 24. Only released (i.e., not draft) references are cited. (ORP QAPP criterion |

* spot checks only.

- 2.1)
- | | | | |
|-------------------------------------|--------------------------|-------------------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 25. Referenced documents are retrievable or otherwise available. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 26. The most recent version of each reference is cited, as appropriate.
(ORP QAPP criterion 2.1) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 27. There are no duplicate citations in the reference list. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 28. Referenced documents are spelled out (title and number) the first time they are cited. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 29. All acronyms are spelled out the first time they are used. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 30. The Table of Contents is correct. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 31. All figure, table, and section callouts are correct. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 32. Unit conversions are correct and consistent. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 33. The number of significant digits is appropriate and consistent. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 34. Chemical reactions are correct and balanced. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 35. All tables are formatted consistently and are free of blank cells. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 36. The document is complete (pages, attachments, and appendices) and in the proper order. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 37. The document is free of typographical errors. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 38. The tables are internally consistent. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions". |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 40. Impacted documents are appropriately identified in Blocks 7 and 25 of the Engineering Change Notice (form A-6003-S63.1). |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 41. If more than one Technical Peer Reviewer was designated for this document, an overall review of the entire document was performed after resolution of all Technical Peer Review comments and confirmed that the document is self-consistent and complete. |
- ☒ ☐ ☐ **Concurrence**


 Reviewer (Printed Name and Signature)

9/28/06
 Date

* If No or NA is chosen, provide an explanation on this form.
 Items 22-33, 35-39, and 41 were checked by this reviewer. The remaining items were checked by the technical editor (See checklist below).

Items marked "NA" were not applicable.

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Methodology for Use in Tank Farms*, Rev. 6

Scope of Review (e.g., document section or portion of calculation): Technical edit

Yes No NA*

- | | | | |
|--------------------------|--------------------------|-------------------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 2. Problem is completely defined. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 3. Accident scenarios are developed in a clear and logical manner. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 4. Analytical and technical approaches and results are reasonable and appropriate. (ORP QAPP criterion 2.8) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 5. Necessary assumptions are reasonable, explicitly stated, and supported. (ORP QAPP criterion 2.2) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 6. Computer codes and data files are documented. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 7. Data used in calculations are explicitly stated. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Documented Safety Analysis). |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 9. Data were checked for consistency with original source information as applicable. (ORP QAPP criterion 2.9) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. (ORP QAPP criterion 2.17) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 11. Mathematical derivations were checked including dimensional consistency of results. (ORP QAPP criterion 2.16) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 13. Spreadsheet results and all hand calculations were verified. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. (ORP QAPP criterion 2.5) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 15. Software input is correct and consistent with the document reviewed. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 16. Software output is consistent with the input and with the results reported in the document reviewed. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 17. Software verification and validation are addressed adequately. (ORP QAPP criterion 2.6) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. (ORP QAPP criterion 2.9) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 19. Safety margins are consistent with good engineering practices. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 20. Conclusions are consistent with analytical results and applicable limits. |

WJA-06
10-18

CHECKLIST FOR TECHNICAL PEER REVIEW

- ☐ ☐ ☒ 21. Results and conclusions address all points in the purpose. (*ORP QAPP criterion 2.3*)
☒ ☐ ☐ 22. All references cited in the text, figures, and tables are contained in the reference list.
☒ ☐ ☐ 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list.
☒ ☐ ☐ 24. Only released (i.e., not draft) references are cited. (*ORP QAPP criterion 2.1*)
☒ ☐ ☐ 25. Referenced documents are retrievable or otherwise available.
☒ ☐ ☐ 26. The most recent version of each reference is cited, as appropriate. (*ORP QAPP criterion 2.1*)
☒ ☐ ☐ 27. There are no duplicate citations in the reference list.
☒ ☐ ☐ 28. Referenced documents are spelled out (title and number) the first time they are cited.
☒ ☐ ☐ 29. All acronyms are spelled out the first time they are used.
☒ ☐ ☐ 30. The Table of Contents is correct.
☒ ☐ ☐ 31. All figure, table, and section callouts are correct.
☒ ☐ ☐ 32. Unit conversions are correct and consistent.
☒ ☐ ☐ 33. The number of significant digits is appropriate and consistent.
☐ ☐ ☒ 34. Chemical reactions are correct and balanced.
☒ ☐ ☐ 35. All tables are formatted consistently and are free of blank cells.
☒ ☐ ☐ 36. The document is complete (pages, attachments, and appendices) and in the proper order.
☒ ☐ ☐ 37. The document is free of typographical errors.
☒ ☐ ☐ 38. The tables are internally consistent.
☒ ☐ ☐ 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".
☐ ☐ ☒ 40. Impacted documents are appropriately identified in Blocks 7 and 25 of the Engineering Change Notice (form A-6003-563.1).
☒ ☐ ☐ 41. If more than one Technical Peer Reviewer was designated for this document, an overall review of the entire document was performed after resolution of all Technical Peer Review comments and confirmed that the document is self-consistent and complete.
☒ ☐ ☐ **Concurrence**

Leona Germain
 Reviewer (Printed Name and Signature)

10-16-06
 Date

* If No or NA is chosen, provide an explanation on this form.

Technical Edit at redlined changes only

Effective Date: 2/12/2004

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 6-B

Scope of Review (e.g., document section or portion of calculation): Changes made for revision 6-B.

Yes No NA*

- | | | | |
|-------------------------------------|--------------------------|-------------------------------------|---|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 2. Problem is completely defined. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 3. Accident scenarios are developed in a clear and logical manner. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 4. Analytical and technical approaches and results are reasonable and appropriate. (ORP QAPP criterion 2.8) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 5. Necessary assumptions are reasonable, explicitly stated, and supported. (ORP QAPP criterion 2.2) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 6. Computer codes and data files are documented. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 7. Data used in calculations are explicitly stated. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Final Safety Analysis Report). |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 9. Data were checked for consistency with original source information as applicable. (ORP QAPP criterion 2.9) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. (ORP QAPP criterion 2.17) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 11. Mathematical derivations were checked including dimensional consistency of results. (ORP QAPP criterion 2.16) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 13. Spreadsheet results and all hand calculations were verified. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. (ORP QAPP criterion 2.5) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 15. Software input is correct and consistent with the document reviewed. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 16. Software output is consistent with the input and with the results reported in the document reviewed. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 17. Software verification and validation are addressed adequately. (ORP QAPP criterion 2.6) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. (ORP QAPP criterion 2.9) |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 19. Safety margins are consistent with good engineering practices. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 20. Conclusions are consistent with analytical results and applicable limits. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 21. Results and conclusions address all points in the purpose. (ORP QAPP criterion 2.3) |

KR

RPP-13482 REV 7

Effective Date: 2/12/2004

- [X] ☐ ☐ 22. All references cited in the text, figures, and tables are contained in the reference list.
- [X] ☐ ☐ 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list.
- [X] ☐ ☐ 24. Only released (i.e., not draft) references are cited. (ORP QAPP criterion 2.1)
- [X] ☐ ☐ 25. Referenced documents are retrievable or otherwise available.
- [X] ☐ ☐ 26. The most recent version of each reference is cited, as appropriate. (ORP QAPP criterion 2.1)
- [X] ☐ ☐ 27. There are no duplicate citations in the reference list.
- [X] ☐ ☐ 28. Referenced documents are spelled out (title and number) the first time they are cited.
- [X] ☐ ☐ 29. All acronyms are spelled out the first time they are used.
- [X] ☐ ☐ 30. The Table of Contents is correct.
- [X] ☐ ☐ 31. All figure, table, and section callouts are correct.
- [X] ☐ ☐ 32. Unit conversions are correct and consistent.
- [X] ☐ ☐ 33. The number of significant digits is appropriate and consistent.
- [X] ☐ ☐ 34. Chemical reactions are correct and balanced.
- [X] ☐ ☐ 35. All tables are formatted consistently and are free of blank cells.
- [X] ☐ ☐ 36. The document is complete (pages, attachments, and appendices) and in the proper order.
- [X] ☐ ☐ 37. The document is free of typographical errors.
- [X] ☐ ☐ 38. The tables are internally consistent.
- [X] ☐ ☐ 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".
- [X] ☐ ☐ 40. Impacted documents are appropriately identified in Blocks 7 and 25 of the Engineering Change Notice (form A-6003-563.1).
- [X] ☐ ☐ 41. If more than one Technical Peer Reviewer was designated for this document, an overall review of the entire document was performed after resolution of all Technical Peer Review comments and confirmed that the document is self-consistent and complete.
- [X] ☐ ☐ **Concurrence**

K. R. Sandgren K. R. Sandgren 7/3/08
 Reviewer (Printed Name and Signature) Date

* If No or NA is chosen, provide an explanation on this form.

- No computer codes were used for the changes included in this revision.

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 6-B

Scope of Review (e.g., document section or portion of calculation): Technical edit

Yes No NA*

- | | | | |
|--------------------------|--------------------------|-------------------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 2. Problem is completely defined. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 3. Accident scenarios are developed in a clear and logical manner. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 4. Analytical and technical approaches and results are reasonable and appropriate. (ORP QAPP criterion 2.8) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 5. Necessary assumptions are reasonable, explicitly stated, and supported. (ORP QAPP criterion 2.2) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 6. Computer codes and data files are documented. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 7. Data used in calculations are explicitly stated. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Documented Safety Analysis). |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 9. Data were checked for consistency with original source information as applicable. (ORP QAPP criterion 2.9) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. (ORP QAPP criterion 2.17) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 11. Mathematical derivations were checked including dimensional consistency of results. (ORP QAPP criterion 2.16) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 13. Spreadsheet results and all hand calculations were verified. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. (ORP QAPP criterion 2.5) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 15. Software input is correct and consistent with the document reviewed. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 16. Software output is consistent with the input and with the results reported in the document reviewed. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 17. Software verification and validation are addressed adequately. (ORP QAPP criterion 2.6) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. (ORP QAPP criterion 2.9) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 19. Safety margins are consistent with good engineering practices. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | 20. Conclusions are consistent with analytical results and applicable limits. |

Wm
07-21-08

CHECKLIST FOR TECHNICAL PEER REVIEW

- ☐ ☐ ☒ 21. Results and conclusions address all points in the purpose. (*ORP QAPP criterion 2.3*)
☒ ☐ ☐ 22. All references cited in the text, figures, and tables are contained in the reference list.
☒ ☐ ☐ 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list.
☒ ☐ ☐ 24. Only released (i.e., not draft) references are cited. (*ORP QAPP criterion 2.1*)
☒ ☐ ☐ 25. Referenced documents are retrievable or otherwise available.
☒ ☐ ☐ 26. The most recent version of each reference is cited, as appropriate. (*ORP QAPP criterion 2.1*)
☒ ☐ ☐ 27. There are no duplicate citations in the reference list.
☒ ☐ ☐ 28. Referenced documents are spelled out (title and number) the first time they are cited.
☒ ☐ ☐ 29. All acronyms are spelled out the first time they are used.
☒ ☐ ☐ 30. The Table of Contents is correct.
☒ ☐ ☐ 31. All figure, table, and section callouts are correct.
☒ ☐ ☐ 32. Unit conversions are correct and consistent.
☒ ☐ ☐ 33. The number of significant digits is appropriate and consistent.
☐ ☐ ☒ 34. Chemical reactions are correct and balanced.
☒ ☐ ☐ 35. All tables are formatted consistently and are free of blank cells.
☒ ☐ ☐ 36. The document is complete (pages, attachments, and appendices) and in the proper order.
☒ ☐ ☐ 37. The document is free of typographical errors.
☒ ☐ ☐ 38. The tables are internally consistent.
☒ ☐ ☐ 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".
☐ ☐ ☒ 40. Impacted documents are appropriately identified in Blocks 7 and 25 of the Engineering Change Notice (form A-6003-563.1).
☒ ☐ ☐ 41. If more than one Technical Peer Reviewer was designated for this document, an overall review of the entire document was performed after resolution of all Technical Peer Review comments and confirmed that the document is self-consistent and complete.
☒ ☐ ☐ **Concurrence**

Leona Germain

Reviewer (Printed Name and Signature)

07-21-08
Date

* If No or NA is chosen, provide an explanation on this form.

Technical Edit

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*

Scope of Review (e.g., document section or portion of calculation): Revision 7

Yes	No	NA*	
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2. Problem is completely defined.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3. Accident scenarios are developed in a clear and logical manner.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4. Analytical and technical approaches and results are reasonable and appropriate. (<i>ORP QAPP criterion 2.8</i>)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5. Necessary assumptions are reasonable, explicitly stated, and supported. (<i>ORP QAPP criterion 2.2</i>)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	6. Computer codes and data files are documented.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	7. Data used in calculations are explicitly stated.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Documented Safety Analysis).
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	9. Data were checked for consistency with original source information as applicable. (<i>ORP QAPP criterion 2.9</i>)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. (<i>ORP QAPP criterion 2.17</i>)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	11. Mathematical derivations were checked including dimensional consistency of results. (<i>ORP QAPP criterion 2.16</i>)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	13. Spreadsheet results and all hand calculations were verified.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. (<i>ORP QAPP criterion 2.5</i>)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	15. Software input is correct and consistent with the document reviewed.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	16. Software output is consistent with the input and with the results reported in the document reviewed.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	17. Software verification and validation are addressed adequately. (<i>ORP QAPP criterion 2.6</i>)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. (<i>ORP QAPP criterion 2.9</i>)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	19. Safety margins are consistent with good engineering practices.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	20. Conclusions are consistent with analytical results and applicable limits.

CHECKLIST FOR TECHNICAL PEER REVIEW

- ☒ ☐ ☐ 21. Results and conclusions address all points in the purpose. (*ORP QAPP criterion 2.3*)
☒ ☐ ☐ 22. All references cited in the text, figures, and tables are contained in the reference list.
☒ ☐ ☐ 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list.
☒ ☐ ☐ 24. Only released (i.e., not draft) references are cited. (*ORP QAPP criterion 2.1*)
☒ ☐ ☐ 25. Referenced documents are retrievable or otherwise available.
☒ ☐ ☐ 26. The most recent version of each reference is cited, as appropriate. (*ORP QAPP criterion 2.1*)
☒ ☐ ☐ 27. There are no duplicate citations in the reference list.
☒ ☐ ☐ 28. Referenced documents are spelled out (title and number) the first time they are cited.
☒ ☐ ☐ 29. All acronyms are spelled out the first time they are used.
☒ ☐ ☐ 30. The Table of Contents is correct.
☒ ☐ ☐ 31. All figure, table, and section callouts are correct.
☒ ☐ ☐ 32. Unit conversions are correct and consistent.
☒ ☐ ☐ 33. The number of significant digits is appropriate and consistent.
☐ ☐ ☒ 34. Chemical reactions are correct and balanced.
☒ ☐ ☐ 35. All tables are formatted consistently and are free of blank cells.
☒ ☐ ☐ 36. The document is complete (pages, attachments, and appendices) and in the proper order.
☒ ☐ ☐ 37. The document is free of typographical errors.
☒ ☐ ☐ 38. The tables are internally consistent.
☒ ☐ ☐ 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".
☐ ☐ ☒ 40. If more than one Technical Peer Reviewer was designated for this document, an overall review of the entire document was performed after resolution of all Technical Peer Review comments and confirmed that the document is self-consistent and complete.
☒ ☐ ☐ **Concurrence**

Lawrence J. Kripps
 Reviewer (Printed Name and Signature)

11/16/10
 Date

* If No or NA is chosen, provide an explanation on this form.

RPP-13482, Rev. 7, does not use any computer codes (i.e., software) or calculations, and there are no chemical equations.