RECEIVED
MAY 10 1993
OSTI

PNL-3777 Rev 2

Hanford Environmental Dose Overview Panel

RECOMMENDED ENVIRONMENTAL DOSE CALCULATION METHODS AND HANFORD-SPECIFIC PARAMETERS

R. G. Schreckhise
K. Rhoads
J. S. Davis[a]
B. A. Napier
J. V. Ramsdell

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. 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. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

March 1993

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

MASTER

[a] Westinghouse Hanford Company
Richland, Washington 99352

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

APPROVAL

This document was developed under the auspices of the Hanford Environmental Dose Overview Panel. The signature of the Chairperson below indicates the Panel's approval to issue this version of the document. Future revised sections and appendixes of this document will be issued only with approval of the Panel.

HANFORD ENVIRONMENTAL DOSE OVERVIEW PANEL APPROVAL

Document Title: Recommended Environmental Dose Calculation Methods and Hanford-Specific Parameters

Document Number: PNL-3777 Rev 2

Revision Number: 2

Issuance Date: March 1993

Authors: R. G. Schreckhise, K. Rhoads, J. S. Davis, B. A. Napier, and J. V. Ramsdell

Approval: Charles T. Kincaid, Chairperson
Hanford Environmental Dose Overview Panel

Date: 3/31/93

THIS PAGE BLANK INTENTIONALLY

PREFACE

This document was developed under the auspices of the Hanford Environmental Dose Overview Panel (hereinafter referred to as the Panel or HEDOP). The Panel was established in 1977 and originally named the Hanford Dose Overview Panel. The Panel is responsible for reviewing all assessments of potential doses received by humans and other biota resulting from the actual or possible environmental releases of radioactive and other hazardous materials from facilities and/or operations belonging to the U.S. Department of Energy (DOE) on the Hanford Site in south-central Washington. These assessments (hereinafter referred to as environmental and health dose assessments) are reviewed for their consistency with HEDOP-approved methods or for their technical validity if other than HEDOP-approved methods were used. The Panel also determines the adequacy of the documentation that supports the assessments.

The Panel serves as the technical representative for DOE's Richland Field Office (RL) for matters related to environmental and health dose assessments. The Panel is comprised of representatives from the Hanford Environmental Health Foundation, Pacific Northwest Laboratory, Westinghouse Hanford Company, and RL.

This document is intended to support HEDOP's responsibilities. It serves as a guide for developing estimates of potential radiation doses, or other measures of risk or health impacts, to people and other biota in the environs on and around the Hanford Site. It provides information needed to develop technically sound estimates of retrospective or prospective exposures to receptors resulting from the environmental transport of potentially harmful materials (i.e., radioactive and non-radioactive hazardous substances) that have been, or could be, released from the Hanford Site. The document includes listings of parameters and information that are specific to the Hanford environs as well as other supporting material. It is updated periodically to reflect improved knowledge about the parameters and other information. Revised versions also reflect changes in applicable regulations.

The first version of this document was issued originally as

McCormack, W. D. 1982. Hanford Dose Overview Program: Standardized Methods and Data for Hanford Environmental Dose Calculations. PNL-3777, Pacific Northwest Laboratory, Richland, Washington.

The first revision was issued as

McCormack, W. D., J. V. Ramsdell and B. A. Napier. 1984. Hanford Dose Overview Program: Standardized Methods and Data for Hanford Environmental Dose Calculations. PNL-3777 Rev 1, Pacific Northwest Laboratory, Richland, Washington.

This second revision of the document (i.e., PNL-3777 Rev 2) is being issued as a controlled-distribution document in a loose-leaf notebook format. This is being done so that as sections of the document are periodically updated, they can be provided to registered recipients to replace the corresponding segments. This will eliminate the need to issue the entire document each time particular sections are updated.

The distribution of this version and all future updates will be controlled by the Executive Secretary of HEDOP. Contact the Executive Secretary[a] to receive an updated version and to be placed on the controlled-distribution list for this document. Readers are encouraged to contact the Executive Secretary to pass along ideas for improving this "living" document.

---

[a] Please provide the information requested in Appendix A, "Document Request Form," to the Executive Secretary of HEDOP. See Appendix C.2, "Hanford Environmental Dose Overview Panel Members for 1992/1993," for the name, address, and phone number of the current Executive Secretary.

SUMMARY

This document was developed to support the Hanford Environmental Dose Overview Panel (HEDOP). The Panel is responsible for reviewing all assessments of potential doses received by humans and other biota resulting from the actual or possible environmental releases of radioactive and other hazardous material from facilities and/or operations belonging to the U.S. Department of Energy on the Hanford Site in south-central Washington. These environmental and health dose assessments are reviewed for their consistency with HEDOP-approved methods or for their technical validity if other than HEDOP-approved methods were used. The Panel also determines the adequacy of the documentation that supports the assessments.

This document serves as a guide to be used for developing estimates of potential radiation doses, or other measures of risk or health impacts, to people and other biota in the environs on and around the Hanford Site. It provides information to develop technically sound estimates of exposure (i.e., potential or actual) to humans or other biotic receptors that could result from the environmental transport of potentially harmful materials that have been, or could be, released from Hanford operations or facilities. Parameter values and information that are specific to the Hanford environs as well as other supporting material are included in this document.

This document, which is the second revision of "Standardized Methods and Data for Hanford Environmental Dose Calculations" (i.e., PNL-3777 and PNL-3777 Rev 1), will continue to be updated periodically. The dissemination of this controlled-distribution document and future updates will be administered by the Executive Secretary of HEDOP.

THIS PAGE BLANK INTENTIONALLY

ACKNOWLEDGMENTS

The authors wish to acknowledge Mr. W. David McCormack, who was the sole author of the first version and lead author of the second version of this report. He had the foresight to see the need for a document of this type and was primarily responsible for its development. Mr. McCormack should also be recognized for his labors in establishing the function of what is now called the Hanford Environmental Dose Overview Panel and serving as its Chairperson for a number of years. Ron Kathren, the late Ed Watson, Jerry Martin, Gene Schreckhise and Janet Davis also should be acknowledged for their leadership during their tenures as Chairpersons of the Panel.

The authors especially want to thank Mr. Joseph K. Soldat for his critical review of this document. The credibility of a document of this type is greatly enhanced by the fact that someone of Mr. Soldat's stature and reputation (i.e., the "grandfather" of environmental dosimetry codes at Hanford as well as probably the entire world) has reviewed and passed his multi-colored pen over it. The authors also wish to acknowledge the valuable review comments provided by Brit Hey, Dave Himes, Paul Rittmann, and Monte Sula along with the capable editorial support provided by Don Hanley.

The authors also want to thank the other members of the Panel for their support and patience during the development of this version of the document.

THIS PAGE BLANK INTENTIONALLY

CONTENTS

APPROVAL iii

PREFACE v

SUMMARY vii

ACKNOWLEDGMENTS ix

1.0 INTRODUCTION 1.0. 1

2.0 THE HANFORD ENVIRONMENTAL DOSE OVERVIEW PANEL 2.0. 1

2.1 CHARTER 2.0. 1

2.2 PURPOSE 2.0. 2

2.3 SCOPE 2.0. 2

2.4 PANEL MEMBERSHIP 2.0. 3

2.5 HEDOP-MANDATED REVIEWS 2.0. 3

2.6 HEDOP-APPROVED CODES 2.0. 3

3.0 ENVIRONMENTAL DOSE CALCULATION METHODS 3.0. 1

3.0.1 REFERENCES 3.0. 4

3.1 ATMOSPHERIC RELEASES 3.1. 1

3.1.1 Atmospheric Transport 3.1. 1

3.1.2 Retrospective and Prospective Analyses of Chronic and Acute Releases 3.1. 4

3.1.2.1 Chronic Atmospheric Releases 3.1. 4

3.1.2.2 Acute Atmospheric Releases 3.1. 4

3.1.3 Exposure Pathways for Atmospheric Releases . . . 3.1. 4

3.1.4 Collective Doses from Atmospheric Releases . . . 3.1. 7

3.1.5 References 3.1. 7

3.2 LIQUID RELEASES TO SURFACE AND GROUND WATER 3.2. 1

3.2.1 Surface-Water Transport 3.2. 1

3.2.2 Ground-Water Transport 3.2. 2

3.2.3 Exposure Pathways for Liquid Releases 3.2. 2

3.2.4 Collective Doses from Liquid Releases 3.2. 3

3.2.5 References 3.2. 4

3.3 TYPES OF ENVIRONMENTAL RADIATION DOSE ESTIMATES 3.3. 1

3.3.1 Dose Equivalent 3.3. 1

3.3.2 Committed Dose 3.3. 2

3.3.3 Committed Dose Equivalent 3.3. 2

3.3.4 Effective Dose Equivalent 3.3. 3
3.3.5 Other Types of Dose Estimates 3.3. 4
3.3.6 References 3.3. 5
3.4 RECEPTOR LOCATIONS FOR ENVIRONMENTAL RELEASES 3.4. 1
3.4.1 Chronic Releases 3.4. 1
3.4.2 Acute Releases 3.4. 2
3.4.3 Maximally Exposed Individual Locations 3.4. 3
4.0 HEDOP-APPROVED ENVIRONMENTAL AND HEALTH DOSE ASSESSMENT CODES 4.0. 1
4.0.1 References 4.0. 1
4.1 THE GENII COMPUTER CODE 4.1. 1
4.1.1 References 4.1. 3
4.2 EPA-MANDATED CODES 4.2. 1
4.2.1 The CAP-88 Code Package 4.2. 1
4.2.2 The AIRDOS-PC Code 4.2. 2
4.2.3 The COMPLY Code 4.2. 2
4.2.4 References 4.2. 3
4.3 OTHER CODES 4.3. 1
4.3.1 REFERENCES 4.3. 1
5.0 PERSPECTIVE ON ENVIRONMENTAL DOSES 5.0. 1
5.1 SOURCES OF NATURAL BACKGROUND RADIATION 5.0. 2
5.2 ANTHROPOGENIC SOURCES OF RADIATION 5.0. 2
5.3 ESTIMATES OF RISK FROM RADIATION DOSES 5.0. 2
5.4 REFERENCES 5.0. 4
APPENDIX A - DOCUMENT REQUEST FORM . . . . . A. 1
APPENDIX B - CHARTER OF THE HANFORD ENVIRONMENTAL DOSE OVERVIEW PANEL . . . . . B. 1
APPENDIX C.1 - CURRENT HEDOP-APPROVED REVIEWERS C.1. 1
APPENDIX C.2 - HANFORD ENVIRONMENTAL DOSE OVERVIEW PANEL MEMBERS FOR 1992/1993 . . . . . C.2. 1
APPENDIX D - HEDOP-MANDATED REVIEW REQUIREMENTS AND PROCEDURES . . D. 1
APPENDIX E - HEDOP CODE APPROVAL POLICY . . . . . E. 1
APPENDIX F.1 - CURRENT HEDOP-APPROVED CODES F.1. 1
F.1.1 - REFERENCES F.1. 3
APPENDIX F.2 - HEDOP GUIDANCE FOR USING EPA-MANDATED CODES AT HANFORD F.2. 1

APPENDIX G.1 - HANFORD SITE DESCRIPTION G.1. 1
G.1.1 - SITE ENVIRONMENT G.1. 3
G.1.2 - LAND USE G.1. 3
G.1.3 - CLIMATE AND METEOROLOGY G.1. 5
G.1.4 - GEOLOGY G.1. 6
G.1.5 - GROUND-WATER HYDROLOGY G.1. 7
G.1.6 - SURFACE-WATER HYDROLOGY G.1. 9
G.1.7 - ECOLOGICAL CHARACTERISTICS G.1.10
G.1.8 - REFERENCES G.1.11
APPENDIX G.2 - RESIDENTIAL POPULATION DISTRIBUTIONS WITHIN 80 KM OF THE HANFORD SITE AREAS G.2. 1
APPENDIX H.1 - ATMOSPHERIC DISPERSION MODELING AT HANFORD H.1. 1
H.1.1 - JOINT FREQUENCY DISTRIBUTIONS H.1. 3
H.1.2 - CHRONIC RELEASES H.1. 5
H.1.3 - ACUTE RELEASES H.1. 6
H.1.4 - REFERENCES H.1. 7
APPENDIX H.2 - IMPLEMENTATION AND USE OF THE ATMOSPHERIC DISPERSION MODELS IN GENII H.2. 1
H.2.1 - CHRONIC RELEASE OPTIONS H.2. 3
H.2.2 - ACUTE RELEASE OPTIONS H.2. 5
H.2.3 - OPTIONAL MODELS H.2. 8
H.2.4 - ATMOSPHERIC DISPERSION AND AIR-SUBMERSION MODEL INTERACTIONS H.2.10
H.2.5 - REFERENCES H.2.11
APPENDIX H.3 - HANFORD AREA METEOROLOGICAL INFORMATION BASED ON 1983 THROUGH 1991 OBSERVATIONS H.3. 1
H.3.1 - GUIDELINES FOR USING JOINT FREQUENCY DATA WITH THE GENII CODE H.3. 3
H.3.2 - HANFORD-AREA JOINT FREQUENCY TABLES BASED ON 1983 THROUGH 1991 METEOROLOGICAL INFORMATION H.3. 4
APPENDIX H.4 - ATMOSPHERIC DISPERSION FACTORS: ANNUAL SECTOR-AVERAGED $\overline{\chi}/Q'$ VALUES FOR CHRONIC RELEASES FROM HANFORD AREAS BASED ON 1983 THROUGH 1991 METEOROLOGICAL INFORMATION H.4. 1
APPENDIX H.5 - ATMOSPHERIC DISPERSION FACTORS: 95TH PERCENTILE CENTER-LINE E/Q VALUES FOR ACUTE ATMOSPHERIC RELEASES FROM THE HANFORD AREAS BASED ON 1983 THROUGH 1991 METEOROLOGICAL INFORMATION . . . H.5. 1

APPENDIX H.6 - ATMOSPHERIC DISPERSION FACTORS: 99.5TH PERCENTILE CENTER-LINE E/Q VALUES FOR ACUTE ATMOSPHERIC RELEASES FROM THE HANFORD AREAS BASED ON 1983 THROUGH 1991 METEOROLOGICAL INFORMATION . . . H.6. 1

APPENDIX H.7 - RECEPTOR LOCATIONS FOR MAXIMALLY EXPOSED INDIVIDUALS RESULTING FROM ATMOSPHERIC RELEASES FROM SPECIFIED HANFORD FACILITIES H.7. 1

APPENDIX I - RECOMMENDED SCENARIO DEFINITIONS FOR ATMOSPHERIC AND LIQUID RELEASES . . . . . I. 1

APPENDIX J - RECOMMENDED PARAMETERS FOR CALCULATING POTENTIAL ENVIRONMENTAL RADIATION DOSES AT HANFORD . . . . . J. 1

J.1 - ATMOSPHERIC TRANSPORT . . . . . J. 3

J.1.1 - Atmospheric Dispersion Factors . . . . . J. 4

J.1.2 - Deposition . . . . . J. 4

J.1.3 - Fractional Intercept Values . . . . . J. 4

J.1.4 - Resuspension . . . . . J. 4

J.2 - SURFACE-WATER TRANSPORT . . . . . J. 5

J.3 - SUBSURFACE SOURCES . . . . . J. 5

J.4 - INGESTION PATHWAYS . . . . . J. 5

J.4.1 - Drinking Water . . . . . J. 5

J.4.2 - Aquatic Foodstuffs . . . . . J. 5

J.4.2.1 - Concentration Ratios . . . . . J. 6

J.4.2.2 - Water Treatment Cleanup Factors . . . . J. 7

J.4.3 - Terrestrial Food Products . . . . . J. 7

J.4.3.1 - Chronic Releases . . . . . J. 7

J.4.3.2 - Acute Releases . . . . . J. 7

J.4.3.3 - Default Values . . . . . J. 8

J.4.3.4 - Carbon-14 and Tritium Models . . . . . J. 8

J.4.3.5 - Deposition Velocity . . . . . J. 8

J.4.3.6 - Concentration Ratio . . . . . J. 9

J.4.3.7 - Equilibrium Transfer Coefficients . . . J. 9

J.4.3.8 - Leaching Factor J.10

J.5 - EXTERNAL EXPOSURE J.11

J.6 - MISCELLANEOUS PARAMETERS J.11

J.7 - REFERENCES J.11

APPENDIX K - GLOSSARY . . . . . K. 1
K.1 - ABBREVIATIONS, ACRONYMS, AND DEFINITIONS . . . . . K. 3
K.2 - REFERENCES . . . . . K. 9
DISTRIBUTION Distri-1

FIGURES

3.1 Primary Exposure Pathways at Hanford 3.0. 1

G.1.1 Hanford Site G.1. 4

TABLES

3.3.1	Quality Factors	3.3. 2
3.3.2	Weighting Factors	3.3. 3
5.1	Radiation Doses to an Average Member of the U.S. Populations from Natural and Artificial Sources	5.0. 1
5.2	Lifetime Fatal Cancer Risk Factors from Whole-Body Exposure to Low-LET Radiation	5.0. 3
5.3	Estimated Risk from Various Activities and Exposures	5.0. 4
G.2.1	Residential Population Distributions Within 80 km of the 100 N Area Based on 1990 Census Data	G.2. 4
G.2.2	Residential Population Distributions Within 80 km of the 200 Areas Based on 1990 Census Data	G.2. 4
G.2.3	Residential Population Distributions Within 80 km of the 300 Area Based on 1990 Census Data	G.2. 5
G.2.4	Residential Population Distributions Within 80 km of the 400 Area Based on 1990 Census Data	G.2. 5
H.1.1	Wind Speed Classifications	H.1. 3
H.1.2	Atmospheric Stability Classifications	H.1. 4
H.3.1	Joint Frequency Distributions for the 100 N Area for a 10-m Tower Based on 1983-91 Data	H.3. 5
H.3.2	Joint Frequency Distributions for the 100 N Area for a 61-m Tower Based on 1983-91 Data	H.3. 6
H.3.3	Joint Frequency Distributions for the 100 N Area for an 89-m Tower Based on 1983-91 Data	H.3. 7
H.3.4	Joint Frequency Distributions for the 200 Areas for a 10-m Tower Based on 1983-91 Data	H.3. 8
H.3.5	Joint Frequency Distributions for the 200 Areas for a 61-m Tower Based on 1983-91 Data	H.3. 9
H.3.6	Joint Frequency Distributions for the 200 Areas for an 89-m Tower Based on 1983-91 Data	H.3.10
H.3.7	Joint Frequency Distributions for the 300 Area for a 10-m Tower Based on 1983-91 Data	H.3.11
H.3.8	Joint Frequency Distributions for the 300 Area for a 61-m Tower Based on 1983-91 Data	H.3.12
H.3.9	Joint Frequency Distributions for the 300 Area for an 89-m Tower Based on 1983-91 Data	H.3.13
H.3.10	Joint Frequency Distributions for the 400 Area for a 10-m Tower Based on 1983-91 Data	H.3.14

H.3.11 Joint Frequency Distributions for the 400 Area for a 61-m Tower Based on 1983-91 Data H.3.15

H.3.12 Joint Frequency Distributions for the 400 Area for an 89-m Tower Based on 1983-91 Data H.3.16

H.4.1 $\overline{\chi}/Q'$ Values for Chronic Ground-Level Releases from 100 N Area Based on 1983-91 Meteorological Information . H.4. 4

H.4.2 $\overline{\chi}/Q'$ Values for Chronic 30-m Stack Releases from 100 N Area Based on 1983-91 Meteorological Information . H.4. 4

H.4.3 $\overline{\chi}/Q'$ Values for Chronic 60-m Stack Releases from 100 N Area Based on 1983-91 Meteorological Information . H.4. 5

H.4.4 $\overline{\chi}/Q'$ Values for Chronic 90-m Stack Releases from 100 N Area Based on 1983-91 Meteorological Information . H.4. 5

H.4.5 $\overline{\chi}/Q'$ Values for Chronic Ground-Level Releases from 200 Areas Based on 1983-91 Meteorological Information . . H.4. 6

H.4.6 $\overline{\chi}/Q'$ Values for Chronic 30-m Stack Releases from 200 Areas Based on 1983-91 Meteorological Information . . H.4. 6

H.4.7 $\overline{\chi}/Q'$ Values for Chronic 60-m Stack Releases from 200 Areas Based on 1983-91 Meteorological Information . . H.4. 7

H.4.8 $\overline{\chi}/Q'$ Values for Chronic 90-m Stack Releases from 200 Areas Based on 1983-91 Meteorological Information . . H.4. 7

H.4.9 $\overline{\chi}/Q'$ Values for Chronic Ground-Level Releases from 300 Area Based on 1983-91 Meteorological Information . . H.4. 8

H.4.10 $\overline{\chi}/Q'$ Values for Chronic 30-m Stack Releases from 300 Area Based on 1983-91 Meteorological Information . . H.4. 8

H.4.11 $\overline{\chi}/Q'$ Values for Chronic 60-m Stack Releases from 300 Area Based on 1983-91 Meteorological Information . . H.4. 9

H.4.12 $\overline{\chi}/Q'$ Values for Chronic Ground-Level Releases from 400 Area Based on 1983-91 Meteorological Information . . H.4. 9

H.4.13 $\overline{\chi}/Q'$ Values for Chronic 10-m Stack Releases from 400 Area Based on 1983-91 Meteorological Information . . H.4.10

H.4.14 $\overline{\chi}/Q'$ Values for Chronic 30-m Stack Releases from 400 Area Based on 1983-91 Meteorological Information . . H.4.10

H.5.1 95th Percentile E/Q Values for Acute Ground-Level Releases from 100 N Area Based on 1983 Through 1991 Meteorological Information H.5. 4

H.5.2 95th Percentile E/Q Values for Acute 30-m Stack Releases from 100 N Area Based on 1983 Through 1991 Meteorological Information H.5. 4

H.5.3 95th Percentile E/Q Values for Acute 60-m Stack Releases from 100 N Area Based on 1983 Through 1991 Meteorological Information H.5. 5

H.5.4 95th Percentile E/Q Values for Acute 90-m Stack Releases from 100 N Area Based on 1983 Through 1991 Meteorological Information H.5. 5

H.5.5 95th Percentile E/Q Values for Acute Ground-Level Releases from 200 Areas Based on 1983 Through 1991 Meteorological Information H.5. 6

H.5.6 95th Percentile E/Q Values for Acute 30-m Stack Releases from 200 Areas Based on 1983 Through 1991 Meteorological Information H.5. 6

H.5.7 95th Percentile E/Q Values for Acute 60-m Stack Releases from 200 Areas Based on 1983 Through 1991 Meteorological Information H.5. 7

H.5.8 95th Percentile E/Q Values for Acute 90-m Stack Releases from 200 Areas Based on 1983 Through 1991 Meteorological Information H.5. 7

H.5.9 95th Percentile E/Q Values for Acute Ground-Level Releases from 300 Area Based on 1983 Through 1991 Meteorological Information H.5. 8

H.5.10 95th Percentile E/Q Values for Acute 30-m Stack Releases from 300 Area Based on 1983 Through 1991 Meteorological Information H.5. 8

H.5.11 95th Percentile E/Q Values for Acute 60-m Stack Releases from 300 Area Based on 1983 Through 1991 Meteorological Information H.5. 9

H.5.12 95th Percentile E/Q Values for Acute Ground-Level Releases from 400 Area Based on 1983 Through 1991 Meteorological Information H.5. 9

H.5.13 95th Percentile E/Q Values for Acute 10-m Stack Releases from 400 Area Based on 1983 Through 1991 Meteorological Information H.5.10

H.5.14 95th Percentile E/Q Values for Acute 30-m Stack Releases from 400 Area Based on 1983 Through 1991 Meteorological Information H.5.10

H.6.1 99.5th Percentile E/Q Values for Acute Ground-Level Releases from 100 N Area Based on 1983 Through 1991 Meteorological Information H.6. 4

H.6.2 99.5th Percentile E/Q Values for Acute 30-m Stack Releases from 100 N Area Based on 1983 Through 1991 Meteorological Information H.6. 4

H.6.3 99.5th Percentile E/Q Values for Acute 60-m Stack Releases from 100 N Area Based on 1983 Through 1991 Meteorological Information H.6. 5

H.6.4 99.5th Percentile E/Q Values for Acute 90-m Stack Releases from 100 N Area Based on 1983 Through 1991 Meteorological Information H.6. 5

H.6.5 99.5th Percentile E/Q Values for Acute Ground-Level Releases from 200 Areas Based on 1983 Through 1991 Meteorological Information H.6. 6

H.6.6 99.5th Percentile E/Q Values for Acute 30-m Stack Releases from 200 Areas Based on 1983 Through 1991 Meteorological Information H.6. 6

H.6.7 99.5th Percentile E/Q Values for Acute 60-m Stack Releases from 200 Areas Based on 1983 Through 1991 Meteorological Information H.6. 7

H.6.8 99.5th Percentile E/Q Values for Acute 90-m Stack Releases from 200 Areas Based on 1983 Through 1991 Meteorological Information H.6. 7

H.6.9 99.5th Percentile E/Q Values for Acute Ground-Level Releases from 300 Area Based on 1983 Through 1991 Meteorological Information H.6. 8

H.6.10 99.5th Percentile E/Q Values for Acute 30-m Stack Releases from 300 Area Based on 1983 Through 1991 Meteorological Information H.6. 8

H.6.11 99.5th Percentile E/Q Values for Acute 60-m Stack Releases from 300 Area Based on 1983 Through 1991 Meteorological Information H.6. 9

H.6.12 99.5th Percentile E/Q Values for Acute Ground-Level Releases from 400 Area Based on 1983 Through 1991 Meteorological Information H.6. 9

H.6.13 99.5th Percentile E/Q Values for Acute 10-m Stack Releases from 400 Area Based on 1983 Through 1991 Meteorological Information H.6.10

H.6.14 99.5th Percentile E/Q Values for Acute 30-m Stack Releases from 400 Area Based on 1983 Through 1991 Meteorological Information H.6.10

H.7.1 Site Boundary Locations and Corresponding Maximum $\overline{\chi}/Q'$ and E/Q Values for the PUREX Plant H.7. 4

H.7.2 Site Boundary Locations and Corresponding Maximum $\overline{\chi}/Q'$ and E/Q Values for PFP H.7. 5

H.7.3 Site Boundary Locations and Corresponding Maximum $\overline{\chi}/Q'$ and E/Q Values for FFTF H.7. 6

I.1 Recommended Exposure Scenarios for Atmospheric Releases From the Hanford Site . . . . . I. 4

I.2 Recommended Exposure Scenarios for Liquid Releases to the Columbia River From the Hanford Site . . . . . I. 5

J.1 Recommended Parameter Values -- Atmospheric Transport . . J.13

J.2 Recommended Parameter Values -- Surface-Water Transport . J.15

J.3 Recommended Parameter Values -- Subsurface Sources . . . J.17

J.4 Recommended Parameter Values -- Drinking Water Ingestion J.19
J.5 Recommended Parameter Values -- Ingestion of Aquatic Foodstuffs J.20
J.6 Recommended Parameter Values -- Aquatic Transfer Factors J.21
J.7 Recommended Parameter Values -- Ingestion of Food Crops . J.25
J.8 Recommended Parameter Values -- Ingestion of Animals Products J.28
J.9 Recommended Parameter Values -- Terrestrial Transfer Factors J.33
J.10 Recommended Parameter Values -- Carbon and Hydrogen Content of Selected Environmental Media J.37
J.11 Recommended Parameter Values -- External Exposure J.38
J.12 Recommended Parameter Values -- Miscellaneous J.39

THIS PAGE BLANK INTENTIONALLY

1.0 INTRODUCTION

Estimates of potential doses received by humans and other biota are required to be developed whenever conditions or operations on the Hanford Site have resulted in, or present the possibility of, releases of radioactive or other hazardous materials to the environment. (A description of the Hanford Site and surrounding region is presented in Appendix G.1.) These calculations, hereinafter referred to as environmental and health dose assessments, include prospective and retrospective analyses. Prospective assessments are performed to evaluate the adequacy of proposed control systems and general operations to comply with applicable environmental regulations. Retrospective assessments of present as well as past operations are also conducted to evaluate potential health and environmental impacts and to demonstrate compliance with applicable rules and regulations. Because the results of these assessments are very sensitive to the models, parameters, input data, and assumptions selected, it is important that the methods and supporting information employed be appropriate and technically consistent throughout the Site.

The importance of consistency in these assumptions was recognized in 1975 when the predecessor agency of the U.S. Department of Energy's Richland Field Office (RL) requested Pacific Northwest Laboratory (PNL) to provide a means to improve the consistency and accuracy of all documented Hanford-related environmental radiation dose calculations. As a result of the request, the now-designated Hanford Environmental Dose Overview Panel (HEDOP) was established in 1977. The Panel is responsible for reviewing all Hanford-related environmental and health dose assessments for 1) technical consistency, 2) technical validity, and 3) adequacy of the documentation that supports the assessments.

The Panel serves as the technical representative for RL on matters related to environmental and health dose assessments of operations and facilities belonging to the U.S. Department of Energy on the Hanford Site. The voting members are the representatives from the Hanford Environmental Health Foundation (HEHF), Pacific Northwest Laboratory (PNL), and Westinghouse Hanford Company (WHC). The nonvoting members include a representative from RL

and the manager of PNL's Hanford Environmental Dosimetry Coordination Project who serves as the Executive Secretary of HEDOP. (One function of the DOE-funded Hanford Environmental Dosimetry Coordination Project is to provide technical and administrative support to HEDOP.) A Panel member from HEHF, PNL or WHC is elected each year by the HEDOP members to serve as chairperson. The current members of the Panel are listed in Appendix C.2

This report, which has been updated twice, was developed to support HEDOP's responsibilities. It serves as a guide for developing estimates of potential radiation doses, or other measures of risk or health impacts, to people and other biota in the environs on and around the Hanford Site. It provides the information necessary to develop technically sound estimates of potential or actual exposure to receptors involving the environmental transport of potentially harmful material that has been, or could be, released from Hanford operations and facilities. The document includes parameters and other Hanford-specific information as well as other supplemental material. The Panel plans to update this report periodically to reflect improved knowledge about the parameters and other forms of information that are used in dose-estimating procedures and to indicate changes in applicable regulations.

An overview of the charter, purpose, scope, and responsibilities of HEDOP is presented in Section 2. Section 3 presents a synopsis of the methods used to estimate various types of potential radiation doses that could result from the release of radionuclides to the atmosphere and surface and ground water. Section 4 describes the environmental and health dose assessment computer codes that have been approved by HEDOP. Perspectives on environmental sources and levels of background radiation are presented in Section 5. In addition, estimates of potential risk from radiation doses as published by various national and international organizations are summarized. The appendixes include details on how to request a copy of this document, information on HEDOP-mandated requirements, and a list of HEDOP-approved codes. A description of the Site and surrounding region, the various Hanford-specific parameters and other supporting information that are used in the codes, and a list of acronyms and glossary of terms used throughout this document are included in the Appendices.

2.0 THE HANFORD ENVIRONMENTAL DOSE OVERVIEW PANEL

The organization now known as the Hanford Environmental Dose Overview Panel (HEDOP) was established in 1977 in response to a request from the predecessor agency of the U.S. Department of Energy's Richland Field Office (RL). The Panel was established to help RL ensure that estimates of potential radiation doses to the public and the environment that could result from releases of radioactive materials from facilities and operations on the Hanford Site are technically defensible and consistent. Estimates of dose or risk from releases of radionuclides and other potentially hazardous materials to the environment are performed for a number of purposes by several organizations on the Hanford Site. Emissions from past activities are evaluated to determine their potential impact on the environment and public health, and to demonstrate compliance with applicable regulations and standards. Estimates of potential doses from future facilities are also developed to support engineering design and safety analyses, secure federal and state permits for construction or modification of facilities, and demonstrate compliance with applicable regulations and standards.

The Panel serves as the technical representative for RL on matters related to environmental and health dose assessments of operations and facilities that belong to the U.S. Department of Energy (DOE) on the Hanford Site. Environmental and health dose assessments may include

- the use of various types of models to project the environmental transport of potentially harmful materials
- the development of exposure and/or dose estimates
- application of health risk conversion factors.

2.1 Charter

The Panel operated rather informally until a Charter was developed by Hanford contractor and RL personnel. The Charter was formally approved by the members of the then-named "Hanford Dose Overview Panel" and RL. It was issued by RL to the Hanford contractors on June 25, 1990. A copy of the Charter is

presented in Appendix B. It describes the Panel's purpose, membership, and responsibilities.

2.2 PURPOSE

The purposes of HEDOP are to assure that appropriate radiological and nonradiological environmental and health dose assessment methods are used at Hanford and that all Hanford-related environmental and health dose assessments are technically consistent. The Panel also fosters communication among the Hanford contractors regarding environmental and health dose assessments.

As part of its responsibilities, HEDOP recommends methods and parameters to be used in risk assessments, particularly for radiological-type evaluations. However, the Panel also evaluates methods for conducting non-radiological assessments because the Hanford Site has a growing need to address the potential exposure of humans and other biota to hazardous materials other than just radioactive materials.

One of the primary functions of the Panel is to support a group of qualified reviewers who are available to review Hanford-related environmental and health dose assessments according to criteria established by the Panel.

2.3 SCOPE

Although the initial emphasis of HEDOP was, and continues to be, the potential environmental radiation doses that could result from Hanford operations, the methods and parameters used to estimate potential doses are also applicable to evaluations for other types of hazardous materials as well. Accordingly, the Panel also addresses non-radiological issues.

The scope of HEDOP covers all environmental and health dose assessments for potential or actual exposure to onsite and offsite receptors that involve the environmental transport of potentially harmful material that has been, or could be, released from a Hanford operation or facility. Environmental and health dose assessments performed for locations other than Hanford and for facilities that do not belong to DOE on the Site (e.g., the commercial radioactive burial site, operated by US Ecology, and the electricity-generating nuclear reactor, owned by Washington Power Production Supply System) are outside the scope of HEDOP.

2.4 PANEL MEMBERSHIP

The Panel is comprised of up to four representatives each from the Hanford Environmental Health Foundation (HEHF), Pacific Northwest Laboratory (PNL), and Westinghouse Hanford Company (WHC). A non-voting representative from RL is also a member of the Panel. The manager of PNL's Hanford Environmental Dosimetry Coordination Project serves as the Executive Secretary, and also a non-voting member. Each year the Panel elects one of its voting members to serve as chairperson. The members represent a variety of scientific and technical disciplines related to environmental and health dose assessments. The current membership of the Panel is presented in Appendix C.2.

In addition to the HEDOP members, other Hanford staff and offsite personnel are occasionally requested to assist the Panel. Working groups, comprised of individuals with specialized scientific knowledge, may be established by the Panel Chairperson to address a variety of technical issues.

2.5 HEDOP-MANDATED REVIEWS

A review process for environmental dose and risk assessments has been established by HEDOP as the most efficient means of assuring technical defensibility and consistency across the various groups that perform these analyses on the Hanford Site. As stated in the HEDOP charter, "Hanford contractors shall assure that all applicable environmental and health dose assessments are reviewed according to the requirement[s] of HEDOP." To provide the reviews in a timely manner, the Panel has designated several Hanford contractor staff to serve as "official reviewers" of applicable environmental and health dose assessments developed at Hanford. The designated reviewers have a broad spectrum of expertise and some also serve as members of HEDOP. The current list of the HEDOP-Approved Reviewers is presented in Appendix C.1. The policies and procedures for obtaining a HEDOP review are presented in Appendix D.

2.6 HEDOP-APPROVED CODES

The recommended methods and parameters for evaluating radiation doses are described in the following sections of this document. Many of these methods may also be used to evaluate potential risks from other types of

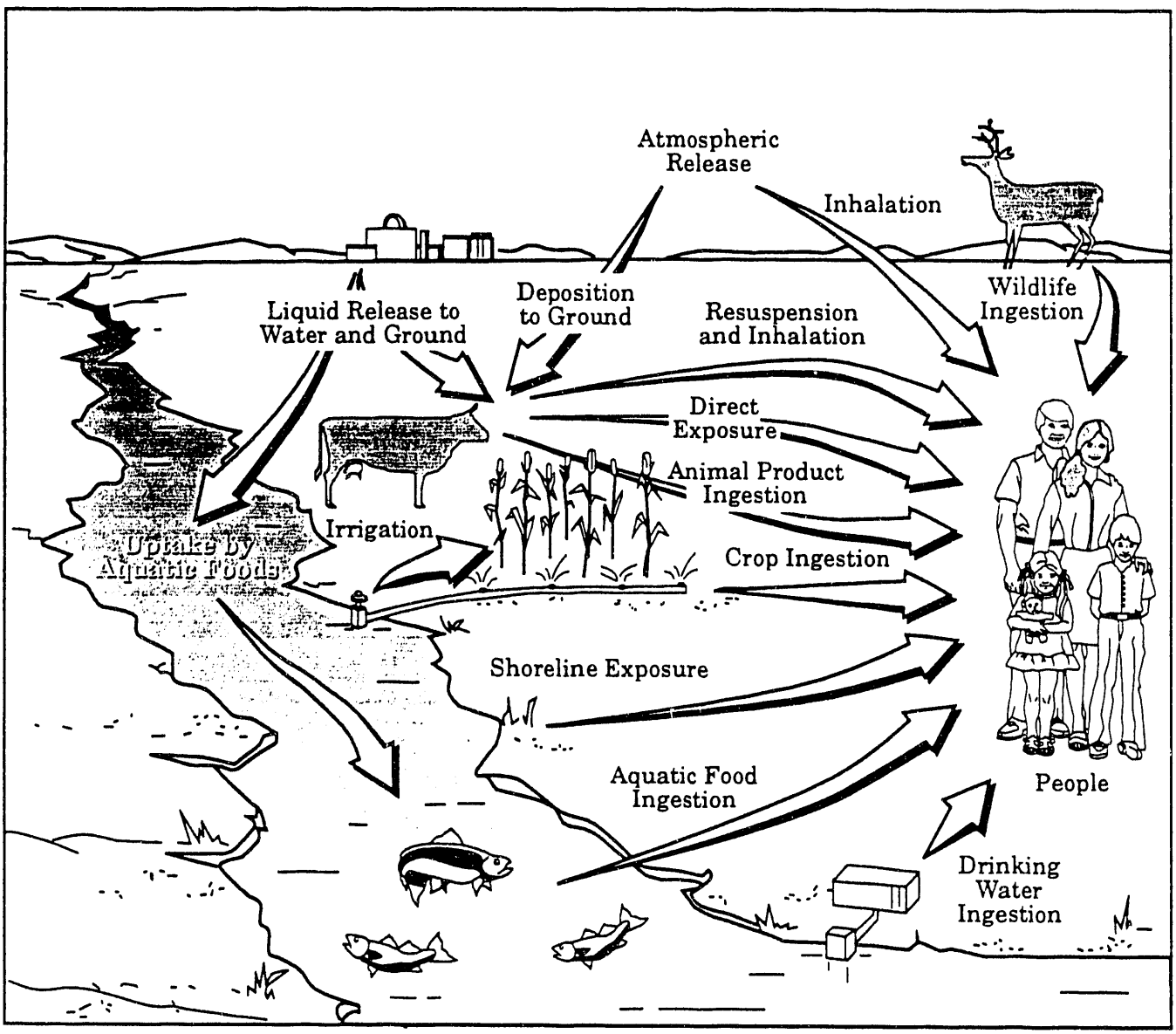
hazardous materials as appropriate. The methods and parameters used for radiation dose assessments are also included in a set of computer codes that have been approved by HEDOP. The codes are maintained by PNL's Environmental Dosimetry Coordination Project.

A policy for evaluating and approving computer codes for various types of assessments has been implemented by the Panel to facilitate the HEDOP-mandated review of routine calculations (see Appendix E). Evaluation of the codes involve investigating its quality, technical adequacy, and intended purpose along with identifying any limitations that may apply to its use at Hanford. The HEDOP approval process is not intended to restrict the methods used for environmental and health dose assessments, but to provide guidelines and information as an aid in maintaining consistency across the Hanford Site. Alternative methods may be used where they are specified by a client or by regulatory agencies, or where it can be demonstrated that they are more technically appropriate for the particular application than the HEDOP-recommended method.

The codes approved for various types of calculations are described in Appendix F. Contact the Executive Secretary of HEDOP for information on how to gain access to the HEDOP-approved codes. The name, address, and phone number of the current Executive Secretary are provided in Appendix C.2.

3.0 ENVIRONMENTAL DOSE CALCULATION METHODS

To evaluate the potential impacts of any hazardous material in the environment on humans or other biota, it is necessary to obtain quantitative information about the material's routes of exposure to the receptor via all the significant pathways shown in Figure 3.1. To project any potential impacts, it is also necessary to know what potential effects the exposure might have on the receptor.



S9203058.131

Figure 3.1. Primary Exposure Pathways at Hanford

Ideally, the environmental levels of a hazardous material would be measured at the location of interest. The subsequent potential impacts to an individual at that location would then be predicted based on accurate information as to how the material behaves biologically and how organisms are expected to respond to given exposure levels. However, in most instances it is impossible or impractical to obtain accurate estimates of the actual environmental levels of the hazardous material at the receptor location.

Therefore, simulation models are used to depict the environmental and biological behavior of hazardous materials to project potential biological effects at the receptor location. The mathematical models are usually based on the best available information about representative behavior of natural as well as hazardous materials in the environment and in the biological systems with which they interact. The accuracy of such estimates depends on the validity of the models themselves and on the accuracy with which important input parameters required for the models are known. Each step in obtaining or estimating the required information is associated with substantial uncertainties due to the inherent natural variability in biological and environmental systems and to limitations in the analytical methods used.

The first step in assessing the potential impacts of hazardous material in the environment to an individual involves establishing a scenario that describes the circumstances under which the material enters the environment and is transported to the receptor location. The scenario may further describe several pathways by which an individual receptor is exposed. It provides the bases for estimating the probable consequences of that exposure in terms of health risk. At the Hanford Site, the most common routes by which hazardous materials enter the environment are via releases to the atmosphere, to surface water (such as the Columbia River), and by ground disposal (e.g., discharge to underground leach fields and surface-water impoundments and solid waste burial).

As noted by Soldat (1989), in the past the annual projected potential radiation doses received by people exposed to radionuclides from liquid releases at Hanford during some years were smaller and, during other years, larger than the potential doses resulting from airborne emissions. The shifts in the relative importance between the liquid and the airborne pathways were

primarily caused by the types of operations in place on the Hanford Site during the year that the potential doses were calculated. Therefore, it is important all potential routes of exposure be considered when evaluating environmental releases.

The rates at which release, transport, and exposure take place also play a significant role in determining the potential impacts of any hazardous material in the environment. Releases may generally be described as acute (i.e., occurring over a relatively short time) or chronic (i.e., continuing at a fairly constant rate for a long period of time).

For most acute release situations, the receptor is typically exposed to a short-term increase in environmental levels of the hazardous material. The rate at which the environmental levels return to pre-release amounts is governed by the physical, chemical, and environmental characteristics of the material. In chronic release situations, the release is basically continuous and the environmental levels of the material normally increase to an equilibrium level (i.e., the loss rate from a particular compartment, such as by physical decay, chemical degradation, or transfer to other compartments, is equal to the input rate into the compartment).

In some cases (e.g., underground waste burial), the actual release to the near-field environment may take place over a relatively short period of time, while the actual time between release of the material and transport to the receptor may be years or even centuries. Environmental transport mechanisms will actually determine the time period and rate at which the material eventually reaches the receptor. The eventual exposure to the receptor may actually approximate a chronic exposure situation even though it was originally an acute environmental release.

As part of this document, HEDOP is providing information on currently acceptable models and associated computer codes for evaluating the potential impacts of radionuclides and other hazardous materials. The values of the models' input parameters applicable to the Hanford Site are presented in Appendix J. As the models and/or the input parameters are updated, revised sections and appendixes will be provided to registered recipients of this document.

3.0.1 REFERENCES

Soldat, J. K. 1989. Offsite Radiation Doses from Hanford Operations for the Years 1983 through 1987: A Comparison of Results Calculated by Two Methods. PNL-7135, Pacific Northwest Laboratory, Richland, Washington.

3.1 ATMOSPHERIC RELEASES

Radioactive and other hazardous materials may be released to the atmosphere from stacks and/or vents of buildings and other structures on the Hanford Site. Airborne material can also arise from more diffuse sources, such as evaporation from ponds or spills, by resuspension of particulate materials from contaminated equipment or soil surfaces, and fugitive releases from openings in buildings or other structures. After a substance enters the atmosphere, it is dispersed by wind and diffusion. The quantity of material reaching a particular downwind location depends on the magnitude of forces that act to disperse it as well as mechanisms that tend to remove material from the plume. The potential impacts of an atmospheric release depend not only on the amount of material transported to the receptor's location, but on the extent of the individual's exposure to the material.

3.1.1 Atmospheric Transport

Dispersion of airborne materials is controlled by factors that generally promote mixing in the atmosphere, such as wind and thermal effects. The concentration of material in air downwind from a point source is a combined function of the effective release height, distance from the source, and atmospheric conditions during and after the release. Effective release height includes the physical height of the stack or building from which the release occurs and other forces that may cause the plume to rise or fall after leaving the release point. These forces include thermal effects (e.g., buoyancy of an air stream with a higher temperature than that of the surrounding environment) and momentum effects for effluents that leave the stack at high velocity. The proximity of the release point to large structures may also affect dispersion of the plume by causing it to disperse more rapidly (i.e., building wake effect) or by temporarily pulling it downward (i.e., building downwash).

Atmospheric conditions affect dispersion in a number of ways, and the cumulative effect of a given set of conditions is most commonly estimated using a straight-line Gaussian plume model (Gifford 1968; USNRC 1977). In this model, wind speed and atmospheric stability generally control mixing in the horizontal plane. Mixing in the vertical direction is also a function of atmospheric stability. Input to the plume model consists of the effective

release height, distance from source to receptor, and meteorological data that provide information on wind speed, direction, and atmospheric stability. Building wake effects are generally only considered for acute releases and depend on the release height relative to the dimensions of nearby structures. Downwash is either generally neglected for most environmental calculations of interest or is accounted for by modeling the release as if it occurred at ground level.

It should be noted that the Gaussian plume model is valid under limited conditions. It should not be used for receptors that are very near (i.e., <100 m) or distant (i.e., >80 km) from the source. It also should not be used where complex terrain invalidates the assumptions inherent to the straight-line model. The model also assumes that the release rate is constant and, therefore, should not be used where the release rate varies markedly over time.

The Gaussian plume model is used to calculate a quantity that represents the normalized concentration of material in air at the chosen location. The quantity is referred to as the atmospheric dispersion factor (i.e., $\overline{\chi}/Q'$ for chronic and E/Q for acute release situations) and has units of sec m^{-3}. These quantities can be used to calculate the exposure from material in air at a specified location given quantitative information about the release of the material at the emission source. Examples of chronic and acute release calculations are presented below:

- Chronic atmospheric releases -- Multiplying $\overline{\chi}/Q'$ (i.e., sec m^{-3}) for a particular receptor location times a given release rate of a radionuclide to the atmosphere (i.e., Bq sec^{-1}) provides an estimate of the average concentration of the radionuclide in air (i.e., Bq m^{-3}) at the receptor location.

- Acute atmospheric releases -- Multiplying E/Q (i.e., sec m^{-3}) for a particular receptor location times a given total amount of a radionuclide released to the atmosphere over the release period (i.e., Bq) provides an estimate of the time-integrated concentration of the radionuclide (i.e., Bq sec m^{-3}) at the receptor location.

These qualities can then be multiplied times such parameters as the breathing rate (i.e., m^3 sec^{-1}) or deposition velocity (i.e., m sec^{-1}) to develop estimates of the quantity of the radionuclide that was inhaled (i.e., Bq) or

deposited on the surface of vegetation, ground, or other applicable objects (i.e., Bq m^{-2}).

The atmospheric dispersion factors can be calculated based on the average value of the normalized concentrations of material over an entire directional sector or, alternately, at the centerline of the plume. Centerline averages are generally used to develop E/Q values for acute individual and population exposures. Sector-averaged values are used to develop $\overline{\chi}/Q'$ values for chronic exposures to individuals and to the population.

The meteorological data set (i.e., the joint frequency distribution) generally describes the frequency with which hourly observations of wind direction, wind speed, and atmospheric stability fall into one of a discrete set of categories. Wind direction consists of 16 compass sectors (i.e., N, NNE, NE, etc.). Wind speed are generally divided into several ranges, using the midpoint of each range as the representative wind speed for all observations within that range. Atmospheric stability may be determined in a variety of ways and is generally categorized into one of 6 or 7 classes.

In addition to atmospheric dispersion, a number of other forces act to control the concentration of material in the plume as it moves away from the release point. For emissions in particulate form, gravitational forces cause larger particles to deposit on the ground. Smaller airborne particles are also intercepted by vegetation and other obstacles in their path. Gaseous materials may react with other compounds in the atmosphere or on the ground surface. Radioactive materials undergo physical decay, which effectively removes them from the plume. However, radioactive decay products of the parent radionuclides may also build up in the plume. The levels of particular radionuclides in the plume depend on their physical half-lives and the transit time between the release point and receptor. All of these may be important factors that should be considered in estimating the ultimate concentrations of material in the plume at the receptor location.

Additional information on meteorological data collection and atmospheric dispersion modeling at Hanford is contained in Appendixes H.1 and H.2.

3.1.2 Retrospective and Prospective Analyses of Chronic and Acute Releases

The type of meteorological data used for a given analysis depends on the conditions under which the release and exposure occur.

3.1.2.1 Chronic Atmospheric Releases

For retrospective evaluations of chronic releases, averaged data for the period of interest (e.g., a calendar year) are generally used. Prospective estimates for chronic emission sources, such as those used in permitting and environmental impact analyses, utilize historical data averaged over a longer period--ideally several years.

3.1.2.2 Acute Atmospheric Releases

For retrospective evaluations of acute releases, using the meteorological conditions existing at and after the time of the release is most appropriate. For prospective analyses, because there is no way to predict conditions under which a future accidental release may take place, a conservative estimate is usually made based on "worst case" conditions with a preselected probability of occurrence. For such a scenario, multi-year historical data are used to predict the frequency of E/Q estimates for each possible set of atmospheric conditions; the results are ordered; and the estimate for the desired cumulative frequency of occurrence is used in the analysis. The probability level used for this type of evaluation varies with its intended application. However, typical choices represent worst-case atmospheric conditions that would be exceeded no more than 50%, 25%, 10%, 5%, or 0.5% of the time. Additional information about applications of the model for specific situations is presented in Appendix H.2.

3.1.3 Exposure Pathways for Atmospheric Releases

After the quantity of a substance reaching the receptor has been estimated, the receptor's potential exposure is evaluated for all applicable atmospheric pathways. Pathways typically applied to atmospheric emissions of radioactive materials are

- external exposure to material deposited on the ground
- external exposure from submersion in the plume

- internal exposure by inhalation
- internal exposure from ingestion of contaminated food products
- direct uptake through the skin is considered for specific substances, notably tritium in water vapor.

Depending on the circumstances of each case, some or all of these pathways may need to be considered when estimating the total potential dose that could result from an atmospheric release. For nonradioactive substances the external exposure pathways generally do not apply, and typically only inhalation and ingestion are considered.

The magnitude of external exposure to radionuclides that emit penetrating radiation is a combined function of the quantity and geometry of the source, the receptor location relative to the source, and the nature of any shielding material between the source and receptor. For radionuclides deposited on the ground following an atmospheric release, the source is generally considered to be an infinite plane. The resulting exposure rates may be modified to account for the amount of time spent in the contaminated area, for the shielding effects of buildings and other structures, and for the roughness of the ground surface.

The exposure geometry for radionuclides suspended in the plume is determined by the size and height of the plume at the receptor location. For a receptor sufficiently distant from the source, the plume can be modeled as a semi-infinite cloud surrounding the receptor. If the plume is partially or entirely above the receptor, or if the size of the plume is small relative to the range of the radiation in question, a finite plume model is needed to characterize the specific geometry at the point of interest. Depending on the atmospheric stability, at typical release heights such conditions occur when the receptor is relatively close to the source (i.e., usually within a few hundred to a thousand meters). Residence time in the plume modifies the potential dose from this pathway.

Inhalation exposure is a function of the quantity of material taken in via breathing and, therefore, depends on the breathing rate of the exposed individual and the duration of exposure to contaminated air. For chronic exposures, the breathing rate is averaged over 24 hours to include both

sleeping and active periods. Acute exposures are assumed to occur during a time when the receptor is active, and, therefore, a higher than average breathing rate is used to estimate intake. When appropriate, age- and gender-specific breathing rates may also be applied to determine exposure for particular demographic groups. Default breathing rates used to determine the potential impacts of chronic and acute releases at Hanford are listed in Appendix J. They are based on values published by the International Commission on Radiological Protection in its Publication No. 23 (ICRP 1975).

Estimating intake via ingestion is more complex than for other pathways because it requires knowledge about the transport mechanisms for specific substances through the several food chains that may lead to the ultimate receptor(s). Following an atmospheric release, food products can be contaminated by direct deposition onto vegetative surfaces and by root uptake from contaminated soil. The extent of contamination depends on the chemical, physical, and biological properties of the material deposited and the type of vegetation involved. The vegetation can subsequently be consumed by animals whose flesh or other products are used as food by humans or other omnivores and carnivores. Therefore, the rate at which radioactive or other hazardous materials are incorporated into these products must also be determined. Consumption rates for particular foodstuffs may also vary greatly with geographic region and the demographic characteristics of the individual or population under consideration. Default assumptions for the ingestion pathways at Hanford are listed in Appendix J.

For chronic releases, an equilibrium-state situation is normally assumed to exist. The concentrations of deposited materials in the environment and in food products are assumed to increase and eventually reach a constant level. That is, the loss or removal rates of material in and/or on the various environmental and biological components are assumed to equal the rates of input of additional material into those components.

For acute releases, the potential doses that could result via the ingestion pathway depend heavily on the time of year during which the release takes place. In general, maximum radionuclide intake results from a release that takes place immediately prior to harvest (i.e., in late summer or fall), whereas minimal radionuclide intake results from a release during the winter.

The ingestion pathway is often omitted from consideration if the affected food supply is quarantined following an acute release or if the receptor is temporarily located where no food is produced (e.g., on the Hanford Site or an adjacent highway). However, the magnitude of the potential dose resulting from the ingestion pathway should help determine if interdiction (i.e., removal of the affected food products from the market) is required.

3.1.4 Collective Doses from Atmospheric Releases

Collective doses are generally calculated for populations within 80 km (50 mi) of an emission source because this is the maximum practical applicable limit of the Gaussian plume model used to estimate dispersion. Because it is impractical to estimate an individual dose for each person in a large population, the area within an 80-km distance from the source is partitioned into a circular grid consisting of 16 compass directions and a number of radial distances. The dispersion estimates for a location at the center of each sector are then applied to the entire population within that sector to obtain a population-weighted atmospheric dispersion factor estimate. For a chronic release the weighted estimates are summed over all 16 compass directions, whereas an acute release is only assumed to affect the sectors in a single direction.

The direction for a hypothetical acute release in a prospective analysis is determined for the sector having the greatest population-weighted E/Q estimate based on long-term joint frequency data. A retrospective analysis should be performed using meteorological data from the period over which the release actually occurred and the dose calculated for the downwind direction only. The most recent estimates of the population within 80 km of the major Hanford operating areas are provided in Appendix G.2.

3.1.5 References

Gifford, F. A. 1968. "An Outline of Theories of Diffusion in the Lower Layers of the Atmosphere." In: Meteorology and Atomic Energy - 1969. TIC-24190, U.S. Atomic Energy Commission, Washington, D.C.

International Commission on Radiological Protection (ICRP). 1975. "ICRP Publication 23, Report of the Task Group on Reference Man." Annals of the ICRP. Pergamon Press, New York.

U.S. Nuclear Regulatory Commission (USNRC). 1977. Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors. Regulatory Guide 1.23 (formerly Safety Guide 23), Washington, D.C.

3.2 LIQUID RELEASES TO SURFACE AND GROUND WATER

At the Hanford Site, radionuclides and other hazardous materials may enter surface water, primarily the Columbia River, by a number of routes. Liquid effluent streams may be released directly to the river from facilities or waste-disposal structures. In the past, liquid wastes have also been released to surface ponds and to the soil column via cribs and trenches. Depending on their proximity to the river, liquid wastes disposed to the ground may then seep directly into the river or percolate downward into underground aquifers and subsequently make their way to the river. Although ground disposal of liquids has largely been discontinued, plumes of waste materials from past operations continue to reach the river via ground water (Woodruff and Hanf 1992).

Solid wastes have also been buried on the Site. Even though recharge of water from precipitation to ground water may occur at a very low rate due to the low precipitation rate at Hanford (i.e., approximately 16 cm yr^{-1} as noted in Appendix G.1), over long time periods radionuclides and other hazardous materials can be leached from the buried waste, percolated downward into underground aquifers, and eventually reach the river.

3.2.1 Surface-Water Transport

Various surface-water transport models are available to describe common release and exposure scenarios. The models currently in use at Hanford are those recommended by the U.S. Nuclear Regulatory Commission (Strenge et al. 1986). The downstream concentrations of radionuclides in the river water are corrected for radioactive decay and are estimated by using a simple mixing ratio model. That is, releases to the Columbia River are considered to be fully mixed in the water volume prior to reaching the downstream withdrawal points. For prospective evaluations, the model uses the annual average river flow rate for chronic releases and the average minimum flow rate for acute releases. Measured river flow rates for the period of interest should be used as available for retrospective calculations. More sophisticated models are required for circumstances in which the effluents are not completely mixed with the river volume or for other types of water bodies, such as waste ponds. Use of these models requires some knowledge of release conditions and the

physical and chemical characteristics of the water body receiving the effluents.

3.2.2 Ground-Water Transport

Determination of the fate of radioactive and other hazardous materials during transport through soil to ground water and subsequently to receptors is a complex task. The rate of transport depends on the

- physical form of the disposed material (e.g., liquids or solids)
- chemical characteristics of the disposed material
- volume and influx rate of water (e.g., discharge of uncontaminated water to the ground and recharge from precipitation) and other liquids (e.g., the disposed material itself)
- depth to ground water
- physical and chemical characteristics of the intervening soil layers
- flow rate of the ground water.

The potential for individuals to be exposed to contaminated ground water is highly site-specific. Exposure may be via water usage from domestic wells drilled into underground aquifers or by the ultimate flow of ground water back to surface waters.

Simulation of contaminant transport in the subsurface environment generally requires the use of specialized hydrological models to predict contaminant levels at various points in an aquifer system. The models can be combined with assumptions about water use and consumption patterns to estimate potential doses resulting from a particular disposal practice. The time periods required for contaminants to migrate from the disposal point to the receptor are often sufficiently long so that the maximum potential doses may not occur for hundreds or even thousands of years after the initial disposal or release to the subsurface environment.

3.2.3 Exposure Pathways for Liquid Releases

Exposures from liquid releases can occur via external and internal pathways. Radionuclides in a surface-water body or those deposited on the shoreline may result in direct external exposure via swimming, boating, and

other recreational activities in the vicinity of the beach. Use of the water for irrigation can contribute to external exposure from the contaminated material that is deposited onto the soil during irrigation. Buildup of contaminants on the soil depends on the application rate of the water and duration of the annual irrigation season.

Internal exposure pathways include direct consumption of contaminated water and foodstuffs prepared with contaminated water. Corrections for radioactive decay and removal of contaminants by water treatment facilities should be considered where applicable. When contaminated water is used for irrigation, exposures may also result from inhalation of resuspended contaminated soil or from consumption of contaminated food products grown in the soil. Animal food products may also become contaminated as a result of the animals consuming contaminated feed and water. Aquatic organisms accumulate radionuclides directly from contaminated water and from their food sources and, therefore, should be considered as possible routes of exposure.

The projected levels of radionuclides in terrestrial vegetation and animals, as well as aquatic and marine organisms and plants, are estimated by using experimentally determined concentration ratio (CR) values or bioaccumulation factors. The CR values normally relate the concentration of a radionuclide or other hazardous material in edible tissues to the concentration in soil or water (e.g., Bq ^{90}Sr kg^{-1} vegetative tissue divided by Bq ^{90}Sr kg^{-1} soil; Bq ^{137}Cs kg^{-1} edible fish tissue divided by Bq ^{137}Cs L^{-1} water). These CR values depend on a variety of parameters, such as the chemical characteristics of the material, soil, and aquatic environments, and the species of the plants or animals accumulating the contaminant.

3.2.4 Collective Doses from Liquid Releases

Potential doses to an individual resulting from liquid effluents are estimated using appropriate consumption and occupancy factors for all applicable exposure pathways. Population doses are estimated considering only the population exposed via a particular pathway. For Hanford releases to the Columbia River, the fraction of the total population exposed via a particular pathway differs according to the ways in which the river is used. The

assumptions concerning these pathways are listed in Appendix I. The rationale for restricting certain pathways to specific populations is presented below:

- River Recreation -- External exposure to populations via external recreational activities such as boating, swimming, and other shoreline activities is conservatively estimated to occur in one-third of the total population within 80-km of the Hanford Site.

- Fish Consumption -- The population exposure resulting from fish consumption is based on a total estimated catch of sport fish from the Columbia River without reference to the number of people projected to actually consume the fish.

- Drinking Water -- The major portion of the population of Pasco, Kennewick, and Richland obtain their drinking water from the Columbia River. Factors that account for reduction in the levels of radionuclides in the sanitary water by holdup and treatment in the water systems are generally included in dose calculations for this population. There are also other sources of drinking water in the Tri-Cities area. For example, many local communities depend on domestic or community water wells.

- Irrigation Water -- Water is withdrawn from the Columbia River for relatively small farming operations within the Hanford reach at the Ringold and Taylor Flats areas and below Hanford, such as the Riverview area west of Pasco in Franklin County. However, the majority of irrigation water for the Columbia Basin is obtained from the Columbia River upstream from the Hanford Site (i.e., from Lake Roosevelt, which is the impoundment behind Grand Coulee Dam). Irrigation and drinking water withdrawn from the Columbia River below the Tri-Cities is generally not considered for radiological dose calculations because of substantial dilution by inflow from the Yakima and Snake Rivers at the Tri-Cities, and by numerous other sources further downstream from Hanford.

3.2.5 References

Strenge, D. L., R. A. Peloquin, G. Whelan, and M. E. Wangler. 1986. LADTAP II - Technical Reference and User's Guide. NUREG/CR-4013, PNL-5270, NRC Office of Nuclear Reactor Regulation, Washington, D.C.

Woodruff, R. K., and R. W. Hanf (eds.). 1992. Hanford Site Environmental Report for Calendar Year 1991. PNL-8148, Pacific Northwest Laboratory, Richland, Washington.

3.3 TYPES OF ENVIRONMENTAL RADIATION DOSE ESTIMATES

The term, "dose" (i.e., radiation dose) can have several meanings. The basic term, "absorbed dose," is defined as

> the amount of energy deposited by ionizing radiation in a given amount of material (e.g., tissue, organ, whole body, metal, concrete). It is expressed in SI units of gray (Gy), or in rad (1 rad = 0.01 Gy), as a total dose over a specified time period (D) or as a function of time (D_t).

Humans and other biota can receive doses of radiation as a result of exposure to external sources of radiation and/or from internally deposited radionuclides.

3.3.1 Dose Equivalent

External doses usually result from penetrating radiation emitted by sources outside the body. The distribution of the deposited energy is usually relatively uniform over the entire body. However, internally deposited radionuclides, particularly those that emit beta or alpha particles, may produce a markedly nonuniform pattern of energy deposition in biological tissues. The dose delivered to an organ or tissue from internally deposited radionuclides is a function of the route of administration, the physical properties of the radiation, and the metabolic characteristics of the substance inhaled or ingested. The relative effectiveness of the various types of radiations in producing biological damage depends on the radiosensitivity of the target organ and the energy-deposition patterns within the tissue of the organ. The term, "dose equivalent," is used to compare the relative biological effectiveness of different kinds of radiation on a particular tissue, organ, or the whole body. "Dose equivalent" (H or H_t) is defined as

> the product of the absorbed dose (D or D_t), the quality factor, and any other modifying factors. It is expressed in SI units of sievert (Sv), or in rem (1 rem = 0.01 Sv), as a total dose equivalent over a specified time period (H) or as a function of time (H_t).

"Quality factor" (Q) is defined as

> a numerical value for normalizing the absorbed dose produced by a given type of radiation according to the biological effectiveness

of the radiation. It is based primarily on the linear energy transfer values for the radiation in question. The values of Q, as recommended by the International Commission on Radiological Protection (ICRP 1984), are given in Table 3.3.1.

3.3.2 Committed Dose

The dose from an external exposure continues only as long as the source is present, whereas internally deposited radionuclides continue to expose the tissue in which they were deposited for some time after the initial intake. The total dose delivered to a given tissue following a single, or relatively short-term, intake of a radionuclide can be calculated for the entire lifetime of the individual or for some shorter period of time. This calculated internal dose is referred to as the "committed dose" and is defined as

> the predicted total internal dose to a tissue or organ over a specified time period (e.g., 50 years) following the intake of a radionuclide(s) into the body. It does not include contributions from external dose. It is expressed in SI units of gray (Gy) or in rad (1 rad = 0.01 Gy).

3.3.3 Committed Dose Equivalent

The total "dose equivalent" delivered to a given tissue following a single intake of a radionuclide can also be projected for the entire lifetime of the individual or for some shorter period of time. The committed dose equivalent is defined as

> the predicted total internal dose equivalent to a tissue or organ over a specified time period (e.g., 50 years) following the intake of a radionuclide(s) into the body. It does not include contributions from external dose. It is expressed in SI units of sievert (Sv) or in rem (1 rem = 0.01 Sv).

TABLE 3.3.1. Quality Factors (Q) from ICRP Publication 42 (ICRP 1984)

Radiation Type	Q
Photons, negatrons, and positrons	1
Neutrons, protons, and singularly-charged particles of unknown energy with rest mass >1 amu	10
Alpha particles and multi-charged particles of unknown energy	20

3.3.4 Effective Dose Equivalent

To put external and internal radiation exposure on a comparable basis, the International Commission on Radiological Protection in its Publication 26 (ICRP 1977) recommended the use of a quantity known as the "effective dose equivalent" (EDE). The "effective dose equivalent" is defined as

> an estimate of the total risk of potential health effects from radiation exposure to individual tissues or organs relative to the risk from irradiation of the whole body. According to DOE report EH-0071 (USDOE 1988b), it is the summation of the products of the "dose equivalent (H_t)" received by specified tissues of the body and a tissue-specific "weighting factor (w_T)." It includes the committed effective dose equivalent (H_{50}) from radionuclides that were deposited internally during the year of exposure plus the dose equivalent (H) due to penetrating radiation from sources external to the body during the year of exposure. It is expressed in SI units of sievert (Sv) or in rem (1 rem = 0.01 Sv).

This quantity is the sum of the external dose to the body during one year plus the sum of the weighted projected doses to specific organs from radionuclides that were deposited in the body during the one-year exposure period. Each organ dose is weighted according to the relative risk of radiation-induced health effects in that particular organ (ICRP 1977, USDOE 1988b, USEPA 1988). The weighting factors are presented in Table 3.3.2. The projected weighted organ doses are summed over a specified commitment period (most commonly

Table 3.3.2. Weighting Factors (W_T) As Taken from ICRP Publication 42 (ICRP 1984)

Organ or Tissue	w_T
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lung	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder[1]	0.30

(1) The "remainder" category consists of the 5 "other" organs with the highest dose. The "other" organs include the liver, kidney, spleen, thymus, adrenal glands, pancreas, stomach, small intestine, and upper and lower large intestine. (The skin, lens of the eye, and extremities are not included.) The weighting factor for each "other" organ is 0.06.

50 years), and the entire dose is assigned to the period during which the exposure took place.

The concept of EDE has been adopted for public and environmental protection purposes by the U.S. Department of Energy (USDOE 1990). Internal dose factors that relate EDE to given quantities of inhaled and ingested radionuclides have been published by USDOE (1988b) and the U.S. Environmental Protection Agency (USEPA 1988).

3.3.5 Other Types of Dose Estimates

In assessing radionuclide intakes and exposure to external radiation, the exposure period for chronic emissions is generally defined on an annual basis for regulatory purposes. It may also be evaluated for the entire life of a facility. In evaluations of existing facilities, the external exposure due to environmental build-up from past emissions may also be included in the dose calculation. The exposure period for an acute release is assumed to be the entire duration of the release unless evacuation or other protective measures are being considered. Radionuclide-specific dose conversion factors for external exposure have also been published by USDOE (1988a) and USEPA (1988).

A quantity generally referred to as "cumulative dose" is also sometimes used in prospective evaluations to account for continuing exposure to residual long-lived radionuclides that accumulate in the environment as the result of chronic emission sources. Cumulative dose includes future doses that are projected to occur as a result of external exposure to, and ingestion and/or inhalation of, residual radionuclides that were deposited in the environment during previous years plus the dose that is projected to occur from the radionuclides emitted during the year being evaluated. It is generally evaluated for a 50- or 70-year period.

In addition to the EDE, other methods of computing doses are sometimes used for specialized purposes. Annual doses from both external exposure and internally deposited radionuclides are sometimes estimated to reflect the actual dose received during a calendar year from all applicable pathways. In this case, the internal dose is assigned to the years in which it will actually occur, rather than to the year of intake.

3.3.6 References

International Commission on Radiological Protection (ICRP). 1977. "ICRP Publication 26, Recommendations of the International Commission on Radiological Protection." Annals of the ICRP, Vol. 1, No. 3, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1984. "ICRP Publication 42, A Compilation of the Major Concepts and Quantities in use by ICRP." Annals of the ICRP, Vol. 14, No. 4, Pergamon Press, New York.

U.S. Department of Energy (USDOE). 1988a. External Dose-Rate Conversion Factors for Calculation of Dose to the Public. DOE/EH-0070, DOE Assistant Secretary for Environment, Safety and Health, Washington, D.C.

U.S. Department of Energy (USDOE). 1988b. Internal Dose Conversion Factors for Calculation of Dose to the Public. DOE/EH-0071, DOE Assistant Secretary for Environment, Safety and Health, Washington, D.C.

U.S. Department of Energy (USDOE). 1990. Radiation Protection of the Public and the Environment. DOE Order 5400.5, DOE Assistant Secretary for Environment, Safety and Health, Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 1988. Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion. Federal Guidance Report No. 11. EPA/520/1-88-020, EPA Office of Radiation Programs, Washington, D.C.

THIS PAGE BLANK INTENTIONALLY

3.4 RECEPTOR LOCATIONS FOR ENVIRONMENTAL RELEASES

Models for plume dispersion and depletion and ground- and surface-water transport are combined with estimated release rates to predict the concentration of a given material in the environmental media at the location of a receptor or other point of interest. For most regulatory purposes, it is necessary to determine the location of the maximally exposed individual (MEI) for an actual or potential source of environmental release. In other instances it is desirable to estimate potential collective doses to an entire exposed population. In these instances, the environmental levels are generally calculated for a grid surrounding the source, and the result for each location is applied to the population living in that region.

The MEI is generally defined as a hypothetical person whose location and lifestyle result in maximum exposure from all credible pathways. This individual is typically a resident just outside the boundary of the Hanford Site whose food is produced at that location. However, for some applications, such as for certain regulatory compliance reports, locations such as businesses and schools should also be considered. In most instances, the location of this individual is determined by comparing the predicted concentrations of radionuclides or other hazardous materials in air for all 16 compass directions at the nearest receptor in each direction. The location may vary depending on the meteorological conditions and resulting atmospheric dispersion characteristics during the period being evaluated. In addition, exposure via ground- and surface-water routes must also be considered.

3.4.1 Chronic Releases

With the exception of U.S. Environmental Protection Agency (USEPA)-mandated dose assessments, for prospective evaluations of an atmospheric release, the receptor in all sectors should be located at the Site boundary using long-term average meteorological data. However, USEPA-mandated dose assessments must identify the location(s) that represents the highest effective dose equivalent to any member of the public at any offsite point where a residence, school, business, or office exists and must be performed using USEPA-mandated codes.

Retrospective analyses should use actual receptors in the appropriate sector and joint frequency data for the period being evaluated if that information is available. This is true for USEPA-mandated dose assessments, which presently only address atmospheric releases, as well as for other types of evaluations. When considering multiple sources, such as for all the operational areas at Hanford, calculations for each location must be combined to produce a composite dose for the MEI. Furthermore, to produce a representative composite of the MEI for the entire Site, other applicable routes of exposure (e.g., surface and ground water) must also be considered.

3.4.2 Acute Releases

The MEI for acute releases is not necessarily in the same location as those for chronic emissions. Meteorological data for the period of interest and probability levels appropriate for the purpose of the analysis should be used for evaluating acute releases of material to the atmosphere. Locations other than a permanent offsite residence should also be evaluated for short-term releases. Accessible points on or adjacent to the Hanford Site that could be occupied by a member of the public during an accident should also be considered. Examples of these include public highways near or within the Site boundaries and the Columbia River. The potential exposure to onsite workers at adjacent facilities is also evaluated for some types of accident analyses. Because the atmospheric plume disperses vertically and horizontally after leaving an elevated stack, the location of the maximum downwind concentration at ground level may be some distance from the release point. Therefore, if the nearest receptor in a given direction is closer than 1 km from an elevated release, several distances between the nearest receptor location and 1 km should be evaluated to ensure that the point of maximum air concentration has been identified.

The potential exposure to an individual that could result from the acute release of material to surface water must also be evaluated as discussed previously. Acute releases to the ground water, which normally take a considerable amount of time to reach the receptor, can usually be disregarded for near-term MEI-related evaluations. However, such releases should be considered for long-term performance assessments.

3.4.3 Maximally Exposed Individual Locations

The locations of the MEI for major operational facilities at Hanford, as listed in Appendix H.7, were determined for receptors at the boundary of the Hanford Site using the updated joint frequency data sets provided in Appendix H.3.2 and are appropriate for use in prospective estimates for Hanford facilities at the listed areas. Receptor locations for retrospective estimates at specific facilities should be determined on a case-by-case basis, especially for USEPA-mandated dose assessments, using input appropriate to the facility and time period being considered.

THIS PAGE BLANK INTENTIONALLY

4.0 HEDOP-APPROVED ENVIRONMENTAL AND HEALTH DOSE ASSESSMENT CODES

The current requirements for calculating potential radiation doses that could result from releases of radioactive material from U.S. Department of Energy (DOE) facilities are contained in DOE order 5400.5, "Radiation Protection of the Public and the Environment" (USDOE 1990). As part of this order, DOE has adopted the dosimetry system recommended by the International Commission on Radiological Protection (ICRP) in its Publications No. 26 (ICRP 1977) and 30 (ICRP 1979a, 1979b, 1980, 1981a, 1981b, 1982a, and 1982b). The ICRP recommendations have been incorporated into updated versions of existing environmental pathway analysis models for use on the Hanford Site. Other governmental agencies may require the use of other methods for specific dose calculations.

The codes and methods that have been approved by the Hanford Environmental Dose Overview Panel (HEDOP) for particular applications on the Hanford Site are described in the following sections.

Other environmental transport and dosimetry models and their associated computer codes are being considered for use in radiological and nonradiological risk assessments in conjunction with the cleanup and/or closure of hazardous waste sites on the Hanford Site (USDOE 1991). Some of these codes may be mandated for use at Hanford by the Hanford Federal Facility Agreement and Consent Order, more commonly known as the "Tri-Party Agreement" (Washington State Department of Ecology 1989). Descriptions of these and any other applicable codes will be added to this document if HEDOP reviews and approves them.

4.0.1 References

International Commission on Radiological Protection (ICRP). 1977. "ICRP Publication 26, Recommendations of the International Commission on Radiological Protection." Annals of the ICRP, Vol. 1, No. 3, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1979a. "ICRP Publication 30, Part 1, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 2, No. 3/4, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1979b. "ICRP Publication 30, Supplement to Part 1, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 3, No. 1-4, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1980. "ICRP Publication 30, Part 2, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 4, No. 3/4, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1981a. "ICRP Publication 30, Supplement to Part 2, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 5, No. 1-6, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1981b. "ICRP Publication 30, Part 3 Including Addendum to Parts 1 and 2, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 6, No. 2/3, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1982a. "ICRP Publication 30, Supplement A to Part 3, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 7, No. 1-3, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1982b. "ICRP Publication 30, Supplement B to Part 3 Including Addendum to Supplements to Parts 1 and 2, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 8, No. 1-3, Pergamon Press, New York.

U.S. Department of Energy (USDOE). 1990. Radiation Protection of the Public and the Environment. DOE Order 5400.5, DOE Assistant Secretary for Environment, Safety and Health, Washington, D.C.

U.S. Department of Energy (USDOE). 1991. Description of Codes and Models To Be Used in Risk Assessment. DOE/RL-91-44, U.S. Department of Energy Richland Field Office, Richland, Washington.

Washington State Department of Ecology. 1989. Hanford Federal Facility Agreement and Consent Order. Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy Richland Field Office, Richland, Washington.

4.1 THE GENII COMPUTER CODE

An environmental radiation dosimetry model and associated computer code were developed at Pacific Northwest Laboratory (PNL) to incorporate the internal radiation dosimetry models as recommended by the International Commission on Radiological Protection (ICRP) in its Publications No. 26 (ICRP 1977) and 30 (ICRP 1979a, 1979b, 1980, 1981a, 1981b, 1982a, and 1982b). The resulting code is an extensive update of the environmental pathway analysis models that were previously used for a number of years at Hanford (i.e., DACRIN, PABLM, ARRRG, FOOD, KRONIC, SUBDOSA, and MAXI). The resulting second generation of environmental dosimetry computer codes was compiled as the Hanford Environmental Dosimetry System and is known as the GENII code. It was documented in three volumes.

- Volume 1, Conceptual Representation (Napier et al. 1988a), describes the theoretical considerations of the system, including conceptual diagrams, mathematical representation of the solutions, and descriptions of solution techniques, where appropriate.

- Volume 2, Users' Manual (Napier et al. 1988b), provides code structure, users' instructions, required system configurations, and topics related to quality assurance.

- Volume 3, Code Maintenance Manual (Napier et al. 1988c), is intended for the user who requires knowledge of code detail, including code logic diagrams, global dictionary, worksheets, example hand calculations, and listings of the code and its associated data libraries.

The GENII code is currently the primary environmental dosimetry code accepted for use at Hanford by the Hanford Environmental Dose Overview Panel (HEDOP). In situations where limitations of the GENII code preclude its use, other methods and/or computer codes may be used. Calculations made with other methods and/or codes will be reviewed on a case-by-case basis by HEDOP. The Panel does not mandate the use of GENII at Hanford; however, using HEDOP-approved codes usually expedites the HEDOP-mandated review process.

The GENII code includes capabilities for calculating radiation doses that could result from acute or chronic releases. It has the option to calculate annual, committed, or cumulative doses. All or any desired combination of the major exposure pathways can be included in a given calculation. Routes of external exposure can include

- water (swimming, boating, and fishing)
- soil (surface and buried sources)
- air (semi-infinite cloud and finite cloud geometries).

Internal exposure routes include inhalation and ingestion of various food classes. The release scenarios include

- releases to the air from ground level or elevated sources
- releases to surface-water bodies
- initial contamination of the soil or other surfaces.

Source terms can be specified to account for radioactive decay and the buildup of progeny that occurs between the time of release and actual exposure, or to consider the total amount or specified fraction of radioactive materials released at the source. Measured or postulated levels of radionuclides in the environmental media (e.g., air, soil, water, foodstuffs) may be entered directly into the code. The code provides for interfacing with the output from other types of codes (e.g., atmospheric dispersion, geohydrology, biotic transport, and surface-water transport). Receptors are identified by distance and direction for offsite individuals and populations, and for individuals intruding into contaminated areas onsite.

The GENII code was developed under stringent quality assurance (QA) requirements based on the American National Standards Institute's (ANSI) standard, NQA-1 (ASME 1986). The NQA-1 requirements were incorporated into PNL's Quality Assurance Manual, PNL-MA-70 (PNL 1991). All steps of the code development were documented and tested by extensive hand calculations. Two separate external peer reviews of the code were conducted and the recommendations of the review committees were incorporated into the final product.

Contact the Executive Secretary of HEDOP for information on how to gain access to the GENII code. The name, address, and phone number of the current Executive Secretary are provided in Appendix C.2.

4.1.1 References

American Society of Mechanical Engineers (ASME). 1986. Quality Assurance Program Requirements for Nuclear Facilities. ANSI/ASME NQA-1, ASME, New York.

International Commission on Radiological Protection (ICRP). 1977. "ICRP Publication 26, Recommendations of the International Commission on Radiological Protection." Annals of the ICRP, Vol. 1, No. 3, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1979a. "ICRP Publication 30, Part 1, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 2, No. 3/4, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1979b. "ICRP Publication 30, Supplement to Part 1, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 3, No. 1-4, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1980. "ICRP Publication 30, Part 2, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 4, No. 3/4, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1981a. "ICRP Publication 30, Supplement to Part 2, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 5, No. 1-6, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1981b. "ICRP Publication 30, Part 3 Including Addendum to Parts 1 and 2, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 6, No. 2/3, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1982a. "ICRP Publication 30, Supplement A to Part 3, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 7, No. 1-3, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1982b. "ICRP Publication 30, Supplement B to Part 3 Including Addendum to Supplements to Parts 1 and 2, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 8, No. 1-3, Pergamon Press, New York.

Napier, B. A., D. L. Strenge, R. A. Peloquin, and J. V. Ramsdell. 1988a. GENII - The Hanford Environmental Radiation Dosimetry Software System, Volume 1: Conceptual Representation. PNL-6584 Vol. 1, Pacific Northwest Laboratory, Richland, Washington.

Napier, B. A., D. L. Strenge, R. A. Peloquin, and J. V. Ramsdell. 1988b. GENII - The Hanford Environmental Radiation Dosimetry Software System, Volume 2: Users' Manual. PNL-6584 Vol. 2, Pacific Northwest Laboratory, Richland, Washington.

Napier, B. A., D. L. Strenge, R. A. Peloquin, and J. V. Ramsdell. 1988c. GENII - The Hanford Environmental Radiation Dosimetry Software System, Volume 3: Code Maintenance Manual. PNL-6584 Vol. 3, Pacific Northwest Laboratory, Richland, Washington.

Pacific Northwest Laboratory (PNL). 1991. Quality Assurance Manual. PNL-MA-70, Rev. 5/31/91, Pacific Northwest Laboratory, Richland, Washington.

4.2 EPA-MANDATED CODES

As part of the December 1989 amendments to the Clean Air Act (40 CFR 61, 1989) for radionuclide emissions from U.S. Department of Energy (DOE) facilities (i.e., Subpart H), the U.S. Environmental Protection Agency (EPA) specifies a public dose limit along with the procedures and codes to be used to demonstrate compliance with the limit. Under this regulation, all DOE sites with potential radionuclide air emissions are required to submit annual reports to EPA describing the site's estimated releases for the previous calendar year and the potential doses received by a maximally exposed member of the public. The regulations require the use of the AIRDOS-EPA model or some other "approved" method to estimate the potential dose to the receptor. The CAP-88, AIRDOS-PC, and, for certain situations, the COMPLY codes have been approved for use by EPA. The CAP-88 and AIRDOS-PC codes are also used to support permit applications for construction or modification of Hanford facilities. Specific features of these codes are described below.

4.2.1 The CAP-88 Code Package

The CAP-88 code package (Beres 1990) contains an updated version of the AIRDOS-EPA (Moore et al. 1979) code that was developed originally at Oak Ridge National Laboratory for EPA. The AIRDOS-EPA code was subsequently combined with auxiliary codes to better facilitate the input of parameters. The CAP-88 code implements a steady-state Gaussian plume-type atmospheric dispersion model (Gifford 1968; USNRC 1977b) to estimate concentrations of radionuclides in air. The environmental transport models, as described in the U.S. Nuclear Regulatory Commission's Regulatory Guide 1.109 (USNRC 1977a), were coupled to the code package to calculate potential doses received by humans. Radionuclide-specific data, which generally correspond to the International Commission on Radiological Protection's (ICRP) internal dosimetry models as recommended in Publication No. 30 (ICRP 1979a, 1979b, 1980, 1981a, 1981b, 1982a, and 1982b), are provided with the code package.

The CAP-88 code is limited to performing radiation dose calculations for chronic air-emission scenarios. It provides the most flexibility of the EPA-mandated codes in terms of ability to input site-specific data; however, it is also the most difficult and expensive of the codes to operate because it

operates on a mainframe or minicomputer system and uses a FORTRAN NAMELIST interface.

The CAP-88 code package is currently maintained at Pacific Northwest Laboratory on a mainframe computer system. Contact the Executive Secretary of HEDOP for information on how to gain access to the code package. The name, address, and phone number of the current Executive Secretary are provided in Appendix C.2.

Another version of the code, designated "CAP88-PC" (Parks 1992), operates on a personal computer and has an updated user interface that simplifies operation. However, it has less flexibility to include site-specific information than does the mainframe version. Even with site-specific information, other assumptions incorporated into the code may result in over- or under-estimates of doses under certain conditions. Copies of the CAP88-PC code may be obtained by direct request to EPA.

4.2.2 The AIRDOS-PC Code

The AIRDOS-PC code (USEPA 1989a) is a simplified version of the CAP-88 package that was modified to operate on a personal computer. It contains a user-friendly interface that facilitates data entry and requires a minimum amount of site-specific input data. The results from AIRDOS-PC are comparable to those from the CAP-88 code using the default parameters. However, it has some major limitations, including the following:

- Its radionuclide library consists of less than 20 radionuclides -- compared to several hundred in CAP-88.
- It lacks the ability to perform collective dose calculations.
- It lacks flexibility in accepting site-specific information.

The AIRDOS-PC code is available by direct request to EPA.

4.2.3 The COMPLY Code

The COMPLY code (USEPA 1989b) is a four-level screening model. Each level requires increasingly detailed site-specific information and, in turn, produces more realistic (i.e., usually less conservative) results. The COMPLY code runs on a personal computer and does not require all of the site-specific information that is necessary to run the CAP-88 code. It has a large

radionuclide library (comparable to CAP-88) and can also address situations in which the receptor is located nearer the site than is appropriate for the AIRDOS codes. Depending on the level at which the code is executed and the amount of site-specific information, results from COMPLY are generally more conservative (i.e., they produce a higher dose estimate) than do those from the AIRDOS codes. The primary disadvantage of the code at Hanford is that its use is restricted to sites where the receptor is within 3 km of all release points. The COMPLY code is available by direct request to EPA.

4.2.4 References

40 CFR 61. 1989. U.S. Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants; Radionuclides; Final Rule and Notice of Reconsideration." U.S. Code of Federal Regulations.

Beres, D. A. 1990. The Clean Air Act Assessment Package-1988 (CAP-88). A Dose and Risk Assessment Methodology for Radionuclide Emissions to Air. Vol. 1, User's Manual. U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, D.C.

Gifford, F. A. 1968. "An Outline of Theories of Diffusion in the Lower Layers of the Atmosphere." In: Meteorology and Atomic Energy - 1969. TIC-24190, U.S. Atomic Energy Commission, Washington, D.C.

International Commission on Radiological Protection (ICRP). 1979a. "ICRP Publication 30, Part 1, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 2, No. 3/4, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1979b. "ICRP Publication 30, Supplement to Part 1, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 3, No. 1-4, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1980. "ICRP Publication 30, Part 2, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 4, No. 3/4, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1981a. "ICRP Publication 30, Supplement to Part 2, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 5, No. 1-6, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1981b. "ICRP Publication 30, Part 3 Including Addendum to Parts 1 and 2, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 6, No. 2/3, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1982a. "ICRP Publication 30, Supplement A to Part 3, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 7, No. 1-3, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1982b. "ICRP Publication 30, Supplement B to Part 3 Including Addendum to Supplements to Parts 1 and 2, Limits for Intakes of Radionuclides by Workers." Annals of the ICRP, Vol. 8, No. 1-3, Pergamon Press, New York.

Moore, R. E., C. F. Baes III, L. M. McDowell-Boyer, A. P. Watson, F. O. Hoffman, J. C. Pleasant, and C. W. Miller. 1979. AIRDOS-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides. ORNL-5532, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Parks, B. S. 1992. User's Guide for CAP88-PC. Version 1.0. 402-B-92-001. Office of Radiation Programs, U. S. Environmental Protection Agency, Las Vegas, Nevada.

U.S. Environmental Protection Agency (USEPA). 1989a. User's Guide for AIRDOS-PC. Version 3.0. EPA/520/6-89-035, EPA Office of Radiation Programs, Las Vegas, Nevada.

U.S. Environmental Protection Agency (USEPA). 1989b. User's Guide for the COMPLY Code. Rev. 1, EPA/520/1-89-003, EPA Office of Radiation Programs, Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1977a. Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I. Regulatory Guide 1.109, NRC Office of Standards Development, Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1977b. Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors. Regulatory Guide 1.23 (formerly Safety Guide 23), Washington, D.C.

4.3 OTHER CODES

In the future, additional models and computer codes will be considered by the Hanford Environmental Dose Overview Panel (HEDOP) for use in radiological and non-radiological environmental and health dose assessments on the Hanford Site. Some of the models and codes will undoubtedly be used in conjunction with the cleanup and closure of hazardous waste sites at Hanford. Discussion of applicable models and codes is presented in a U.S. Department of Energy publication entitled "Description of Codes and Models to be Used in Risk Assessments" (USDOE 1991). Any newly HEDOP-approved codes will be added to updated versions of this section and Appendix F of this document.

4.3.1 References

U.S. Department of Energy (USDOE). 1991. Description of Codes and Models to be Used in Risk Assessment. DOE/RL-91-44, U.S. Department of Energy Richland Field Office, Richland, Washington.

THIS PAGE BLANK INTENTIONALLY

5.0 PERSPECTIVE ON ENVIRONMENTAL DOSES

In many types of documents, it may be appropriate to include information that provides perspective on the degree of risk associated with releases of hazardous materials from various operations. One commonly used method is to compare the estimated dose that could result from a given operation to that received by an average member of the public from natural background and other anthropogenic sources of radiation. The average radiation exposure to a member of the U.S. population from natural and artificial sources as listed in Table 5.1 was taken from the National Council on Radiation Protection and Measurements' Publication No. 93 (NCRP 1987). These exposure levels are assumed to be representative of the population surrounding the Hanford Site. However, some components of the natural background dose (radon in particular) vary substantially from region to region.

TABLE 5.1. Radiation Doses to an Average Member of the U. S. Population from Natural and Artificial Sources (from NCRP 1987)

Sources	Annual Effective Dose Equivalent[a] mSv/year	mrem/year
Natural Background:		
Cosmic Radiation	0.3	30.
Terrestrial Radiation	0.3	30.
Internally Deposited Radionuclides	0.4	40.
Inhaled Radon Progeny	2.0	200.
Anthropogenic Sources:		
Medical X-Rays	0.39	39.
Nuclear Medicine	0.14	14.
Consumer Products	0.1	10.
Occupational	0.01	1.0
Fallout	<0.001	<0.1
Nuclear Fuel Cycle	0.0004	0.04
Miscellaneous	0.0004	0.04
TOTAL	3.6	360.

[a] Annual effective dose equivalent (EDE) includes the external dose received during the year plus the 50-year committed dose that is projected to occur as the result of any radionuclides that were deposited in the body during the year.

Alternatively, an estimate of risk to an individual or population from a given exposure may be calculated for various adverse consequences such as cancer induction or genetic effects. These risks may be compared with the risks from other sources in the population under consideration.

5.1 SOURCES OF NATURAL BACKGROUND RADIATION

Natural background radiation comes from four major sources

- cosmic radiation (mainly high-energy particles)
- terrestrial radiation from naturally occurring radionuclides in soil
- inhalation of naturally occurring airborne radionuclides (largely progeny of radon)
- naturally occurring radionuclides that are resident in the body (primarily ^{40}K).

As shown in Table 5.1, inhaled radon progeny account for about two-thirds of the total exposure from natural sources. The remainder is about evenly divided among the other sources.

5.2 ANTHROPOGENIC SOURCES OF RADIATION

The most significant exposures from anthropogenic sources are from medical and dental applications (e.g., X-rays and nuclear medicine procedures) and consumer products. Miscellaneous other minor sources such as occupational exposure, fallout from nuclear weapons testing, and nuclear fuel cycle facilities account for a relatively small fraction of the total.

5.3 ESTIMATES OF RISK FROM RADIATION DOSES

Projected radiation doses can be used to predict the risk of fatal cancer and other health effects using appropriate risk conversion factors. Risk conversion factors have been published by various national and international organizations (NRC 1990; ICRP 1990; UNSCEAR 1988; USEPA 1989).

The risk factor as recommended by the International Commission on Radiological Protection (ICRP) in Publication No. 60 (ICRP 1990) for the general population is 5 fatal cancers per 100 Sv (5 per 10,000 rem) for chronic, whole-body exposures to low doses at low dose rates for low-LET (i.e., linear energy transfer) radiation. The value is 4 fatal cancers per

100 Sv for workers. The difference is primarily attributable to the presence of children in the general population. It should be noted that the risk for acute exposures (i.e., doses received within minutes to hours) is estimated in "BEIR V" (NRC 1990) to be about a factor of two larger than that for chronic exposures (i.e., approximately 9 fatal cancers per 100 Sv) for the general population. The chronic exposure values, as summarized in Table 5.2, were used to develop the radiation dose and other associated limits (e.g., allowable limits of intake, derived air concentration) in 10 CFR Part 20 (1991).

The risk factors may be used to determine potential risks to the population from radionuclides released to the environment based upon the calculated radiation doses to the target population. These risks can then be compared to other types of risks to which the population is exposed. Examples of risks from other types of activities, as summarized by Woodruff and Hanf (1992), are presented in Table 5.3.

TABLE 5.2. Lifetime Fatal Cancer Risk Factors from Whole-Body Exposure to Low-LET Radiation (from ICRP 1990 and NRC 1990)

Type of Exposure	Fatal Cancers Per Sv	Fatal Cancers Per rem
Chronic (Long-Term Exposure)[a]:		
General Public	5×10^{-2}	5×10^{-4}
Workers	4×10^{-2}	4×10^{-4}
Acute (Doses Received Within Minutes to Hours):		
General Public	9×10^{-2}	9×10^{-4}
Workers	8×10^{-2}	8×10^{-4}

[a] It should be noted that acute as well as chronic releases to the environment are normally considered to result in chronic exposures.

TABLE 5.3. Estimated Risk from Various Activities and Exposures as Summarized from Woodruff and Hanf (1992)

Activity and Corresponding Consequence	Risk of Fatality Per Person[a]
Accident from riding in or driving 483 km (300 miles) in a car	2×10^{-6}[b]
Home accidents	1×10^{-4}[b]
Liver cancer/cirrhosis from drinking 355 ml (12 oz) of beer or 118 ml (4 oz) of wine per day	1×10^{-5}
Accidents from pleasure boating	6×10^{-6}[b]
Accidents from sport/recreational firearms	1×10^{-5}[b]
Lung/heart/other diseases from smoking 1 pack (20 cigarettes) per day	4×10^{-3}
Gastrointestinal-tract cancer from eating 49 kg (90 lb) of charcoal-broiled steaks	1×10^{-6}
Trace chloroform cancer from drinking chlorinated tap water	3×10^{-6}
Accident from flying round trip as a passenger on a cross-country trip	8×10^{-6}[b]

(a) As noted in Woodruff and Hanf (1992), "these values are generally accepted approximations with varying levels of uncertainty; there can be significant variation[s] as a result of differences in individual lifestyle and biological factors (Ames et al. 1987; Atallah 1980; Dinman 1980; Wilson and Crouch 1987; Travis and Hester 1990)."

(b) As noted in Woodruff and Hanf (1992), these represent real actuarial values. The other values are predicted from statistical models.

5.4 REFERENCES

10 CFR 20. 1991. U.S. Nuclear Regulatory Commission, "Standards for Protection Against Radiation." U.S. Code of Federal Regulations.

Ames, B. N., R. Magaw, and L. S. Gold. 1987 "Ranking Possible Carcinogenic Hazards." Science 236:271-280.

Atallah, S. 1980. "Assessing and Managing Industrial Risk." Chemical Engineering 9\8\80:94-103.

Dinman, B. D. 1980. "The Reality and Acceptance of Risk." Journal of the American Medical Association (11):1226-1228.

International Commission on Radiological Protection (ICRP). 1990. "ICRP Publication 60, Recommendations of the International Commission on Radiological Protection." Annals of the ICRP, Vol. 21, No. 1-3, Pergamon Press, New York.

National Council on Radiation Protection and Measurements (NCRP). 1987. Ionizing Radiation Exposure of the Population of the United States. NCRP Report No. 93, NCRP, Bethesda, Maryland.

National Research Council (NRC). 1990. Health Effects of Exposure to Low Levels of Ionizing Radiation. BEIR V. Committee on the Biological Effects of Ionizing Radiation, National Academy Press, Washington, D.C.

Travis, C. C., and S. T. Hester. 1990. "Background Exposure to Chemicals." Risk Analysis 10(4).

United Nations Scientific Committee on the Effects of Atomic Radiations (UNSCEAR). 1988. Sources, Effects, and Risks of Ionizing Radiation. Report E.88.IX.7, United Nations, New York.

U.S. Environmental Protection Agency (USEPA). 1989. Risk Assessment Methodology. Draft Environmental Impact Statement for Proposed NESHAPS for Radionuclides. Background Information Document. Vol. 1, EPA/520/1-89-005, EPA Office of Radiation Programs, Washington, D.C.

Wilson, R., and E. S. C. Crouch. 1987. "Risk Assessment and Comparisons: An Introduction." Science 236(4799):267-270.

Woodruff, R. K., and R. W. Hanf (eds). 1992. Hanford Site Environmental Report for Calendar Year 1991. PNL-8148, Pacific Northwest Laboratory, Richland, Washington.

THIS PAGE BLANK INTENTIONALLY

APPENDIX A

DOCUMENT REQUEST FORM

THIS PAGE BLANK INTENTIONALLY

APPENDIX A

DOCUMENT REQUEST FORM

To receive a copy of Recommended Environmental Dose Calculation Methods and Hanford-Specific Parameters (PNL-3777 Rev 2) and to be placed on the distribution list to receive updated sections of the report, please copy and complete the following form and send it to the Executive Secretary of the Hanford Environmental Overview Panel. The name, mailing address, and phone number of the current Executive Secretary is provided in Appendix C.2.

Please type or print

Name: _____

Organization: _____
(e.g., HEHF, PNL, USDOE, WHC)

Mailing Address (MSIN): _____

_____

_____

Phone Number: _____

On Hanford Local Area Network? (Yes/No): _____

Other electronic mail system: _____

_____
(Signature)

Comments:

THIS PAGE BLANK INTENTIONALLY

APPENDIX B

CHARTER OF THE HANFORD ENVIRONMENTAL DOSE OVERVIEW PANEL

THIS PAGE BLANK INTENTIONALLY

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

JUN 2 5 1990

Contractors, Richland, Washington

Director
Pacific Northwest Laboratory

President
Hanford Environmental Health Foundation

President
Westinghouse Hanford Company

Gentlemen:

HANFORD ENVIRONMENTAL DOSE OVERVIEW PANEL (HEDOP) CHARTER

This letter apprises you of the formalization of a Hanford Environmental Dose Overview Panel and your responsibility to appoint up to four members to the panel by July 16, 1990. The enclosed charter specifies the panel's purpose, scope, authority, responsibilities, and membership.

In the past, the consistency and accuracy of environmental dose calculations were reviewed and approved through PNL's Dose Overview Project. However, several instances have occurred recently identifying inconsistencies in dose calculations among Hanford contractors. Therefore, in order to ensure that appropriate environmental and health dose assessment methods used at Hanford are technically consistent and to increase communication among the Hanford contractors regarding these assessments, this panel has been formalized.

According to the charter, the panel will consist of up to 12 voting members, an executive secretary, and a DOE-RL representative. Each of the voting members shall have one vote. The voting members of HEDOP shall consist of up to four representatives each from Westinghouse Hanford Company, Hanford Environmental Health Foundation, and Pacific Northwest Laboratory. The representatives shall have expertise in various environmental assessment subjects (e.g., toxicology, environmental transport, and health physics). Please provide me with the names of up to four representatives from your respective organizations to serve as panel members for the first term by July 16, 1990.

Should you have any questions regarding this subject, please contact Mr. Randall F. Brich of my staff at 376-9031.

Sincerely,

M. W. Tiernan, Acting Director
Safety and Environment Division

SED:RFB

Enclosure

cc w/encl: S. E. Dietert, HEHF
J. T. A. Roberts, PNL
D. E. Simpson, WHC

HANFORD ENVIRONMENTAL DOSE OVERVIEW PANEL

CHARTER

17 May 1990

I. PURPOSE

The Hanford Environmental Dose Overview Panel (HEDOP) serves as the technical representative for the U.S. Department of Energy's Richland Operations Office (DOE-RL) for matters related to environmental and health dose assessments of operations and facilities on the Hanford Site. Environmental and health dose assessments may include:

- the use of various types of models to project the environmental transport of potentially harmful materials,
- the development of exposure and/or dose estimates, and
- application of health risk conversion factors.

The purpose of the Panel is to:

- ensure that appropriate radiological and nonradiological environmental and health dose assessment methods are used at Hanford,
- ensure that all Hanford-related environmental and health dose assessments are technically consistent, and
- foster communication among the Hanford contractors regarding environmental and health dose assessments.

II. SCOPE

The scope of HEDOP covers all environmental and health dose assessments of potential or actual exposure to onsite and offsite receptors that involve the environmental transport of potentially harmful material that could be or has been released from a Hanford operation or facility. Environmental and health dose assessments performed for locations other than Hanford are outside the scope of HEDOP.

III. MEMBERSHIP

The Panel shall consist of up to twelve (12) voting members, an Executive Secretary, and a DOE-RL Representative. Each of the voting members shall have one vote. The voting members of HEDOP shall consist of up to four (4) representatives from each of the following contractors (listed by area of responsibility on the Hanford Site):

- occupational medicine and environmental health services,
- operations and engineering, and
- research and development.

The Executive Secretary and the DOE-RL Representative shall be non-voting members of HEDOP. The manager of the Dose Overview Project shall serve as the Executive Secretary.

Annual Establishment of HEDOP

A new Panel shall be established by July 1 of each year, concurrent with the appointment of new HEDOP members.

Appointment of Voting Members

Individuals shall be appointed to the Panel by their respective contractors by June 1 to replace a member whose term expires that year. Outgoing members may be re-appointed. Contractors should select individuals that are knowledgeable in environmental and health assessment dose methods and represent the various pertinent functions performed by that contractor (e.g., emergency preparedness, safety analysis, environmental assessment, environmental monitoring and surveillance, performance assessment).

Terms of Voting Members

The term for each voting member shall be four (4) years beginning the first of July. The terms of the voting members shall be staggered such that one position from each contractor is renewed each year (i.e., up to one fourth of the voting membership could be replaced each year). In the event that a member must be replaced prior to completing a term, the responsible contractor shall promptly appoint an individual to serve the remainder of the unexpired term.

Election of Chairperson

A Chairperson shall be elected from the eligible voting Panel members before July 1 of each year. Eligible members are those whose memberships will not expire when the new Panel is established on July 1. The Chairperson shall serve a one-year term beginning July 1.

IV. RESPONSIBILITIES

Hanford Environmental Dose Overview Panel

At least one half of the voting members of the Panel are needed to constitute a quorum. Measures voted upon will be accepted with a majority of a quorum voting in favor.

The Panel may revise the Charter based on a two thirds (2/3) majority vote of the voting members. The revised Charter must be submitted by the Chairperson to the DOE-RL Representative for concurrence.

The Panel shall:

- provide recommendations to DOE-RL regarding technical issues related to environmental and health dose assessments at Hanford,
- establish criteria for selecting methods (i.e., models, codes, related input parameters, and calculational procedures) used to conduct environmental and health dose assessments that pertain to Hanford operations or facilities,
- review and maintain a list of HEDOP-approved codes and related Hanford-specific input parameters that may be used routinely to conduct environmental and health dose assessments that pertain to Hanford operations or facilities,
- annually provide a document to Hanford contractors and DOE-RL that
  - lists the codes and related Hanford-specific input parameters that are approved by the Panel, and
  - details the procedures for securing HEDOP approval for all environmental and health dose assessments that pertain to Hanford operations or facilities,
- designate code custodians to
  - maintain the HEDOP-approved version of the various codes and related Hanford-specific input parameters, and
  - make the codes available to Hanford users,
- establish and terminate *ad hoc* working groups to address specific issues,
- establish minimum qualifications required for individuals to serve as Panel-Approved Reviewers,
- determine if individuals nominated by Panel members or Hanford contractors are qualified to serve as Panel-Approved Reviewers,
- annually evaluate the qualifications of individuals designated to serve as Panel-Approved Reviewers,
- assure that periodic reviews of HEDOP-mandated operations of the Hanford contractors are performed,
- annually review the operations of the Panel,
- elect a Chairperson of the Panel by July 1 of each year, and
- meet at least once each quarter.

Hanford Contractors

Hanford contractors shall:

- assure that all applicable environmental and health dose assessments are reviewed according to the requirement of HEDOP,
- provide resources for HEDOP-Approved Reviewers to review all contractor-developed environmental and health dose assessments related to Hanford operations or facilities,
- maintain documented reviews to demonstrate compliance with HEDOP requirements,
- designate contractor personnel to serve on the Panel, and
- provide resources for contractor personnel to serve as Panel members.

Executive Secretary

The Executive Secretary shall provide administrative and technical support to the Panel. The Executive Secretary shall:

- act as the point of contact with DOE-RL,
- coordinate the *ad hoc* working groups,
- coordinate requests from Hanford contractors,
- coordinate input to the Panel Chairperson on agenda items for HEDOP meetings,
- provide a written version of the meeting minutes along with an executive summary of the minutes to the Chairperson for approval,
- distribute the meeting minutes to Panel members and other interested Hanford personnel,
- maintain a distribution list of selected Hanford personnel that should receive an executive summary of the minutes of the Panel meetings and other pertinent information related to HEDOP,
- distribute the executive summary,
- provide a central filing and tracking system for HEDOP activities, and
- coordinate updates to the formal HEDOP policy and procedures document.

Panel Chairperson

The Panel Chairperson shall ensure that the operations of the Panel are in compliance with the HEDOP Charter. The Chairperson shall:

- call and conduct meetings,
- with input from the Executive Secretary, prepare the agenda for the Panel meetings,
- select an individual to chair each *ad hoc* working group,
- ensure that the *ad hoc* working groups are properly staffed,
- approve the minutes and executive summary of each Panel meeting,
- call for Hanford contractors to appoint individuals to replace Panel members whose terms expire or who leave the Panel for some other reason, and
- call for the election of a Chairperson prior to July 1 of each year.

Panel-Approved Reviewers

Panel-Approved reviewers shall conduct documented reviews of all applicable environmental and health dose assessments for:

- consistency with HEDOP-approved methods,
- technical validity if other than HEDOP-approved methods were used, and
- appropriate level of documentation.

DOE-RL Representative

The DOE-RL Representative shall serve as the spokesman for DOE-RL and provide input to the Panel on DOE policies. All recommendations furnished to DOE-RL by HEDOP shall be provided through the DOE-RL Representative.

V. ORGANIZATION

The functional and organizational relationships of HEDOP, Hanford contractors, DOE-RL, and the Dose Overview Project are shown in the attached figure.

VI. APPROVAL

This Charter was prepared and approved by the members of the Hanford Dose Overview Panel.

R. Gene Schreckhise, Chairperson — 17 May 1990 Date

Janet S. Davis — 5/18/90 Date

Larry P. Diediker — 5-18-90 Date

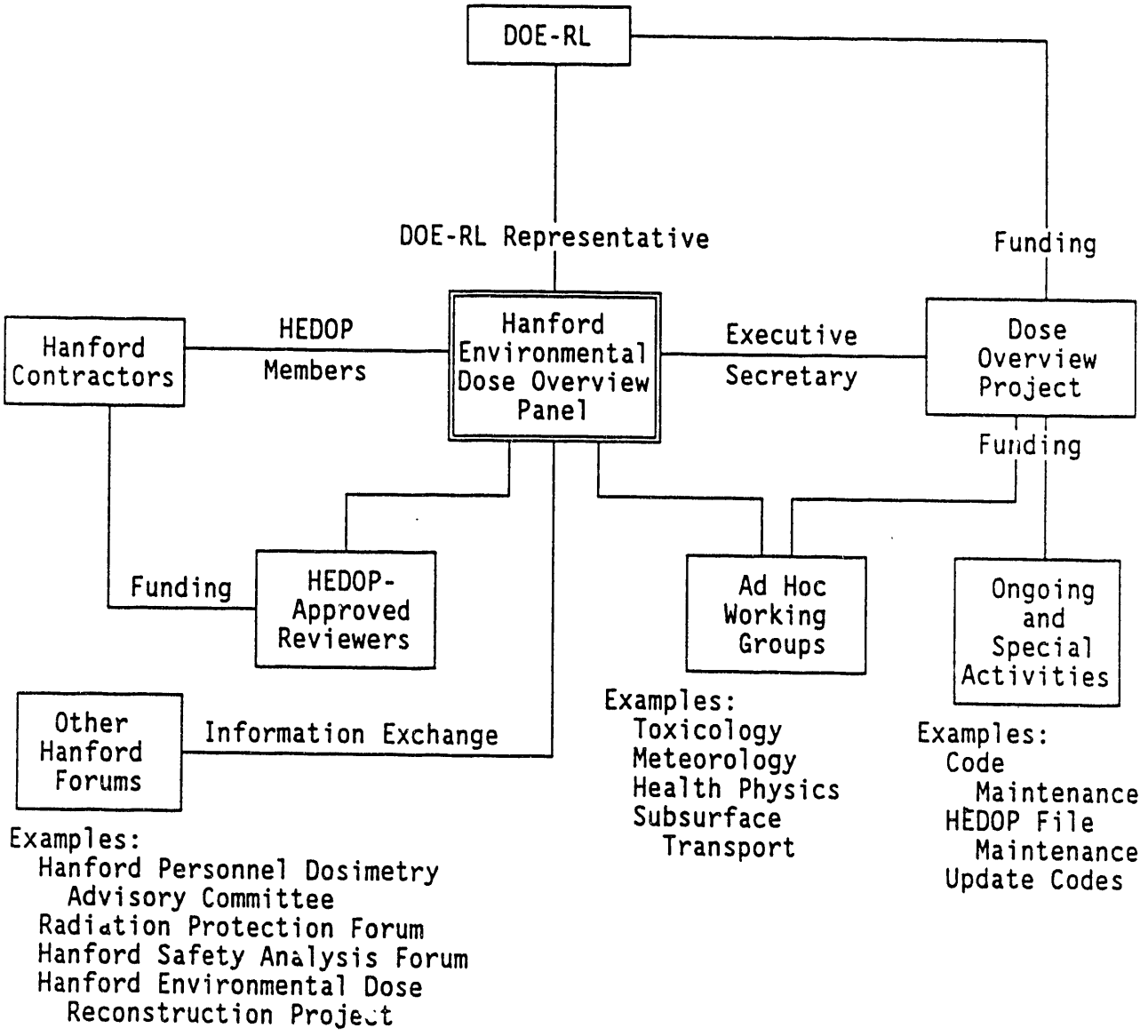
Donna E. Lucas — May 18, 1990 Date

Bruce A. Napier — 17 May 90 Date

Paul D. Rittmann — May 18, 1990 Date

VII. CONCURRENCE

R. F. Brich, DOE-RL Representative
Safety and Environment Division
U. S. Department of Energy
Richland Operations Office — May 17, 1990 Date



Functional and Organizational Relationships of the Hanford Environmental Dose Overview Panel

THIS PAGE BLANK INTENTIONALLY

APPENDIX C.1

CURRENT HEDOP-APPROVED REVIEWERS

THIS PAGE BLANK INTENTIONALLY

APPENDIX C.1

CURRENT HEDOP-APPROVED REVIEWERS

Name	Work Location	Phone #	MSIN
Pacific Northwest Laboratory:			
Tracy A. Ikenberry	Rm 30/RTL Bldg/RCHN Area	375-2338	K3-54
William E. Kennedy, Jr.	Rm 25/RTL Bldg/RCHN Area	375-3849	K3-54
Bruce A. Napier	Rm 36/RTL Bldg/RCHN Area	375-3896	K3-54
Kathleen Rhoads	Rm 40/RTL Bldg/RCHN Area	375-6832	K3-54
R. Gene Schreckhise	Rm 38/RTL Bldg/RCHN Area	375-3941	K3-54
Joseph K. Soldat	Rm 34/RTL Bldg/RCHN Area	375-3942	K3-54
Monte J. Sula	Rm 3147/337 Bldg/300 Area	376-0605	P7-78
Westinghouse Hanford Company:			
Janet S. Davis	Rm 602/4706 Bldg/400 Area	376-9284	N1-19
David A. Himes	Rm 607/4706 Bldg/400 Area	376-8190	N1-19
Paul D. Rittmann	Rm 7A/345 Hills Bldg/RCHN Area	376-8715	H4-14
Rick J. Van Vleet	Rm 20/450 Hills Bldg/RCHN Area	376-2613	H6-31

THIS PAGE BLANK INTENTIONALLY

APPENDIX C.2

HANFORD ENVIRONMENTAL DOSE OVERVIEW PANEL MEMBERS FOR 1992/1993

THIS PAGE BLANK INTENTIONALLY

APPENDIX C.2

HANFORD ENVIRONMENTAL DOSE OVERVIEW PANEL MEMBERS FOR 1992/1993

Name	Term Expires 30 June	Work/Technical Area	Phone #	MS
HEHF:				
Ramesh Dowray	1993	Occupational medicine	376-7186	H1-02
Thomas W. Henn	1994	Occupational medicine	376-6137	H1-02
Mitzi L. Dentler	1995	Industrial hygiene, toxicology	372-0532	H1-52
Burton B. Milburn	1996	Industrial hygiene, safety engineering	376-7040	B2-75
PNL:				
J. Van Ramsdell, Jr.	1993	Atmospheric sciences	376-8626	K6-03
Charles T. Kincaid[a]	1994	Soil physics and groundwater hydrology	376-8324	K6-77
Bruce A. Napier	1995	Environmental health physics, primary author of GENII	375-3896	K3-54
Michael Yurconic	1996	Laboratory safety, industrial hygiene and risk assessment	376-9644	P7-78
WHC:				
Janet S. Davis	1993	Radiological safety analysis	376-9284	N1-19
Paul D. Rittmann	1994	Environmental technology, health physics	376-8715	H4-14
Robert H. Ruben	1995	Health physics	376-4181	L8-20
A. Ray Johnson	1992	Environmental protection	372-3056	H6-30
DOE-RL Representative[b]:				
Randall F. Brich	--	Health physics	376-9031	A5-55
Executive Secretary[b]:				
R. Gene Schreckhise	--	Hanford Environmental Dosimetry Coordination Project Manager, environmental health physics	375-3941	K3-54

[a] Chair for 1992/1993 term

[b] Non-voting positions on the Panel

THIS PAGE BLANK INTENTIONALLY

APPENDIX D

HEDOP-MANDATED REVIEW REQUIREMENTS AND PROCEDURES

THIS PAGE BLANK INTENTIONALLY

APPENDIX D

HEDOP-MANDATED REVIEW REQUIREMENTS AND PROCEDURES

The following section, taken from the Policy Manual[a] of the Hanford Environmental Dose Overview Panel, describes the procedures for securing a HEDOP-mandated review. The requirements of the review, along with a check-off list that may be used for the review, are included.

A HEDOP-Approved Reviewer, the Chairperson, or the Executive Secretary of the Panel should be contacted to initiate the review. Their names, addresses, and telephone numbers are provided in Appendix C.2.

---

[a] Policy Manual of the Hanford Environmental Dose Overview Panel, dated September 25, 1991.

Approved by: Original signed by Janet S. Davis
Janet S. Davis, HEDOP Chairperson

Purpose

The purpose of this policy is to provide guidelines for the calculation review process for environmental and health dose assessments of operations and facilities on the Hanford Site. HEDOP reviews are performed to assure that (1) appropriate methods are used, (2) all Hanford-related environmental and health dose assessments are technically consistent, and (3) communication occurs among the Hanford contractors regarding these assessments.

Policy / Requirements

1. Analyses requiring HEDOP reviews may be submitted to the HEDOP Chairperson or to an individual HEDOP-Approved Reviewer. A list of the current HEDOP Chairperson and HEDOP-Approved Reviewers may be obtained from the HEDOP Executive Secretary (R.G. Schreckhise, PNL; K3-54, 375-3941, cc:Mail).

2. The HEDOP review is an overview, as implied by the Panel name (Hanford Environmental Dose Overview Panel), although technical issues may also be addressed as part of the review. The HEDOP reviewer shall verify that:

   a. A technically accurate, defensible and appropriate code was used (i.e., the code is consistent with HEDOP recommendations in PNL-3777 Revision 2).

   b. Appropriate receptor locations were evaluated.

   c. Appropriate pathways were evaluated for each receptor.

   d. Appropriate models (finite plume, semi-infinite cloud, building wake, etc.) were used.

   e. Data and parameters appropriate for the Hanford Site were used, and the analysis is otherwise consistent with HEDOP recommendations in PNL-3777 Revision 2.

   f. Model adjustments external to the computer program were justified and performed correctly (for example, adjustments to the chi/Q value for airborne releases with a duration between those assumed for the acute and chronic air transport models).

   g. A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed.

The HEDOP reviewer shall also determine if detailed technical reviews have been performed on the scenario and release determinations prior to approval by HEDOP. It is highly desirable that these reviews be conducted, but since they are outside the scope of HEDOP responsibilities, HEDOP approval of analyses without these reviews will not be withheld. However, absence of these reviews will be noted in the HEDOP review documentation.

The form provided at the end of this policy shall be used to document HEDOP review and approval. Review calculations, comments and/or notes shall be attached to the review documentation as appropriate.

3. All environmental transport and dose calculation portions of analyses shall have received a detailed technical review and approval prior to submittal for HEDOP review, unless the HEDOP-Approved Reviewer is being requested to perform the detailed technical review in addition to the HEDOP review.

4. Documentation of assessments submitted for HEDOP review shall include:

   a. Complete documentation of the assessment.

   b. Complete computer code input and output, if used (may be in either electronic or hard copy form).

   c. Documentation of detailed technical reviews and approvals (see item 2.g, the paragraph following item 2.g, and item 3 above).

5. HEDOP-Approved Reviewers are responsible for reviewing only those analyses within their area of expertise (e.g., those with only limited experience with nonradiological release calculations will not approve nonradiological release calculations). If a reviewer discovers portions of the work lie outside his/her expertise, the reviewer shall try to find another HEDOP-Approved Reviewer with the appropriate expertise.

   In cases where a HEDOP-Approved Reviewer cannot be found, a HEDOP-Approved Reviewer may request that an evaluation be conducted by a knowledgeable person who is not a HEDOP-Approved Reviewer. The HEDOP-Approved Reviewer who requested the outside evaluation would approve or reject the analysis based on input from and discussions with the knowledgeable reviewer.

6. HEDOP-Approved Reviewers shall report their HEDOP review activities to the Panel quarterly. The report shall include reviews resulting in approval and rejection, reviews currently underway, and issues and comments and corresponding resolutions.

7. The completed HEDOP review checklist (on the following page) should become an integral part of the document reviewed.

8. HEDOP-Approved Reviewers shall provide copies of completed checklists to the Panel representative who maintains HEDOP files for the contractor preparing the document.

HEDOP REVIEW CHECKLIST
for
Radiological and Nonradiological Release Calculations

Document reviewed (include title or description of calculation, document number, author, and date, as applicable):

Submitted by: Date Submitted:

Scope of Review:

YES	NO*	N/A		
[ ]	[ ]	[ ]	1.	A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
[ ]	[ ]	[ ]	2.	Detailed technical review(s) and approval(s) of scenario and release determinations have been performed and documented.
[ ]	[ ]	[ ]	3.	HEDOP-approved code(s) were used.
[ ]	[ ]	[ ]	4.	Receptor locations were selected according to HEDOP recommendations.
[ ]	[ ]	[ ]	5.	All applicable environmental pathways and code options were included and are appropriate for the calculations.
[ ]	[ ]	[ ]	6.	Hanford site data were used.
[ ]	[ ]	[ ]	7.	Model adjustments external to the computer program were justified and performed correctly.
[ ]	[ ]	[ ]	8.	The analysis is consistent with HEDOP recommendations.
[ ]		[ ]	9.	Supporting notes, calculations, comments, comment resolutions, or other information is attached. (Use the "Page 1 of X" page numbering format and sign and date each added page.)
[ ]	[ ]		10.	Approval is granted on behalf of the Hanford Environmental Dose Overview Panel.

* All "NO" responses must be explained and use of nonstandard methods justified.

HEDOP-Approved Reviewer (Printed Name and Signature) Date

COMMENTS (add additional signed and dated pages if necessary):

THIS PAGE BLANK INTENTIONALLY

APPENDIX E

HEDOP CODE APPROVAL POLICY

THIS PAGE BLANK INTENTIONALLY

APPENDIX E

HEDOP CODE APPROVAL POLICY

The following section, taken from the Policy Manual[a] of the Hanford Environmental Dose Overview Panel, describes the procedures for securing HEDOP approval of a code to be used for evaluating environmental and health dose assessments related to operations and/or facilities on the Hanford Site. The use of HEDOP-approved codes is not required by the Panel. However, the use of codes and associated parameters that have been approved by the Panel usually expedites the HEDOP-mandated review process. The codes that have been approved by HEDOP are listed in Appendix F.

---

[a] Policy Manual of the Hanford Environmental Dose Overview Panel, dated September 25, 1991.

Approved by: Original signed by Janet S. Davis
Janet S. Davis, HEDOP Chairperson

Purpose

The purpose of this policy is to specify the criteria and method for the Hanford Environmental Dose Overview Panel, (HEDOP or Panel), to evaluate and approve software that has been technically reviewed and quality assured for application in the conduct of environmental and health dose assessments of existing and/or proposed Hanford Site facilities and/or operations.

Through this policy, the HEDOP-mandated review and approval of dose calculations will be expedited by eliminating the need for detailed software review during calculation reviews. Application of the policy will lead to the approval of software and to the creation of a suite of HEDOP approved software for Hanford Site application.

Approval by HEDOP simply means acceptance of software for use at the Hanford Site. This approval for use may be based on its prior acceptance or approval by technical peers elsewhere or by its use in other government agencies, (e.g., the U.S. Environmental Protection Agency, or the State of Washington's Departments of Health or Ecology), and therefore, should not necessarily be interpreted as Hanford Site approval or acceptance of the technical basis embodied in the software.

Objectives

The objectives of the software approval policy are to:

- determine if appropriate quality assurance procedures exist and have been followed, and if the code has been fully documented and reviewed by qualified QA auditors and independent technical reviewers. This is done to ensure that a quality product is being considered for approval by the Panel.

- ensure that necessary protocols are in place and honored so as to inform the Panel of discovered problems or errors in the software and their resolution.

- determine if the software is capable of accepting Hanford-specific data where such data are deemed essential by HEDOP for the satisfactory simulation of Hanford Site cases. In addition, the policy is designed to reveal whether specific software options should be employed or disabled to appropriately represent Hanford Site conceptual models.

- ensure that engineering or scientific software under consideration is evaluated in an impartial and consistent fashion.

Policy / Requirements

1. SCOPE OF HEDOP REVIEW AND APPROVAL: The software approval policy applies to both commercial and public domain software that fall under the software quality assurance requirements of the Richland office of the Department of Energy. The software of interest is that used in the conduct of environmental and health dose assessments of existing and/or proposed Hanford Site facilities and/or operations. Software used solely for generation of presentations or a finished report, e.g., word processors, is excluded.

2. APPLYING FOR SOFTWARE APPROVAL: Contractors or individuals desiring to have new or revised software reviewed and approved shall give a presentation and provide a written summary to the Panel addressing the issues outlined below under the policies for approval of new, (i.e., initial), or revised software.

3. RECORDS OF SOFTWARE REVIEW AND APPROVAL: Upon submittal of software for review, a file containing all correspondence, records of presentation, and Panel actions will be created and maintained. This record shall be maintained in accordance with the records maintenance requirements of the Hanford Environmental Dosimetry Coordination Project. The Panel will complete the Checklist for HEDOP Software Approval (provided at the end of this policy) and it will become part of the record.

4. INTERNAL TESTING AND BENCHMARK CASES FOR SOFTWARE REVIEW: To ensure an impartial and consistent evaluation, the software approval policy requires that the Panel, through an ad hoc Working Group assigned to evaluate the software, specify internal testing and benchmark cases that are based primarily on the intended end-use of software at Hanford. These testing and benchmark cases shall be retained on file by the Hanford Environmental Dosimetry Coordination Project. The cases shall, at a minimum, exercise the software options and the range of variables likely to be encountered in applications of software to Hanford Site situations. The cases will be designed to reveal the use of Hanford-specific data, and identify the need for Hanford-specific software options. The ad hoc Working Group will specify performance measures and associated criteria for the cases to ensure an impartial and consistent evaluation.

   Rather than create these internal testing and benchmark cases, the ad hoc Working Group may adopt cases proposed for this purpose by the applicant or custodian of the software. The performance measures and criteria adopted by the ad hoc Working Group should be peer-accepted measures of software performance. The performance measures, taken together with the criteria, should provide a repeatable means of impartially evaluating software with regard to its application to Hanford Site facilities.

5. APPROVAL OF SOFTWARE: If all criteria are met, a formal approval of the software, with all Panel modeling preferences identified, will be issued to the Contractor or individual. A disclaimer indicating HEDOP approval and Panel modeling preferences will be provided by the Panel. In order to alert HEDOP-Approved Reviewers of the status of software used in calculations, this disclaimer is to be placed on the cover page of draft material submitted for HEDOP review.

6. CONDITIONAL APPROVAL OR REJECTION OF SOFTWARE: If any criterion is not met, the Panel may take one of the following four actions:

   a. Conditional Approval: If use of the software is mandated by the Department of Energy or another federal or state agency, then aspects of the review and approval policy that are viewed as illogical and uneconomical to complete because they would not influence software approval, (e.g., an independent technical peer review, or internal test and benchmark case simulations), may not be required by the Panel. Because one or more criteria has not been met, the approval would be conditional. As in the case of the unconditional approval (Item 5 above), a disclaimer indicating conditional approval and Panel modeling preferences will be provided by the Panel. In order to alert HEDOP-Approved Reviewers of the status of software used in calculations, this disclaimer is to be placed on the cover page of draft material submitted for HEDOP review.

   b. Recommendation to Approve upon Revision: The Panel may reject software with a recommendation for specific revisions prior to a subsequent expedited review and approval. In such cases, the Panel will identify needed (1) revisions to the software, (2) internal test or benchmark cases, or (3) supplemental documentation. Specific actions necessary to obtain approval through an abbreviated review process will be outlined, and deadlines for further consideration will be stipulated.

   c. Rejection with Recommendation for Major Revisions: The Panel may reject software with recommendations for major revisions to the software or its documentation, or simulations of internal test and benchmark cases, or adoption of necessary quality assurance protocols. Upon completion of recommended revisions, simulations, or protocols, the Contractor or individual should resubmit the software for complete review by HEDOP.

   d. Rejection without Recommendation: The Panel may reject without detailed recommendations for revision or resubmittal. Such an action would be appropriate if there was inadequate justification for the proposed software, it simply duplicated existing approved software, and it provided no new or improved capability.

7. HEDOP-APPROVED SOFTWARE SUMMARY: A list of approved software and a listing or statement of the following items for each shall be maintained by the Executive Secretary of the Panel:

   a. software status (approved, conditionally approved, rejected),
   b. software design purpose,
   c. underlying theory,
   d. primary assumptions and major limitations,
   e. past applications (including references),
   f. available documentation (including references), and
   g. code custodian (address, telephone, facsimile, etc.)

Initial Approval of Software

The policy for HEDOP evaluation and initial approval of software is provided below. An impartial and consistent evaluation will be achieved by following the steps A through E outlined below and reviewing the adequacy of software justification, quality assurance, general technical basis, Hanford-specific applications, and software control procedures. The checklist summarizes the issues raised and uses the same capital letter designations as below:

A. Justification: The introduction of new software must be justified to the Panel. The justification can be based on one or a variety of scientific, regulatory, and/or economic reasons.

B. Quality Assurance Review: The design, development, documentation, control, and maintenance of the software shall have been reviewed and accepted within a software quality assurance program consistent with quality assurance guidance from DOE Field Office, Richland (RL).

C. General Technical Expert Review: The software shall have been reviewed by qualified independent technical experts. These technical experts shall have determined whether the software was correctly formulated, encoded, verified, benchmarked, and validated.

D. HEDOP Technical Expert Review: Simulations, submitted by the applicant employing the candidate software on internal test and benchmark cases stipulated by the Panel, (i.e., its ad hoc Working Group), shall be reviewed by Panel-designated technical experts. These experts shall determine whether satisfactory performance has been achieved by the candidate software, whether Hanford-specific data can be employed, and whether Hanford-specific options should be required by the Panel.

   This step in the review may be satisfied under item C when the internal test and benchmark cases, and the Panel-designated technical experts are both included as part of the General Technical Expert Certification.

E. HEDOP Notification of Software Changes: The software shall be controlled under software control procedures by the code custodian such that HEDOP and the user community will be immediately notified of:

a. problem or error identification,
b. problem or error resolution,
c. interim software corrections,
d. formal approval and re-release of the software,
e. changes to the HEDOP user community list, and
f. changes in code custodianship.

The Panel will notify *HEDOP-Approved Reviewers* of the changed status of a code (or of portions of the code affected) pending resubmittal of the software for testing and re-evaluation by the HEDOP. The code custodian will retain responsibility for notification of *all users* of software errors and corrections in accordance with established software control procedures.

Approval of Software Revisions

The policy for evaluation and approval of a software revision is provided below. An impartial and consistent evaluation of the software revision will be achieved by following the steps A through E outlined below and reviewing the adequacy of software revision justification, quality assurance, general technical basis, Hanford-specific applications, and software control procedures. The checklist summarizes the issues raised and uses the same capital letter designations:

A. Justification: The introduction of revisions to HEDOP approved software must be justified to the Panel. The justification can be based on one or a variety of reasons; however, it is anticipated such revisions will occur as result of corrections to observed software errors, or as normal upgrades or updates to software.

B. Quality Assurance Review: The design, development, and documentation of the revision to the software, and the control and maintenance of the previously approved software shall have been reviewed and accepted within a software quality assurance program consistent with quality assurance guidance from RL.

C. General Technical Expert Review: The revised software shall have been reviewed by qualified independent technical experts. These technical experts shall have determined whether the revision was correctly formulated, encoded, verified, benchmarked, and validated.

D. HEDOP Technical Expert Review: Simulations, submitted by the applicant, employing the revised software on the internal test and benchmark cases stipulated by the Panel (i.e., its ad hoc Working Group) and retained on

file by the Hanford Environmental Dosimetry Coordination Project, shall be reviewed by Panel-designated technical experts. The applicant shalldescribe in narrative form and quantitatively demonstrate the type of simulations impacted by the changes to the software. At a minimum, the impacts of software changes shall be demonstrated by presenting the differences between results generated using old and new versions of the software. The Panel-designated technical experts shall determine whether satisfactory performance has been achieved by the revised software, whether Hanford-specific data can still be employed, and whether Panel-required Hanford-specific software options still apply.

This step in the review may be satisfied under Item C if the internal test and benchmark cases and the Panel-designated technical experts are both included as part of the General Technical Expert Certification.

E. HEDOP Notification of Software Changes: The revised software shall have been controlled under software control procedures by the code custodian such that HEDOP and the user community were immediately notified of the need for revision. The procedures and protocols followed by the code custodian shall be reviewed to ensure they have met HEDOP requirements. Specifically, the written record of HEDOP notification regarding the following items will be reviewed:

a. problem or error identification,
b. problem or error resolution,
c. interim corrections and a discussion of impacts of revisions, and
d. formal approval and re-release of the software.

CHECKLIST FOR HEDOP SOFTWARE APPROVAL

Page 1 of 2

Software Evaluated:

Documentation:

Software Custodian:

	YES	NO	NA	(Explanations are required)
A.	[ ]	[ ]	[ ]	Justification. Is the justification for adding or revising this software appropriate and clearly documented?

Summary:

B.	[ ]	[ ]	[ ]	Quality Assurance Review. Has the software or its revision been designed, developed, documented, controlled, and maintained under quality assurance protocols in keeping with QA guidance from DOE Field Office, Richland?

Summary:

C.	[ ]	[ ]	[ ]	General Technical Expert Review. Have independent technical experts found the subject software or its revision has been correctly formulated, encoded, verified, benchmarked, and validated?

Summary:

D.	[ ]	[ ]	[ ]	HEDOP Technical Expert Review. Have independent technical experts identified by the Panel reviewed and found the software or its revision properly simulates internal test and benchmark cases stipulated by the Panel?

Summary:

CHECKLIST FOR HEDOP SOFTWARE APPROVAL Page 2 of 2

E. [ ] [ ] [ ] HEDOP Software Control Procedures/Records. Are software control procedures in place, or have they been followed, such that HEDOP and the user community will be or were immediately notified of: coding errors, problems, their resolution, interim corrections, potential impacts, and re-release of the software?

Summary:

HEDOP Decision:

Chairperson, Hanford Environmental Dose Overview Panel Date
(Printed name and signature)

THIS PAGE BLANK INTENTIONALLY

APPENDIX F.1

CURRENT HEDOP-APPROVED CODES

THIS PAGE BLANK INTENTIONALLY

APPENDIX F.1

CURRENT HEDOP-APPROVED CODES

The Hanford Environmental Dose Overview Panel (HEDOP) has approved the following codes for use at Hanford to conduct environmental and health dose assessments:

- GENII - Version 1.485 - This version, along with the associated parameters, was approved by HEDOP at the March 5, 1990, meeting of the Panel. The GENII code is documented in Napier et al. (1988a-c).

- AIRDOS-EPA - The CAP-88 (Beres 1990) and AIRDOS-PC (USEPA 1989) versions of the AIRDOS-EPA code were approved for use by HEDOP at the May 16, 1991, meeting of the Panel. (A copy of the Section from the HEDOP Policy Manual[a] entitled "Guidance for Using EPA-Approved Computer Codes for Environmental Dose Calculations at Hanford" is provided in Appendix F.1.) The Panel noted that even though the AIRDOS-EPA codes may not realistically represent the environmental conditions at Hanford, they are required by 40 CFR 61 (1989) and, therefore, should be used as required. Furthermore, HEDOP also recommended to the U.S. Department of Energy's Richland Field Office that when a version of AIRDOS-EPA is used as required by regulations, each evaluation should also be accompanied by an evaluation using the HEDOP-approved version of GENII.

Contact the Executive Secretary of HEDOP for information on how to gain access to the above codes. The name, address, and phone number of the current Executive Secretary are provided in Appendix C.2.

F.1.1 REFERENCES

40 CFR 61. 1989. U.S. Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants; Radionuclides; Final Rule and Notice of Reconsideration." U.S. Code of Federal Regulations.

Beres, D. A. 1990. The Clean Air Act Assessment Package-1988 (CAP-88). A Dose and Risk Assessment Methodology for Radionuclide Emissions to Air. Vol. 1, User's Manual. U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, D.C.

---

[a] Policy Manual of the Hanford Environmental Dose Overview Panel, dated September 25, 1991.

Napier, B. A., D. L. Strenge, R. A. Peloquin, and J. V. Ramsdell. 1988a. GENII - The Hanford Environmental Radiation Dosimetry Software System, Volume 1: Conceptual Representation. PNL-6584 Vol. 1, Pacific Northwest Laboratory, Richland, Washington.

Napier, B. A., D. L. Strenge, R. A. Peloquin, and J. V. Ramsdell. 1988b. GENII - The Hanford Environmental Radiation Dosimetry Software System, Volume 2: Users' Manual. PNL-6584 Vol. 2, Pacific Northwest Laboratory, Richland, Washington.

Napier, B. A., D. L. Strenge, R. A. Peloquin, and J. V. Ramsdell. 1988c. GENII - The Hanford Environmental Radiation Dosimetry Software System, Volume 3: Code Maintenance Manual. PNL-6584 Vol. 3, Pacific Northwest Laboratory, Richland, Washington.

U.S. Environmental Protection Agency (USEPA). 1989. User's Guide for AIRDOS-PC. Version 3.0. EPA/520/6-89-035, EPA Office of Radiation Programs, Las Vegas, Nevada.

APPENDIX F.2

HEDOP GUIDANCE FOR USING EPA-MANDATED CODES AT HANFORD

THIS PAGE BLANK INTENTIONALLY

APPENDIX F.2

HEDOP GUIDANCE FOR USING EPA-MANDATED CODES AT HANFORD

Guidance provided by the Hanford Environmental Dose Overview Panel (HEDOP) on the use of versions of the AIRDOSE-EPA code, as listed in the Policy Manual[a] of the Panel, is presented below.

---

[a] Policy Manual of the Hanford Environmental Dose Overview Panel, dated September 25, 1991.

Approved by: Original signed by Janet S. Davis
Janet S. Davis, HEDOP Chairperson

Summary

U.S. Environmental Protection Agency (EPA)-mandated compliance computer codes should be used for environmental dose calculations at Hanford only to the extent required by EPA, Washington State - Department of Health (WDOH), and U.S. Department Of Energy regulations (DOE), unless their use is specifically approved by the Hanford Environmental Dose Overview Panel (HEDOP). The EPA codes are national compliance dose codes that use generic parameters which may not be representative of environmental exposure conditions at Hanford. The HEDOP has developed a disclaimer statement that should be used in any document referencing or using an EPA-mandated compliance dose code.

Background

The EPA and the WDOH have established requirements pertaining to radioactive emissions from facilities.[a] The requirements place a limit on the offsite dose resulting from annual emissions of radioactive materials from a facility and require agency approvals for construction of new or modification of existing sources. The agencies further require that compliance evaluations of offsite dose be performed using methods that are approved by the EPA.

The HEDOP has established the computer code GENII as a recommended method for calculation of environmental radiation doses that might result from the release of radioactive materials from Hanford operations; however, GENII has not been approved by the EPA. Therefore, compliance assessments required by the EPA and WDOH cannot be performed using GENII. As a result, the HEDOP has established guidelines for using EPA compliance codes for all environmental dose calculations that fall under its purview. The purpose of the guidelines is to assist Hanford users in applying the codes in a consistent and appropriate manner.

(a) U.S. Environmental Protection Agency, 40 CFR Part 61, "National Emission Standards for Hazardous Air Pollutants (NESHAPS)".

Washington State Department of Health, WAC 402 - 80, "Monitoring and Enforcement of Air Quality and Emission Standards for Radionuclides".

Guidance for Use of EPA Compliance Codes

This guidance pertains to use of EPA compliance codes for all applications that fall under the purview of the HEDOP. Two basic types of compliance assessments are performed:

1. Prospective compliance evaluations:

   Calculations based on assumed projected emissions to support notification/approval efforts for new construction or modification to existing facilities as required by EPA and WDOH.

2. Retrospective compliance assessments:

   Calculations performed to assess compliance of past air emissions with EPA's and/or WDOH's emission standards.

Requirements

The following provides general requirements for use of EPA compliance codes as well as specific requirements based on whether the code is used for prospective or retrospective compliance assessment.

General Requirements:

1. EPA compliance codes (eg., AIRDOS-PC, CAP-88), be used only in the following circumstances:

   - if required by the EPA and/or WDOH for compliance evaluations or assessments,

   - if required by DOE,

   - if the application is specifically approved by HEDOP.

2. Documents that reference or include discussion of Hanford environmental dose calculations performed using an EPA compliance method shall include the following statement:

   "Note: < computer code > is a mandated compliance assessment method that may not provide realistic estimates of environmental doses for Hanford applications."

3. Each environmental dose calculation, performed using an EPA compliance code, shall be reviewed by a HEDOP-approved reviewer.

Requirements for Retrospective Assessments:

1. Retrospective dose calculations shall be performed using CAP-88 with Hanford site specific input parameters to maximize the appropriateness of the calculated dose.

2. A concurrent retrospective dose calculation shall also be performed using GENII. To the extent possible, site specific input parameters and data should be consistent between the two codes.

3. All documentation of retrospective dose calculations performed using CAP-88 shall also state the GENII calculated dose.

4. The compliance dose calculation shall represent the highest effective CAP-88 dose equivalent to any member of the public at any offsite point where a residence, school, business, or office exists. All applicable pathways considered by CAP-88 must be included.

Requirements for Prospective Assessments:

1. Prospective dose calculations may be performed using any applicable EPA-approved compliance code.

2. Where the code permits modification of default input parameters to accommodate site specific conditions, use of this capability is left to the discretion of the user. Hanford specific input parameters must conform to recommendations of the HEDOP.

3. Prospective dose calculations do not require that a concurrent calculation be performed using GENII. However, sufficient information should be maintained for each prospective dose calculation so that a GENII calculation can be performed at a later date.

4. The receptor for calculation of offsite dose should be the offsite location where a residence, school, business, or office is or could be located that results in the maximum calculated dose as a result of the release quantity associated with the proposed activity. All pathways considered by the compliance code used for the calculation must be included.

APPENDIX G.1

HANFORD SITE DESCRIPTION

THIS PAGE BLANK INTENTIONALLY

APPENDIX G.1

HANFORD SITE DESCRIPTION

Most of the following information on the environmental description of the Hanford Site was taken from Woodruff and Hanf (1992). Additional information about the Site is also provided in Cushing (1992).

G.1.1 SITE ENVIRONMENT

The Hanford Site lies within the semiarid Pasco Basin of the Columbia Plateau in south central Washington state (see Figure G.1.1). The Columbia River flows eastward through the northern part of the Site and then turns south, forming part of the eastern boundary. The Site occupies an area of about 1,450 km^2. This relatively large area, with restricted public access, provides a buffer for the locations on the Site that have been used for the production of nuclear materials, waste storage and disposal, and energy research and development. About 6% of the land area has been disturbed and is actively used. Land areas to the west, north, and east of the Site are principally range and irrigated farm lands. The cities of Richland, Kennewick, and Pasco (i.e., the Tri-Cities) constitute the nearest population center and are located south and southeast of the Site. Smaller communities are also located in the counties surrounding the Site (i.e., Adams, Benton, Franklin, Grant, Walla Walla, and Yakima counties). Current estimates of the number of people living within 80 km of the major operational areas on the Hanford Site are presented in Appendix G.2.

G.1.2 LAND USE

The Hanford Site consists of four major operational areas:

- The six 100 Areas, bordering on the right bank (south shore) of the Columbia River, are the sites of the 9 retired plutonium production reactors. The 100 Areas occupy about 11 km^2.

- The 200-West and 200-East Areas are located about in the middle of the Site on a plateau approximately 8 and 11 km, respectively, south of the Columbia River. These areas historically have been dedicated to fuel reprocessing and waste management and disposal activities. The 200 Areas cover about 16 km^2.

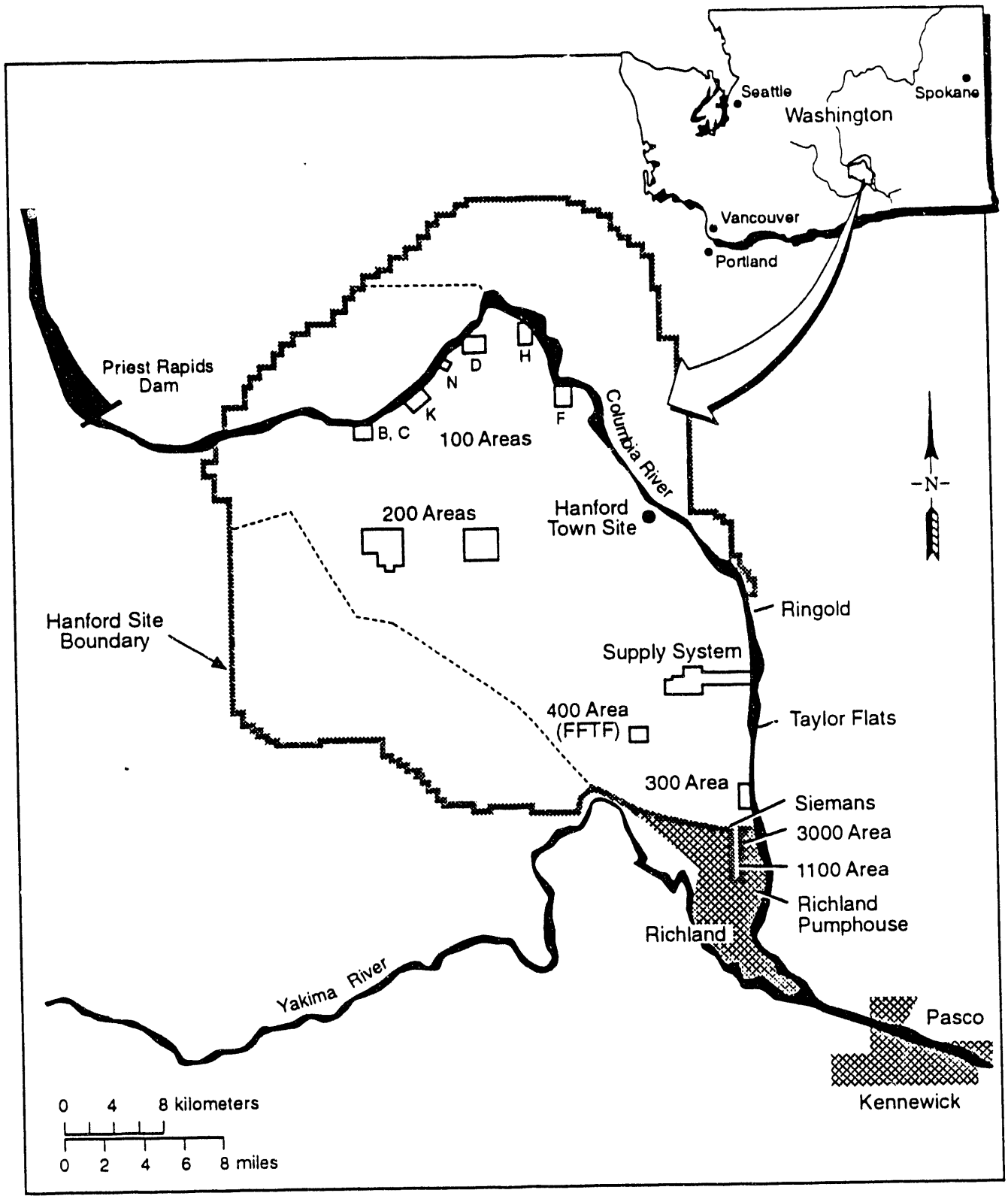


Figure G.1.1 Hanford Site

- The 300 Area, located just north of the city of Richland, is the site of research and development activities. It occupies about 2 km^2.

- The 400 Area, located about 15 km northwest of the city of Richland, is the site of a test breeder reactor system. It occupies about 2 km^2.

The area along the south-western boundary of the Site is designated as the Arid Lands Ecology Reserve. The western portion of the Site located north of the Columbia River is designated as the U.S. Fish and Wildlife Service Saddle Mountain National Wildlife Refuge; the portion on the east is the Washington State Department of Game Reserve. These three areas total about 655 km^2.

Land use surrounding the site includes urban and industrial development, irrigated and dryland farming, and grazing. In 1989, wheat represented the largest single crop in terms of area planted in Benton and Franklin Counties (i.e., 87,412 ha). Corn, alfalfa, potatoes, asparagus, apples, cherries, and grapes are other major crops. More than 20 processors in Benton and Franklin Counties process food products, including potato products, canned fruits and vegetables, wine, and animal feed.

G.1.3 CLIMATE AND METEOROLOGY

The Cascade Mountains beyond Yakima to the west greatly influence the climate of the Hanford Site. This range creates a rain shadow effect and also serves as a source of cold air drainage, which has a considerable effect on the wind regime.

The prevailing wind direction on the 200 Area plateau is from the northwest in all months of the year. The secondary wind direction is from the southwest. Summaries of wind direction indicate that winds from the northwest quadrant occur more often during the winter and summer. During the spring and fall, the frequency of southwesterly winds increases with a corresponding decrease in northwest flow. Monthly average wind speeds are lowest during the winter months (averaging 10 to 11 km h^{-1}) and highest during the summer (averaging 14 to 16 km h^{-1}). Wind speeds that are well above average are usually associated with southwesterly winds. However, the summertime drainage winds are generally northwesterly and frequently reach 50 km h^{-1}. These winds are most prevalent over the northern portion of the Site.

Diurnal and monthly averages and extremes of temperature, dew point, and humidity are given by Stone et al. (1983). The record maximum temperature is 46 °C, and the record minimum temperature is -32.8 °C. For the period 1912 through 1980, the average monthly temperatures ranged from a low of -1.5 °C in January to a high of 24.7 °C in July. During the winter, the highest monthly average temperature at the Hanford Meteorological Station (HMS) was 6.9 °C, and the record lowest was -5.9 °C; both occurred during February. During the summer, the record maximum monthly average temperature was 27.9 °C (in July), and the record lowest was 17.2 °C (in June). The annual average relative humidity at HMS is 54%. It is highest during the winter months, averaging about 75%, and lowest during the summer, averaging about 35%. Average annual precipitation at HMS is 16 cm. Most of the precipitation occurs during the winter, with nearly half of the annual amount occurring in the months of November through February.

Atmospheric dispersion is a function of wind speed, duration and direction, atmospheric stability, and mixing depth. Dispersion conditions are generally good if winds are moderate to strong, the atmosphere is of neutral or unstable stratification, and there is a deep mixing layer. Good dispersion conditions associated with neutral and unstable stratification exist about 57% of the time during the summer. Less favorable dispersion conditions may occur when the wind speed is light and the mixing layer is shallow. These conditions are most common during the winter, when moderately to extremely stable stratification exists about 66% of the time. Occasionally there are extended periods of poor dispersion conditions, primarily during winter months, that are associated with stagnant air in stationary high-pressure systems.

G.1.4 GEOLOGY

Principal geologic units beneath the Hanford Site include, in ascending order, the Columbia River Basalt Group, the Ringold Formation, and a series of deposits informally referred to as the Hanford formation. These units are covered locally by a few meters or less of recent alluvial or windblown deposits. Older geologic units have been deformed into a series of roughly east-west trending folds.

The Columbia River Basalt Group is composed of numerous basaltic lava flows. River and lake sediments of the Ringold Formation contain a wide range of sediment types, with beds ranging from weakly cemented coarse sandy gravel to compacted silt and clay. Within the Pasco Basin, the Hanford formation consists of mostly coarse gravel and sand that overlie the eroded surface of the Ringold Formation, but in places the Hanford formation directly overlies basalt. Near the 200 West Area, the Ringold and Hanford formations are separated by a well-developed buried soil (Plio-Pleistocene unit) and fine-grained wind deposits (early "Palouse" soil) (Last et al. 1989). Hajek (1966) lists and describes 15 different soil types on the Site, varying from sand to silty and sandy loam.

G.1.5 GROUND-WATER HYDROLOGY

Both confined and unconfined aquifers are present beneath the Hanford Site. The confined aquifers, where ground water is under pressure greater than that of the atmosphere, are found primarily within the Columbia River basalts. In general, the unconfined or water-table aquifer is located in the Ringold Formation and glaciofluvial sediments, as well as some more recent alluvial sediments in areas adjacent to the Columbia River (Gephart et al. 1979). This relatively shallow aquifer has been affected by waste-water disposal at Hanford (Graham et al. 1981). Therefore, the unconfined aquifer is the most thoroughly monitored aquifer beneath the Site.

The unconfined aquifer is bounded below by either the basalt surface or, in places, the relatively impervious clays and silts of the Ringold Formation. The water table defines the upper boundary of the unconfined aquifer. Laterally, the aquifer is bounded by the basalt ridges that surround the basin and by the Yakima and Columbia rivers. The basalt ridges have a low permeability and act as a barrier to lateral flow of ground water (Gephart et al. 1979) where they rise above the water table. The saturated thickness of the unconfined aquifer is greater than 61 m in some areas of the Hanford Site and pinches out along the flanks of the basalt ridges. Depth from the ground surface to the water table ranges from less than 0.3 m at the Columbia River to more than 106 m in the center of the Site.

Recharge to the unconfined aquifer originates from several sources (Graham et al. 1981). Natural recharge occurs from precipitation at higher elevations and runoff from intermittent streams, such as Cold Creek and Dry Creek on the western margin of the Site. The unconfined aquifer is recharged by the Yakima River as it flows near the southwest boundary of the Hanford Site. The Columbia River recharges the unconfined aquifer during high stages when river water is transferred to the aquifer along the river bank. The unconfined aquifer receives little, if any, recharge from precipitation directly on vegetated areas of the Hanford Site because of a high rate of evapotranspiration by the vegetation.

Large-scale artificial recharge occurs from offsite agricultural irrigation and liquid-waste disposal in the operating areas. Recharge from irrigation in the Cold Creek Valley enters the Hanford Site as ground-water flow across the western boundary. Recharge to ground water across the Columbia River from the Hanford Site is primarily from irrigation and irrigation canal leakage.

The operational discharge of water has created ground-water mounds near each of the major waste-water disposal facilities in the 200 Areas. These mounds have altered the aquifer's local flow pattern, which is generally from the recharge areas in the west to the discharge areas (primarily the Columbia River) in the east. Water levels in the unconfined aquifer have changed continually during Site operations because of variations in the volume of waste water discharged. Consequently, the movement of ground water and its associated constituents has also changed with time.

Ground-water mounding also occurs in the 100 and 300 Areas. Ground-water mounding in these areas is not as significant as in the 200 Areas because of differences in discharge volumes and subsurface geology. In the 100 and 300 Areas, water levels are also greatly influenced by river stage.

As significant quantities of liquid effluents are discharged to the ground at Hanford facilities, these effluents percolate downward through the unsaturated zone to the water table. As effluents move through the unsaturated zone, adsorption onto soil particles, chemical precipitation, and ion exchange attenuate or delay the movement of some radionuclides (e.g., Sr,

Cs, and Pu). These constituents move through the soil column at varying rates and eventually enter the ground water. Other ions, such as nitrate, and radionuclides, such as H, Tc, and I, are not as readily retained by the soil and move downgradient in the same direction as, and at a rate nearly equal to, the flow of ground water. When the liquid effluents reach the ground water, their concentrations are reduced by dilution. As these constituents move with the ground water, radionuclide and chemical concentrations are further reduced by spreading (dispersion), and radionuclide concentrations are reduced by radioactive decay.

G.1.6 SURFACE-WATER HYDROLOGY

The Columbia River is the dominant surface water body on the Site. The Columbia, which originates in the mountains of eastern British Columbia, Canada, drains a total area of approximately 70,800 km^2 enroute to the Pacific Ocean. Flow of the Columbia River is regulated by 11 dams within the United States, 7 upstream and 4 downstream of the Site. Priest Rapids is the nearest dam upstream of the Site, and McNary is the nearest dam downstream. The Hanford Reach of the Columbia River extends from Priest Rapids Dam to the head of Lake Wallula (created by McNary Dam), near Richland. This Reach is the last stretch of the Columbia River in the United States above Bonneville Dam that remains unimpounded. The width of the river varies from approximately 300 m to 1,000 m within the Hanford Site.

Flows in the Hanford Reach fluctuate significantly because of the relatively small storage capacities and the operational practices at upstream dams. Flow rate of the Columbia River through the Site is regulated primarily by Priest Rapids Dam. Flow rate of the Columbia River through the Site is regulated primarily by Priest Rapids Dam. Typical daily flows range from 1,000 $m^3\ s^{-1}$ to 7,000 $m^3\ s^{-1}$, with peak spring run-off flows of up to 12,600 $m^3\ s^{-1}$. The minimum regulated flow is 1,020 $m^3\ s^{-1}$. Typical annual average flows at Priest Rapids Dam are 2,800 $m^3\ s^{-1}$ to 3,400 $m^3\ s^{-1}$. Monthly mean flows typically peak from April through June and are lowest from September through October.

The temperature of the Columbia River varies seasonally. Minimum temperatures are observed during January and February, and maximum

temperatures typically occur during August and September. Mean monthly temperatures for the river range from approximately 3 °C to about 20 °C during a year. Solar radiation, water storage management practices at upstream dams, and water flow rate dictate, to a large extent, the thermal characteristics of the Columbia River along the Hanford Reach.

The Columbia River has been developed extensively for hydroelectric power, flood control, navigation, irrigation, and municipal and industrial water supplies. In addition, the Hanford Reach is used for a variety of recreational activities, including fishing, hunting, boating, water skiing, and swimming. The state of Washington has classified the stretch of the Columbia River from the Washington-Oregon border to Grand Coulee Dam (which includes the Hanford Reach) as Class A (Excellent) and has established water quality criteria and water use guidelines that are appropriate for this class designation.

G.1.7 ECOLOGICAL CHARACTERISTICS

The Hanford Site is a relatively large, undisturbed area that contains numerous plant and animal species adapted to the region's semiarid environment. The vegetation mosaic of the Site consists of eight major plant communities: 1) sagebrush/bluebunch wheatgrass, 2) sagebrush/cheatgrass or sagebrush/Sandberg's bluegrass, 3) sagebrush-bitterbrush/cheatgrass, 4) greasewood/cheatgrass-saltgrass, 5)winterfat/Sandberg's bluegrass, 6) thyme buckwheat/Sandberg's bluegrass, 7) cheatgrass-tumble mustard, and 8) willow. More than 240 species of plants have been identified on the Hanford Site (USERDA 1975).

More than 300 species of terrestrial and aquatic insects, 12 species of reptiles and amphibians, 44 species of fish, 187 species of birds, and about 39 species of mammals have been found on the Hanford Site (Cushing 1992). Deer and elk are the major large mammals on the Site; coyotes are plentiful, and the Great Basin pocket mouse is the most abundant mammal. Waterfowl are numerous on the Columbia River, and the bald eagle is a regular winter visitor along the river. Salmon and steelhead are the fish species of most interest. There are two types of natural aquatic habitats on the Hanford Site -- one is the Columbia River, and the other is provided by the small spring-fed streams

and seeps located mainly on the Arid Lands Ecology Reserve located along the eastern side of Rattlesnake Mountain. These include Rattlesnake Springs, Dry Creek, and Snively Springs. West Lake, a small natural pond, is located north of the 200-East Area. Several artificial water bodies, both ponds and ditches, have been formed as a result of waste-water disposal practices associated with the operation of the reactors and separation facilities; these water bodies form established aquatic ecosystems complete with representative flora and fauna (Emery and McShane 1980).

G.1.8 REFERENCES

Cushing, C. E. (ed). 1992. Hanford Site National Environmental Policy Act (NEPA) Characterization. PNL-6415 Rev 5, Pacific Northwest Laboratory, Richland, Washington.

Emery, R. M., and M. C. McShane. 1980. "Nuclear Waste Ponds and Streams on the Hanford Site: An Ecological Search for Radiation Effects." Health Physics 38:787-809.

Gephart, R. E., R. C. Arnett, R. G. Baca, L. S. Leonhart, and F. A. Spane, Jr. 1979. Hydrologic Studies Within the Columbia Plateau, Washington: An Integration of Current Knowledge. RHO-BWI-ST-5, Rockwell Hanford Operations, Richland, Washington.

Graham, M. J., M. D. Hall, S. R. Strait, W. R. Brown. 1981. Hydrology of the Separations Area. RHO-ST-42, Rockwell Hanford Operations, Richland, Washington.

Hajek, B. F. 1966. Soil Survey: Hanford Project in Benton County, Washington. BNWL-243, Pacific Northwest Laboratory, Richland, Washington.

Last, G. V., B. N. Bjornstad, M. P. Bergeron, R. W. Wallace, D. R. Newcomer, J. A. Schramke, M. A. Chamness, C. S. Cline, S. P. Airhart, and J. S. Wilbur. 1989. Hydrogeology of the 200 Areas Low-level Burial Grounds - An Interim Report. PNL-6820, 2 Vols., Pacific Northwest Laboratory, Richland, Washington.

Stone, W. A., J. M. Thorp, O. P. Gifford, and D. J. Hoitink. 1983. Climatological Summary for the Hanford Area. PNL-4622, Pacific Northwest Laboratory, Richland, Washington.

U.S. Energy Research and Development Administration (USERDA). 1975. Final Environmental Impact Statement of Waste Management Operations, Hanford Reservation, Richland, Washington. ERDA-1538, 2 Vols., Washington, D.C.

Woodruff, R. K., and R. W. Hanf (eds). 1992. Hanford Site Environmental Report for Calendar Year 1991. PNL-8148, Pacific Northwest Laboratory, Richland, Washington.

THIS PAGE BLANK INTENTIONALLY

APPENDIX G.2

RESIDENTIAL POPULATION DISTRIBUTIONS WITHIN 80 KM OF THE HANFORD SITE AREAS

THIS PAGE BLANK INTENTIONALLY

APPENDIX G.2

RESIDENTIAL POPULATION DISTRIBUTIONS WITHIN 80 KM OF THE HANFORD SITE AREAS

The number of residents living within specified areas (i.e., 100, 200, 300 and 400 Areas) of the Hanford Site are presented in the following tables (i.e., G.2.1-4). The values were taken from Beck et al.[a] and are based on the 1990 census.

---

[a] Beck, D. M., M. J. Scott, M. D. Davis, S. F. Shindle, B. A. Napier, A. G. Thurman, D. B. Pittenger, and N. C. Batishko. 1991. Hanford Area 1990 Population and 50-Year Projections. PNL-7803, Pacific Northwest Laboratory, Richland, Washington.

TABLE G.2.1. Residential Population Distributions Within 80 km of the **100 N Area** Based on 1990 Census Data

Distance (Range) From 100 Areas (km)	Mid-Point Distance (km)	Number of People — Sector (Direction Away From 100 Areas)																
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.0 - 1.6	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.6 - 3.2	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.2 - 4.8	4.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.8 - 6.4	5.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.4 - 8.0	7.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.0 - 16.1	12.1	92	35	7	0	0	0	0	0	0	0	0	0	76	123	135	130	598
16.1 - 32.2	24.1	548	563	829	799	573	477	47	0	269	177	582	672	622	536	548	548	7790
32.2 - 48.3	40.2	559	691	1761	6161	1099	1596	2485	22090	4419	1602	5382	1885	1257	637	802	683	53109
48.3 - 64.4	56.3	1497	20440	2111	1292	1409	892	37108	50`26	1613	14573	18241	7608	4249	876	600	979	163614
64.4 - 80.0	72.4	8376	1784	451	306	677	571	10229	5662	166	525	780	18468	91485	4928	681	5049	150138
0.0 - 80.0		11072	23513	5159	8558	3758	3536	49869	77878	6467	16877	24985	28633	97689	7100	2766	7389	375249

TABLE G.2.2. Residential Population Distributions Within 80 km of the **200 Areas** Based on 1990 Census Data

Distance (Range) From 200 Areas (km)	Mid-Point Distance (km)	Number of People — Sector (Direction Away From 200 Areas)																
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.0 - 1.6	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.6 - 3.2	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.2 - 4.8	4.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.8 - 6.4	5.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.4 - 8.0	7.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.0 - 16.1	12.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.1 - 32.2	24.1	434	268	393	423	452	289	1141	2796	2842	713	1308	1956	771	641	548	544	15519
32.2 - 48.3	40.2	822	1030	6176	1217	1373	1674	35519	8309	1622	11983	19589	5406	1295	1087	738	909	98749
48.3 - 64.4	56.3	969	5220	2658	1652	1416	270	73156	2394	237	503	1132	16336	6269	1189	784	876	115061
64.4 - 80.0	72.4	2418	17567	1145	664	751	767	4918	5891	1144	738	637	7525	94203	2375	809	4979	146531
0.0 - 80.0		4643	24085	10372	3956	3992	3000	114734	19390	5845	13937	22666	31223	102538	5292	2879	7308	375860

TABLE G.2.3. Residential Population Distributions Within 80 km of the **300 Area** Based on 1990 Census Data

Distance (Range) From 300 Area (km)	Mid-Point Distance (km)	Number of People — Sector (Direction Away From 300 Area)																
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.0 - 1.6	0.8	0	0	1	2	3	2	2	0	0	0	0	0	0	0	0	0	10
1.6 - 3.2	2.4	0	3	11	11	11	11	11	7	0	0	0	0	0	0	0	0	65
3.2 - 4.8	4.0	0	16	18	18	18	18	18	18	3	0	0	0	0	0	0	0	127
4.8 - 6.4	5.6	2	25	25	25	25	25	25	25	198	0	0	0	0	0	0	0	375
6.4 - 8.0	7.2	6	33	33	33	33	33	33	121	2231	297	59	0	0	0	0	0	2912
8.0 - 16.1	12.1	85	277	277	277	276	264	277	616	17726	3518	2364	967	0	0	0	0	26924
16.1 - 32.2	24.1	602	678	827	754	170	117	15318	57047	12449	3788	2916	3238	730	0	0	0	98634
32.2 - 48.3	40.2	4203	2242	1094	741	255	454	3337	4098	123	288	1619	5812	1669	417	181	273	26806
48.3 - 64.4	56.3	2894	2411	590	480	761	878	1322	3779	13473	651	311	13516	16968	1703	1279	1277	62293
64.4 - 80.0	72.4	9998	1218	306	535	1001	10548	3257	4785	10913	1859	763	713	12843	2120	1428	1153	63440
0.0 - 80.0		17790	6903	3182	2876	2553	12350	23600	70496	57116	10401	8032	24246	32210	4240	2888	2703	281586

TABLE G.2.4. Residential Population Distributions Within 80 km of the **400 Area** Based on 1990 Census Data

Distance (Range) From 400 Area (km)	Mid-Point Distance (km)	Number of People — Sector (Direction Away From 400 Area)																
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.0 - 1.6	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.6 - 3.2	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.2 - 4.8	4.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.8 - 6.4	5.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.4 - 8.0	7.2	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
8.0 - 16.1	12.1	0	56	177	266	277	268	1082	6360	2350	1836	118	0	0	0	0	0	12790
16.1 - 32.2	24.1	189	655	680	995	727	511	27517	48564	5382	2822	2632	1659	175	0	0	0	92508
32.2 - 48.3	40.2	1234	6078	1192	1148	227	260	18278	11354	1037	504	6356	8677	3473	930	636	562	61946
48.3 - 64.4	56.3	1413	2503	1083	841	560	789	1627	3280	6254	263	427	17820	6265	1732	1205	1214	47276
64.4 - 80.0	72.4	15906	1803	321	399	1006	1210	2690	9199	11030	1557	830	723	16502	3125	1235	1169	68705
0.0 - 80.0		18742	11095	3453	3649	2800	3038	51194	78757	26053	6982	10363	28879	26415	5787	3076	2945	283228

THIS PAGE BLANK INTENTIONALLY

APPENDIX H.1

ATMOSPHERIC DISPERSION MODELING AT HANFORD

THIS PAGE BLANK INTENTIONALLY

APPENDIX H.1

ATMOSPHERIC DISPERSION MODELING AT HANFORD

Modeling atmospheric dispersion at Hanford is based on the joint frequency of occurrence of wind direction, wind speed, and atmospheric stability. The sources of meteorological data used to generate joint frequency tables are

- wind and temperature data from the Hanford Meteorological Station (HMS), which is located just east of the 200 West Area
- wind data from the remote meteorological stations located on the Site that are collected via a telemetry system
- surface weather observations made by the weather forecasting staff at HMS.

H.1.1 JOINT FREQUENCY DISTRIBUTIONS

To assemble joint frequency tables (see Appendix H.3 for the most recently compiled joint frequency distributions), wind directions are first distributed into 18 classes. The first 16 classes correspond to the compass points N, NNE, NE, etc. The other two classes are "variable" and "calm." Prior to computing the joint frequency values, the entries in the variable and calm classes are distributed in the lowest wind speed class in proportion to the occurrence of direction in that class. Eight wind speed classes are used as defined in Table H.1.1.

TABLE H.1.1 Wind Speed Classifications

Classification	Wind Speed (m sec^{-1}) Range	Median
1	<1.8	0.89
2	1.8 - 3.6	2.7
3	3.6 - 5.8	4.7
4	5.8 - 8.5	7.2
5	8.5 - 11.	9.8
6	11. - 14.	13.
7	14. - 17.	16.
8	>17.	19.

Frequencies of occurrence of wind speeds and directions are summarized as functions of the 7 atmospheric stability classes shown in Table H.1.2. Prior to March 1983, atmospheric stabilities were determined at HMS using the Pasquill-Gifford-Turner (Gifford 1968; Turner 1969) approach based on sky cover and/or wind speed. Since then, they have been determined using the temperature gradient method as described in the U.S. Nuclear Regulatory Commission's Regulatory Guide 1.23 (USNRC 1974).

The stability as observed at HMS is assumed to be representative for all locations on the Hanford Site. This assumption is reasonable for estimating $\overline{\chi}/Q'$ as long as climatological models are used. However in the event of an actual release, the assumption must be re-evaluated in the context of the actual meteorological conditions during and after the release.

Separate joint frequency distributions have been compiled for surface and elevated (i.e., 89-m) releases. Both distributions at HMS were determined using observed data directly. For surface releases at other locations, the local surface wind data and the HMS atmospheric stability data were used to generate the distributions. Finally, for elevated releases for other locations, the distributions were generated from

- the local wind direction
- a wind speed estimated from the local wind speed
- a correction factor determined from the vertical profile of the wind data collected on the tower at HMS along with the HMS stability data.

The wind speed correction factor is based on the assumption that the wind

TABLE H.1.2 Atmospheric Stability Classifications (from USNRC 1974)

Stability Classification	Pasquill Category
Extremely unstable	A
Moderately unstable	B
Slightly unstable	C
Neutral	D
Slightly stable	E
Moderately stable	F
Extremely stable	G

speed profile can be adequately represented by a power law. The correction further assumes that the wind speed shears at HMS are representative for the entire Hanford Site.

Atmospheric dispersion factors have been calculated for both chronic and acute releases using the joint frequency distributions. The models used for the computations are based on the Gaussian plume diffusion model (Gifford 1968). A sector-average model was used for chronic release $\overline{\chi}/Q'$ estimates. Estimates of E/Q were made for acute releases using a Gaussian plume model assuming that the receptor is located at the center of the plume. For all computations, it was assumed that the ground reflected the plume without depleting it.

H.1.2 CHRONIC RELEASES

For chronic releases, the sector-average model, described by Gifford (1968) and in USNRC's Regulatory Guide 1.111 (USNRC 1977), is shown below:

$$\overline{\chi}/Q' = \sum\sum \left[\frac{2.032\ F}{\sigma_z\ x\ u} \exp -\left(\frac{1}{2} \left(\frac{h_e}{\sigma_z} \right)^2 \right) \right]$$

where, $\overline{\chi}/Q'$ = joint frequency value (sec m^{-3})

σ_z = the vertical diffusion coefficient (m)

x = the downwind distance (m)

u = the wind speed (m sec^{-1})

h_e = the effective release height (m)

F = the frequency of occurrence of a joint wind direction, wind speed, and stability class from the joint frequency table.

The constant, 2.032, comes from the constants in the Gaussian plume equation and the relationship between sector width and downwind distance.

Diffusion coefficients are functions of atmospheric stability and distance from the source. The wind speed is an average for the wind speed class and should be the wind speed at the effective release height. This is the reason for developing separate joint frequency tables for surface and elevated releases. As a result of the double summation over atmospheric

stability and wind speed, the chronic release $\overline{\chi}/Q'$ values are functions only of wind direction and distance from the source. They have dimensions of sec m^{-3}.

The diffusion coefficients used in the $\overline{\chi}/Q'$ computations were developed by Briggs (1973) to represent diffusion over open country. They are based on diffusion data from a variety of locations and, in that respect, are more representative than the familiar Pasquill-Gifford curves. In addition, the coefficients are defined mathematically rather than graphically as are the Pasquill-Gifford curves.

H.1.3 ACUTE RELEASES

For acute releases, the items of interest are specific points on the one-hour average E/Q frequency distribution (i.e., values of E/Q that are exceeded no more than 0.5, 1, 5, 10 or 50% of the time). When used to compute E/Q values for this purpose, the sector-average model resembles the equation above, except that F does not appear and the double summation does not take place. Values of E/Q are computed and stored as functions of wind direction, wind speed, atmospheric stability and distance. These values are then paired with the corresponding frequencies in the joint frequency table. For each wind direction and distance, the frequencies are adjusted to give 100% in each direction, the paired values are arranged in order according to the magnitude of E/Q, and the required points in the frequency distribution are determined by interpolation.

A centerline Gaussian plume model has also been used to estimate E/Q for acute releases. The equation for this model is shown below:

$$E/Q = \frac{1}{\pi\ \sigma_z\ \sigma_y\ \bar{u}} \exp -\left[\frac{1}{2}\left(\frac{h_e}{\sigma_z}\right)^2\right]$$

where σ_y = the horizontal diffusion coefficient (m).

The other variables remain as previously defined. The constant, 1, has been adjusted to account for the differences between the sector-average and centerline models.

H.1.4 REFERENCES

Briggs, B. A. 1973. Diffusion Estimation for Small Emissions. ATDL Contribution File No. 79, Atmospheric Turbulence and Diffusion Laboratory, National Oceanic and Atmospheric Administration, Oak Ridge, Tennessee.

Gifford, F. A. 1968. "An Outline of Theories of Diffusion in the Lower Layers of the Atmosphere." In: Meteorology and Atomic Energy - 1969. TIC-24190, U.S. Atomic Energy Commission, Washington, D.C.

Turner, D. B. 1969. Workbook of Atmospheric Dispersion Estimates. 999-AP-26, U.S. Department of Health, Education and Welfare, Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1974. Onsite Meteorological Programs, Regulatory Guide 1.23 (formerly Safety Guide 23), Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1977. Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors. Regulatory Guide 1.111 (formerly Safety Guide 23), Washington, D.C.

THIS PAGE BLANK INTENTIONALLY

APPENDIX H.2

IMPLEMENTATION AND USE OF THE ATMOSPHERIC DISPERSION MODELS IN GENII

THIS PAGE BLANK INTENTIONALLY

APPENDIX H.2

IMPLEMENTATION AND USE OF THE ATMOSPHERIC DISPERSION MODELS IN GENII

The GENII computer code (Napier et al. 1988a-c) incorporates a straight-line Gaussian plume atmospheric dispersion model for estimating downwind concentrations of radionuclides following release to the atmosphere. The model as implemented in the code is capable of simulating a variety of release conditions, including acute or chronic emissions, variable release height, momentum or buoyant plume rise, and building wake effects. The atmospheric transport model also interacts with the external dosimetry model to produce estimates of the air submersion dose from either a finite or semi-infinite plume. The following explanation of the operation of these models is provided as a concise practical guide for implementing the options provided in the code and, in some cases, to supplement information provided in the code documentation.

H.2.1 CHRONIC RELEASE OPTIONS

Several options are available in the GENII code for evaluating atmospheric dispersion of chronic emissions from a point source. The code evaluates atmospheric transport using atmospheric dispersion factors (i.e., $\overline{\chi}/Q'$). The $\overline{\chi}/Q'$ values represent the projected average concentration of radionuclides in air at a downwind location normalized by the rate in which the radionuclides are released from the source (e.g., Bq m^{-3} divided by Bq sec^{-1}). Therefore, the units of $\overline{\chi}/Q'$ are sec m^{-3}.

The code has the flexibility to either accept pre-calculated $\overline{\chi}/Q'$ values, or to calculate them from meteorological information in the form of joint frequency distributions of wind direction, wind speed, and atmospheric stability. (Joint frequency distributions for the Hanford Site, based on 1983 through 1991 meteorological observations, are tabulated in Appendix H.3.) If the $\overline{\chi}/Q'$ values are calculated from joint frequency data, the code assumes annual average atmospheric conditions and a uniform radionuclide release rate from the source.

For population dose calculations, the population-weighted $\overline{\chi}/Q'$ values are used to represent collective exposure resulting from the dispersed atmospheric emissions in the region surrounding the source. The population-weighted $\overline{\chi}/Q'$ represents the average $\overline{\chi}/Q'$ for a given location multiplied by the number of individuals in the corresponding sector for which that level of exposure applies. Therefore, the units of population-weighted $\overline{\chi}/Q'$ are person sec m^{-3}. In practice, the population-weighted $\overline{\chi}/Q'$ is generally calculated by dividing a circular area around the source into a grid of 16 compass directions by a number of distances out to 80 km (approximately 50 miles) from the source. The population residing in each sector of the circular grid is determined, and the $\overline{\chi}/Q'$ is calculated for a location corresponding to the center of each sector. The population-weighted $\overline{\chi}/Q'$ is the sum of the products of population and $\overline{\chi}/Q'$ for each sector.

For a chronic release population dose calculation, the GENII code will calculate the population-weighted $\overline{\chi}/Q'$ values if the population data and meteorological information, in the form of either a $\overline{\chi}/Q'$ grid or a joint frequency data set, are provided. Population and meteorological data are supplied to the code via text files formatted as described in the code documentation. For the population and $\overline{\chi}/Q'$ grids, the circular area within 80 km of the source is divided into a series of up to 10 concentric rings. The population within the 80-km area is then distributed among these rings in each of the 16 compass directions to produce an array containing 160 values. If a $\overline{\chi}/Q'$ grid is supplied by the user, the distances and directions must correspond to those used for the population grid. The code will calculate the $\overline{\chi}/Q'$ grid if joint frequency data are provided. The user will be requested to supply additional information about the source, including the release height and other stack parameters needed to calculate plume rise, if applicable. If either population distributions or meteorological data are unavailable, the GENII code will also accept a precalculated population-weighted $\overline{\chi}/Q'$. If precalculated $\overline{\chi}/Q'$ values are used, the code cannot account for radioactive decay of short-lived radionuclides in transit from the source to the receptor.

Distances for the 10 concentric rings in the $\overline{\chi}/Q'$ and population grids are supplied to the code via the DEFAULT.IN file, which may be modified using a text editor. For a population calculation, the distance values in the

DEFAULT.IN file are assumed to correspond to the midpoints of each of the 10 radial rings, and the $\overline{\chi}/Q'$ values are calculated for those distances. For example, the population residing between 10 and 20 miles from the source in a northerly direction is evaluated in the code as if the entire population in that sector were located at a point 15 miles north of the source.

For an individual dose calculation, the code will also accept a precalculated $\overline{\chi}/Q'$ value. The user may also specify the location of an individual receptor in terms of distance and direction from the source, in which case the code calculates the $\overline{\chi}/Q'$ for that location. This option requires the user to supply meteorological information about the source location in the form of either joint frequency data or a set of pre-calculated $\overline{\chi}/Q'$ values for the circular grid surrounding the source. If a precalculated $\overline{\chi}/Q'$ value or grid is used to determine the receptor air concentration, decay of radionuclides in transit cannot be accounted for by the code.

If a population distribution and meteorological information are both available, the code can also determine the location where individual exposures would be the highest. The code determines which occupied segment of the circular grid has the highest corresponding $\overline{\chi}/Q'$ and places the individual at that location. However, if the grid distances in the DEFAULT.IN file correspond to sector midpoints, a nonconservative dose estimate may result because an individual could theoretically reside nearer to the source than the midpoint of the sector. When using this option to select the maximum individual location, a more conservative approach would be to reset the default distances to represent the near boundary of the sector rather than the midpoint.

H.2.2 ACUTE RELEASE OPTIONS

The acute exposure models in the GENII code were developed primarily to provide prospective estimates of potential accident consequences for facility siting and safety evaluation purposes. The code was not intended for use as an emergency response tool, and its application in that manner is not recommended. From the user's standpoint, the acute atmospheric dispersion options in GENII operate in a similar manner to those for a chronic release. However, there are some theoretical and operational differences of which the

user should be aware. For a scenario involving an acute atmospheric release, exposure is calculated in terms of a time-integrated air concentration for a finite period rather than the long-term equilibrium air concentration used for the chronic case. Although the acute atmospheric dispersion factor has the same units as the annual average $\overline{\chi}/Q'$ calculated for a chronic scenario, the method used to calculate it differs, and the factor is referred to as E/Q. The E/Q is based on the total activity of a radionuclide released per event, rather than a continuous average release rate, and atmospheric conditions are chosen to estimate a concentration of radionuclides in air that would not be exceeded at the receptor location for a specified fraction of the time.

Options within the GENII code include calculation of an acute E/Q that would not be exceeded more than 50%, 25%, 10%, 5%, or 0.5% of the time in a particular downwind direction. This option is set within the DEFAULT.IN data file, and the initial default setting is 5%. The 5% E/Q has traditionally been used for safety evaluations and environmental impact statements to estimate the consequences of low- to moderate- severity accidents. However, for accident calculations, some regulatory requirements, such as U.S. Department of Energy Order 6430.1A (USDOE 1989), may specify the use of the 0.5% E/Q in a single direction or the 5% E/Q in all directions, whichever is greater. For these estimates, the default value for E/Q should be reset to 0.5% to obtain the E/Q for a single direction. The 5% value for all directions is not calculated by the GENII code, and must be determined independently.

In an acute scenario, the release is assumed to be of sufficiently short duration that the specified meteorologic conditions remain constant throughout. In reality, such a situation would generally be limited to a period of a few hours, after which changes in wind direction and atmospheric stability would cause greater dispersion of the plume. For releases that are substantially longer than a few hours, but which cannot be considered chronic (e.g., those lasting a few days to weeks), a manual interpolation method can be used to estimate an E/Q value intermediate between the acute and chronic values calculated by the code. This can be performed graphically by creating a log-log plot of the atmospheric dispersion factor versus release time, where the acute E/Q calculated by the code corresponds to a 2-hour release time, and

the chronic $\overline{\chi}/Q'$ corresponds to a 1-year release. If the two points are connected by a straight line on the logarithmic plot, the E/Q value for an intermediate release time can be read directly from the graph. Alternatively, the E/Q value for a release of intermediate duration may be calculated using the following equation, which is a mathematical representation of the graphic method:

$$\overline{\chi}/Q'_i = \exp\{[\frac{\ln(\overline{\chi}/Q'_c) - \ln(E/Q_a)}{\ln(8766) - \ln(2)}][\ln(T_i) - \ln(2)] + \ln(E/Q_a)\}$$

where, $\overline{\chi}/Q'_i$ = dispersion factor at intermediate time i (sec m^{-3})

$\overline{\chi}/Q'_c$ = annual average dispersion factor for an one-year release (sec m^{-3})

E/Q_a = acute dispersion factor for a two-hour release (sec m^{-3})

T_i = duration of intermediate release (h).

Please note that this method is only an approximation, and may be significantly in error at times very near either end of the time spectrum (i.e., two hours or one year). A model to estimate E/Qs for various time periods using hourly wind data was under development in the Atmospheric Sciences Department of Pacific Northwest Laboratory at the time this report was issued.

The GENII code has two options for calculating dispersion factors following an acute release. The E/Q or population-weighted E/Q values may be supplied directly by the user or the code can be requested to calculate appropriate values for user-specified receptor locations using either a joint frequency data set or $\overline{\chi}/Q'$ grid. In the case of a population scenario, a population data file will also be requested. When joint frequency data are used for the dispersion calculation, the code requires additional information about release conditions, including release height and, if applicable, additional facility parameters for the plume rise and building wake models. Because atmospheric conditions are assumed to remain constant during an acute release, the population dose is only estimated for a single downwind direction, rather than for the entire circular grid surrounding the source as

in a chronic case. Also, the code cannot identify the location of the maximally exposed individual or population sector for an acute release scenario -- these must be predetermined by the user. Exposure of the receptor(s) to the plume is based on a user-provided value expressed as a fraction of the total plume passage time, assuming a uniform release rate. If the release rate is markedly nonuniform, as from a pressurized container, it would be preferable to divide the release into a number of phases and perform a separate dispersion and dose calculation for each phase of the release.

H.2.3 OPTIONAL MODELS

When the GENII code is requested to calculate dispersion factors for atmospheric releases using joint frequency data in either chronic or acute cases, the user will be requested to supply additional information about release conditions. The downwind concentration of radionuclides following an atmospheric release is a function of the height at which the release occurs, the atmospheric conditions during the release period, the interaction of the plume with nearby structures, and the distance and direction to the downwind receptor. Atmospheric conditions are determined by the code using joint frequency data. The receptor location(s) may be specified by the methods described previously for particular scenarios. The effective release height and the effect of adjacent structures may be determined using special models for plume rise and building wake effects within the code, respectively, at the user's option.

Plume rise models are used within the code to calculate an effective stack height when the airborne effluent from a facility has an upward momentum that carries it higher than the physical exit point of the stack or vent before the plume is dispersed in a horizontal direction. This effect may result from forces such as the momentum of a high velocity effluent stream or the thermal buoyancy of an effluent stream that exits the stack at a temperature substantially higher than the ambient temperature. As a conservative estimate for acute scenarios, or when the facility parameters are not known, the physical release height is often used as the effective release height. If the operating parameters of the facility exhaust system are known, this information may be used by plume rise models within the code to calculate

the effective release height for transport purposes. The effective release height is a combination of physical release height and plume rise.

Two models for plume rise are available in the GENII code to estimate the effects of effluent momentum or thermal buoyancy, either individually or in combination. Implementation of these models is described in the code documentation (Napier et al. 1988a-c). If the user selects either plume rise model, the code will request facility information such as the release height, stack dimensions, effluent flow rate, and effluent temperature. A pre-calculated effective release height may also be supplied to the code if available.

A building wake model is available in the GENII code to evaluate the increased dispersion that results from turbulence caused by a structure in close proximity to the effluent release point. The building wake model is appropriate for situations where effluents exit the facility from a stack or vent that is less than about 2.5 times the building height, or where there are other nearby structures of comparable height. The building wake model, as implemented in GENII, is an empirical correction factor that actually incorporates corrections for short-term (i.e., one-hour) plume meander in addition to the building wake correction. The building wake effect is maximized at a wind speed of about 4 m sec^{-1}, whereas the plume meander component becomes more important at very low wind speeds. If the building wake model in GENII is not implemented, an external correction for plume meander may be applied according to U.S. Nuclear Regulatory Commission recommendations (USNRC 1983). However, the external correction factor for plume meander should only be used for acute releases, and should not be used in addition to the building wake model. Information required by the code to perform calculations using the building wake model includes the building height and its vertical cross-section perpendicular to the prevailing wind direction. In practice, the minimum cross section is typically used to produce a conservative estimate where the building orientation with respect to wind direction cannot be predicted. The GENII code only implements the building wake model for acute releases where the receptor is located within 10 km of the source; it is relatively insignificant under other conditions.

H.2.4 ATMOSPHERIC DISPERSION AND AIR SUBMERSION MODEL INTERACTIONS

The atmospheric dispersion model within the GENII code estimates concentrations of radionuclides in air at downwind receptor locations for use within the exposure pathway models that ultimately calculate radiation dose. The dispersion model also interacts with the external air submersion dose model by providing an estimate of plume size in the lateral and vertical dimensions. Plume size and other characteristics of radionuclides in the cloud determine the external dose to a person submerged in it. For most purposes, the plume is sufficiently large that it can be modeled as if the receptor were at the center of a "semi-infinite" cloud. However, that condition does not hold true if the receptor is near the source, where the plume size is limited or where the center of the plume from an elevated release may be above the receptor. These two situations are implemented in the code as the "Infinite Plume" and "Finite Plume" models. If the receptor is near the source, assuming the receptor is at the center of a semi-infinite plume, the code can over- or under-estimate the air submersion dose depending on the relative size and location of the plume. In this case, use of the finite plume is recommended to account for the plume size or to account for external irradiation of the receptor by radionuclides contained in an elevated plume. However, it should be noted the code can produce over-estimates of the air submersion dose because building wake and/or plume meander are not accounted for in the finite plume model.

The finite plume option should not be used where the receptor is more than 5-10 km from the source, depending on the atmospheric conditions in a particular scenario, because this model does not account for reflection of the plume by the atmospheric mixing layer when the plume becomes very large. The infinite plume model assumes uniform mixing of radionuclides in the atmosphere between the ground and the mixing layer after the vertical dimension of the plume becomes equal to the mixing layer height. The finite plume model allows the plume to expand indefinitely as it travels downwind from the source. Use of the model will underestimate the air submersion dose at distances where the plume height is greater than the mixing layer height. If the user has a question as to which model is appropriate for a given scenario, both models should be run to determine which results in a higher air submersion dose. In

practice, this distinction is only important when air submersion is an important component of the dose from all pathways considered in the scenario. It should also be noted that joint frequency data must be available to determine meteorological conditions for the scenario under consideration if the finite plume option is to be used. The finite plume dimensions cannot be determined if a $\overline{\chi}/Q'$ value or grid is provided by the user rather than having the code perform the air transport calculations.

H.2.5 REFERENCES

Napier, B. A., D. L. Strenge, R. A. Peloquin, and J. V. Ramsdell. 1988a. GENII - The Hanford Environmental Radiation Dosimetry Software System, Volume 1: Conceptual Representation. PNL-6584 Vol. 1, Pacific Northwest Laboratory, Richland, Washington.

Napier, B. A., D. L. Strenge, R. A. Peloquin, and J. V. Ramsdell. 1988b. GENII - The Hanford Environmental Radiation Dosimetry Software System, Volume 2: Users' Manual. PNL-6584 Vol. 2, Pacific Northwest Laboratory, Richland, Washington.

Napier, B. A., D. L. Strenge, R. A. Peloquin, and J. V. Ramsdell. 1988c. GENII - The Hanford Environmental Radiation Dosimetry Software System, Volume 3: Code Maintenance Manual. PNL-6584 Vol. 3, Pacific Northwest Laboratory, Richland, Washington.

U.S. Department of Energy (USDOE). 1989. General Design Criteria. USDOE Order 6430.1A (Issued 4-6-89), Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1983. Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants. Regulatory Guide 1.145, Revision 1 (updated), Office of Nuclear Regulatory Research, Washington, D.C.

THIS PAGE BLANK INTENTIONALLY

APPENDIX H.3

HANFORD AREA METEOROLOGICAL INFORMATION BASED ON 1983 THROUGH 1991 OBSERVATIONS

THIS PAGE BLANK INTENTIONALLY

APPENDIX H.3

HANFORD AREA METEOROLOGICAL INFORMATION BASED ON 1983 THROUGH 1991 OBSERVATIONS

A description of the procedures used to develop the joint frequency distributions listed in Tables H.3.1-12 is presented in Appendix H.1. These tables are based on Hanford meteorological information averaged for the years 1983 through 1991. The values are presented as percentage of the time that the wind is blowing towards the direction listed (e.g., S, SSW, SW, ...) for the given Midpoint Wind Speed Class and Pasquill Category. The corresponding wind speed ranges and description of the Pasquill stability classifications are presented in Tables H.1.1 and H.1.2, respectively.

H.3.1 GUIDELINES FOR USING JOINT FREQUENCY DATA WITH THE GENII CODE

When using one of the atmospheric dispersion options in the GENII code with joint frequency data such as provided in this appendix, it is important to use the data set that most closely represents the conditions under which the release is postulated to occur. In all cases, use the data set that corresponds most closely to the release height and location on the Hanford Site (e.g., 100, 200 East, 200 West, 300 or 400 Areas). Within limits, the code automatically corrects wind speeds to account for the difference between the release height and the height at which the joint frequency data were actually taken. However, the code will produce an error if the data set was taken at a height very different from the release height (e.g., joint frequency data collected at 89 m to evaluate a ground-level release).

The period over which the release occurred should also be taken into consideration when selecting the appropriate joint frequency data. For prospective evaluations (e.g., those used for permitting or safety analyses purposes), a multi-year-averaged data set is recommended to provide representative atmospheric conditions that would be expected to occur in the future for both chronic and acute releases. For retrospective analyses (e.g., compliance evaluations), data sets that pertain to the period of interest are more appropriate.

The GENII code custodian[a] can provide multi-year summaries for several release heights at the major Hanford operating areas. Annual-averaged data are also available for recent years. Special data sets for other locations and time periods can also be obtained from personnel in Pacific Northwest Laboratory's Atmospheric Sciences Department.

H.3.2 HANFORD-AREA JOINT FREQUENCY TABLES BASED ON 1983 THROUGH 1991 METEOROLOGICAL INFORMATION

The joint frequency values for the Hanford Areas, based on meteorological information averaged for the years 1983 through 1991, are summarized in the following tables.

---

[a] The Executive Secretary of the Hanford Environmental Dose Overview Panel can provide the name, address, and phone number of the current GENII code custodian. The name, address, and phone number of the current Executive Secretary are provided in Appendix C.2.

TABLE H.3.1. Joint Frequency Distributions for the **100 N Area -- 10-m Tower -- 1983-1991 Data**

Midpoint Wind Speed Class ($m\ sec^{-1}$)	Pasquill Category	Percentage of Time Wind Blows from the 100 N Area Towards the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.34	0.14	0.14	0.13	0.27	0.17	0.13	0.11	0.17	0.11	0.13	0.19	0.35	0.32	0.34	0.30
	B	0.12	0.06	0.07	0.05	0.14	0.10	0.09	0.08	0.07	0.06	0.08	0.08	0.13	0.11	0.12	0.11
	C	0.15	0.07	0.08	0.10	0.13	0.11	0.10	0.07	0.11	0.07	0.07	0.10	0.11	0.11	0.11	0.10
	D	0.71	0.42	0.38	0.45	1.03	0.89	0.70	0.53	0.75	0.51	0.59	0.57	0.90	0.64	0.62	0.57
	E	0.60	0.37	0.42	0.48	0.98	0.68	0.54	0.44	0.56	0.42	0.51	0.61	0.86	0.67	0.54	0.52
	F	0.57	0.32	0.41	0.46	0.88	0.51	0.42	0.25	0.35	0.29	0.40	0.63	0.92	0.67	0.58	0.52
	G	0.25	0.17	0.18	0.22	0.36	0.18	0.15	0.11	0.15	0.13	0.22	0.35	0.63	0.41	0.32	0.28
2.7	A	0.60	0.42	0.32	0.14	0.32	0.28	0.25	0.17	0.16	0.14	0.33	0.45	0.73	0.48	0.40	0.43
	B	0.13	0.12	0.08	0.05	0.13	0.11	0.10	0.07	0.06	0.03	0.08	0.14	0.20	0.09	0.11	0.09
	C	0.11	0.09	0.09	0.06	0.12	0.10	0.10	0.07	0.05	0.03	0.08	0.11	0.18	0.09	0.08	0.09
	D	0.60	0.47	0.37	0.37	0.72	0.71	0.65	0.39	0.39	0.32	0.52	1.05	1.33	0.68	0.50	0.41
	E	0.33	0.23	0.28	0.42	0.86	0.63	0.48	0.32	0.33	0.24	0.50	1.18	1.97	0.76	0.38	0.22
	F	0.18	0.14	0.16	0.41	0.84	0.38	0.23	0.16	0.14	0.16	0.28	0.68	1.08	0.49	0.28	0.16
	G	0.05	0.05	0.08	0.19	0.32	0.13	0.09	0.05	0.05	0.06	0.13	0.29	0.59	0.18	0.09	0.04
4.7	A	0.15	0.24	0.13	0.04	0.08	0.08	0.13	0.06	0.07	0.10	0.23	0.29	0.48	0.35	0.19	0.09
	B	0.03	0.06	0.05	0.02	0.03	0.03	0.03	0.02	0.03	0.02	0.06	0.07	0.13	0.09	0.04	0.02
	C	0.03	0.06	0.03	0.01	0.03	0.02	0.04	0.03	0.02	0.03	0.06	0.05	0.11	0.07	0.04	0.02
	D	0.19	0.21	0.17	0.07	0.09	0.16	0.26	0.16	0.12	0.20	0.33	0.56	1.17	0.59	0.19	0.12
	E	0.14	0.13	0.09	0.05	0.09	0.08	0.22	0.13	0.12	0.13	0.26	0.68	1.79	0.72	0.17	0.09
	F	0.08	0.07	0.03	0.05	0.06	0.04	0.07	0.04	0.02	0.02	0.06	0.25	0.33	0.13	0.04	0.05
	G	0.02	0.01	0.00	0.01	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.06	0.06	0.02	0.01	0.01
7.2	A	0.05	0.09	0.07	0.02	0.01	0.01	0.03	0.02	0.02	0.05	0.14	0.12	0.28	0.34	0.17	0.03
	B	0.03	0.05	0.02	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.06	0.03	0.09	0.09	0.04	0.01
	C	0.01	0.02	0.02	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.05	0.03	0.06	0.07	0.03	0.01
	D	0.09	0.13	0.05	0.02	0.01	0.02	0.05	0.05	0.05	0.10	0.28	0.19	0.56	0.61	0.20	0.05
	E	0.10	0.10	0.04	0.02	0.00	0.01	0.03	0.03	0.03	0.07	0.11	0.15	0.65	0.56	0.13	0.04
	F	0.02	0.05	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.03	0.06	0.02	0.01	0.02
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
9.8	A	0.01	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.05	0.08	0.16	0.10	0.00
	B	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.03	0.05	0.03	0.00
	C	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.00
	D	0.05	0.06	0.02	0.01	0.00	0.00	0.00	0.01	0.01	0.08	0.12	0.09	0.13	0.25	0.14	0.01
	E	0.05	0.05	0.03	0.01	0.00	0.00	0.00	0.00	0.01	0.03	0.05	0.04	0.07	0.14	0.06	0.01
	F	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.	A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.05	0.04	0.00
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00
	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	D	0.01	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.04	0.04	0.02	0.04	0.06	0.02	0.01
	E	0.02	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.02	0.02	0.01
	F	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.	A	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	E	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	F	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.	A	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D	0.07	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	E	0.07	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	F	0.03	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE H.3.2. Joint Frequency Distributions for the **100 N Area -- 61-m Tower -- 1983-1991 Data**

Midpoint Wind Speed Class ($m\ sec^{-1}$)	Pasquill Category	Percentage of Time Wind Blows from the 100 N Area Towards the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.32	0.14	0.13	0.12	0.26	0.17	0.12	0.09	0.16	0.10	0.12	0.17	0.34	0.30	0.32	0.28
	B	0.10	0.05	0.07	0.05	0.13	0.10	0.09	0.08	0.07	0.05	0.08	0.08	0.12	0.11	0.11	0.09
	C	0.14	0.07	0.07	0.08	0.12	0.10	0.09	0.06	0.10	0.06	0.07	0.09	0.10	0.12	0.10	0.09
	D	0.55	0.34	0.29	0.36	0.80	0.67	0.54	0.41	0.56	0.36	0.46	0.43	0.68	0.49	0.46	0.41
	E	0.39	0.24	0.27	0.32	0.67	0.42	0.33	0.29	0.40	0.28	0.33	0.36	0.48	0.37	0.32	0.33
	F	0.37	0.23	0.26	0.38	0.64	0.34	0.29	0.17	0.25	0.23	0.30	0.42	0.60	0.43	0.39	0.36
	G	0.18	0.14	0.14	0.20	0.34	0.16	0.13	0.09	0.13	0.10	0.16	0.25	0.46	0.30	0.26	0.22
2.7	A	0.59	0.34	0.28	0.14	0.33	0.28	0.24	0.16	0.15	0.12	0.29	0.41	0.65	0.46	0.40	0.43
	B	0.12	0.11	0.06	0.05	0.13	0.10	0.09	0.05	0.05	0.03	0.05	0.11	0.19	0.08	0.12	0.10
	C	0.11	0.08	0.09	0.06	0.11	0.10	0.09	0.06	0.05	0.04	0.08	0.09	0.15	0.08	0.08	0.09
	D	0.59	0.38	0.35	0.35	0.71	0.69	0.57	0.35	0.36	0.28	0.42	0.70	0.93	0.54	0.48	0.43
	E	0.33	0.24	0.30	0.39	0.69	0.53	0.36	0.27	0.29	0.22	0.34	0.58	0.89	0.56	0.37	0.28
	F	0.27	0.16	0.20	0.29	0.61	0.32	0.20	0.15	0.17	0.16	0.21	0.44	0.69	0.43	0.32	0.22
	G	0.08	0.06	0.09	0.14	0.23	0.10	0.06	0.05	0.06	0.07	0.11	0.22	0.49	0.20	0.12	0.08
4.7	A	0.18	0.28	0.15	0.03	0.09	0.09	0.13	0.06	0.07	0.09	0.20	0.29	0.48	0.28	0.14	0.10
	B	0.04	0.06	0.06	0.02	0.04	0.03	0.04	0.03	0.03	0.02	0.06	0.08	0.11	0.06	0.03	0.03
	C	0.04	0.06	0.04	0.03	0.05	0.03	0.05	0.03	0.02	0.02	0.06	0.05	0.10	0.04	0.03	0.02
	D	0.22	0.27	0.20	0.12	0.22	0.24	0.30	0.16	0.15	0.18	0.34	0.65	0.97	0.43	0.19	0.16
	E	0.17	0.14	0.15	0.16	0.34	0.28	0.30	0.16	0.19	0.16	0.35	0.81	1.47	0.50	0.23	0.12
	F	0.11	0.06	0.08	0.16	0.30	0.19	0.14	0.09	0.07	0.07	0.17	0.40	0.61	0.27	0.14	0.10
	G	0.03	0.03	0.02	0.06	0.11	0.05	0.04	0.02	0.03	0.04	0.07	0.16	0.24	0.09	0.05	0.03
7.2	A	0.07	0.12	0.11	0.03	0.02	0.02	0.04	0.03	0.03	0.06	0.17	0.15	0.31	0.32	0.16	0.04
	B	0.02	0.04	0.03	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.05	0.05	0.11	0.07	0.03	0.02
	C	0.02	0.03	0.02	0.00	0.01	0.00	0.02	0.02	0.01	0.03	0.04	0.03	0.08	0.07	0.03	0.01
	D	0.13	0.13	0.11	0.04	0.04	0.06	0.13	0.10	0.09	0.15	0.25	0.43	0.85	0.48	0.16	0.08
	E	0.14	0.10	0.07	0.06	0.10	0.10	0.15	0.09	0.10	0.08	0.21	0.64	1.52	0.57	0.14	0.07
	F	0.07	0.06	0.04	0.06	0.13	0.04	0.06	0.03	0.03	0.02	0.07	0.26	0.37	0.13	0.04	0.05
	G	0.01	0.01	0.01	0.02	0.03	0.01	0.01	0.01	0.01	0.00	0.02	0.05	0.10	0.03	0.01	0.01
9.8	A	0.03	0.05	0.03	0.01	0.00	0.01	0.01	0.01	0.01	0.02	0.08	0.08	0.14	0.21	0.13	0.02
	B	0.03	0.03	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.04	0.02	0.04	0.08	0.03	0.00
	C	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.02	0.02	0.04	0.06	0.03	0.00
	D	0.07	0.08	0.03	0.01	0.01	0.01	0.04	0.05	0.03	0.08	0.20	0.16	0.49	0.45	0.16	0.03
	E	0.06	0.06	0.04	0.02	0.03	0.02	0.06	0.05	0.04	0.07	0.12	0.22	0.77	0.51	0.08	0.03
	F	0.03	0.04	0.01	0.02	0.03	0.02	0.02	0.01	0.01	0.01	0.02	0.08	0.13	0.05	0.02	0.01
	G	0.01	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.03	0.03	0.01	0.00	0.00
13.	A	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.04	0.07	0.13	0.07	0.00
	B	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.03	0.04	0.03	0.00
	C	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.05	0.02	0.00
	D	0.06	0.07	0.02	0.00	0.00	0.00	0.01	0.01	0.02	0.08	0.11	0.10	0.21	0.32	0.13	0.02
	E	0.07	0.07	0.06	0.03	0.00	0.00	0.01	0.02	0.01	0.03	0.06	0.08	0.27	0.32	0.11	0.02
	F	0.01	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.03	0.04	0.02	0.01	0.01
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00
16.	A	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.02	0.05	0.03	0.00
	B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
	C	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
	D	0.02	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.05	0.07	0.03	0.06	0.11	0.06	0.01
	E	0.04	0.04	0.03	0.01	0.00	0.00	0.00	0.01	0.01	0.03	0.03	0.02	0.07	0.09	0.04	0.01
	F	0.01	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.	A	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00
	B	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	D	0.05	0.07	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.01	0.03	0.03	0.01	0.01
	E	0.06	0.09	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.01	0.02	0.03	0.03	0.01
	F	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE H.3.3. Joint Frequency Distributions for the **100 N Area -- 89-m Tower -- 1983-1991 Data**

Midpoint Wind Speed Class (m sec^{-1})	Pasquill Category	Percentage of Time Wind Blows from the 100 N Area Towards the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.31	0.13	0.13	0.13	0.24	0.18	0.11	0.09	0.15	0.10	0.12	0.18	0.32	0.30	0.32	0.27
	B	0.10	0.05	0.06	0.05	0.12	0.10	0.09	0.08	0.06	0.05	0.08	0.08	0.12	0.11	0.10	0.09
	C	0.14	0.06	0.07	0.08	0.11	0.10	0.09	0.06	0.09	0.07	0.07	0.09	0.11	0.11	0.11	0.10
	D	0.53	0.32	0.27	0.33	0.79	0.65	0.54	0.40	0.54	0.35	0.45	0.43	0.65	0.47	0.45	0.42
	E	0.35	0.23	0.25	0.30	0.64	0.37	0.32	0.30	0.38	0.27	0.32	0.36	0.47	0.34	0.31	0.31
	F	0.34	0.22	0.25	0.36	0.58	0.31	0.28	0.17	0.25	0.23	0.29	0.43	0.61	0.46	0.39	0.33
	G	0.17	0.14	0.14	0.19	0.29	0.16	0.12	0.09	0.13	0.10	0.17	0.26	0.52	0.33	0.26	0.23
2.7	A	0.58	0.33	0.26	0.13	0.33	0.27	0.24	0.15	0.15	0.12	0.28	0.38	0.65	0.45	0.39	0.43
	B	0.12	0.11	0.06	0.05	0.12	0.09	0.08	0.05	0.05	0.03	0.05	0.10	0.18	0.08	0.12	0.10
	C	0.11	0.08	0.08	0.06	0.11	0.10	0.09	0.06	0.05	0.03	0.07	0.09	0.15	0.08	0.08	0.09
	D	0.57	0.38	0.33	0.37	0.70	0.67	0.53	0.32	0.36	0.27	0.40	0.63	0.87	0.52	0.46	0.40
	E	0.34	0.24	0.30	0.33	0.65	0.50	0.34	0.23	0.29	0.22	0.32	0.52	0.73	0.48	0.35	0.28
	F	0.28	0.16	0.19	0.27	0.58	0.31	0.19	0.14	0.14	0.14	0.21	0.41	0.68	0.39	0.29	0.23
	G	0.09	0.06	0.09	0.14	0.25	0.10	0.08	0.05	0.06	0.07	0.12	0.24	0.45	0.18	0.11	0.07
4.7	A	0.20	0.29	0.17	0.04	0.09	0.09	0.12	0.07	0.06	0.10	0.20	0.28	0.47	0.28	0.14	0.11
	B	0.04	0.05	0.06	0.02	0.05	0.04	0.04	0.03	0.03	0.02	0.06	0.08	0.11	0.06	0.03	0.02
	C	0.04	0.06	0.05	0.03	0.05	0.03	0.05	0.03	0.02	0.02	0.05	0.05	0.10	0.04	0.03	0.02
	D	0.25	0.27	0.22	0.12	0.22	0.27	0.30	0.18	0.15	0.16	0.31	0.59	0.87	0.40	0.20	0.17
	E	0.20	0.14	0.13	0.20	0.35	0.30	0.30	0.17	0.19	0.15	0.31	0.68	1.24	0.47	0.20	0.11
	F	0.11	0.06	0.10	0.17	0.33	0.19	0.13	0.08	0.08	0.07	0.15	0.37	0.56	0.24	0.16	0.11
	G	0.03	0.03	0.02	0.07	0.11	0.05	0.03	0.02	0.02	0.03	0.05	0.14	0.22	0.07	0.05	0.03
7.2	A	0.06	0.12	0.11	0.03	0.03	0.02	0.06	0.03	0.03	0.05	0.17	0.15	0.31	0.28	0.14	0.04
	B	0.02	0.04	0.03	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.05	0.05	0.10	0.08	0.03	0.02
	C	0.02	0.03	0.02	0.00	0.01	0.01	0.02	0.02	0.01	0.02	0.04	0.03	0.08	0.06	0.03	0.01
	D	0.12	0.13	0.11	0.04	0.05	0.07	0.16	0.11	0.10	0.15	0.26	0.47	0.82	0.44	0.15	0.09
	E	0.11	0.10	0.08	0.08	0.14	0.13	0.16	0.11	0.11	0.10	0.22	0.66	1.42	0.50	0.15	0.08
	F	0.07	0.05	0.04	0.08	0.14	0.07	0.08	0.04	0.03	0.03	0.06	0.23	0.34	0.14	0.05	0.05
	G	0.02	0.01	0.01	0.02	0.04	0.02	0.01	0.01	0.01	0.01	0.02	0.05	0.09	0.03	0.01	0.01
9.8	A	0.03	0.06	0.03	0.01	0.00	0.01	0.02	0.01	0.01	0.03	0.09	0.08	0.15	0.22	0.13	0.02
	B	0.03	0.03	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.03	0.02	0.05	0.07	0.03	0.00
	C	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.02	0.04	0.06	0.03	0.00
	D	0.07	0.08	0.03	0.01	0.02	0.02	0.04	0.05	0.04	0.07	0.19	0.20	0.60	0.43	0.15	0.03
	E	0.07	0.06	0.04	0.02	0.03	0.03	0.07	0.04	0.05	0.06	0.14	0.32	0.97	0.47	0.09	0.04
	F	0.03	0.04	0.01	0.02	0.06	0.02	0.01	0.01	0.01	0.01	0.03	0.12	0.16	0.07	0.02	0.01
	G	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.01	0.00	0.00
13.	A	0.01	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.05	0.06	0.08	0.15	0.09	0.00
	B	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.03	0.04	0.02	0.00
	C	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.01	0.01	0.05	0.02	0.00
	D	0.06	0.07	0.03	0.00	0.00	0.01	0.01	0.02	0.02	0.08	0.14	0.12	0.27	0.38	0.14	0.02
	E	0.06	0.06	0.03	0.02	0.03	0.01	0.03	0.03	0.02	0.03	0.08	0.13	0.45	0.40	0.09	0.03
	F	0.01	0.04	0.01	0.02	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.05	0.07	0.03	0.01	0.01
	G	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
16.	A	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.03	0.05	0.03	0.00
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.00
	C	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.02	0.01	0.00
	D	0.03	0.05	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.06	0.08	0.04	0.08	0.17	0.07	0.01
	E	0.05	0.05	0.07	0.01	0.00	0.00	0.00	0.01	0.01	0.03	0.04	0.05	0.17	0.19	0.06	0.01
	F	0.02	0.03	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.01	0.01
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.	A	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00
	B	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
	D	0.05	0.08	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.05	0.04	0.02	0.06	0.07	0.03	0.01
	E	0.08	0.10	0.03	0.01	0.00	0.00	0.00	0.00	0.01	0.03	0.03	0.02	0.05	0.07	0.06	0.02
	F	0.02	0.05	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.01	0.01
	G	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE H.3.4. Joint Frequency Distributions for the **200 Areas -- 10-m Tower -- 1983-1991 Data**

Midpoint Wind Speed Class ($m\ sec^{-1}$)	Pasquill Category	Percentage of Time Wind Blows from the 200 Areas Towards the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.36	0.20	0.23	0.26	0.40	0.24	0.17	0.10	0.10	0.06	0.06	0.06	0.10	0.10	0.14	0.22
	B	0.15	0.13	0.10	0.11	0.16	0.09	0.07	0.03	0.05	0.02	0.01	0.03	0.04	0.05	0.07	0.10
	C	0.14	0.10	0.09	0.12	0.14	0.10	0.06	0.04	0.04	0.02	0.02	0.02	0.04	0.04	0.10	0.10
	D	0.87	0.58	0.59	0.59	0.77	0.50	0.43	0.32	0.27	0.19	0.21	0.17	0.40	0.44	0.54	0.55
	E	0.39	0.26	0.28	0.25	0.46	0.34	0.31	0.30	0.34	0.21	0.25	0.29	0.49	0.44	0.45	0.39
	F	0.23	0.13	0.12	0.14	0.31	0.23	0.28	0.26	0.35	0.23	0.22	0.27	0.48	0.36	0.32	0.23
	G	0.10	0.04	0.08	0.08	0.13	0.13	0.13	0.14	0.17	0.09	0.10	0.09	0.22	0.14	0.14	0.09
2.7	A	0.69	0.44	0.29	0.32	0.60	0.51	0.45	0.29	0.24	0.12	0.17	0.19	0.25	0.30	0.42	0.48
	B	0.21	0.15	0.06	0.08	0.16	0.13	0.13	0.09	0.08	0.04	0.03	0.05	0.07	0.09	0.16	0.16
	C	0.19	0.12	0.06	0.09	0.13	0.13	0.19	0.10	0.06	0.02	0.03	0.05	0.08	0.10	0.19	0.15
	D	0.84	0.48	0.40	0.33	0.66	0.57	0.75	0.53	0.35	0.18	0.24	0.28	0.69	1.09	1.05	0.77
	E	0.32	0.17	0.11	0.13	0.31	0.34	0.47	0.52	0.46	0.21	0.29	0.48	1.58	1.68	1.11	0.39
	F	0.13	0.05	0.05	0.05	0.16	0.21	0.39	0.44	0.45	0.21	0.27	0.46	1.60	1.69	0.82	0.25
	G	0.04	0.02	0.02	0.03	0.09	0.10	0.20	0.23	0.20	0.08	0.10	0.20	0.82	0.69	0.30	0.08
4.7	A	0.26	0.24	0.10	0.03	0.08	0.10	0.10	0.13	0.12	0.07	0.14	0.34	0.35	0.35	0.40	0.17
	B	0.09	0.06	0.03	0.01	0.03	0.03	0.04	0.05	0.03	0.02	0.05	0.07	0.10	0.14	0.12	0.06
	C	0.08	0.05	0.03	0.01	0.02	0.02	0.04	0.04	0.05	0.02	0.03	0.06	0.09	0.13	0.12	0.03
	D	0.32	0.20	0.09	0.04	0.12	0.11	0.25	0.27	0.24	0.13	0.23	0.39	0.83	1.46	0.84	0.21
	E	0.19	0.09	0.04	0.01	0.06	0.06	0.15	0.25	0.22	0.12	0.18	0.39	1.98	2.50	0.75	0.13
	F	0.04	0.06	0.01	0.01	0.01	0.02	0.05	0.17	0.14	0.03	0.07	0.20	1.19	1.60	0.32	0.06
	G	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.09	0.07	0.01	0.02	0.09	0.56	0.84	0.13	0.01
7.2	A	0.07	0.07	0.05	0.01	0.00	0.00	0.01	0.03	0.04	0.04	0.11	0.25	0.25	0.25	0.33	0.05
	B	0.02	0.03	0.01	0.01	0.00	0.00	0.00	0.01	0.02	0.01	0.04	0.08	0.06	0.07	0.09	0.01
	C	0.02	0.03	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.02	0.07	0.06	0.07	0.06	0.01
	D	0.10	0.10	0.03	0.01	0.00	0.01	0.03	0.07	0.10	0.11	0.25	0.38	0.58	1.14	0.50	0.05
	E	0.07	0.12	0.01	0.00	0.00	0.00	0.01	0.05	0.07	0.08	0.17	0.30	0.65	1.75	0.41	0.02
	F	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.01	0.02	0.07	0.08	0.03	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
9.8	A	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.05	0.16	0.10	0.11	0.24	0.00
	B	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.02	0.03	0.06	0.00
	C	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.05	0.02	0.03	0.05	0.00
	D	0.02	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.16	0.24	0.13	0.50	0.29	0.01
	E	0.01	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.11	0.15	0.06	0.38	0.11	0.00
	F	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.	A	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.02	0.02	0.03	0.00
	B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.01	0.00
	C	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.01	0.01	0.00
	D	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.09	0.09	0.03	0.07	0.08	0.00
	E	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.02	0.01	0.05	0.03	0.00
	F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.	A	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	D	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.02	0.00	0.00	0.00
	E	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	F	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.	A	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D	0.04	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	E	0.07	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	F	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE H.3.5. Joint Frequency Distributions for the **200 Areas -- 61-m Tower -- 1983-1991 Data**

Midpoint Wind Speed Class (m sec^{-1})	Pasquill Category	Percentage of Time Wind Blows from the 200 Areas Towards the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.35	0.18	0.20	0.24	0.38	0.23	0.17	0.09	0.10	0.06	0.05	0.06	0.10	0.10	0.12	0.18
	B	0.12	0.10	0.09	0.10	0.13	0.08	0.06	0.03	0.05	0.02	0.01	0.02	0.04	0.05	0.06	0.08
	C	0.11	0.08	0.07	0.10	0.13	0.09	0.07	0.04	0.03	0.02	0.02	0.03	0.04	0.03	0.08	0.08
	D	0.62	0.42	0.39	0.45	0.60	0.41	0.36	0.27	0.21	0.16	0.17	0.12	0.26	0.32	0.42	0.39
	E	0.23	0.16	0.17	0.15	0.31	0.26	0.23	0.27	0.27	0.16	0.16	0.19	0.31	0.28	0.24	0.22
	F	0.13	0.08	0.08	0.09	0.19	0.20	0.28	0.31	0.33	0.16	0.16	0.21	0.40	0.29	0.23	0.15
	G	0.07	0.03	0.05	0.05	0.12	0.11	0.16	0.21	0.20	0.09	0.09	0.10	0.25	0.14	0.12	0.07
2.7	A	0.60	0.40	0.29	0.33	0.59	0.52	0.42	0.24	0.20	0.11	0.14	0.14	0.20	0.24	0.35	0.43
	B	0.18	0.13	0.06	0.09	0.16	0.12	0.11	0.07	0.07	0.03	0.02	0.04	0.06	0.07	0.14	0.13
	C	0.18	0.11	0.06	0.10	0.13	0.13	0.15	0.07	0.05	0.02	0.02	0.04	0.05	0.08	0.16	0.15
	D	0.81	0.42	0.39	0.32	0.63	0.50	0.62	0.37	0.29	0.13	0.16	0.22	0.42	0.59	0.71	0.68
	E	0.26	0.13	0.14	0.13	0.27	0.26	0.25	0.30	0.32	0.14	0.21	0.29	0.58	0.60	0.57	0.28
	F	0.15	0.06	0.05	0.04	0.16	0.12	0.20	0.20	0.28	0.16	0.19	0.26	0.64	0.57	0.37	0.17
	G	0.04	0.02	0.03	0.03	0.07	0.07	0.10	0.11	0.11	0.06	0.07	0.12	0.46	0.27	0.14	0.06
4.7	A	0.35	0.27	0.11	0.05	0.12	0.10	0.14	0.15	0.14	0.07	0.15	0.29	0.30	0.31	0.34	0.22
	B	0.11	0.08	0.03	0.01	0.04	0.05	0.06	0.06	0.03	0.02	0.05	0.06	0.08	0.10	0.11	0.09
	C	0.09	0.06	0.04	0.02	0.03	0.02	0.06	0.05	0.05	0.02	0.02	0.03	0.07	0.08	0.12	0.05
	D	0.38	0.26	0.14	0.07	0.17	0.16	0.27	0.24	0.20	0.11	0.19	0.25	0.61	0.90	0.79	0.34
	E	0.20	0.11	0.05	0.04	0.12	0.13	0.23	0.23	0.23	0.11	0.15	0.31	1.05	0.95	0.65	0.25
	F	0.08	0.03	0.02	0.03	0.05	0.09	0.11	0.17	0.19	0.10	0.13	0.27	0.89	0.92	0.44	0.13
	G	0.01	0.01	0.01	0.01	0.01	0.02	0.05	0.07	0.06	0.02	0.05	0.10	0.49	0.38	0.15	0.04
7.2	A	0.11	0.11	0.05	0.02	0.01	0.02	0.02	0.06	0.06	0.05	0.10	0.25	0.25	0.26	0.32	0.07
	B	0.05	0.04	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.03	0.05	0.07	0.10	0.08	0.03
	C	0.03	0.03	0.02	0.00	0.01	0.00	0.01	0.02	0.02	0.01	0.02	0.07	0.08	0.11	0.06	0.01
	D	0.19	0.13	0.06	0.01	0.03	0.02	0.10	0.20	0.15	0.09	0.20	0.32	0.59	1.11	0.54	0.11
	E	0.13	0.08	0.03	0.02	0.04	0.04	0.11	0.17	0.13	0.09	0.15	0.31	1.52	1.67	0.62	0.12
	F	0.04	0.03	0.01	0.01	0.03	0.02	0.07	0.10	0.09	0.03	0.06	0.15	0.92	1.03	0.32	0.07
	G	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.04	0.01	0.01	0.05	0.28	0.51	0.13	0.01
9.8	A	0.03	0.05	0.04	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.07	0.14	0.15	0.15	0.23	0.02
	B	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.06	0.05	0.04	0.06	0.00
	C	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.01	0.04	0.04	0.04	0.05	0.00
	D	0.06	0.06	0.01	0.01	0.00	0.01	0.03	0.06	0.07	0.08	0.16	0.29	0.47	0.81	0.35	0.04
	E	0.09	0.09	0.01	0.00	0.01	0.00	0.06	0.08	0.08	0.07	0.13	0.24	0.99	1.92	0.41	0.03
	F	0.03	0.03	0.00	0.00	0.01	0.00	0.02	0.05	0.04	0.01	0.02	0.06	0.45	0.72	0.13	0.01
	G	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.02	0.13	0.29	0.04	0.00
13.	A	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.14	0.08	0.09	0.19	0.00
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.04	0.02	0.03	0.05	0.00
	C	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.04	0.01	0.02	0.04	0.00
	D	0.02	0.04	0.01	0.01	0.00	0.00	0.00	0.02	0.04	0.07	0.15	0.23	0.25	0.77	0.37	0.02
	E	0.05	0.08	0.02	0.00	0.00	0.00	0.02	0.03	0.03	0.04	0.11	0.19	0.36	1.26	0.30	0.01
	F	0.02	0.03	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.01	0.02	0.12	0.29	0.03	0.01
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.05	0.13	0.01	0.00
16.	A	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.02	0.02	0.05	0.00
	B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.02	0.00
	C	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.01	0.01	0.02	0.00
	D	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.13	0.13	0.04	0.29	0.14	0.00
	E	0.01	0.03	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.07	0.10	0.06	0.30	0.10	0.00
	F	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.03	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00
19.	A	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.01	0.01	0.00
	B	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
	C	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
	D	0.03	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.08	0.07	0.04	0.03	0.02	0.00
	E	0.02	0.06	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.04	0.02	0.01	0.03	0.01	0.00
	F	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	G	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE H.3.6. Joint Frequency Distributions for the **200 Areas -- 89-m Tower -- 1983-1991 Data**

Midpoint Wind Speed Class ($m\ sec^{-1}$)	Pasquill Category	Percentage of Time Wind Blows from the 200 Areas Towards the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.34	0.16	0.19	0.24	0.38	0.23	0.17	0.10	0.10	0.05	0.05	0.06	0.10	0.10	0.12	0.17
	B	0.12	0.09	0.09	0.10	0.13	0.09	0.06	0.02	0.05	0.02	0.01	0.02	0.04	0.05	0.06	0.08
	C	0.11	0.09	0.08	0.10	0.13	0.09	0.07	0.04	0.03	0.02	0.02	0.02	0.05	0.03	0.08	0.07
	D	0.62	0.40	0.39	0.45	0.61	0.41	0.36	0.28	0.21	0.16	0.16	0.11	0.25	0.33	0.39	0.39
	E	0.22	0.16	0.16	0.15	0.30	0.26	0.25	0.28	0.27	0.15	0.16	0.17	0.30	0.30	0.27	0.22
	F	0.13	0.08	0.08	0.09	0.19	0.19	0.25	0.29	0.32	0.15	0.16	0.19	0.41	0.34	0.27	0.15
	G	0.07	0.02	0.05	0.05	0.11	0.12	0.16	0.22	0.18	0.08	0.09	0.10	0.31	0.17	0.13	0.07
2.7	A	0.57	0.39	0.29	0.32	0.57	0.49	0.40	0.23	0.20	0.11	0.13	0.13	0.17	0.23	0.33	0.43
	B	0.18	0.14	0.06	0.09	0.16	0.10	0.11	0.07	0.07	0.03	0.02	0.04	0.05	0.07	0.14	0.13
	C	0.17	0.11	0.05	0.09	0.12	0.12	0.14	0.07	0.05	0.01	0.02	0.03	0.04	0.08	0.15	0.14
	D	0.77	0.42	0.38	0.32	0.59	0.47	0.56	0.35	0.27	0.12	0.15	0.22	0.36	0.56	0.69	0.66
	E	0.25	0.13	0.15	0.12	0.25	0.22	0.24	0.29	0.29	0.12	0.17	0.25	0.48	0.55	0.52	0.26
	F	0.11	0.06	0.05	0.05	0.14	0.12	0.21	0.19	0.29	0.16	0.16	0.26	0.59	0.59	0.35	0.17
	G	0.05	0.02	0.03	0.03	0.07	0.06	0.09	0.10	0.13	0.06	0.07	0.12	0.43	0.31	0.14	0.07
4.7	A	0.38	0.27	0.12	0.05	0.13	0.13	0.15	0.15	0.14	0.06	0.14	0.28	0.27	0.29	0.34	0.24
	B	0.11	0.08	0.03	0.01	0.05	0.06	0.06	0.06	0.03	0.02	0.04	0.06	0.09	0.10	0.12	0.07
	C	0.10	0.06	0.04	0.02	0.04	0.03	0.06	0.04	0.04	0.02	0.02	0.04	0.07	0.08	0.12	0.06
	D	0.40	0.26	0.16	0.08	0.19	0.17	0.30	0.25	0.19	0.10	0.19	0.22	0.55	0.81	0.75	0.34
	E	0.19	0.10	0.05	0.05	0.12	0.15	0.19	0.21	0.23	0.12	0.16	0.28	0.86	0.82	0.57	0.24
	F	0.09	0.04	0.03	0.02	0.06	0.08	0.11	0.18	0.18	0.10	0.12	0.25	0.80	0.91	0.41	0.12
	G	0.02	0.01	0.01	0.01	0.02	0.02	0.05	0.07	0.07	0.02	0.04	0.08	0.44	0.52	0.17	0.03
7.2	A	0.11	0.12	0.06	0.02	0.01	0.02	0.03	0.08	0.06	0.06	0.09	0.26	0.25	0.25	0.30	0.08
	B	0.04	0.04	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.03	0.05	0.06	0.09	0.07	0.04
	C	0.03	0.02	0.02	0.01	0.01	0.00	0.01	0.02	0.03	0.01	0.02	0.06	0.08	0.11	0.07	0.01
	D	0.20	0.12	0.05	0.01	0.05	0.04	0.11	0.17	0.16	0.11	0.16	0.29	0.58	0.92	0.54	0.11
	E	0.14	0.07	0.03	0.02	0.04	0.06	0.12	0.16	0.15	0.09	0.15	0.30	1.32	1.32	0.57	0.12
	F	0.04	0.02	0.01	0.01	0.02	0.02	0.06	0.11	0.10	0.04	0.09	0.17	0.85	0.90	0.31	0.07
	G	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.04	0.05	0.01	0.01	0.06	0.32	0.46	0.09	0.01
9.8	A	0.04	0.04	0.03	0.01	0.00	0.00	0.01	0.01	0.02	0.02	0.07	0.14	0.16	0.15	0.23	0.02
	B	0.02	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.06	0.04	0.05	0.07	0.00
	C	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.04	0.04	0.04	0.05	0.00
	D	0.08	0.07	0.02	0.01	0.01	0.01	0.04	0.09	0.08	0.07	0.18	0.27	0.44	0.79	0.32	0.04
	E	0.07	0.08	0.01	0.01	0.01	0.01	0.06	0.08	0.08	0.08	0.12	0.23	1.08	1.49	0.40	0.04
	F	0.02	0.02	0.00	0.01	0.01	0.01	0.02	0.04	0.04	0.01	0.02	0.07	0.49	0.62	0.13	0.02
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.01	0.02	0.11	0.19	0.03	0.00
13.	A	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.13	0.09	0.09	0.19	0.00
	B	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.02	0.03	0.05	0.00
	C	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.02	0.03	0.04	0.00
	D	0.03	0.04	0.01	0.01	0.01	0.00	0.02	0.02	0.04	0.08	0.13	0.26	0.33	0.78	0.38	0.02
	E	0.07	0.10	0.02	0.00	0.01	0.00	0.04	0.04	0.05	0.04	0.10	0.21	0.64	1.63	0.34	0.02
	F	0.02	0.03	0.00	0.00	0.01	0.01	0.02	0.03	0.02	0.00	0.01	0.04	0.23	0.38	0.06	0.01
	G	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.04	0.09	0.01	0.00
16.	A	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.07	0.04	0.03	0.07	0.00
	B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.02	0.00
	C	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.01	0.02	0.00
	D	0.01	0.03	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.04	0.13	0.14	0.09	0.49	0.21	0.01
	E	0.03	0.06	0.01	0.00	0.00	0.00	0.01	0.02	0.01	0.03	0.10	0.14	0.17	0.74	0.18	0.00
	F	0.02	0.03	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.06	0.10	0.01	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00
19.	A	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.01	0.01	0.02	0.00
	B	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.00
	C	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.01	0.01	0.00
	D	0.02	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.12	0.11	0.08	0.14	0.07	0.00
	E	0.02	0.05	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.03	0.07	0.06	0.04	0.17	0.05	0.00
	F	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00
	G	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE H.3.7. Joint Frequency Distributions for the 300 Area -- 10-m Tower -- 1983-1991 Data

Midpoint Wind Speed Class (m sec^{-1})	Pasquill Category	Percentage of Time Wind Blows from the 300 Area Towards the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.10	0.05	0.07	0.09	0.14	0.08	0.08	0.11	0.09	0.05	0.04	0.04	0.03	0.03	0.05	0.07
	B	0.08	0.04	0.03	0.03	0.07	0.04	0.04	0.05	0.05	0.04	0.03	0.03	0.04	0.03	0.02	0.06
	C	0.07	0.03	0.03	0.05	0.08	0.06	0.06	0.06	0.07	0.03	0.02	0.03	0.04	0.03	0.04	0.05
	D	0.41	0.19	0.14	0.15	0.28	0.33	0.32	0.38	0.49	0.33	0.38	0.29	0.38	0.25	0.33	0.43
	E	0.36	0.13	0.11	0.11	0.24	0.32	0.40	0.47	0.65	0.40	0.42	0.37	0.52	0.40	0.43	0.42
	F	0.30	0.14	0.09	0.07	0.20	0.24	0.37	0.41	0.59	0.32	0.33	0.27	0.38	0.34	0.35	0.37
	G	0.19	0.07	0.04	0.03	0.10	0.10	0.16	0.19	0.27	0.13	0.16	0.13	0.20	0.17	0.20	0.19
2.7	A	0.28	0.29	0.34	0.33	0.75	0.45	0.42	0.28	0.23	0.21	0.25	0.19	0.11	0.04	0.06	0.16
	B	0.16	0.13	0.11	0.11	0.18	0.15	0.19	0.12	0.11	0.09	0.07	0.06	0.04	0.03	0.03	0.08
	C	0.15	0.14	0.08	0.09	0.17	0.18	0.21	0.12	0.12	0.09	0.09	0.05	0.03	0.03	0.06	0.10
	D	1.26	0.49	0.32	0.32	0.85	1.04	1.23	0.76	0.89	0.65	0.52	0.38	0.34	0.26	0.50	0.98
	E	1.25	0.24	0.07	0.08	0.36	1.04	1.46	0.95	1.31	0.60	0.53	0.41	0.46	0.40	0.56	1.00
	F	0.79	0.12	0.02	0.01	0.16	0.89	1.50	0.87	0.85	0.39	0.23	0.12	0.18	0.18	0.33	0.66
	G	0.39	0.05	0.01	0.00	0.05	0.35	0.70	0.39	0.32	0.12	0.06	0.03	0.06	0.07	0.16	0.31
4.7	A	0.33	0.46	0.28	0.09	0.15	0.18	0.23	0.13	0.27	0.46	0.54	0.33	0.13	0.06	0.08	0.10
	B	0.12	0.14	0.06	0.03	0.04	0.06	0.07	0.03	0.11	0.17	0.17	0.11	0.06	0.02	0.02	0.07
	C	0.17	0.12	0.07	0.02	0.03	0.06	0.07	0.04	0.10	0.12	0.16	0.10	0.04	0.00	0.05	0.08
	D	0.99	0.45	0.29	0.09	0.17	0.22	0.40	0.25	0.57	0.92	0.89	0.53	0.27	0.14	0.42	0.79
	E	1.23	0.24	0.06	0.04	0.08	0.28	0.29	0.19	0.61	0.78	0.81	0.58	0.30	0.16	0.39	0.63
	F	0.99	0.13	0.02	0.02	0.06	0.26	0.18	0.08	0.31	0.34	0.31	0.13	0.04	0.02	0.06	0.31
	G	0.55	0.05	0.00	0.00	0.02	0.14	0.12	0.03	0.11	0.11	0.09	0.04	0.01	0.00	0.01	0.14
7.2	A	0.17	0.12	0.03	0.00	0.00	0.00	0.02	0.01	0.08	0.24	0.44	0.37	0.12	0.05	0.08	0.05
	B	0.04	0.04	0.01	0.00	0.00	0.00	0.01	0.00	0.04	0.09	0.11	0.11	0.05	0.01	0 03	0.03
	C	0.04	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.10	0.15	0.10	0.04	0.01	0.03	0.03
	D	0.24	0.13	0.03	0.02	0.01	0.02	0.04	0.02	0.21	0.55	0.72	0.45	0.20	0.06	0.34	0.34
	E	0.20	0.07	0.04	0.01	0.01	0.00	0.02	0.01	0.12	0.37	0.53	0.27	0.14	0.05	0.24	0.24
	F	0.07	0.04	0.01	0.02	0.00	0.00	0.00	0.00	0.03	0.07	0.13	0.06	0.01	0.00	0.01	0.05
	G	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.05	0.01	0.00	0.00	0.00	0.01
9.8	A	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.09	0.14	0.11	0.08	0.01	0.03	0.02
	B	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.04	0.05	0.03	0.00	0.01	0.02
	C	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.05	0.05	0.01	0.00	0.01	0.00
	D	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.18	0.29	0.16	0.08	0.01	0.14	0.08
	E	0.04	0.08	0.02	0.01	0.00	0.00	0.00	0.00	0.02	0.11	0.26	0.05	0.03	0.00	0.08	0.06
	F	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00
13.	A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.03	0.04	0.00	0.00	0.00
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.00	0.00	0.00
	C	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00
	D	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.18	0.06	0.03	0.00	0.04	0.02
	E	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.14	0.01	0.01	0.00	0.01	0.00
	F	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.	A	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	C	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
	D	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.01	0.01	0.00	0.00	0.00
	E	0.03	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.00
	F	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.	A	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B	0.02	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C	0.02	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D	0.05	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
	E	0.12	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	F	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE H.3.8. Joint Frequency Distributions for the **300 Area -- 61-m Tower -- 1983-1991 Data**

Midpoint Wind Speed Class (m sec^{-1})	Pasquill Category	Percentage of Time Wind Blows from the 300 Area Towards the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.09	0.05	0.07	0.07	0.15	0.08	0.10	0.12	0.09	0.05	0.04	0.05	0.03	0.02	0.05	0.06
	B	0.07	0.03	0.03	0.03	0.07	0.03	0.06	0.05	0.05	0.03	0.03	0.03	0.04	0.03	0.03	0.06
	C	0.07	0.02	0.02	0.04	0.06	0.06	0.07	0.05	0.06	0.03	0.02	0.02	0.04	0.03	0.04	0.05
	D	0.34	0.16	0.11	0.13	0.26	0.31	0.34	0.34	0.41	0.27	0.29	0.22	0.27	0.17	0.25	0.34
	E	0.25	0.08	0.08	0.06	0.18	0.25	0.36	0.28	0.42	0.25	0.26	0.24	0.32	0.23	0.24	0.28
	F	0.23	0.10	0.05	0.05	0.14	0.30	0.41	0.35	0.43	0.24	0.22	0.17	0.25	0.21	0.25	0.26
	G	0.15	0.06	0.03	0.02	0.08	0.17	0.27	0.22	0.29	0.13	0.14	0.10	0.18	0.11	0.14	0.16
2.7	A	0.20	0.20	0.26	0.28	0.66	0.38	0.35	0.21	0.19	0.17	0.20	0.15	0.08	0.04	0.05	0.13
	B	0.12	0.10	0.08	0.10	0.16	0.13	0.14	0.10	0.09	0.09	0.07	0.06	0.04	0.01	0.03	0.06
	C	0.12	0.10	0.06	0.08	0.15	0.13	0.17	0.09	0.09	0.07	0.08	0.04	0.03	0.02	0.04	0.08
	D	0.83	0.35	0.24	0.23	0.67	0.70	0.85	0.56	0.66	0.49	0.37	0.26	0.24	0.19	0.32	0.61
	E	0.52	0.12	0.07	0.09	0.28	0.56	0.68	0.64	0.80	0.41	0.37	0.25	0.37	0.31	0.40	0.49
	F	0.37	0.08	0.04	0.02	0.12	0.40	0.68	0.55	0.55	0.28	0.21	0.14	0.20	0.18	0.22	0.35
	G	0.20	0.03	0.01	0.01	0.05	0.18	0.29	0.23	0.22	0.10	0.06	0.05	0.07	0.08	0.15	0.19
4.7	A	0.29	0.41	0.31	0.15	0.25	0.26	0.26	0.16	0.27	0.35	0.44	0.23	0.12	0.04	0.04	0.09
	B	0.13	0.13	0.07	0.04	0.07	0.07	0.09	0.05	0.09	0.14	0.11	0.08	0.05	0.02	0.01	0.05
	C	0.15	0.11	0.07	0.04	0.06	0.09	0.08	0.04	0.10	0.10	0.13	0.07	0.03	0.01	0.03	0.08
	D	0.87	0.43	0.26	0.18	0.31	0.40	0.55	0.34	0.55	0.66	0.63	0.38	0.26	0.15	0.36	0.66
	E	0.85	0.21	0.06	0.05	0.17	0.54	0.75	0.46	0.82	0.45	0.47	0.35	0.31	0.24	0.31	0.60
	F	0.54	0.07	0.02	0.02	0.09	0.40	0.61	0.32	0.48	0.23	0.15	0.11	0.11	0.10	0.16	0.38
	G	0.28	0.03	0.00	0.00	0.02	0.16	0.29	0.11	0.16	0.08	0.06	0.03	0.03	0.03	0.08	0.16
7.2	A	0.25	0.25	0.10	0.01	0.02	0.01	0.06	0.03	0.10	0.29	0.46	0.38	0.12	0.06	0.08	0.07
	B	0.07	0.07	0.03	0.01	0.01	0.01	0.02	0.01	0.05	0.09	0.12	0.10	0.05	0.02	0.02	0.04
	C	0.10	0.07	0.02	0.01	0.01	0.01	0.02	0.02	0.03	0.10	0.13	0.09	0.03	0.01	0.04	0.04
	D	0.64	0.26	0.15	0.02	0.03	0.09	0.15	0.12	0.34	0.61	0.70	0.45	0.22	0.11	0.29	0.53
	E	0.88	0.16	0.04	0.01	0.05	0.19	0.25	0.19	0.44	0.51	0.53	0.42	0.23	0.15	0.31	0.53
	F	0.57	0.07	0.01	0.02	0.03	0.17	0.25	0.13	0.20	0.20	0.20	0.08	0.04	0.04	0.08	0.25
	G	0.29	0.04	0.00	0.00	0.01	0.06	0.09	0.04	0.05	0.04	0.04	0.01	0.01	0.01	0.02	0.11
9.8	A	0.06	0.04	0.02	0.01	0.00	0.00	0.01	0.01	0.04	0.14	0.22	0.20	0.08	0.02	0.06	0.03
	B	0.03	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.06	0.05	0.06	0.03	0.01	0.03	0.03
	C	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.07	0.07	0.03	0.01	0.02	0.02
	D	0.19	0.07	0.02	0.01	0.01	0.01	0.03	0.02	0.14	0.34	0.44	0.30	0.15	0.05	0.27	0.31
	E	0.44	0.10	0.03	0.02	0.02	0.05	0.07	0.04	0.14	0.32	0.42	0.26	0.15	0.06	0.22	0.29
	F	0.34	0.07	0.01	0.01	0.01	0.07	0.07	0.02	0.08	0.09	0.13	0.06	0.02	0.01	0.02	0.12
	G	0.18	0.02	0.00	0.00	0.00	0.02	0.03	0.01	0.01	0.03	0.04	0.01	0.01	0.00	0.00	0.04
13.	A	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.07	0.10	0.08	0.08	0.02	0.04	0.01
	B	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.04	0.04	0.04	0.00	0.01	0.02
	C	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.04	0.01	0.00	0.02	0.01
	D	0.06	0.03	0.00	0.00	0.00	0.00	0.01	0.01	0.06	0.19	0.27	0.17	0.07	0.02	0.19	0.14
	E	0.18	0.08	0.01	0.01	0.01	0.02	0.02	0.01	0.06	0.20	0.28	0.14	0.08	0.02	0.19	0.13
	F	0.14	0.03	0.01	0.01	0.01	0.03	0.02	0.01	0.03	0.05	0.07	0.03	0.01	0.00	0.02	0.03
	G	0.08	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.01	0.03	0.00	0.00	0.00	0.00	0.01
16.	A	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.03	0.03	0.00	0.00	0.00
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01
	C	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
	D	0.03	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.09	0.17	0.07	0.04	0.00	0.07	0.04
	E	0.04	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.02	0.09	0.21	0.05	0.02	0.00	0.04	0.04
	F	0.06	0.03	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.04	0.03	0.00	0.00	0.00	0.00	0.01
	G	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
19.	A	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.01	0.01	0.00	0.00	0.00
	B	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
	C	0.02	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.00
	D	0.06	0.07	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.09	0.23	0.04	0.03	0.00	0.02	0.02
	E	0.08	0.12	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.10	0.21	0.02	0.01	0.00	0.01	0.00
	F	0.05	0.04	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.04	0.01	0.00	0.00	0.00	0.00
	G	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00

TABLE H.3.9. Joint Frequency Distributions for the 300 Area -- 89-m Tower -- 1983-1991 Data

Midpoint Wind Speed Class (m sec^{-1})	Pasquill Category	Percentage of Time Wind Blows from the 300 Area Towards the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.09	0.05	0.08	0.07	0.17	0.09	0.10	0.12	0.09	0.05	0.04	0.05	0.03	0.02	0.05	0.06
	B	0.07	0.04	0.03	0.03	0.07	0.03	0.06	0.05	0.05	0.03	0.03	0.02	0.04	0.03	0.02	0.05
	C	0.06	0.02	0.02	0.04	0.06	0.06	0.08	0.06	0.06	0.04	0.03	0.02	0.03	0.03	0.04	0.05
	D	0.35	0.16	0.11	0.13	0.25	0.32	0.36	0.33	0.43	0.27	0.28	0.21	0.25	0.17	0.24	0.37
	E	0.24	0.08	0.06	0.05	0.17	0.27	0.35	0.29	0.41	0.23	0.26	0.24	0.28	0.22	0.23	0.26
	F	0.24	0.10	0.04	0.05	0.15	0.29	0.40	0.34	0.39	0.25	0.22	0.16	0.26	0.18	0.24	0.28
	G	0.18	0.06	0.03	0.02	0.08	0.18	0.27	0.22	0.27	0.14	0.14	0.10	0.17	0.12	0.16	0.18
2.7	A	0.19	0.18	0.25	0.29	0.61	0.36	0.32	0.21	0.20	0.17	0.19	0.13	0.07	0.04	0.05	0.13
	B	0.11	0.09	0.08	0.09	0.15	0.13	0.14	0.10	0.08	0.09	0.06	0.06	0.03	0.01	0.03	0.07
	C	0.12	0.10	0.07	0.08	0.14	0.12	0.15	0.09	0.09	0.07	0.07	0.04	0.03	0.02	0.05	0.07
	D	0.77	0.34	0.22	0.22	0.64	0.64	0.76	0.54	0.61	0.47	0.39	0.24	0.24	0.17	0.29	0.53
	E	0.51	0.12	0.07	0.09	0.26	0.49	0.58	0.57	0.68	0.36	0.33	0.20	0.36	0.27	0.33	0.47
	F	0.40	0.08	0.05	0.03	0.12	0.35	0.61	0.50	0.53	0.24	0.18	0.14	0.17	0.19	0.23	0.34
	G	0.23	0.03	0.01	0.01	0.06	0.17	0.30	0.23	0.19	0.09	0.07	0.05	0.07	0.08	0.14	0.21
4.7	A	0.30	0.42	0.32	0.15	0.28	0.26	0.29	0.16	0.25	0.34	0.43	0.24	0.11	0.05	0.04	0.09
	B	0.13	0.13	0.07	0.04	0.08	0.08	0.09	0.05	0.09	0.14	0.12	0.07	0.04	0.02	0.01	0.04
	C	0.14	0.12	0.06	0.04	0.07	0.09	0.09	0.05	0.09	0.10	0.14	0.07	0.03	0.01	0.03	0.08
	D	0.90	0.41	0.28	0.17	0.33	0.42	0.56	0.33	0.54	0.64	0.60	0.36	0.25	0.14	0.35	0.64
	E	0.73	0.19	0.07	0.05	0.18	0.49	0.71	0.47	0.77	0.43	0.42	0.32	0.27	0.26	0.33	0.57
	F	0.56	0.07	0.02	0.02	0.09	0.38	0.57	0.31	0.44	0.23	0.17	0.09	0.12	0.11	0.15	0.40
	G	0.31	0.04	0.00	0.00	0.02	0.14	0.26	0.11	0.16	0.07	0.04	0.03	0.02	0.03	0.07	0.16
7.2	A	0.23	0.26	0.09	0.02	0.02	0.02	0.06	0.04	0.11	0.28	0.44	0.33	0.12	0.05	0.08	0.07
	B	0.08	0.09	0.03	0.01	0.01	0.01	0.02	0.01	0.05	0.09	0.11	0.11	0.05	0.01	0.02	0.04
	C	0.11	0.06	0.03	0.01	0.02	0.02	0.03	0.02	0.04	0.10	0.13	0.08	0.02	0.01	0.04	0.04
	D	0.58	0.29	0.15	0.03	0.05	0.09	0.20	0.14	0.34	0.57	0.63	0.41	0.21	0.12	0.26	0.52
	E	0.86	0.17	0.04	0.01	0.06	0.26	0.34	0.20	0.52	0.50	0.49	0.39	0.27	0.16	0.31	0.52
	F	0.55	0.07	0.01	0.01	0.02	0.21	0.29	0.16	0.26	0.21	0.18	0.09	0.05	0.04	0.08	0.22
	G	0.27	0.03	0.00	0.00	0.01	0.05	0.10	0.03	0.06	0.05	0.04	0.02	0.01	0.00	0.02	0.10
9.8	A	0.07	0.05	0.02	0.01	0.00	0.00	0.02	0.01	0.04	0.15	0.20	0.21	0.08	0.03	0.06	0.04
	B	0.03	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.06	0.06	0.05	0.04	0.01	0.02	0.03
	C	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.03	0.05	0.06	0.06	0.03	0.01	0.02	0.01
	D	0.24	0.08	0.02	0.01	0.01	0.03	0.03	0.04	0.15	0.35	0.45	0.31	0.15	0.05	0.26	0.32
	E	0.49	0.09	0.02	0.01	0.02	0.07	0.09	0.06	0.18	0.31	0.38	0.26	0.16	0.08	0.21	0.29
	F	0.26	0.06	0.00	0.01	0.01	0.07	0.11	0.04	0.08	0.09	0.12	0.04	0.02	0.01	0.04	0.11
	G	0.15	0.01	0.00	0.00	0.00	0.03	0.03	0.01	0.02	0.02	0.03	0.01	0.01	0.00	0.00	0.02
13.	A	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.07	0.13	0.09	0.07	0.01	0.03	0.01
	B	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.04	0.03	0.00	0.01	0.02
	C	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.04	0.01	0.00	0.02	0.01
	D	0.10	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.08	0.20	0.28	0.19	0.09	0.03	0.21	0.17
	E	0.26	0.08	0.02	0.01	0.01	0.02	0.06	0.03	0.10	0.24	0.32	0.20	0.09	0.02	0.20	0.19
	F	0.16	0.03	0.01	0.01	0.01	0.04	0.04	0.02	0.05	0.05	0.08	0.05	0.01	0.01	0.01	0.05
	G	0.04	0.02	0.00	0.00	0.00	0.02	0.02	0.00	0.01	0.01	0.02	0.01	0.01	0.00	0.00	0.00
16.	A	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.03	0.03	0.00	0.01	0.01
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.01	0.00	0.01	0.01
	C	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.00	0.01	0.01
	D	0.03	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.10	0.17	0.10	0.04	0.01	0.11	0.07
	E	0.07	0.04	0.02	0.01	0.01	0.01	0.02	0.01	0.03	0.13	0.19	0.06	0.03	0.01	0.09	0.06
	F	0.06	0.03	0.01	0.00	0.01	0.02	0.02	0.01	0.01	0.03	0.04	0.01	0.00	0.00	0.01	0.02
	G	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.00
19.	A	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.01	0.02	0.00	0.00	0.00
	B	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00
	C	0.02	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.00	0.00	0.00	0.00	0.00
	D	0.06	0.07	0.00	0.01	0.00	0.00	0.01	0.01	0.02	0.15	0.30	0.06	0.04	0.00	0.03	0.03
	E	0.10	0.14	0.02	0.01	0.00	0.01	0.01	0.00	0.03	0.14	0.35	0.05	0.02	0.00	0.03	0.02
	F	0.07	0.04	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.04	0.06	0.01	0.00	0.00	0.01	0.01
	G	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00

TABLE H.3.10. Joint Frequency Distributions for the **400 Area -- 10-m Tower -- 1983-1991 Data**

Midpoint Wind Speed Class (m sec^{-1})	Pasquill Category	Percentage of Time Wind Blows from the 400 Area Towards the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.12	0.11	0.08	0.11	0.14	0.15	0.10	0.07	0.13	0.08	0.06	0.06	0.08	0.06	0.05	0.07
	B	0.06	0.05	0.05	0.05	0.07	0.05	0.04	0.03	0.06	0.03	0.03	0.02	0.03	0.03	0.03	0.03
	C	0.06	0.06	0.04	0.05	0.07	0.05	0.07	0.05	0.04	0.04	0.04	0.02	0.05	0.03	0.04	0.04
	D	0.44	0.28	0.27	0.23	0.33	0.31	0.29	0.31	0.41	0.31	0.26	0.20	0.29	0.26	0.34	0.34
	E	0.34	0.21	0.19	0.15	0.25	0.23	0.20	0.23	0.46	0.32	0.29	0.28	0.38	0.30	0.29	0.34
	F	0.31	0.20	0.15	0.13	0.19	0.13	0.16	0.16	0.34	0.23	0.25	0.19	0.26	0.20	0.20	0.20
	G	0.18	0.09	0.06	0.05	0.08	0.07	0.07	0.08	0.14	0.12	0.09	0.07	0.14	0.08	0.11	0.10
2.7	A	0.40	0.35	0.36	0.30	0.40	0.40	0.41	0.41	0.70	0.38	0.17	0.12	0.21	0.16	0.17	0.19
	B	0.15	0.11	0.11	0.08	0.13	0.08	0.11	0.13	0.19	0.14	0.05	0.05	0.06	0.04	0.08	0.08
	C	0.15	0.11	0.10	0.06	0.09	0.08	0.12	0.14	0.22	0.10	0.05	0.03	0.06	0.06	0.08	0.09
	D	0.84	0.56	0.47	0.34	0.45	0.37	0.64	0.92	1.21	0.71	0.34	0.23	0.49	0.61	0.82	0.69
	E	0.71	0.38	0.28	0.17	0.21	0.25	0.50	0.84	1.37	0.88	0.53	0.40	0.72	0.73	0.91	0.64
	F	0.70	0.48	0.26	0.12	0.15	0.13	0.35	0.64	1.09	0.61	0.39	0.20	0.30	0.33	0.57	0.50
	G	0.39	0.27	0.13	0.05	0.05	0.05	0.11	0.25	0.47	0.22	0.14	0.07	0.10	0.17	0.28	0.28
4.7	A	0.44	0.33	0.17	0.08	0.11	0.08	0.11	0.15	0.77	0.68	0.24	0.16	0.23	0.16	0.23	0.20
	B	0.15	0.09	0.04	0.02	0.03	0.03	0.04	0.06	0.24	0.24	0.07	0.06	0.04	0.03	0.09	0.07
	C	0.10	0.11	0.05	0.02	0.02	0.03	0.04	0.06	0.17	0.21	0.06	0.03	0.06	0.04	0.08	0.10
	D	0.46	0.36	0.21	0.09	0.07	0.09	0.22	0.55	1.25	1.08	0.40	0.20	0.38	0.71	1.04	0.59
	E	0.27	0.22	0.09	0.04	0.02	0.04	0.21	0.83	1.29	1.02	0.44	0.23	0.44	0.93	1.37	0.56
	F	0.22	0.19	0.06	0.02	0.00	0.01	0.14	0.80	0.99	0.58	0.18	0.07	0.09	0.24	0.69	0.40
	G	0.10	0.07	0.02	0.00	0.00	0.00	0.06	0.43	0.40	0.18	0.05	0.01	0.01	0.08	0.32	0.21
7.2	A	0.10	0.09	0.05	0.01	0.00	0.00	0.01	0.02	0.20	0.62	0.34	0.21	0.22	0.13	0.19	0.11
	B	0.03	0.04	0.01	0.01	0.00	0.00	0.01	0.01	0.05	0.21	0.07	0.07	0.07	0.04	0.05	0.03
	C	0.03	0.03	0.01	0.00	0.00	0.00	0.01	0.01	0.05	0.19	0.09	0.06	0.04	0.05	0.04	0.02
	D	0.14	0.12	0.04	0.01	0.01	0.01	0.05	0.05	0.38	1.02	0.48	0.22	0.22	0.37	0.56	0.16
	E	0.05	0.09	0.04	0.01	0.00	0.01	0.01	0.07	0.29	0.72	0.41	0.17	0.15	0.34	0.49	0.14
	F	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.06	0.16	0.30	0.09	0.02	0.02	0.02	0.05	0.04
	G	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.05	0.09	0.12	0.03	0.01	0.00	0.00	0.03	0.02
9.8	A	0.01	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.13	0.15	0.11	0.09	0.03	0.06	0.01
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.05	0.04	0.02	0.01	0.02	0.01
	C	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.02	0.01	0.01	0.02	0.01
	D	0.02	0.05	0.01	0.01	0.00	0.00	0.00	0.00	0.03	0.21	0.28	0.13	0.09	0.12	0.25	0.03
	E	0.01	0.09	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.17	0.21	0.06	0.03	0.07	0.11	0.01
	F	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00
13.	A	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.03	0.02	0.01	0.01	0.00
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00
	C	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.01	0.00
	D	0.01	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.21	0.05	0.02	0.01	0.04	0.01
	E	0.00	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.08	0.01	0.00	0.01	0.02	0.00
	F	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.	A	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.01	0.00
	B	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	D	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.01	0.02	0.00	0.00	0.00
	E	0.01	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.01	0.00	0.00
	F	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.	A	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	B	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D	0.07	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	E	0.09	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	F	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	G	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE H.3.11. Joint Frequency Distributions for the **400 Area -- 61-m Tower -- 1983-1991 Data**

Midpoint Wind Speed Class ($m\ sec^{-1}$)	Pasquill Category	Percentage of Time Wind Blows from the **400 Area Towards** the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.12	0.10	0.08	0.11	0.14	0.15	0.10	0.08	0.14	0.08	0.05	0.06	0.07	0.05	0.05	0.07
	B	0.05	0.05	0.05	0.05	0.06	0.05	0.04	0.03	0.07	0.03	0.02	0.02	0.03	0.02	0.03	0.03
	C	0.06	0.04	0.04	0.04	0.06	0.04	0.07	0.05	0.04	0.04	0.03	0.01	0.05	0.03	0.04	0.04
	D	0.32	0.23	0.20	0.18	0.25	0.26	0.24	0.28	0.36	0.26	0.19	0.15	0.22	0.19	0.22	0.21
	E	0.19	0.14	0.10	0.10	0.13	0.13	0.14	0.19	0.37	0.22	0.18	0.17	0.23	0.19	0.19	0.19
	F	0.22	0.14	0.10	0.09	0.13	0.11	0.15	0.20	0.34	0.20	0.20	0.12	0.20	0.14	0.16	0.16
	G	0.13	0.08	0.06	0.03	0.06	0.07	0.07	0.18	0.22	0.13	0.09	0.07	0.12	0.09	0.12	0.09
2.7	A	0.32	0.28	0.28	0.28	0.39	0.37	0.37	0.34	0.55	0.32	0.16	0.09	0.17	0.13	0.13	0.15
	B	0.12	0.09	0.08	0.06	0.12	0.07	0.10	0.11	0.15	0.12	0.05	0.05	0.05	0.04	0.06	0.07
	C	0.13	0.08	0.08	0.05	0.09	0.08	0.10	0.11	0.16	0.08	0.04	0.03	0.05	0.03	0.06	0.08
	D	0.58	0.41	0.37	0.26	0.38	0.33	0.46	0.59	0.85	0.49	0.25	0.15	0.33	0.36	0.47	0.41
	E	0.32	0.20	0.19	0.12	0.21	0.21	0.25	0.45	0.68	0.46	0.31	0.24	0.37	0.29	0.38	0.33
	F	0.35	0.23	0.15	0.07	0.12	0.09	0.18	0.36	0.64	0.31	0.23	0.16	0.18	0.18	0.23	0.22
	G	0.18	0.12	0.06	0.03	0.04	0.04	0.08	0.20	0.30	0.16	0.10	0.04	0.08	0.10	0.15	0.16
4.7	A	0.39	0.31	0.21	0.10	0.13	0.13	0.15	0.19	0.77	0.51	0.17	0.13	0.19	0.15	0.16	0.17
	B	0.14	0.09	0.06	0.04	0.04	0.04	0.04	0.07	0.20	0.16	0.06	0.04	0.03	0.02	0.06	0.06
	C	0.10	0.10	0.06	0.03	0.03	0.03	0.04	0.06	0.16	0.16	0.04	0.02	0.05	0.04	0.06	0.07
	D	0.59	0.38	0.26	0.14	0.16	0.14	0.32	0.55	0.97	0.75	0.27	0.15	0.34	0.46	0.63	0.55
	E	0.41	0.21	0.15	0.09	0.10	0.11	0.28	0.60	1.02	0.71	0.37	0.27	0.50	0.53	0.60	0.43
	F	0.37	0.22	0.11	0.06	0.07	0.06	0.17	0.48	0.73	0.44	0.21	0.11	0.16	0.20	0.37	0.29
	G	0.19	0.11	0.05	0.02	0.02	0.01	0.04	0.19	0.26	0.14	0.06	0.02	0.04	0.07	0.19	0.13
7.2	A	0.22	0.17	0.08	0.02	0.02	0.01	0.03	0.05	0.32	0.63	0.28	0.17	0.23	0.11	0.19	0.15
	B	0.07	0.05	0.01	0.01	0.00	0.00	0.02	0.01	0.10	0.22	0.06	0.05	0.05	0.03	0.07	0.03
	C	0.04	0.05	0.02	0.01	0.00	0.01	0.02	0.02	0.07	0.18	0.06	0.04	0.03	0.03	0.05	0.04
	D	0.27	0.19	0.09	0.04	0.02	0.04	0.10	0.25	0.65	0.86	0.37	0.20	0.29	0.50	0.75	0.40
	E	0.27	0.18	0.07	0.02	0.02	0.04	0.15	0.43	0.73	0.74	0.34	0.20	0.39	0.73	0.94	0.44
	F	0.21	0.14	0.06	0.02	0.02	0.01	0.09	0.33	0.52	0.39	0.14	0.07	0.09	0.16	0.45	0.26
	G	0.13	0.08	0.04	0.01	0.01	0.01	0.03	0.11	0.19	0.13	0.04	0.02	0.01	0.04	0.14	0.13
9.8	A	0.05	0.05	0.03	0.01	0.00	0.00	0.00	0.01	0.08	0.29	0.21	0.12	0.12	0.08	0.12	0.04
	B	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.08	0.04	0.04	0.04	0.02	0.03	0.02
	C	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.08	0.06	0.03	0.03	0.03	0.03	0.01
	D	0.09	0.08	0.02	0.01	0.00	0.01	0.03	0.04	0.24	0.58	0.32	0.16	0.19	0.33	0.57	0.14
	E	0.10	0.12	0.04	0.01	0.00	0.01	0.06	0.17	0.37	0.51	0.26	0.13	0.17	0.43	0.73	0.22
	F	0.10	0.11	0.03	0.01	0.01	0.00	0.03	0.14	0.21	0.20	0.07	0.02	0.03	0.08	0.23	0.16
	G	0.05	0.04	0.02	0.00	0.00	0.00	0.01	0.07	0.09	0.05	0.03	0.00	0.00	0.02	0.10	0.07
13.	A	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.09	0.10	0.10	0.08	0.03	0.07	0.01
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.04	0.04	0.02	0.01	0.03	0.01
	C	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.02	0.02	0.01	0.02	0.01
	D	0.03	0.03	0.01	0.00	0.00	0.00	0.01	0.02	0.07	0.27	0.24	0.12	0.09	0.19	0.32	0.05
	E	0.04	0.08	0.03	0.01	0.00	0.00	0.02	0.05	0.13	0.32	0.25	0.10	0.07	0.20	0.33	0.07
	F	0.04	0.05	0.02	0.01	0.00	0.00	0.02	0.06	0.08	0.13	0.05	0.01	0.01	0.02	0.10	0.06
	G	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.03	0.01	0.00	0.00	0.01	0.05	0.04
16.	A	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.03	0.02	0.01	0.01	0.00
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00
	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.00	0.01	0.00
	D	0.02	0.03	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.11	0.19	0.06	0.03	0.06	0.10	0.01
	E	0.01	0.04	0.03	0.00	0.00	0.00	0.01	0.02	0.05	0.16	0.16	0.04	0.02	0.04	0.09	0.01
	F	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.05	0.02	0.00	0 01	0.00	0.01	0.02
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.00
19.	A	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.01	0.01	0.00	0.01	0.00
	B	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
	C	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
	D	0.03	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.22	0.04	0.03	0.01	0.02	0.00
	E	0.03	0.10	0.02	0.00	0.00	0.00	0.00	0.02	0.02	0.10	0.14	0.02	0.01	0.01	0.01	0.00
	F	0.02	0.04	0.01	0.00	0.00	0.00	0.00	0.03	0.03	0.04	0.02	0.00	0.00	0.00	0.01	0.00
	G	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.01	0.00

TABLE H.3.12. Joint Frequency Distributions for the **400 Area -- 89-m Tower -- 1983-1991 Data**

Midpoint Wind Speed Class (m sec^{-1})	Pasquill Category	Percentage of Time Wind Blows from the 400 Area Towards the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.12	0.10	0.08	0.11	0.13	0.15	0.10	0.08	0.14	0.08	0.05	0.05	0.07	0.05	0.05	0.06
	B	0.05	0.05	0.05	0.05	0.06	0.05	0.04	0.03	0.07	0.04	0.02	0.02	0.03	0.02	0.03	0.03
	C	0.06	0.04	0.03	0.04	0.06	0.04	0.07	0.05	0.05	0.04	0.03	0.01	0.05	0.03	0.03	0.04
	D	0.33	0.22	0.21	0.18	0.23	0.26	0.23	0.30	0.37	0.26	0.20	0.14	0.22	0.19	0.23	0.22
	E	0.18	0.15	0.11	0.10	0.12	0.13	0.14	0.20	0.38	0.23	0.17	0.16	0.23	0.18	0.18	0.18
	F	0.25	0.14	0.10	0.08	0.12	0.09	0.14	0.19	0.35	0.19	0.20	0.11	0.19	0.15	0.17	0.17
	G	0.15	0.10	0.05	0.03	0.05	0.07	0.07	0.19	0.22	0.13	0.09	0.07	0.12	0.10	0.14	0.12
2.7	A	0.30	0.27	0.25	0.26	0.38	0.35	0.35	0.33	0.51	0.32	0.16	0.10	0.16	0.12	0.12	0.15
	B	0.13	0.09	0.08	0.06	0.11	0.07	0.10	0.09	0.14	0.12	0.04	0.04	0.05	0.04	0.06	0.06
	C	0.13	0.08	0.08	0.05	0.10	0.08	0.10	0.11	0.16	0.07	0.04	0.03	0.05	0.03	0.06	0.07
	D	0.54	0.40	0.34	0.25	0.37	0.30	0.43	0.56	0.81	0.45	0.24	0.14	0.30	0.34	0.42	0.39
	E	0.30	0.19	0.17	0.11	0.20	0.19	0.24	0.41	0.62	0.39	0.26	0.20	0.28	0.29	0.37	0.32
	F	0.32	0.23	0.12	0.07	0.10	0.11	0.16	0.36	0.60	0.30	0.19	0.14	0.16	0.16	0.26	0.23
	G	0.21	0.11	0.07	0.03	0.04	0.03	0.07	0.19	0.26	0.15	0.09	0.04	0.08	0.09	0.17	0.15
4.7	A	0.40	0.31	0.24	0.11	0.15	0.14	0.17	0.19	0.77	0.50	0.17	0.12	0.19	0.15	0.16	0.18
	B	0.13	0.09	0.06	0.04	0.04	0.05	0.05	0.08	0.21	0.15	0.06	0.03	0.03	0.02	0.06	0.06
	C	0.10	0.10	0.07	0.03	0.04	0.03	0.04	0.06	0.16	0.17	0.05	0.02	0.05	0.03	0.06	0.06
	D	0.56	0.38	0.25	0.15	0.18	0.15	0.32	0.49	0.94	0.72	0.24	0.13	0.30	0.39	0.63	0.54
	E	0.38	0.19	0.13	0.09	0.11	0.12	0.25	0.52	0.87	0.62	0.35	0.27	0.45	0.45	0.53	0.38
	F	0.35	0.18	0.12	0.05	0.07	0.05	0.18	0.43	0.64	0.41	0.22	0.11	0.15	0.21	0.35	0.29
	G	0.19	0.13	0.05	0.02	0.03	0.01	0.05	0.18	0.27	0.13	0.07	0.02	0.04	0.07	0.16	0.16
7.2	A	0.23	0.17	0.08	0.03	0.02	0.02	0.03	0.06	0.34	0.59	0.25	0.17	0.21	0.10	0.18	0.14
	B	0.08	0.06	0.02	0.01	0.01	0.00	0.01	0.02	0.11	0.22	0.06	0.06	0.04	0.03	0.06	0.03
	C	0.05	0.05	0.02	0.01	0.00	0.02	0.02	0.03	0.07	0.17	0.06	0.03	0.03	0.04	0.05	0.05
	D	0.31	0.21	0.10	0.04	0.03	0.05	0.13	0.28	0.63	0.80	0.35	0.18	0.31	0.46	0.65	0.38
	E	0.27	0.17	0.08	0.03	0.03	0.04	0.16	0.44	0.78	0.74	0.33	0.20	0.40	0.61	0.82	0.42
	F	0.21	0.15	0.06	0.03	0.03	0.02	0.09	0.32	0.55	0.36	0.13	0.08	0.10	0.15	0.41	0.25
	G	0.09	0.07	0.03	0.01	0.00	0.01	0.03	0.12	0.20	0.11	0.03	0.01	0.01	0.04	0.17	0.12
9.8	A	0.06	0.06	0.03	0.01	0.00	0.00	0.01	0.01	0.09	0.30	0.22	0.13	0.13	0.08	0.11	0.04
	B	0.02	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.09	0.03	0.04	0.04	0.02	0.04	0.03
	C	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.10	0.06	0.03	0.03	0.03	0.04	0.02
	D	0.10	0.06	0.03	0.01	0.01	0.01	0.04	0.07	0.27	0.59	0.28	0.16	0.18	0.34	0.51	0.15
	E	0.13	0.10	0.03	0.01	0.01	0.01	0.07	0.18	0.39	0.48	0.25	0.13	0.24	0.49	0.66	0.26
	F	0.08	0.08	0.03	0.02	0.01	0.00	0.04	0.13	0.22	0.20	0.08	0.02	0.04	0.08	0.21	0.14
	G	0.03	0.02	0.01	0.00	0.00	0.00	0.01	0.05	0.06	0.05	0.02	0.01	0.00	0.03	0.09	0.05
13.	A	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.11	0.11	0.09	0.08	0.04	0.07	0.01
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.04	0.04	0.03	0.01	0.03	0.02
	C	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.02	0.01	0.01	0.03	0.01
	D	0.05	0.05	0.02	0.01	0.00	0.00	0.01	0.03	0.11	0.29	0.24	0.14	0.11	0.23	0.40	0.08
	E	0.06	0.10	0.04	0.01	0.00	0.00	0.03	0.11	0.19	0.36	0.25	0.12	0.10	0.28	0.50	0.11
	F	0.06	0.07	0.03	0.01	0.00	0.00	0.03	0.11	0.12	0.15	0.05	0.02	0.01	0.03	0.11	0.07
	G	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.04	0.06	0.03	0.01	0.00	0.00	0.00	0.03	0.02
16.	A	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.06	0.04	0.03	0.02	0.02	0.00
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.01	0.01	0.00
	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.00	0.01	0.00
	D	0.02	0.04	0.01	0.00	0.00	0.00	0.00	0.02	0.03	0.14	0.18	0.06	0.05	0.12	0.19	0.02
	E	0.02	0.06	0.02	0.01	0.00	0.00	0.01	0.03	0.09	0.19	0.17	0.05	0.04	0.10	0.16	0.03
	F	0.01	0.05	0.01	0.00	0.00	0.00	0.01	0.05	0.07	0.07	0.02	0.01	0.01	0.01	0.03	0.02
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.03	0.01	0.00	0.00	0.00	0.01	0.00
19.	A	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.01	0.01	0.00	0.01	0.00
	B	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00
	C	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.00	0.01	0.00	0.01	0.00
	D	0.03	0.08	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.15	0.31	0.07	0.05	0.03	0.06	0.01
	E	0.03	0.10	0.04	0.00	0.00	0.00	0.01	0.04	0.06	0.20	0.23	0.03	0.01	0.03	0.05	0.01
	F	0.02	0.06	0.01	0.00	0.00	0.00	0.01	0.04	0.05	0.07	0.05	0.00	0.00	0.00	0.01	0.01
	G	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX H.4

ATMOSPHERIC DISPERSION FACTORS: ANNUAL SECTOR-AVERAGED $\overline{\chi}/Q'$ VALUES FOR CHRONIC RELEASES FROM THE HANFORD AREAS BASED ON 1983 THROUGH 1991 METEOROLOGICAL INFORMATION

THIS PAGE BLANK INTENTIONALLY

APPENDIX H.4

ATMOSPHERIC DISPERSION FACTORS: ANNUAL SECTOR-AVERAGED $\overline{\chi}/Q'$ VALUES FOR CHRONIC RELEASES FROM THE HANFORD AREAS BASED ON 1983 THROUGH 1991 METEOROLOGICAL INFORMATION

Atmospheric dispersion factors for chronic releases from the four major Hanford Areas are presented in the following tables (i.e., H.4.1-14). The annual sector-averaged $\overline{\chi}/Q'$ values were calculated using the GENII code based on meteorological information averaged over the years 1983 through 1991. A description of the computation of the sector-averaged $\overline{\chi}/Q'$ values is presented in Appendix H.1.

TABLE H.4.1. $\overline{\chi}/Q'$ Values (sec m^{-3}) for Chronic **Ground-Level** Releases from **100 N Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 100 N Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	2.3E-04	1.5E-04	1.5E-04	1.9E-04	3.6E-04	2.3E-04	1.9E-04	1.3E-04	1.7E-04	1.4E-04	2.0E-04	3.1E-04	5.1E-04	3.2E-04	2.4E-04	2.0E-04	0.1
0.2	6.3E-05	4.1E-05	4.3E-05	5.2E-05	1.0E-04	6.4E-05	5.2E-05	3.7E-05	4.7E-05	3.8E-05	5.5E-05	8.6E-05	1.4E-04	8.7E-05	6.5E-05	5.5E-05	0.2
0.3	3.0E-05	1.9E-05	2.1E-05	2.5E-05	4.8E-05	3.1E-05	2.5E-05	1.8E-05	2.2E-05	1.8E-05	2.6E-05	4.1E-05	6.8E-05	4.1E-05	3.1E-05	2.6E-05	0.3
0.4	1.8E-05	1.2E-05	1.2E-05	1.5E-05	2.9E-05	1.8E-05	1.5E-05	1.0E-05	1.3E-05	1.1E-05	1.6E-05	2.5E-05	4.0E-05	2.5E-05	1.8E-05	1.6E-05	0.4
0.5	1.2E-05	7.7E-06	8.2E-06	1.0E-05	1.9E-05	1.2E-05	1.0E-05	7.0E-06	8.9E-06	7.2E-06	1.1E-05	1.7E-05	2.7E-05	1.7E-05	1.2E-05	1.1E-05	0.5
0.6	8.6E-06	5.6E-06	5.9E-06	7.3E-06	1.4E-05	8.8E-06	7.2E-06	5.1E-06	6.4E-06	5.2E-06	7.6E-06	1.2E-05	2.0E-05	1.2E-05	8.9E-06	7.6E-06	0.6
0.7	6.5E-06	4.2E-06	4.5E-06	5.5E-06	1.1E-05	6.7E-06	5.5E-06	3.8E-06	4.9E-06	4.0E-06	5.8E-06	9.1E-06	1.5E-05	9.1E-06	6.8E-06	5.8E-06	0.7
0.8	5.1E-06	3.3E-06	3.5E-06	4.4E-06	8.4E-06	5.3E-06	4.3E-06	3.0E-06	3.9E-06	3.1E-06	4.5E-06	7.2E-06	1.2E-05	7.2E-06	5.3E-06	4.5E-06	0.8
0.9	4.2E-06	2.7E-06	2.9E-06	3.5E-06	6.8E-06	4.3E-06	3.5E-06	2.5E-06	3.1E-06	2.5E-06	3.7E-06	5.8E-06	9.5E-06	5.8E-06	4.3E-06	3.7E-06	0.9
1.0	3.5E-06	2.2E-06	2.4E-06	2.9E-06	5.6E-06	3.6E-06	2.9E-06	2.1E-06	2.6E-06	2.1E-06	3.1E-06	4.8E-06	7.9E-06	4.8E-06	3.6E-06	3.1E-06	1.0
2.4	8.0E-07	5.2E-07	5.5E-07	6.8E-07	1.3E-06	8.3E-07	6.7E-07	4.7E-07	6.0E-07	4.9E-07	7.1E-07	1.1E-06	1.8E-06	1.1E-06	8.3E-07	7.1E-07	2.4
4.0	3.6E-07	2.4E-07	2.5E-07	3.1E-07	6.0E-07	3.8E-07	3.1E-07	2.1E-07	2.7E-07	2.2E-07	3.2E-07	5.2E-07	8.4E-07	5.1E-07	3.8E-07	3.2E-07	4.0
5.6	2.2E-07	1.4E-07	1.5E-07	1.9E-07	3.6E-07	2.3E-07	1.9E-07	1.3E-07	1.7E-07	1.3E-07	2.0E-07	3.1E-07	5.1E-07	3.1E-07	2.3E-07	2.0E-07	5.6
7.2	1.5E-07	9.9E-08	1.1E-07	1.3E-07	2.5E-07	1.6E-07	1.3E-07	9.0E-08	1.1E-07	9.3E-08	1.4E-07	2.2E-07	3.6E-07	2.2E-07	1.6E-07	1.4E-07	7.2
12.1	7.4E-08	4.8E-08	5.2E-08	6.4E-08	1.2E-07	7.6E-08	6.2E-08	4.3E-08	5.5E-08	4.5E-08	6.6E-08	1.1E-07	1.7E-07	1.1E-07	7.8E-08	6.7E-08	12.1
24.1	2.9E-08	1.8E-08	2.0E-08	2.5E-08	4.7E-08	2.9E-08	2.4E-08	1.6E-08	2.1E-08	1.7E-08	2.5E-08	4.1E-08	6.7E-08	4.1E-08	3.0E-08	2.6E-08	24.1
40.3	1.4E-08	9.3E-09	1.0E-08	1.3E-08	2.4E-08	1.4E-08	1.2E-08	8.1E-09	1.0E-08	8.5E-09	1.3E-08	2.0E-08	3.4E-08	2.0E-08	1.5E-08	1.3E-08	40.3
56.3	9.2E-09	5.9E-09	6.4E-09	8.0E-09	1.5E-08	9.2E-09	7.5E-09	5.2E-09	6.6E-09	5.4E-09	8.0E-09	1.3E-08	2.2E-08	1.3E-08	9.7E-09	8.3E-09	56.3
72.4	6.6E-09	4.3E-09	4.6E-09	5.8E-09	1.1E-08	6.6E-09	5.3E-09	3.7E-09	4.7E-09	3.9E-09	5.8E-09	9.4E-09	1.5E-08	9.4E-09	7.0E-09	6.0E-09	72.4

TABLE H.4.2. $\overline{\chi}/Q'$ Values (sec m^{-3}) for Chronic **30-m Stack** Releases from **100 N Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 100 N Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	4.3E-07	3.3E-07	5.5E-07	7.3E-07	1.3E-06	1.1E-06	9.5E-07	8.1E-07	1.0E-06	6.0E-07	5.0E-07	3.3E-07	7.2E-07	5.1E-07	4.5E-07	3.4E-07	0.1
0.2	7.9E-07	6.0E-07	9.8E-07	1.3E-06	2.1E-06	1.7E-06	1.6E-06	1.3E-06	1.7E-06	1.0E-06	8.8E-07	6.2E-07	1.3E-06	9.7E-07	8.6E-07	6.6E-07	0.2
0.3	8.0E-07	6.0E-07	9.0E-07	1.1E-06	1.8E-06	1.4E-06	1.3E-06	1.1E-06	1.4E-06	8.6E-07	7.6E-07	6.1E-07	1.3E-06	9.9E-07	8.8E-07	6.6E-07	0.3
0.4	8.6E-07	6.4E-07	9.0E-07	1.1E-06	1.8E-06	1.3E-06	1.1E-06	9.5E-07	1.2E-06	7.8E-07	7.0E-07	6.4E-07	1.3E-06	1.1E-06	9.4E-07	6.9E-07	0.4
0.5	8.8E-07	6.6E-07	9.0E-07	1.2E-06	1.8E-06	1.3E-06	1.0E-06	8.8E-07	1.1E-06	7.4E-07	6.7E-07	6.5E-07	1.4E-06	1.1E-06	9.6E-07	7.1E-07	0.5
0.6	8.7E-07	6.5E-07	8.8E-07	1.1E-06	1.8E-06	1.2E-06	9.6E-07	8.2E-07	1.1E-06	6.9E-07	6.3E-07	6.5E-07	1.3E-06	1.1E-06	9.4E-07	6.9E-07	0.6
0.7	8.3E-07	6.2E-07	8.4E-07	1.1E-06	1.8E-06	1.2E-06	8.9E-07	7.7E-07	9.9E-07	6.4E-07	6.0E-07	6.3E-07	1.3E-06	1.1E-06	8.9E-07	6.6E-07	0.7
0.8	7.8E-07	5.8E-07	7.9E-07	1.1E-06	1.7E-06	1.1E-06	8.3E-07	7.1E-07	9.2E-07	6.0E-07	5.6E-07	6.0E-07	1.2E-06	1.0E-06	8.4E-07	6.2E-07	0.8
0.9	7.2E-07	5.5E-07	7.4E-07	1.0E-06	1.6E-06	1.0E-06	7.8E-07	6.6E-07	8.5E-07	5.5E-07	5.2E-07	5.7E-07	1.2E-06	9.3E-07	7.8E-07	5.7E-07	0.9
1.0	6.7E-07	5.1E-07	6.9E-07	9.4E-07	1.5E-06	9.6E-07	7.2E-07	6.2E-07	7.9E-07	5.1E-07	4.9E-07	5.4E-07	1.1E-06	8.7E-07	7.3E-07	5.3E-07	1.0
2.4	2.7E-07	2.1E-07	2.9E-07	4.3E-07	6.9E-07	4.3E-07	3.2E-07	2.7E-07	3.3E-07	2.2E-07	2.2E-07	2.5E-07	5.1E-07	3.7E-07	3.0E-07	2.2E-07	2.4
4.0	1.4E-07	1.1E-07	1.6E-07	2.4E-07	3.8E-07	2.4E-07	1.8E-07	1.5E-07	1.8E-07	1.2E-07	1.2E-07	1.4E-07	2.8E-07	1.9E-07	1.6E-07	1.1E-07	4.0
5.6	9.2E-08	7.3E-08	1.0E-07	1.6E-07	2.5E-07	1.6E-07	1.2E-07	9.9E-08	1.2E-07	7.5E-08	7.8E-08	9.3E-08	1.8E-07	1.3E-07	1.0E-07	7.3E-08	5.6
7.2	6.6E-08	5.3E-08	7.4E-08	1.1E-07	1.8E-07	1.1E-07	8.4E-08	7.2E-08	8.4E-08	5.4E-08	5.7E-08	6.8E-08	1.3E-07	9.0E-08	7.4E-08	5.2E-08	7.2
12.1	3.3E-08	2.7E-08	3.8E-08	5.9E-08	9.6E-08	5.9E-08	4.4E-08	3.7E-08	4.3E-08	2.8E-08	2.9E-08	3.6E-08	6.9E-08	4.6E-08	3.7E-08	2.6E-08	12.1
24.1	1.3E-08	1.1E-08	1.5E-08	2.4E-08	3.9E-08	2.4E-08	1.8E-08	1.5E-08	1.8E-08	1.1E-08	1.2E-08	1.5E-08	2.8E-08	1.8E-08	1.5E-08	1.0E-08	24.1
40.3	6.7E-09	5.4E-09	7.9E-09	1.2E-08	2.0E-08	1.2E-08	9.3E-09	7.9E-09	9.0E-09	5.8E-09	6.2E-09	7.5E-09	1.5E-08	9.3E-09	7.5E-09	5.3E-09	40.3
56.3	4.3E-09	3.5E-09	5.1E-09	8.1E-09	1.3E-08	8.1E-09	6.0E-09	5.1E-09	5.8E-09	3.8E-09	4.0E-09	4.9E-09	9.4E-09	6.0E-09	4.9E-09	3.4E-09	56.3
72.4	3.1E-09	2.5E-09	3.7E-09	5.8E-09	9.5E-09	5.9E-09	4.4E-09	3.7E-09	4.2E-09	2.7E-09	2.9E-09	3.5E-09	6.8E-09	4.3E-09	3.5E-09	2.4E-09	72.4

TABLE H.4.3. $\overline{\chi}/Q'$ Values (sec m^{-3}) for Chronic **60-m Stack** Releases from **100 N Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 100 N Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	1.4E-09	7.9E-10	6.5E-10	4.3E-10	9.4E-10	6.8E-10	5.6E-10	3.8E-10	5.5E-10	4.0E-10	7.0E-10	9.4E-10	1.7E-09	1.4E-09	1.3E-09	1.1E-09	0.1
0.2	2.6E-07	1.5E-07	1.3E-07	8.3E-08	1.8E-07	1.4E-07	1.1E-07	7.8E-08	1.1E-07	7.8E-08	1.4E-07	1.8E-07	3.3E-07	2.7E-07	2.4E-07	2.1E-07	0.2
0.3	4.9E-07	2.9E-07	2.5E-07	1.6E-07	3.6E-07	2.7E-07	2.3E-07	1.6E-07	2.1E-07	1.5E-07	2.7E-07	3.5E-07	6.2E-07	5.0E-07	4.5E-07	3.9E-07	0.3
0.4	4.1E-07	2.5E-07	2.1E-07	1.5E-07	3.2E-07	2.4E-07	2.1E-07	1.5E-07	1.9E-07	1.3E-07	2.3E-07	3.0E-07	5.1E-07	4.2E-07	3.8E-07	3.2E-07	0.4
0.5	3.1E-07	1.9E-07	1.7E-07	1.2E-07	2.7E-07	2.0E-07	1.8E-07	1.3E-07	1.6E-07	1.1E-07	1.9E-07	2.4E-07	4.0E-07	3.2E-07	2.9E-07	2.5E-07	0.5
0.6	2.6E-07	1.6E-07	1.5E-07	1.1E-07	2.4E-07	1.9E-07	1.6E-07	1.2E-07	1.4E-07	1.0E-07	1.7E-07	2.1E-07	3.3E-07	2.7E-07	2.4E-07	2.0E-07	0.6
0.7	2.3E-07	1.5E-07	1.3E-07	1.1E-07	2.3E-07	1.8E-07	1.6E-07	1.2E-07	1.4E-07	1.0E-07	1.6E-07	1.9E-07	3.1E-07	2.4E-07	2.1E-07	1.8E-07	0.7
0.8	2.2E-07	1.4E-07	1.3E-07	1.1E-07	2.3E-07	1.9E-07	1.6E-07	1.2E-07	1.5E-07	1.0E-07	1.6E-07	1.9E-07	3.0E-07	2.3E-07	1.9E-07	1.7E-07	0.8
0.9	2.1E-07	1.4E-07	1.2E-07	1.1E-07	2.3E-07	1.9E-07	1.7E-07	1.2E-07	1.5E-07	1.1E-07	1.6E-07	1.9E-07	3.0E-07	2.2E-07	1.9E-07	1.6E-07	0.9
1.0	2.1E-07	1.4E-07	1.2E-07	1.2E-07	2.4E-07	2.0E-07	1.7E-07	1.3E-07	1.5E-07	1.1E-07	1.6E-07	2.0E-07	3.1E-07	2.2E-07	1.8E-07	1.6E-07	1.0
2.4	1.5E-07	1.0E-07	9.5E-08	1.1E-07	2.2E-07	1.7E-07	1.4E-07	1.0E-07	1.3E-07	9.5E-08	1.3E-07	1.7E-07	2.7E-07	1.8E-07	1.4E-07	1.2E-07	2.4
4.0	1.0E-07	6.7E-08	6.5E-08	7.6E-08	1.5E-07	1.1E-07	9.2E-08	6.7E-08	8.6E-08	6.4E-08	8.9E-08	1.2E-07	1.9E-07	1.2E-07	9.3E-08	8.0E-08	4.0
5.6	7.4E-08	4.8E-08	4.8E-08	5.7E-08	1.1E-07	8.0E-08	6.6E-08	4.8E-08	6.1E-08	4.7E-08	6.5E-08	9.0E-08	1.4E-07	9.0E-08	6.8E-08	5.9E-08	5.6
7.2	5.7E-08	3.7E-08	3.7E-08	4.5E-08	8.8E-08	6.2E-08	5.1E-08	3.7E-08	4.7E-08	3.6E-08	5.0E-08	7.1E-08	1.1E-07	7.1E-08	5.4E-08	4.6E-08	7.2
12.1	3.3E-08	2.2E-08	2.2E-08	2.7E-08	5.2E-08	3.5E-08	2.9E-08	2.1E-08	2.7E-08	2.1E-08	2.9E-08	4.2E-08	6.6E-08	4.2E-08	3.2E-08	2.7E-08	12.1
24.1	1.5E-08	9.9E-09	1.0E-08	1.3E-08	2.5E-08	1.6E-08	1.3E-08	9.1E-09	1.2E-08	9.3E-09	1.3E-08	2.0E-08	3.1E-08	2.0E-08	1.5E-08	1.3E-08	24.1
40.3	8.2E-09	5.5E-09	5.6E-09	7.3E-09	1.4E-08	8.5E-09	6.9E-09	4.9E-09	6.4E-09	5.1E-09	7.2E-09	1.1E-08	1.8E-08	1.1E-08	8.5E-09	7.2E-09	40.3
56.3	5.5E-09	3.7E-09	3.8E-09	5.0E-09	9.3E-09	5.7E-09	4.6E-09	3.3E-09	4.3E-09	3.4E-09	4.9E-09	7.4E-09	1.2E-08	7.4E-09	5.7E-09	4.9E-09	56.3
72.4	4.1E-09	2.7E-09	2.8E-09	3.7E-09	6.9E-09	4.2E-09	3.4E-09	2.4E-09	3.1E-09	2.5E-09	3.6E-09	5.5E-09	8.9E-09	5.5E-09	4.3E-09	3.7E-09	72.4

TABLE H.4.4. $\overline{\chi}/Q'$ Values (sec m^{-3}) for Chronic **90-m Stack** Releases from **100 N Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 100 N Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	2.2E-14	1.3E-14	1.1E-14	7.4E-15	1.5E-14	1.2E-14	8.9E-15	6.3E-15	8.7E-15	6.8E-15	1.1E-14	1.6E-14	2.7E-14	2.3E-14	2.1E-14	1.8E-14	0.1
0.2	1.6E-08	9.0E-09	7.5E-09	5.2E-09	1.1E-08	8.2E-09	6.3E-09	4.5E-09	6.1E-09	4.8E-09	8.1E-09	1.1E-08	1.9E-08	1.6E-08	1.5E-08	1.2E-08	0.2
0.3	1.8E-07	1.1E-07	8.9E-08	6.2E-08	1.3E-07	9.8E-08	7.6E-08	5.4E-08	7.3E-08	5.7E-08	9.6E-08	1.3E-07	2.3E-07	1.9E-07	1.7E-07	1.5E-07	0.3
0.4	2.3E-07	1.4E-07	1.2E-07	8.0E-08	1.6E-07	1.3E-07	1.0E-07	7.4E-08	9.4E-08	7.4E-08	1.3E-07	1.7E-07	2.9E-07	2.4E-07	2.2E-07	1.9E-07	0.4
0.5	1.9E-07	1.1E-07	9.8E-08	7.0E-08	1.4E-07	1.1E-07	9.1E-08	6.8E-08	8.1E-08	6.4E-08	1.1E-07	1.4E-07	2.4E-07	2.0E-07	1.8E-07	1.5E-07	0.5
0.6	1.5E-07	9.2E-08	8.0E-08	5.8E-08	1.2E-07	9.6E-08	7.9E-08	5.9E-08	6.8E-08	5.3E-08	8.9E-08	1.1E-07	1.9E-07	1.6E-07	1.4E-07	1.2E-07	0.6
0.7	1.2E-07	7.5E-08	6.6E-08	5.0E-08	1.0E-07	8.2E-08	6.9E-08	5.2E-08	5.8E-08	4.5E-08	7.4E-08	9.5E-08	1.6E-07	1.3E-07	1.2E-07	9.9E-08	0.7
0.8	1.1E-07	6.4E-08	5.7E-08	4.5E-08	8.9E-08	7.3E-08	6.2E-08	4.7E-08	5.2E-08	4.0E-08	6.5E-08	8.1E-08	1.3E-07	1.1E-07	9.7E-08	8.3E-08	0.8
0.9	9.3E-08	5.6E-08	5.1E-08	4.1E-08	8.1E-08	6.7E-08	5.8E-08	4.3E-08	4.8E-08	3.7E-08	5.9E-08	7.3E-08	1.2E-07	9.3E-08	8.4E-08	7.3E-08	0.9
1.0	8.4E-08	5.2E-08	4.7E-08	3.9E-08	7.7E-08	6.5E-08	5.6E-08	4.2E-08	4.7E-08	3.6E-08	5.5E-08	6.8E-08	1.1E-07	8.5E-08	7.6E-08	6.6E-08	1.0
2.4	6.9E-08	4.5E-08	4.0E-08	4.1E-08	8.5E-08	7.1E-08	6.1E-08	4.4E-08	5.4E-08	4.0E-08	5.6E-08	7.0E-08	1.1E-07	7.4E-08	6.1E-08	5.3E-08	2.4
4.0	5.4E-08	3.5E-08	3.2E-08	3.5E-08	7.3E-08	5.8E-08	4.9E-08	3.6E-08	4.5E-08	3.3E-08	4.6E-08	6.0E-08	9.3E-08	6.1E-08	4.8E-08	4.2E-08	4.0
5.6	4.2E-08	2.8E-08	2.6E-08	2.9E-08	6.0E-08	4.6E-08	3.9E-08	2.9E-08	3.6E-08	2.7E-08	3.7E-08	4.9E-08	7.6E-08	4.9E-08	3.8E-08	3.3E-08	5.6
7.2	3.4E-08	2.3E-08	2.1E-08	2.4E-08	5.0E-08	3.7E-08	3.1E-08	2.3E-08	2.9E-08	2.2E-08	3.0E-08	4.0E-08	6.3E-08	4.0E-08	3.1E-08	2.7E-08	7.2
12.1	2.1E-08	1.4E-08	1.4E-08	1.6E-08	3.2E-08	2.3E-08	1.9E-08	1.4E-08	1.8E-08	1.4E-08	1.9E-08	2.6E-08	4.0E-08	2.6E-08	2.0E-08	1.7E-08	12.1
24.1	1.0E-08	6.9E-09	6.8E-09	8.2E-09	1.6E-08	1.1E-08	9.2E-09	6.7E-09	8.5E-09	6.6E-09	9.2E-09	1.3E-08	2.1E-08	1.3E-08	1.0E-08	8.7E-09	24.1
40.3	6.0E-09	4.0E-09	4.0E-09	4.9E-09	9.5E-09	6.2E-09	5.2E-09	3.8E-09	4.8E-09	3.8E-09	5.3E-09	7.8E-09	1.2E-08	7.8E-09	6.0E-09	5.1E-09	40.3
56.3	4.1E-09	2.8E-09	2.8E-09	3.5E-09	6.6E-09	4.3E-09	3.6E-09	2.6E-09	3.3E-09	2.6E-09	3.7E-09	5.4E-09	8.6E-09	5.5E-09	4.2E-09	3.6E-09	56.3
72.4	3.1E-09	2.1E-09	2.1E-09	2.7E-09	5.0E-09	3.2E-09	2.7E-09	1.9E-09	2.5E-09	2.0E-09	2.8E-09	4.2E-09	6.6E-09	4.2E-09	3.2E-09	2.7E-09	72.4

TABLE H.4.5. $\overline{\chi}/Q'$ Values (sec m^{-3}) for Chronic **Ground-Level** Releases from **200 Areas** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 200 Areas **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	1.7E-04	1.0E-04	9.9E-05	1.0E-04	1.7E-04	1.4E-04	1.6E-04	1.5E-04	1.6E-04	9.0E-05	1.1E-04	1.4E-04	3.8E-04	4.0E-04	2.5E-04	1.5E-04	0.1
0.2	4.6E-05	2.8E-05	2.7E-05	2.7E-05	4.7E-05	3.8E-05	4.3E-05	4.3E-05	4.5E-05	2.5E-05	3.0E-05	3.9E-05	1.1E-04	1.1E-04	6.9E-05	4.0E-05	0.2
0.3	2.2E-05	1.3E-05	1.3E-05	1.3E-05	2.2E-05	1.8E-05	2.1E-05	2.0E-05	2.1E-05	1.2E-05	1.4E-05	1.9E-05	5.0E-05	5.3E-05	3.3E-05	1.9E-05	0.3
0.4	1.3E-05	7.8E-06	7.5E-06	7.5E-06	1.3E-05	1.1E-05	1.2E-05	1.2E-05	1.3E-05	7.1E-06	8.4E-06	1.1E-05	3.0E-05	3.2E-05	2.0E-05	1.1E-05	0.4
0.5	8.4E-06	5.2E-06	5.0E-06	5.0E-06	8.7E-06	7.1E-06	8.2E-06	8.1E-06	8.6E-06	4.8E-06	5.7E-06	7.5E-06	2.0E-05	2.2E-05	1.3E-05	7.5E-06	0.5
0.6	6.1E-06	3.7E-06	3.6E-06	3.6E-06	6.3E-06	5.1E-06	5.9E-06	5.9E-06	6.2E-06	3.5E-06	4.1E-06	5.4E-06	1.5E-05	1.6E-05	9.5E-06	5.4E-06	0.6
0.7	4.6E-06	2.8E-06	2.7E-06	2.7E-06	4.8E-06	3.9E-06	4.5E-06	4.5E-06	4.7E-06	2.6E-06	3.1E-06	4.1E-06	1.1E-05	1.2E-05	7.2E-06	4.1E-06	0.7
0.8	3.6E-06	2.2E-06	2.1E-06	2.1E-06	3.8E-06	3.1E-06	3.5E-06	3.5E-06	3.7E-06	2.1E-06	2.5E-06	3.3E-06	8.8E-06	9.4E-06	5.7E-06	3.2E-06	0.8
0.9	2.9E-06	1.8E-06	1.7E-06	1.7E-06	3.1E-06	2.5E-06	2.9E-06	2.9E-06	3.0E-06	1.7E-06	2.0E-06	2.7E-06	7.2E-06	7.6E-06	4.6E-06	2.6E-06	0.9
1.0	2.4E-06	1.5E-06	1.4E-06	1.4E-06	2.5E-06	2.1E-06	2.4E-06	2.4E-06	2.5E-06	1.4E-06	1.7E-06	2.2E-06	6.0E-06	6.3E-06	3.9E-06	2.2E-06	1.0
2.4	5.5E-07	3.4E-07	3.3E-07	3.3E-07	5.8E-07	4.8E-07	5.5E-07	5.5E-07	5.8E-07	3.3E-07	3.9E-07	5.1E-07	1.4E-06	1.5E-06	8.9E-07	5.0E-07	2.4
4.0	2.5E-07	1.5E-07	1.5E-07	1.5E-07	2.6E-07	2.2E-07	2.5E-07	2.5E-07	2.7E-07	1.5E-07	1.8E-07	2.3E-07	6.4E-07	6.7E-07	4.1E-07	2.3E-07	4.0
5.6	1.5E-07	9.1E-08	8.9E-08	8.9E-08	1.6E-07	1.3E-07	1.5E-07	1.5E-07	1.6E-07	9.1E-08	1.1E-07	1.4E-07	3.9E-07	4.1E-07	2.5E-07	1.4E-07	5.6
7.2	1.0E-07	6.2E-08	6.1E-08	6.1E-08	1.1E-07	9.1E-08	1.1E-07	1.1E-07	1.1E-07	6.3E-08	7.5E-08	9.9E-08	2.7E-07	2.9E-07	1.7E-07	9.4E-08	7.2
12.1	4.9E-08	3.0E-08	2.9E-08	2.9E-08	5.3E-08	4.4E-08	5.1E-08	5.2E-08	5.5E-08	3.1E-08	3.6E-08	4.8E-08	1.3E-07	1.4E-07	8.2E-08	4.5E-08	12.1
24.1	1.9E-08	1.1E-08	1.1E-08	1.1E-08	2.0E-08	1.7E-08	2.0E-08	2.0E-08	2.1E-08	1.2E-08	1.4E-08	1.9E-08	5.1E-08	5.3E-08	3.1E-08	1.7E-08	24.1
40.3	9.2E-09	5.5E-09	5.5E-09	5.5E-09	1.0E-08	8.4E-09	9.8E-09	1.0E-08	1.1E-08	6.0E-09	7.0E-09	9.3E-09	2.6E-08	2.7E-08	1.6E-08	8.6E-09	40.3
56.3	5.9E-09	3.5E-09	3.5E-09	3.5E-09	6.4E-09	5.3E-09	6.3E-09	6.4E-09	6.9E-09	3.8E-09	4.5E-09	6.0E-09	1.7E-08	1.7E-08	1.0E-08	5.5E-09	56.3
72.4	4.2E-09	2.5E-09	2.5E-09	2.5E-09	4.6E-09	3.8E-09	4.5E-09	4.6E-09	5.0E-09	2.7E-09	3.2E-09	4.3E-09	1.2E-08	1.2E-08	7.1E-09	3.9E-09	72.4

TABLE H.4.6. $\overline{\chi}/Q'$ Values (sec m^{-3}) for Chronic **30-m Stack** Releases from **200 Areas** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 200 Areas **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	1.2E-06	7.4E-07	6.2E-07	6.6E-07	1.1E-06	7.5E-07	6.0E-07	3.9E-07	3.7E-07	2.1E-07	2.8E-07	4.2E-07	5.1E-07	5.5E-07	7.5E-07	7.5E-07	0.1
0.2	2.0E-06	1.3E-06	1.1E-06	1.2E-06	1.8E-06	1.3E-06	1.0E-06	6.7E-07	6.5E-07	3.5E-07	4.5E-07	6.9E-07	8.6E-07	9.7E-07	1.3E-06	1.3E-06	0.2
0.3	1.7E-06	1.1E-06	9.0E-07	9.8E-07	1.5E-06	1.0E-06	9.0E-07	6.0E-07	5.6E-07	3.1E-07	3.9E-07	5.6E-07	8.1E-07	9.9E-07	1.2E-06	1.1E-06	0.3
0.4	1.5E-06	9.9E-07	8.3E-07	8.7E-07	1.3E-06	9.1E-07	8.4E-07	5.9E-07	5.4E-07	3.1E-07	3.9E-07	5.2E-07	9.0E-07	1.2E-06	1.2E-06	1.0E-06	0.4
0.5	1.3E-06	9.0E-07	7.7E-07	7.9E-07	1.2E-06	8.3E-07	8.0E-07	5.9E-07	5.3E-07	3.1E-07	4.0E-07	5.2E-07	9.9E-07	1.3E-06	1.2E-06	9.5E-07	0.5
0.6	1.2E-06	8.2E-07	7.1E-07	7.1E-07	1.1E-06	7.7E-07	7.5E-07	5.8E-07	5.2E-07	3.1E-07	4.0E-07	5.1E-07	1.0E-06	1.4E-06	1.2E-06	8.8E-07	0.6
0.7	1.1E-06	7.4E-07	6.4E-07	6.4E-07	9.7E-07	7.0E-07	7.0E-07	5.6E-07	5.1E-07	3.0E-07	3.9E-07	4.9E-07	1.1E-06	1.4E-06	1.1E-06	8.1E-07	0.7
0.8	9.9E-07	6.6E-07	5.8E-07	5.8E-07	8.8E-07	6.4E-07	6.5E-07	5.3E-07	4.8E-07	2.9E-07	3.7E-07	4.7E-07	1.0E-06	1.3E-06	1.1E-06	7.5E-07	0.8
0.9	9.0E-07	5.9E-07	5.3E-07	5.2E-07	8.0E-07	5.9E-07	6.0E-07	5.0E-07	4.6E-07	2.8E-07	3.5E-07	4.5E-07	1.0E-06	1.3E-06	1.0E-06	6.8E-07	0.9
1.0	8.1E-07	5.4E-07	4.8E-07	4.7E-07	7.3E-07	5.4E-07	5.5E-07	4.7E-07	4.4E-07	2.6E-07	3.4E-07	4.2E-07	9.7E-07	1.2E-06	9.3E-07	6.2E-07	1.0
2.4	2.9E-07	1.9E-07	1.7E-07	1.7E-07	2.8E-07	2.1E-07	2.3E-07	2.1E-07	2.1E-07	1.3E-07	1.5E-07	2.0E-07	4.9E-07	5.7E-07	3.9E-07	2.4E-07	2.4
4.0	1.5E-07	9.3E-08	8.6E-08	8.4E-08	1.4E-07	1.1E-07	1.2E-07	1.2E-07	1.2E-07	6.9E-08	8.4E-08	1.1E-07	2.8E-07	3.2E-07	2.1E-07	1.2E-07	4.0
5.6	9.2E-08	5.8E-08	5.4E-08	5.3E-08	9.1E-08	7.2E-08	8.0E-08	7.7E-08	7.9E-08	4.6E-08	5.5E-08	7.3E-08	1.9E-07	2.1E-07	1.3E-07	7.9E-08	5.6
7.2	6.5E-08	4.1E-08	3.8E-08	3.8E-08	6.5E-08	5.1E-08	5.8E-08	5.6E-08	5.8E-08	3.3E-08	4.0E-08	5.3E-08	1.4E-07	1.5E-07	9.6E-08	5.7E-08	7.2
12.1	3.2E-08	2.0E-08	1.9E-08	1.9E-08	3.3E-08	2.6E-08	3.0E-08	2.9E-08	3.0E-08	1.7E-08	2.1E-08	2.7E-08	7.2E-08	7.8E-08	4.9E-08	2.8E-08	12.1
24.1	1.3E-08	7.8E-09	7.4E-09	7.4E-09	1.3E-08	1.1E-08	1.2E-08	1.2E-08	1.2E-08	7.1E-09	8.4E-09	1.1E-08	3.0E-08	3.2E-08	2.0E-08	1.1E-08	24.1
40.3	6.4E-09	3.9E-09	3.7E-09	3.7E-09	6.6E-09	5.4E-09	6.1E-09	6.1E-09	6.5E-09	3.6E-09	4.3E-09	5.8E-09	1.5E-08	1.6E-08	1.0E-08	5.7E-09	40.3
56.3	4.1E-09	2.5E-09	2.4E-09	2.4E-09	4.3E-09	3.5E-09	4.0E-09	4.0E-09	4.2E-09	2.4E-09	2.8E-09	3.7E-09	1.0E-08	1.1E-08	6.4E-09	3.7E-09	56.3
72.4	2.9E-09	1.8E-09	1.7E-09	1.7E-09	3.1E-09	2.5E-09	2.9E-09	2.9E-09	3.0E-09	1.7E-09	2.0E-09	2.7E-09	7.2E-09	7.6E-09	4.6E-09	2.6E-09	72.4

TABLE H.4.7. $\overline{\chi}/Q'$ Values (sec m^{-3}) for Chronic **60-m Stack** Releases from **200 Areas** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 200 Areas **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	1.5E-09	9.3E-10	7.9E-10	8.7E-10	1.4E-09	1.0E-09	8.2E-10	5.0E-10	4.9E-10	2.9E-10	3.6E-10	5.3E-10	6.6E-10	7.0E-10	9.1E-10	9.0E-10	0.1
0.2	3.0E-07	1.8E-07	1.5E-07	1.7E-07	2.8E-07	2.0E-07	1.6E-07	9.6E-08	9.5E-08	5.5E-08	6.8E-08	1.0E-07	1.3E-07	1.4E-07	1.8E-07	1.8E-07	0.2
0.3	5.6E-07	3.5E-07	2.9E-07	3.3E-07	5.3E-07	3.7E-07	3.0E-07	1.8E-07	1.9E-07	1.0E-07	1.3E-07	1.9E-07	2.4E-07	2.6E-07	3.5E-07	3.4E-07	0.3
0.4	4.7E-07	3.1E-07	2.5E-07	2.8E-07	4.4E-07	3.1E-07	2.6E-07	1.6E-07	1.6E-07	8.6E-08	1.0E-07	1.6E-07	2.0E-07	2.2E-07	3.0E-07	2.9E-07	0.4
0.5	3.6E-07	2.4E-07	1.9E-07	2.2E-07	3.4E-07	2.4E-07	2.0E-07	1.2E-07	1.3E-07	6.6E-08	7.8E-08	1.2E-07	1.6E-07	1.8E-07	2.5E-07	2.3E-07	0.5
0.6	3.0E-07	2.1E-07	1.6E-07	1.9E-07	2.8E-07	2.0E-07	1.7E-07	1.1E-07	1.1E-07	5.6E-08	6.6E-08	1.0E-07	1.4E-07	1.6E-07	2.2E-07	2.0E-07	0.6
0.7	2.7E-07	1.8E-07	1.5E-07	1.7E-07	2.5E-07	1.8E-07	1.6E-07	1.0E-07	9.6E-08	5.3E-08	6.2E-08	9.0E-08	1.3E-07	1.6E-07	2.1E-07	1.8E-07	0.7
0.8	2.6E-07	1.7E-07	1.4E-07	1.6E-07	2.3E-07	1.7E-07	1.5E-07	1.0E-07	9.3E-08	5.2E-08	6.3E-08	8.6E-08	1.4E-07	1.7E-07	2.1E-07	1.7E-07	0.8
0.9	2.5E-07	1.7E-07	1.3E-07	1.5E-07	2.2E-07	1.6E-07	1.5E-07	1.0E-07	9.2E-08	5.3E-08	6.5E-08	8.5E-08	1.4E-07	1.8E-07	2.1E-07	1.7E-07	0.9
1.0	2.4E-07	1.6E-07	1.3E-07	1.5E-07	2.2E-07	1.6E-07	1.5E-07	1.1E-07	9.3E-08	5.5E-08	6.7E-08	8.6E-08	1.5E-07	2.0E-07	2.1E-07	1.7E-07	1.0
2.4	1.5E-07	1.0E-07	8.6E-08	8.9E-08	1.4E-07	1.1E-07	1.1E-07	9.6E-08	8.7E-08	5.2E-08	6.3E-08	7.9E-08	1.7E-07	2.1E-07	1.7E-07	1.2E-07	2.4
4.0	9.3E-08	6.0E-08	5.2E-08	5.3E-08	8.9E-08	7.0E-08	7.4E-08	6.8E-08	6.4E-08	3.7E-08	4.5E-08	5.7E-08	1.3E-07	1.5E-07	1.1E-07	7.4E-08	4.0
5.6	6.4E-08	4.1E-08	3.6E-08	3.6E-08	6.2E-08	5.0E-08	5.4E-08	5.1E-08	4.9E-08	2.8E-08	3.3E-08	4.3E-08	9.8E-08	1.1E-07	8.2E-08	5.2E-08	5.6
7.2	4.8E-08	3.0E-08	2.7E-08	2.7E-08	4.7E-08	3.8E-08	4.2E-08	4.0E-08	3.9E-08	2.2E-08	2.6E-08	3.4E-08	7.8E-08	8.8E-08	6.3E-08	3.9E-08	7.2
12.1	2.6E-08	1.6E-08	1.4E-08	1.5E-08	2.6E-08	2.1E-08	2.4E-08	2.4E-08	2.4E-08	1.3E-08	1.5E-08	2.1E-08	4.8E-08	5.2E-08	3.6E-08	2.2E-08	12.1
24.1	1.1E-08	6.7E-09	6.1E-09	6.1E-09	1.1E-08	9.6E-09	1.1E-08	1.2E-08	1.2E-08	6.2E-09	7.2E-09	9.7E-09	2.4E-08	2.4E-08	1.6E-08	9.5E-09	24.1
40.3	5.7E-09	3.5E-09	3.2E-09	3.3E-09	6.1E-09	5.2E-09	6.2E-09	6.6E-09	6.6E-09	3.5E-09	4.0E-09	5.4E-09	1.3E-08	1.3E-08	8.8E-09	5.1E-09	40.3
56.3	3.7E-09	2.3E-09	2.1E-09	2.1E-09	4.1E-09	3.5E-09	4.2E-09	4.5E-09	4.5E-09	2.4E-09	2.7E-09	3.7E-09	9.2E-09	9.1E-09	5.9E-09	3.4E-09	56.3
72.4	2.7E-09	1.7E-09	1.6E-09	1.6E-09	3.0E-09	2.6E-09	3.1E-09	3.4E-09	3.4E-09	1.8E-09	2.0E-09	2.7E-09	6.9E-09	6.7E-09	4.3E-09	2.5E-09	72.4

TABLE H.4.8. $\overline{\chi}/Q'$ Values (sec m^{-3}) for Chronic **90-m Stack** Releases from **200 Areas** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 200 Areas **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	2.5E-14	1.5E-14	1.3E-14	1.4E-14	2.4E-14	1.7E-14	1.3E-14	8.6E-15	8.1E-15	4.3E-15	5.7E-15	8.6E-15	1.1E-14	1.1E-14	1.5E-14	1.5E-14	0.1
0.2	1.8E-08	1.0E-08	9.1E-09	1.0E-08	1.7E-08	1.2E-08	9.5E-09	6.1E-09	5.7E-09	3.1E-09	4.0E-09	6.1E-09	7.4E-09	8.0E-09	1.1E-08	1.1E-08	0.2
0.3	2.1E-07	1.2E-07	1.1E-07	1.2E-07	2.0E-07	1.4E-07	1.1E-07	7.2E-08	6.8E-08	3.6E-08	4.7E-08	7.2E-08	8.8E-08	9.6E-08	1.3E-07	1.2E-07	0.3
0.4	2.6E-07	1.6E-07	1.4E-07	1.6E-07	2.5E-07	1.8E-07	1.4E-07	9.0E-08	8.8E-08	4.6E-08	5.9E-08	9.0E-08	1.1E-07	1.2E-07	1.6E-07	1.6E-07	0.4
0.5	2.2E-07	1.4E-07	1.2E-07	1.3E-07	2.1E-07	1.5E-07	1.2E-07	7.5E-08	7.6E-08	3.9E-08	4.8E-08	7.5E-08	9.4E-08	1.1E-07	1.4E-07	1.4E-07	0.5
0.6	1.8E-07	1.1E-07	9.5E-08	1.1E-07	1.7E-07	1.2E-07	9.7E-08	5.9E-08	6.1E-08	3.1E-08	3.7E-08	5.8E-08	7.6E-08	8.5E-08	1.2E-07	1.1E-07	0.6
0.7	1.5E-07	9.6E-08	7.8E-08	8.9E-08	1.4E-07	9.8E-08	8.1E-08	4.8E-08	5.0E-08	2.5E-08	3.0E-08	4.7E-08	6.2E-08	7.1E-08	9.7E-08	9.2E-08	0.7
0.8	1.2E-07	8.3E-08	6.7E-08	7.6E-08	1.2E-07	8.3E-08	6.9E-08	4.1E-08	4.3E-08	2.1E-08	2.5E-08	3.9E-08	5.4E-08	6.2E-08	8.6E-08	7.9E-08	0.8
0.9	1.1E-07	7.4E-08	5.9E-08	6.8E-08	1.0E-07	7.3E-08	6.2E-08	3.7E-08	3.8E-08	1.9E-08	2.2E-08	3.4E-08	4.8E-08	5.6E-08	7.8E-08	7.0E-08	0.9
1.0	9.9E-08	6.8E-08	5.4E-08	6.2E-08	9.2E-08	6.6E-08	5.7E-08	3.5E-08	3.5E-08	1.8E-08	2.0E-08	3.0E-08	4.5E-08	5.4E-08	7.4E-08	6.5E-08	1.0
2.4	7.8E-08	5.1E-08	4.4E-08	4.7E-08	7.1E-08	5.2E-08	5.1E-08	3.9E-08	3.3E-08	2.0E-08	2.4E-08	2.9E-08	5.6E-08	7.5E-08	7.3E-08	5.5E-08	2.4
4.0	5.8E-08	3.7E-08	3.3E-08	3.4E-08	5.3E-08	4.0E-08	4.0E-08	3.4E-08	2.9E-08	1.7E-08	2.1E-08	2.6E-08	5.3E-08	6.9E-08	6.0E-08	4.3E-08	4.0
5.6	4.3E-08	2.8E-08	2.4E-08	2.5E-08	4.0E-08	3.1E-08	3.2E-08	2.8E-08	2.5E-08	1.4E-08	1.8E-08	2.1E-08	4.6E-08	5.8E-08	4.8E-08	3.3E-08	5.6
7.2	3.4E-08	2.2E-08	1.9E-08	2.0E-08	3.2E-08	2.5E-08	2.6E-08	2.3E-08	2.1E-08	1.2E-08	1.5E-08	1.8E-08	3.9E-08	4.9E-08	3.9E-08	2.6E-08	7.2
12.1	1.9E-08	1.2E-08	1.1E-08	1.1E-08	1.9E-08	1.5E-08	1.6E-08	1.5E-08	1.4E-08	7.8E-09	9.4E-09	1.2E-08	2.7E-08	3.2E-08	2.4E-08	1.6E-08	12.1
24.1	8.6E-09	5.5E-09	4.9E-09	5.0E-09	8.6E-09	7.1E-09	7.7E-09	7.6E-09	7.4E-09	4.0E-09	4.8E-09	6.2E-09	1.5E-08	1.7E-08	1.2E-08	7.3E-09	24.1
40.3	4.7E-09	3.0E-09	2.7E-09	2.7E-09	4.8E-09	4.0E-09	4.5E-09	4.6E-09	4.5E-09	2.4E-09	2.8E-09	3.7E-09	8.9E-09	9.9E-09	6.8E-09	4.1E-09	40.3
56.3	3.1E-09	2.0E-09	1.8E-09	1.8E-09	3.3E-09	2.8E-09	3.1E-09	3.2E-09	3.2E-09	1.7E-09	2.0E-09	2.6E-09	6.4E-09	6.9E-09	4.7E-09	2.7E-09	56.3
72.4	2.3E-09	1.4E-09	1.3E-09	1.4E-09	2.4E-09	2.1E-09	2.4E-09	2.5E-09	2.5E-09	1.3E-09	1.5E-09	2.0E-09	5.0E-09	5.3E-09	3.5E-09	2.1E-09	72.4

TABLE H.4.9. $\overline{\chi}/Q'$ Values (sec m^{-3}) for Chronic **Ground-Level** Releases from **300 Area** Based on 1983 Through 1991 Meteorological Information

Distance	Sector (Wind from 300 Area **Towards** Direction Indicated)																Distance
(km)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	(km)
0.1	2.9E-04	9.0E-05	5.1E-05	4.4E-05	1.2E-04	2.0E-04	2.8E-04	2.3E-04	3.0E-04	1.9E-04	1.9E-04	1.4E-04	1.7E-04	1.3E-04	1.8E-04	2.4E-04	0.1
0.2	7.8E-05	2.5E-05	1.4E-05	1.2E-05	3.2E-05	5.4E-05	7.6E-05	6.2E-05	8.3E-05	5.2E-05	5.3E-05	3.9E-05	4.6E-05	3.7E-05	4.8E-05	6.5E-05	0.2
0.3	3.8E-05	1.2E-05	6.5E-06	5.6E-06	1.5E-05	2.6E-05	3.7E-05	3.0E-05	4.0E-05	2.5E-05	2.5E-05	1.8E-05	2.2E-05	1.8E-05	2.3E-05	3.1E-05	0.3
0.4	2.2E-05	6.9E-06	3.8E-06	3.3E-06	8.8E-06	1.5E-05	2.2E-05	1.8E-05	2.4E-05	1.5E-05	1.5E-05	1.1E-05	1.3E-05	1.1E-05	1.4E-05	1.9E-05	0.4
0.5	1.5E-05	4.6E-06	2.5E-06	2.2E-06	5.9E-06	1.0E-05	1.5E-05	1.2E-05	1.6E-05	1.0E-05	1.0E-05	7.3E-06	8.8E-06	7.1E-06	9.3E-06	1.3E-05	0.5
0.6	1.1E-05	3.3E-06	1.8E-06	1.6E-06	4.2E-06	7.4E-06	1.1E-05	8.6E-06	1.2E-05	7.2E-06	7.3E-06	5.3E-06	6.4E-06	5.1E-06	6.7E-06	9.1E-06	0.6
0.7	8.3E-06	2.5E-06	1.4E-06	1.2E-06	3.2E-06	5.6E-06	8.1E-06	6.6E-06	8.8E-06	5.5E-06	5.5E-06	4.0E-06	4.9E-06	3.9E-06	5.1E-06	6.9E-06	0.7
0.8	6.5E-06	2.0E-06	1.1E-06	9.3E-07	2.5E-06	4.5E-06	6.4E-06	5.2E-06	6.9E-06	4.3E-06	4.4E-06	3.2E-06	3.9E-06	3.1E-06	4.1E-06	5.5E-06	0.8
0.9	5.3E-06	1.6E-06	8.7E-07	7.6E-07	2.1E-06	3.6E-06	5.2E-06	4.2E-06	5.6E-06	3.5E-06	3.6E-06	2.6E-06	3.1E-06	2.5E-06	3.3E-06	4.4E-06	0.9
1.0	4.4E-06	1.3E-06	7.2E-07	6.3E-07	1.7E-06	3.0E-06	4.3E-06	3.5E-06	4.7E-06	2.9E-06	3.0E-06	2.2E-06	2.6E-06	2.1E-06	2.7E-06	3.7E-06	1.0
2.4	1.0E-06	3.1E-07	1.7E-07	1.4E-07	3.9E-07	6.9E-07	1.0E-06	8.1E-07	1.1E-06	6.7E-07	6.8E-07	5.0E-07	6.0E-07	4.9E-07	6.4E-07	8.5E-07	2.4
4.0	4.7E-07	1.4E-07	7.5E-08	6.4E-08	1.8E-07	3.2E-07	4.6E-07	3.7E-07	5.0E-07	3.1E-07	3.1E-07	2.3E-07	2.8E-07	2.2E-07	2.9E-07	3.9E-07	4.0
5.6	2.8E-07	8.4E-08	4.5E-08	3.9E-08	1.1E-07	1.9E-07	2.8E-07	2.3E-07	3.0E-07	1.9E-07	1.9E-07	1.4E-07	1.7E-07	1.4E-07	1.8E-07	2.4E-07	5.6
7.2	2.0E-07	5.8E-08	3.1E-08	2.7E-08	7.4E-08	1.3E-07	2.0E-07	1.6E-07	2.1E-07	1.3E-07	1.3E-07	9.5E-08	1.2E-07	9.4E-08	1.2E-07	1.6E-07	7.2
12.1	9.6E-08	2.8E-08	1.5E-08	1.3E-08	3.6E-08	6.5E-08	9.5E-08	7.7E-08	1.0E-07	6.3E-08	6.3E-08	4.6E-08	5.6E-08	4.6E-08	6.0E-08	7.9E-08	12.1
24.1	3.7E-08	1.1E-08	5.7E-09	4.9E-09	1.4E-08	2.5E-08	3.7E-08	3.0E-08	3.9E-08	2.4E-08	2.4E-08	1.8E-08	2.2E-08	1.8E-08	2.3E-08	3.0E-08	24.1
40.3	1.8E-08	5.4E-09	2.9E-09	2.4E-09	6.9E-09	1.3E-08	1.8E-08	1.5E-08	2.0E-08	1.2E-08	1.2E-08	8.8E-09	1.1E-08	8.9E-09	1.1E-08	1.5E-08	40.3
56.3	1.2E-08	3.4E-09	1.8E-09	1.6E-09	4.4E-09	8.0E-09	1.2E-08	9.5E-09	1.3E-08	7.6E-09	7.7E-09	5.6E-09	6.9E-09	5.7E-09	7.3E-09	9.7E-09	56.3
72.4	8.4E-09	2.5E-09	1.3E-09	1.1E-09	3.2E-09	5.7E-09	8.5E-09	6.8E-09	9.0E-09	5.4E-09	5.5E-09	4.0E-09	4.9E-09	4.1E-09	5.2E-09	6.9E-09	72.4

TABLE H.4.10. $\overline{\chi}/Q'$ Values (sec m^{-3}) for Chronic **30-m Stack** Releases from **300 Area** Based on 1983 Through 1991 Meteorological Information

Distance	Sector (Wind from 300 Area **Towards** Direction Indicated)																Distance
(km)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	(km)
0.1	5.2E-07	4.6E-07	4.2E-07	3.8E-07	7.4E-07	4.7E-07	4.8E-07	4.1E-07	4.2E-07	4.5E-07	5.3E-07	4.0E-07	2.2E-07	1.2E-07	1.8E-07	2.9E-07	0.1
0.2	1.0E-06	8.3E-07	7.0E-07	6.5E-07	1.2E-06	8.5E-07	8.9E-07	7.5E-07	8.0E-07	8.1E-07	9.1E-07	7.0E-07	4.3E-07	2.5E-07	3.4E-07	6.0E-07	0.2
0.3	1.0E-06	7.0E-07	5.4E-07	5.2E-07	9.9E-07	7.9E-07	8.5E-07	7.1E-07	8.3E-07	7.8E-07	8.4E-07	6.4E-07	4.7E-07	2.8E-07	4.2E-07	6.9E-07	0.3
0.4	1.1E-06	6.2E-07	4.5E-07	4.3E-07	8.4E-07	7.9E-07	8.8E-07	7.3E-07	9.2E-07	8.1E-07	8.6E-07	6.4E-07	5.4E-07	3.5E-07	5.3E-07	8.3E-07	0.4
0.5	1.1E-06	5.7E-07	3.9E-07	3.7E-07	7.5E-07	8.0E-07	9.1E-07	7.6E-07	1.0E-06	8.4E-07	8.8E-07	6.5E-07	6.0E-07	3.9E-07	6.0E-07	9.0E-07	0.5
0.6	1.1E-06	5.2E-07	3.4E-07	3.3E-07	6.7E-07	7.8E-07	9.1E-07	7.6E-07	1.0E-06	8.3E-07	8.7E-07	6.4E-07	6.2E-07	4.2E-07	6.3E-07	9.2E-07	0.6
0.7	1.1E-06	4.7E-07	3.0E-07	2.9E-07	6.1E-07	7.5E-07	8.8E-07	7.4E-07	1.0E-06	8.0E-07	8.4E-07	6.2E-07	6.1E-07	4.2E-07	6.2E-07	9.0E-07	0.7
0.8	1.0E-06	4.3E-07	2.7E-07	2.6E-07	5.5E-07	7.1E-07	8.5E-07	7.1E-07	9.8E-07	7.6E-07	8.0E-07	5.8E-07	5.9E-07	4.1E-07	6.0E-07	8.6E-07	0.8
0.9	9.5E-07	3.9E-07	2.4E-07	2.3E-07	5.0E-07	6.7E-07	8.1E-07	6.8E-07	9.4E-07	7.2E-07	7.5E-07	5.5E-07	5.6E-07	4.0E-07	5.8E-07	8.2E-07	0.9
1.0	8.9E-07	3.6E-07	2.2E-07	2.1E-07	4.6E-07	6.3E-07	7.7E-07	6.5E-07	8.9E-07	6.7E-07	7.0E-07	5.1E-07	5.3E-07	3.8E-07	5.5E-07	7.7E-07	1.0
2.4	4.0E-07	1.4E-07	8.1E-08	7.4E-08	1.8E-07	2.8E-07	3.7E-07	3.1E-07	4.2E-07	2.9E-07	3.0E-07	2.2E-07	2.4E-07	1.8E-07	2.5E-07	3.4E-07	2.4
4.0	2.2E-07	7.2E-08	4.2E-08	3.7E-08	9.3E-08	1.5E-07	2.1E-07	1.7E-07	2.3E-07	1.6E-07	1.6E-07	1.2E-07	1.3E-07	1.0E-07	1.4E-07	1.9E-07	4.0
5.6	1.4E-07	4.7E-08	2.6E-08	2.4E-08	6.0E-08	1.0E-07	1.4E-07	1.1E-07	1.5E-07	1.0E-07	1.0E-07	7.5E-08	8.6E-08	6.7E-08	9.0E-08	1.2E-07	5.6
7.2	1.0E-07	3.3E-08	1.9E-08	1.7E-08	4.3E-08	7.2E-08	9.9E-08	8.2E-08	1.1E-07	7.3E-08	7.4E-08	5.4E-08	6.3E-08	4.9E-08	6.5E-08	8.8E-08	7.2
12.1	5.4E-08	1.7E-08	9.5E-09	8.3E-09	2.2E-08	3.7E-08	5.2E-08	4.3E-08	5.8E-08	3.7E-08	3.8E-08	2.8E-08	3.2E-08	2.6E-08	3.4E-08	4.5E-08	12.1
24.1	2.2E-08	6.8E-09	3.8E-09	3.3E-09	8.7E-09	1.5E-08	2.1E-08	1.7E-08	2.3E-08	1.5E-08	1.5E-08	1.1E-08	1.3E-08	1.0E-08	1.4E-08	1.8E-08	24.1
40.3	1.1E-08	3.5E-09	1.9E-09	1.7E-09	4.5E-09	7.8E-09	1.1E-08	9.0E-09	1.2E-08	7.6E-09	7.7E-09	5.6E-09	6.7E-09	5.4E-09	7.0E-09	9.4E-09	40.3
56.3	7.3E-09	2.2E-09	1.2E-09	1.1E-09	2.9E-09	5.0E-09	7.2E-09	5.9E-09	7.8E-09	4.9E-09	4.9E-09	3.6E-09	4.3E-09	3.5E-09	4.5E-09	6.0E-09	56.3
72.4	5.2E-09	1.6E-09	9.0E-10	7.8E-10	2.1E-09	3.6E-09	5.2E-09	4.2E-09	5.6E-09	3.5E-09	3.6E-09	2.6E-09	3.1E-09	2.5E-09	3.3E-09	4.4E-09	72.4

TABLE H.4.11. $\overline{\chi}/Q'$ Values (sec m^{-3}) for Chronic **60-m Stack** Releases from **300 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 300 Area Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	6.0E-10	5.6E-10	5.5E-10	4.7E-10	1.0E-09	6.2E-10	6.6E-10	5.4E-10	5.3E-10	5.5E-10	6.7E-10	5.2E-10	2.6E-10	1.2E-10	2.2E-10	3.2E-10	0.1
0.2	1.2E-07	1.1E-07	1.1E-07	9.1E-08	2.0E-07	1.2E-07	1.3E-07	1.1E-07	1.1E-07	1.1E-07	1.3E-07	1.0E-07	5.3E-08	2.6E-08	4.4E-08	6.5E-08	0.2
0.3	2.5E-07	2.1E-07	2.0E-07	1.8E-07	3.7E-07	2.3E-07	2.6E-07	2.1E-07	2.1E-07	2.1E-07	2.5E-07	2.0E-07	1.1E-07	5.5E-08	9.0E-08	1.4E-07	0.3
0.4	2.3E-07	1.9E-07	1.7E-07	1.5E-07	3.1E-07	2.0E-07	2.3E-07	1.8E-07	1.9E-07	1.9E-07	2.1E-07	1.7E-07	1.1E-07	5.4E-08	8.4E-08	1.4E-07	0.4
0.5	2.0E-07	1.5E-07	1.3E-07	1.2E-07	2.4E-07	1.6E-07	1.9E-07	1.5E-07	1.6E-07	1.6E-07	1.7E-07	1.3E-07	9.1E-08	4.9E-08	7.6E-08	1.2E-07	0.5
0.6	1.8E-07	1.3E-07	1.0E-07	9.9E-08	2.0E-07	1.4E-07	1.7E-07	1.3E-07	1.5E-07	1.4E-07	1.5E-07	1.1E-07	8.5E-08	4.8E-08	7.5E-08	1.2E-07	0.6
0.7	1.8E-07	1.1E-07	8.7E-08	8.7E-08	1.7E-07	1.4E-07	1.7E-07	1.3E-07	1.5E-07	1.4E-07	1.4E-07	1.1E-07	8.6E-08	5.0E-08	7.9E-08	1.3E-07	0.7
0.8	1.9E-07	1.1E-07	7.9E-08	8.0E-08	1.6E-07	1.4E-07	1.7E-07	1.3E-07	1.6E-07	1.4E-07	1.4E-07	1.1E-07	8.9E-08	5.3E-08	8.6E-08	1.4E-07	0.8
0.9	1.9E-07	1.1E-07	7.5E-08	7.5E-08	1.5E-07	1.4E-07	1.7E-07	1.3E-07	1.6E-07	1.4E-07	1.5E-07	1.1E-07	9.4E-08	5.7E-08	9.3E-08	1.5E-07	0.9
1.0	2.0E-07	1.0E-07	7.1E-08	7.2E-08	1.5E-07	1.4E-07	1.8E-07	1.4E-07	1.7E-07	1.5E-07	1.5E-07	1.1E-07	9.9E-08	6.1E-08	1.0E-07	1.5E-07	1.0
2.4	1.5E-07	6.0E-08	3.8E-08	3.6E-08	7.8E-08	1.0E-07	1.2E-07	1.0E-07	1.4E-07	1.1E-07	1.1E-07	8.3E-08	8.5E-08	5.9E-08	8.7E-08	1.2E-07	2.4
4.0	9.5E-08	3.7E-08	2.3E-08	2.1E-08	4.8E-08	6.7E-08	8.3E-08	7.0E-08	9.6E-08	7.2E-08	7.5E-08	5.4E-08	5.7E-08	4.1E-08	5.9E-08	8.2E-08	4.0
5.6	6.8E-08	2.5E-08	1.5E-08	1.4E-08	3.3E-08	4.8E-08	6.0E-08	5.0E-08	7.0E-08	5.1E-08	5.3E-08	3.9E-08	4.1E-08	3.0E-08	4.2E-08	5.9E-08	5.6
7.2	5.2E-08	1.9E-08	1.1E-08	1.1E-08	2.4E-08	3.6E-08	4.6E-08	3.9E-08	5.4E-08	3.9E-08	4.0E-08	2.9E-08	3.2E-08	2.3E-08	3.2E-08	4.5E-08	7.2
12.1	2.9E-08	1.0E-08	6.1E-09	5.5E-09	1.3E-08	2.0E-08	2.7E-08	2.2E-08	3.1E-08	2.1E-08	2.2E-08	1.6E-08	1.8E-08	1.3E-08	1.8E-08	2.5E-08	12.1
24.1	1.3E-08	4.4E-09	2.6E-09	2.3E-09	5.7E-09	9.0E-09	1.2E-08	1.0E-08	1.4E-08	9.2E-09	9.4E-09	6.9E-09	7.7E-09	5.9E-09	8.0E-09	1.1E-0824.1	
40.3	6.9E-09	2.3E-09	1.4E-09	1.2E-09	3.0E-09	4.8E-09	6.6E-09	5.4E-09	7.3E-09	4.9E-09	5.0E-09	3.7E-09	4.1E-09	3.2E-09	4.3E-09	5.8E-09	40.3
56.3	4.5E-09	1.5E-09	8.9E-10	7.9E-10	2.0E-09	3.2E-09	4.4E-09	3.6E-09	4.9E-09	3.2E-09	3.3E-09	2.4E-09	2.7E-09	2.1E-09	2.8E-09	3.8E-09	56.3
72.4	3.3E-09	1.1E-09	6.5E-10	5.8E-10	1.5E-09	2.3E-09	3.2E-09	2.7E-09	3.6E-09	2.3E-09	2.4E-09	1.8E-09	2.0E-09	1.6E-09	2.1E-09	2.8E-09	72.4

TABLE H.4.12. $\overline{\chi}/Q'$ Values (sec m^{-3}) for Chronic **Ground-Level** Releases from **400 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 400 Area Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	2.1E-04	1.4E-04	9.6E-05	6.9E-05	9.7E-05	8.5E-05	1.2E-04	1.9E-04	3.1E-04	2.2E-04	1.5E-04	9.9E-05	1.5E-04	1.5E-04	2.1E-04	1.7E-04	0.1
0.2	5.8E-05	3.9E-05	2.6E-05	1.9E-05	2.7E-05	2.3E-05	3.1E-05	5.1E-05	8.5E-05	6.0E-05	4.0E-05	2.7E-05	4.2E-05	4.2E-05	5.8E-05	4.8E-05	0.2
0.3	2.8E-05	1.8E-05	1.2E-05	8.9E-06	1.3E-05	1.1E-05	1.5E-05	2.5E-05	4.1E-05	2.9E-05	1.9E-05	1.3E-05	2.0E-05	2.0E-05	2.8E-05	2.3E-05	0.3
0.4	1.7E-05	1.1E-05	7.4E-06	5.3E-06	7.4E-06	6.5E-06	8.9E-06	1.5E-05	2.4E-05	1.7E-05	1.1E-05	7.7E-06	1.2E-05	1.2E-05	1.7E-05	1.4E-05	0.4
0.5	1.1E-05	7.3E-06	4.9E-06	3.5E-06	5.0E-06	4.3E-06	5.9E-06	9.8E-06	1.6E-05	1.2E-05	7.6E-06	5.2E-06	8.0E-06	8.0E-06	1.1E-05	9.1E-06	0.5
0.6	8.0E-06	5.3E-06	3.6E-06	2.5E-06	3.6E-06	3.1E-06	4.3E-06	7.1E-06	1.2E-05	8.3E-06	5.5E-06	3.8E-06	5.8E-06	5.8E-06	8.1E-06	6.6E-06	0.6
0.7	6.1E-06	4.0E-06	2.7E-06	1.9E-06	2.7E-06	2.4E-06	3.3E-06	5.4E-06	8.9E-06	6.3E-06	4.2E-06	2.9E-06	4.4E-06	4.4E-06	6.2E-06	5.0E-06	0.7
0.8	4.8E-06	3.2E-06	2.1E-06	1.5E-06	2.1E-06	1.9E-06	2.6E-06	4.3E-06	7.0E-06	5.0E-06	3.3E-06	2.3E-06	3.5E-06	3.5E-06	4.9E-06	4.0E-06	0.8
0.9	3.9E-06	2.6E-06	1.7E-06	1.2E-06	1.7E-06	1.5E-06	2.1E-06	3.5E-06	5.7E-06	4.0E-06	2.7E-06	1.8E-06	2.8E-06	2.8E-06	4.0E-06	3.2E-06	0.9
1.0	3.3E-06	2.1E-06	1.4E-06	1.0E-06	1.4E-06	1.3E-06	1.7E-06	2.9E-06	4.7E-06	3.4E-06	2.2E-06	1.5E-06	2.3E-06	2.3E-06	3.3E-06	2.7E-06	1.0
2.4	7.5E-07	4.9E-07	3.3E-07	2.3E-07	3.3E-07	2.9E-07	4.0E-07	6.7E-07	1.1E-06	7.8E-07	5.2E-07	3.5E-07	5.4E-07	5.4E-07	7.6E-07	6.2E-07	2.4
4.0	3.4E-07	2.2E-07	1.5E-07	1.1E-07	1.5E-07	1.3E-07	1.8E-07	3.1E-07	5.0E-07	3.5E-07	2.4E-07	1.6E-07	2.5E-07	2.5E-07	3.5E-07	2.8E-07	4.0
5.6	2.1E-07	1.4E-07	9.1E-08	6.4E-08	9.1E-08	8.0E-08	1.1E-07	1.9E-07	3.1E-07	2.2E-07	1.4E-07	9.8E-08	1.5E-07	1.5E-07	2.1E-07	1.7E-07	5.6
7.2	1.5E-07	9.5E-08	6.3E-08	4.4E-08	6.3E-08	5.5E-08	7.6E-08	1.3E-07	2.1E-07	1.5E-07	1.0E-07	6.8E-08	1.0E-07	1.0E-07	1.5E-07	1.2E-07	7.2
12.1	7.0E-08	4.6E-08	3.1E-08	2.1E-08	3.0E-08	2.7E-08	3.7E-08	6.2E-08	1.0E-07	7.2E-08	4.8E-08	3.3E-08	5.0E-08	5.0E-08	7.1E-08	5.8E-08	12.1
24.1	2.7E-08	1.8E-08	1.2E-08	8.2E-09	1.2E-08	1.0E-08	1.4E-08	2.4E-08	4.0E-08	2.8E-08	1.9E-08	1.3E-08	1.9E-08	1.9E-08	2.7E-08	2.2E-08	24.1
40.3	1.4E-08	8.9E-09	5.8E-09	4.1E-09	5.8E-09	5.1E-09	7.0E-09	1.2E-08	2.0E-08	1.4E-08	9.3E-09	6.3E-09	9.6E-09	9.5E-09	1.4E-08	1.1E-08	40.3
56.3	8.7E-09	5.7E-09	3.7E-09	2.6E-09	3.7E-09	3.2E-09	4.5E-09	7.6E-09	1.3E-08	8.8E-09	5.9E-09	4.0E-09	6.1E-09	6.0E-09	8.6E-09	7.0E-09	56.3
72.4	6.3E-09	4.1E-09	2.7E-09	1.9E-09	2.7E-09	2.3E-09	3.2E-09	5.5E-09	9.1E-09	6.3E-09	4.2E-09	2.9E-09	4.4E-09	4.3E-09	6.1E-09	5.0E-09	72.4

TABLE H.4.13. $\overline{\chi}/Q^{*}$ Values (sec m^{-3}) for Chronic **10-m Stack** Releases from **400 Area** Based on 1983 Through 1991 Meteorological Information

Distance	Sector (Wind from 400 Area **Towards** Direction Indicated)																Distance
(km)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	(km)
0.1	1.3E-05	9.9E-06	7.9E-06	6.8E-06	9.2E-06	8.3E-06	8.9E-06	9.6E-06	1.7E-05	1.4E-05	8.1E-06	5.7E-06	8.3E-06	7.4E-06	9.6E-06	8.5E-06	0.1
0.2	1.3E-05	8.9E-06	7.0E-06	5.5E-06	7.7E-06	7.0E-06	8.4E-06	1.1E-05	1.9E-05	1.5E-05	9.3E-06	6.5E-06	9.8E-06	1.0E-05	1.3E-05	1.1E-05	0.2
0.3	9.6E-06	6.6E-06	5.1E-06	3.9E-06	5.4E-06	4.9E-06	6.1E-06	8.7E-06	1.5E-05	1.1E-05	7.3E-06	5.1E-06	7.7E-06	8.0E-06	1.1E-05	8.2E-06	0.3
0.4	7.4E-06	5.0E-06	3.8E-06	2.8E-06	3.9E-06	3.5E-06	4.6E-06	6.8E-06	1.1E-05	8.5E-06	5.6E-06	3.9E-06	5.9E-06	6.1E-06	8.1E-06	6.4E-06	0.4
0.5	5.9E-06	4.0E-06	2.9E-06	2.1E-06	3.0E-06	2.7E-06	3.5E-06	5.4E-06	9.0E-06	6.7E-06	4.4E-06	3.1E-06	4.6E-06	4.8E-06	6.4E-06	5.0E-06	0.5
0.6	4.8E-06	3.2E-06	2.3E-06	1.7E-06	2.4E-06	2.1E-06	2.8E-06	4.4E-06	7.3E-06	5.3E-06	3.6E-06	2.5E-06	3.7E-06	3.8E-06	5.1E-06	4.1E-06	0.6
0.7	4.0E-06	2.7E-06	1.9E-06	1.4E-06	1.9E-06	1.7E-06	2.3E-06	3.6E-06	6.0E-06	4.4E-06	2.9E-06	2.0E-06	3.0E-06	3.1E-06	4.2E-06	3.4E-06	0.7
0.8	3.3E-06	2.2E-06	1.6E-06	1.1E-06	1.6E-06	1.4E-06	1.9E-06	3.0E-06	5.0E-06	3.7E-06	2.4E-06	1.7E-06	2.5E-06	2.6E-06	3.5E-06	2.8E-06	0.8
0.9	2.9E-06	1.9E-06	1.3E-06	9.6E-07	1.4E-06	1.2E-06	1.6E-06	2.6E-06	4.3E-06	3.1E-06	2.1E-06	1.4E-06	2.2E-06	2.2E-06	3.0E-06	2.4E-06	0.9
1.0	2.5E-06	1.6E-06	1.1E-06	8.2E-07	1.2E-06	1.0E-06	1.4E-06	2.2E-06	3.7E-06	2.7E-06	1.8E-06	1.2E-06	1.9E-06	1.9E-06	2.6E-06	2.1E-06	1.0
2.4	6.8E-07	4.5E-07	3.1E-07	2.2E-07	3.1E-07	2.7E-07	3.7E-07	6.1E-07	1.0E-06	7.2E-07	4.8E-07	3.3E-07	5.0E-07	5.0E-07	7.0E-07	5.7E-07	2.4
4.0	3.2E-07	2.1E-07	1.4E-07	1.0E-07	1.4E-07	1.3E-07	1.7E-07	2.9E-07	4.8E-07	3.4E-07	2.3E-07	1.5E-07	2.4E-07	2.4E-07	3.3E-07	2.7E-07	4.0
5.6	2.0E-07	1.3E-07	8.8E-08	6.2E-08	8.8E-08	7.7E-08	1.1E-07	1.8E-07	2.9E-07	2.1E-07	1.4E-07	9.4E-08	1.5E-07	1.5E-07	2.0E-07	1.7E-07	5.6
7.2	1.4E-07	9.1E-08	6.1E-08	4.3E-08	6.1E-08	5.4E-08	7.4E-08	1.2E-07	2.1E-07	1.5E-07	9.7E-08	6.6E-08	1.0E-07	1.0E-07	1.4E-07	1.2E-07	7.2
12.1	6.9E-08	4.5E-08	3.0E-08	2.1E-08	3.0E-08	2.6E-08	3.6E-08	6.1E-08	1.0E-07	7.1E-08	4.7E-08	3.2E-08	4.9E-08	4.9E-08	6.9E-08	5.6E-08	12.1
24.1	2.7E-08	1.7E-08	1.2E-08	8.1E-09	1.2E-08	1.0E-08	1.4E-08	2.4E-08	3.9E-08	2.7E-08	1.8E-08	1.2E-08	1.9E-08	1.9E-08	2.7E-08	2.2E-08	24.1
40.3	1.4E-08	8.8E-09	5.8E-09	4.1E-09	5.8E-09	5.0E-09	6.9E-09	1.2E-08	2.0E-08	1.4E-08	9.2E-09	6.2E-09	9.5E-09	9.4E-09	1.3E-08	1.1E-08	40.3
56.3	8.6E-09	5.6E-09	3.7E-09	2.6E-09	3.7E-09	3.2E-09	4.4E-09	7.6E-09	1.3E-08	8.8E-09	5.9E-09	4.0E-09	6.1E-09	6.0E-09	8.5E-09	7.0E-09	56.3
72.4	6.2E-09	4.1E-09	2.7E-09	1.9E-09	2.7E-09	2.3E-09	3.2E-09	5.4E-09	9.1E-09	6.3E-09	4.2E-09	2.9E-09	4.4E-09	4.3E-09	6.1E-09	5.0E-09	72.4

TABLE H.4.14. $\overline{\chi}/Q^{*}$ Values (sec m^{-3}) for Chronic **30-m Stack** Releases from **400 Area** Based on 1983 Through 1991 Meteorological Information

Distance	Sector (Wind from 400 Area **Towards** Direction Indicated)																Distance
(km)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	(km)
0.1	6.3E-07	5.4E-07	4.3E-07	4.0E-07	5.3E-07	5.2E-07	4.6E-07	4.2E-07	9.4E-07	7.5E-07	3.9E-07	3.0E-07	4.0E-07	2.9E-07	3.3E-07	3.3E-07	0.1
0.2	1.1E-06	9.4E-07	7.4E-07	6.8E-07	9.1E-07	8.4E-07	7.9E-07	7.5E-07	1.6E-06	1.3E-06	6.8E-07	5.0E-07	6.8E-07	5.0E-07	6.1E-07	6.1E-07	0.2
0.3	9.7E-07	8.0E-07	6.3E-07	5.5E-07	7.5E-07	6.7E-07	7.0E-07	7.1E-07	1.3E-06	1.1E-06	6.1E-07	4.3E-07	6.1E-07	5.2E-07	6.7E-07	6.1E-07	0.3
0.4	9.3E-07	7.2E-07	5.7E-07	4.8E-07	6.5E-07	5.8E-07	6.5E-07	7.4E-07	1.3E-06	1.0E-06	6.1E-07	4.2E-07	6.2E-07	5.9E-07	7.8E-07	6.7E-07	0.4
0.5	9.0E-07	6.6E-07	5.3E-07	4.3E-07	6.0E-07	5.3E-07	6.2E-07	7.5E-07	1.3E-06	1.0E-06	6.1E-07	4.2E-07	6.4E-07	6.5E-07	8.6E-07	7.0E-07	0.5
0.6	8.6E-07	6.2E-07	4.9E-07	3.9E-07	5.4E-07	4.9E-07	5.8E-07	7.4E-07	1.2E-06	9.9E-07	6.1E-07	4.2E-07	6.4E-07	6.6E-07	8.8E-07	7.0E-07	0.6
0.7	8.1E-07	5.7E-07	4.6E-07	3.6E-07	5.0E-07	4.5E-07	5.4E-07	7.1E-07	1.2E-06	9.4E-07	5.9E-07	4.0E-07	6.2E-07	6.5E-07	8.6E-07	6.8E-07	0.7
0.8	7.6E-07	5.3E-07	4.2E-07	3.2E-07	4.5E-07	4.1E-07	5.0E-07	6.8E-07	1.1E-06	8.9E-07	5.6E-07	3.9E-07	5.9E-07	6.3E-07	8.2E-07	6.5E-07	0.8
0.9	7.1E-07	4.9E-07	3.9E-07	3.0E-07	4.1E-07	3.7E-07	4.7E-07	6.4E-07	1.0E-06	8.3E-07	5.3E-07	3.7E-07	5.6E-07	5.9E-07	7.8E-07	6.1E-07	0.9
1.0	6.6E-07	4.5E-07	3.6E-07	2.7E-07	3.8E-07	3.4E-07	4.3E-07	6.0E-07	9.8E-07	7.7E-07	5.0E-07	3.4E-07	5.2E-07	5.6E-07	7.3E-07	5.7E-07	1.0
2.4	2.9E-07	1.9E-07	1.4E-07	1.1E-07	1.5E-07	1.3E-07	1.8E-07	2.7E-07	4.4E-07	3.3E-07	2.2E-07	1.5E-07	2.3E-07	2.4E-07	3.2E-07	2.5E-07	2.4
4.0	1.6E-07	1.1E-07	7.6E-08	5.6E-08	7.9E-08	7.0E-08	9.3E-08	1.5E-07	2.4E-07	1.8E-07	1.2E-07	8.2E-08	1.2E-07	1.3E-07	1.7E-07	1.4E-07	4.0
5.6	1.0E-07	6.9E-08	4.9E-08	3.6E-08	5.1E-08	4.5E-08	6.0E-08	9.5E-08	1.6E-07	1.2E-07	7.7E-08	5.3E-08	8.0E-08	8.3E-08	1.1E-07	8.9E-08	5.6
7.2	7.6E-08	5.0E-08	3.6E-08	2.6E-08	3.6E-08	3.2E-08	4.3E-08	6.9E-08	1.2E-07	8.3E-08	5.6E-08	3.8E-08	5.8E-08	5.9E-08	8.1E-08	6.4E-08	7.2
12.1	3.9E-08	2.6E-08	1.8E-08	1.3E-08	1.8E-08	1.6E-08	2.2E-08	3.6E-08	5.9E-08	4.3E-08	2.9E-08	2.0E-08	3.0E-08	3.0E-08	4.1E-08	3.3E-08	12.1
24.1	1.6E-08	1.1E-08	7.3E-09	5.2E-09	7.4E-09	6.5E-09	8.8E-09	1.4E-08	2.4E-08	1.7E-08	1.2E-08	7.9E-09	1.2E-08	1.2E-08	1.7E-08	1.3E-08	24.1
40.3	8.3E-09	5.5E-09	3.7E-09	2.7E-09	3.8E-09	3.3E-09	4.5E-09	7.4E-09	1.2E-08	8.8E-09	5.9E-09	4.0E-09	6.1E-09	6.1E-09	8.4E-09	6.8E-09	40.3
56.3	5.4E-09	3.5E-09	2.4E-09	1.7E-09	2.4E-09	2.1E-09	2.9E-09	4.8E-09	8.0E-09	5.7E-09	3.8E-09	2.6E-09	3.9E-09	3.9E-09	5.4E-09	4.4E-09	56.3
72.4	3.9E-09	2.6E-09	1.7E-09	1.3E-09	1.8E-09	1.5E-09	2.1E-09	3.5E-09	5.8E-09	4.1E-09	2.7E-09	1.9E-09	2.8E-09	2.8E-09	3.9E-09	3.2E-09	72.4

APPENDIX H.5

ATMOSPHERIC DISPERSION FACTORS: 95TH PERCENTILE CENTER-LINE E/Q VALUES FOR ACUTE ATMOSPHERIC RELEASES FROM THE HANFORD AREAS BASED ON 1983 THROUGH 1991 METEOROLOGICAL INFORMATION

THIS PAGE BLANK INTENTIONALLY

APPENDIX H.5

ATMOSPHERIC DISPERSION FACTORS: 95TH PERCENTILE CENTER-LINE E/Q VALUES FOR ACUTE ATMOSPHERIC RELEASES FROM THE HANFORD AREAS BASED ON 1983 THROUGH 1991 METEOROLOGICAL INFORMATION

Atmospheric dispersion factors for acute releases from the four major Hanford Areas are presented in Tables H.5.1-14. The 95th percentile center-line E/Q values were calculated using the GENII code based on meteorological information averaged over the years 1983 through 1991. A description of the computation of the E/Q values is presented in Appendix H.1. It should be noted that these values are calculated differently from the all-sector 95th percentile values specified in U.S. Nuclear Regulatory Commission Guide 1.145[a].

---

[a] U.S. Nuclear Regulatory Commission. 1983. Atmospheric Dispersion Models for Potential Accident Consequences Assessments at Nuclear Power Plants. Regulatory Guide 1.145, Revision 1 (updated), Office of Nuclear Regulatory Research, Washington, D.C.

TABLE H.5.1. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **Ground-Level** Releases from **100 N Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 100 N Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	6.3E-02	5.1E-02	6.7E-02	7.3E-02	6.9E-02	5.8E-02	5.5E-02	5.3E-02	6.1E-02	5.8E-02	5.5E-02	5.6E-02	5.3E-02	5.7E-02	6.9E-02	7.5E-02	0.1
0.2	1.9E-02	1.5E-02	2.0E-02	2.2E-02	2.1E-02	1.8E-02	1.7E-02	1.6E-02	1.8E-02	1.8E-02	1.6E-02	1.7E-02	1.6E-02	1.7E-02	2.1E-02	2.3E-02	0.2
0.3	9.5E-03	7.7E-03	1.0E-02	1.1E-02	1.0E-02	8.8E-03	8.3E-03	8.0E-03	9.2E-03	8.8E-03	8.3E-03	8.5E-03	8.0E-03	8.6E-03	1.0E-02	1.1E-02	0.3
0.4	5.8E-03	4.8E-03	6.3E-03	6.8E-03	6.5E-03	5.4E-03	5.1E-03	4.9E-03	5.7E-03	5.4E-03	5.1E-03	5.2E-03	4.9E-03	5.3E-03	6.4E-03	7.0E-03	0.4
0.5	4.0E-03	3.3E-03	4.3E-03	4.7E-03	4.4E-03	3.7E-03	3.5E-03	3.4E-03	3.9E-03	3.7E-03	3.5E-03	3.6E-03	3.4E-03	3.6E-03	4.4E-03	4.8E-03	0.5
0.6	3.0E-03	2.4E-03	3.2E-03	3.4E-03	3.3E-03	2.8E-03	2.6E-03	2.5E-03	2.9E-03	2.8E-03	2.6E-03	2.6E-03	2.5E-03	2.7E-03	3.2E-03	3.5E-03	0.6
0.7	2.3E-03	1.9E-03	2.5E-03	2.7E-03	2.5E-03	2.1E-03	2.0E-03	1.9E-03	2.2E-03	2.1E-03	2.0E-03	2.0E-03	1.9E-03	2.1E-03	2.5E-03	2.7E-03	0.7
0.8	1.8E-03	1.5E-03	2.0E-03	2.1E-03	2.0E-03	1.7E-03	1.6E-03	1.5E-03	1.8E-03	1.7E-03	1.6E-03	1.6E-03	1.6E-03	1.7E-03	2.0E-03	2.2E-03	0.8
0.9	1.5E-03	1.2E-03	1.6E-03	1.8E-03	1.7E-03	1.4E-03	1.3E-03	1.3E-03	1.5E-03	1.4E-03	1.3E-03	1.3E-03	1.3E-03	1.4E-03	1.6E-03	1.8E-03	0.9
1.0	1.3E-03	1.0E-03	1.4E-03	1.5E-03	1.4E-03	1.2E-03	1.1E-03	1.1E-03	1.2E-03	1.2E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.4E-03	1.5E-03	1.0
2.4	3.2E-04	2.6E-04	3.5E-04	3.8E-04	3.6E-04	3.0E-04	2.8E-04	2.7E-04	3.2E-04	3.0E-04	2.8E-04	2.9E-04	2.7E-04	2.9E-04	3.5E-04	3.9E-04	2.4
4.0	1.6E-04	1.3E-04	1.7E-04	1.8E-04	1.8E-04	1.5E-04	1.4E-04	1.3E-04	1.5E-04	1.5E-04	1.4E-04	1.4E-04	1.3E-04	1.4E-04	1.7E-04	1.9E-04	4.0
5.6	1.0E-04	8.2E-05	1.1E-04	1.2E-04	1.1E-04	9.4E-05	8.8E-05	8.5E-05	9.9E-05	9.4E-05	8.8E-05	9.0E-05	8.5E-05	9.2E-05	1.1E-04	1.2E-04	5.6
7.2	7.3E-05	5.9E-05	7.8E-05	8.5E-05	8.0E-05	6.8E-05	6.4E-05	6.1E-05	7.1E-05	6.8E-05	6.3E-05	6.5E-05	6.2E-05	6.6E-05	8.0E-05	8.7E-05	7.2
12.1	3.8E-05	3.1E-05	4.1E-05	4.4E-05	4.2E-05	3.5E-05	3.3E-05	3.2E-05	3.7E-05	3.5E-05	3.3E-05	3.4E-05	3.2E-05	3.4E-05	4.1E-05	4.5E-05	12.1
24.1	1.6E-05	1.3E-05	1.7E-05	1.9E-05	1.8E-05	1.5E-05	1.4E-05	1.3E-05	1.6E-05	1.5E-05	1.4E-05	1.4E-05	1.4E-05	1.5E-05	1.8E-05	1.9E-05	24.1
40.3	8.6E-06	7.0E-06	9.2E-06	1.0E-05	9.5E-06	8.0E-06	7.5E-06	7.2E-06	8.4E-06	8.0E-06	7.5E-06	7.7E-06	7.3E-06	7.8E-06	9.4E-06	1.0E-05	40.3
56.3	5.8E-06	4.7E-06	6.2E-06	6.7E-06	6.4E-06	5.4E-06	5.0E-06	4.8E-06	5.6E-06	5.4E-06	5.0E-06	5.1E-06	4.9E-06	5.2E-06	6.3E-06	6.9E-06	56.3
72.4	4.3E-06	3.5E-06	4.6E-06	5.0E-06	4.7E-06	4.0E-06	3.7E-06	3.6E-06	4.2E-06	4.0E-06	3.7E-06	3.8E-06	3.6E-06	3.9E-06	4.7E-06	5.1E-06	72.4

TABLE H.5.2. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **30-m Stack** Releases from **100 N Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 100 N Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	6.6E-05	3.7E-05	3.8E-05	3.7E-05	3.8E-05	3.7E-05	3.7E-05	3.8E-05	4.4E-05	3.7E-05	3.7E-05	3.6E-05	3.6E-05	3.7E-05	6.6E-05	8.3E-05	0.1
0.2	1.5E-04	8.8E-05	1.2E-04	1.1E-04	1.2E-04	1.2E-04	1.1E-04	1.3E-04	1.3E-04	1.1E-04	6.6E-05	5.4E-05	5.3E-05	8.5E-05	1.5E-04	1.5E-04	0.2
0.3	1.1E-04	6.9E-05	9.7E-05	9.7E-05	9.2E-05	9.3E-05	8.9E-05	1.0E-04	1.2E-04	8.9E-05	5.7E-05	4.9E-05	4.9E-05	6.3E-05	1.1E-04	1.2E-04	0.3
0.4	9.6E-05	9.2E-05	9.5E-05	9.6E-05	9.6E-05	9.6E-05	9.6E-05	9.7E-05	9.7E-05	9.6E-05	9.3E-05	8.9E-05	8.0E-05	9.0E-05	9.5E-05	9.7E-05	0.4
0.5	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	9.9E-05	9.0E-05	1.0E-04	1.1E-04	1.1E-04	0.5
0.6	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.0E-04	9.7E-05	1.0E-04	1.1E-04	1.1E-04	0.6
0.7	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	9.8E-05	9.5E-05	9.8E-05	1.0E-04	1.0E-04	0.7
0.8	9.7E-05	9.6E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.4E-05	9.3E-05	9.4E-05	9.7E-05	9.7E-05	0.8
0.9	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.8E-05	8.9E-05	8.9E-05	8.9E-05	0.9
1.0	8.7E-05	8.6E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.5E-05	8.4E-05	8.5E-05	8.7E-05	8.7E-05	1.0
2.4	5.4E-05	5.1E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.3E-05	5.4E-05	5.3E-05	5.2E-05	5.2E-05	5.0E-05	5.1E-05	5.4E-05	5.4E-05	2.4
4.0	3.6E-05	3.5E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.5E-05	3.5E-05	3.6E-05	3.5E-05	3.5E-05	3.5E-05	3.5E-05	3.5E-05	3.6E-05	3.6E-05	4.0
5.6	2.8E-05	2.7E-05	2.8E-05	2.9E-05	2.9E-05	2.8E-05	2.7E-05	2.7E-05	2.8E-05	2.8E-05	2.7E-05	2.7E-05	2.7E-05	2.7E-05	2.8E-05	2.9E-05	5.6
7.2	2.3E-05	2.1E-05	2.3E-05	2.4E-05	2.4E-05	2.2E-05	2.2E-05	2.2E-05	2.3E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.4E-05	2.4E-05	7.2
12.1	1.4E-05	1.3E-05	1.5E-05	1.5E-05	1.5E-05	1.4E-05	1.3E-05	1.3E-05	1.4E-05	1.4E-05	1.3E-05	1.4E-05	1.3E-05	1.4E-05	1.5E-05	1.6E-05	12.1
24.1	7.0E-06	6.2E-06	7.4E-06	7.8E-06	7.5E-06	6.7E-06	6.5E-06	6.3E-06	6.9E-06	6.7E-06	6.5E-06	6.5E-06	6.3E-06	6.6E-06	7.5E-06	7.9E-06	24.1
40.3	4.1E-06	3.5E-06	4.3E-06	4.5E-06	4.4E-06	3.9E-06	3.7E-06	3.6E-06	4.0E-06	3.9E-06	3.7E-06	3.7E-06	3.6E-06	3.8E-06	4.3E-06	4.6E-06	40.3
56.3	2.8E-06	2.4E-06	3.0E-06	3.1E-06	3.0E-06	2.7E-06	2.6E-06	2.5E-06	2.8E-06	2.7E-06	2.5E-06	2.6E-06	2.5E-06	2.6E-06	3.0E-06	3.2E-06	56.3
72.4	2.1E-06	1.8E-06	2.2E-06	2.4E-06	2.3E-06	2.0E-06	1.9E-06	1.9E-06	2.1E-06	2.0E-06	1.9E-06	2.0E-06	1.9E-06	2.0E-06	2.3E-06	2.4E-06	72.4

TABLE H.5.3. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **60-m Stack** Releases from **100 N Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 100 N Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	1.3E-07	8.4E-08	9.0E-08	5.3E-08	7.4E-08	7.5E-08	5.4E-08	5.8E-08	8.4E-08	5.1E-08	5.0E-08	4.7E-08	4.7E-08	5.7E-08	1.2E-07	1.4E-07	0.1
0.2	2.5E-05	1.6E-05	1.8E-05	1.0E-05	1.5E-05	1.5E-05	1.1E-05	1.1E-05	1.7E-05	9.9E-06	9.7E-06	8.9E-06	8.8E-06	1.1E-05	2.3E-05	2.7E-05	0.2
0.3	4.1E-05	2.8E-05	3.1E-05	2.6E-05	3.1E-05	3.1E-05	2.7E-05	3.0E-05	3.5E-05	2.5E-05	2.2E-05	1.8E-05	1.8E-05	2.5E-05	4.1E-05	4.6E-05	0.3
0.4	3.7E-05	2.1E-05	2.9E-05	2.5E-05	3.0E-05	3.0E-05	2.5E-05	3.1E-05	3.5E-05	2.4E-05	1.6E-05	1.5E-05	1.5E-05	1.9E-05	3.7E-05	4.1E-05	0.4
0.5	3.0E-05	2.1E-05	2.6E-05	2.5E-05	2.6E-05	2.7E-05	2.6E-05	2.8E-05	3.0E-05	2.4E-05	1.5E-05	1.3E-05	1.2E-05	1.8E-05	2.8E-05	3.1E-05	0.5
0.6	2.8E-05	1.5E-05	1.8E-05	1.6E-05	1.8E-05	2.0E-05	1.7E-05	2.2E-05	2.9E-05	1.6E-05	1.4E-05	1.4E-05	1.3E-05	1.4E-05	2.3E-05	2.9E-05	0.6
0.7	1.4E-05	1.3E-05	1.4E-05	1.4E-05	1.4E-05	1.4E-05	1.4E-05	1.5E-05	1.5E-05	1.3E-05	1.3E-05	1.2E-05	1.2E-05	1.2E-05	1.3E-05	1.5E-05	0.7
0.8	2.4E-05	2.0E-05	2.2E-05	2.3E-05	2.4E-05	2.5E-05	2.5E-05	2.5E-05	2.6E-05	2.3E-05	2.0E-05	1.6E-05	1.5E-05	1.6E-05	2.2E-05	2.4E-05	0.8
0.9	2.3E-05	2.2E-05	2.2E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.2E-05	1.8E-05	1.6E-05	2.0E-05	2.2E-05	2.3E-05	0.9
1.0	2.8E-05	2.5E-05	2.5E-05	2.7E-05	2.8E-05	2.9E-05	2.8E-05	2.8E-05	3.0E-05	2.7E-05	2.5E-05	2.2E-05	2.0E-05	2.2E-05	2.5E-05	2.7E-05	1.0
2.4	2.3E-05	2.2E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.2E-05	2.1E-05	2.2E-05	2.3E-05	2.3E-05	2.4
4.0	1.7E-05	1.7E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.9E-05	1.8E-05	1.7E-05	1.6E-05	1.4E-05	1.5E-05	1.7E-05	1.8E-05	4.0
5.6	1.4E-05	1.4E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.4E-05	1.4E-05	1.5E-05	1.5E-05	1.4E-05	1.4E-05	1.4E-05	1.4E-05	1.4E-05	1.5E-05	5.6
7.2	1.3E-05	1.2E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.2E-05	1.2E-05	1.1E-05	1.2E-05	1.3E-05	1.3E-05	7.2
12.1	8.5E-06	7.6E-06	8.7E-06	9.8E-06	9.6E-06	8.6E-06	8.4E-06	7.9E-06	8.8E-06	8.7E-06	7.7E-06	7.4E-06	6.6E-06	7.2E-06	8.7E-06	9.4E-06	12.1
24.1	5.6E-06	5.5E-06	5.7E-06	5.9E-06	5.8E-06	5.6E-06	5.6E-06	5.5E-06	5.7E-06	5.6E-06	5.5E-06	5.4E-06	5.2E-06	5.5E-06	5.7E-06	5.8E-06	24.1
40.3	3.6E-06	3.4E-06	3.8E-06	4.2E-06	4.1E-06	3.7E-06	3.6E-06	3.4E-06	3.8E-06	3.7E-06	3.4E-06	3.3E-06	3.1E-06	3.3E-06	3.9E-06	4.1E-06	40.3
56.3	2.7E-06	2.5E-06	2.8E-06	3.2E-06	3.1E-06	2.7E-06	2.6E-06	2.5E-06	2.8E-06	2.7E-06	2.4E-06	2.3E-06	2.2E-06	2.4E-06	2.9E-06	3.2E-06	56.3
72.4	2.1E-06	1.9E-06	2.2E-06	2.6E-06	2.5E-06	2.1E-06	2.0E-06	1.9E-06	2.2E-06	2.1E-06	1.9E-06	1.8E-06	1.7E-06	1.8E-06	2.3E-06	2.6E-06	72.4

TABLE H.5.4. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **90-m Stack** Releases from **100 N Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 100 N Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	2.1E-12	1.3E-12	1.4E-12	9.1E-13	1.1E-12	1.3E-12	8.8E-13	9.0E-13	1.3E-12	8.4E-13	8.3E-13	7.8E-13	7.7E-13	9.2E-13	1.9E-12	2.2E-12	0.1
0.2	1.6E-06	9.8E-07	1.1E-06	6.9E-07	8.6E-07	9.6E-07	6.6E-07	6.8E-07	9.9E-07	6.4E-07	6.3E-07	5.9E-07	5.8E-07	6.9E-07	1.4E-06	1.7E-06	0.2
0.3	1.9E-05	1.2E-05	1.3E-05	8.2E-06	1.0E-05	1.1E-05	7.9E-06	8.2E-06	1.2E-05	7.6E-06	7.5E-06	7.0E-06	6.9E-06	8.3E-06	1.7E-05	2.0E-05	0.3
0.4	1.7E-05	1.1E-05	1.2E-05	1.1E-05	1.2E-05	1.2E-05	1.1E-05	1.2E-05	1.2E-05	1.1E-05	1.0E-05	9.6E-06	9.3E-06	1.1E-05	1.7E-05	2.1E-05	0.4
0.5	2.1E-05	1.4E-05	1.7E-05	1.5E-05	1.6E-05	1.7E-05	1.4E-05	1.6E-05	1.9E-05	1.3E-05	1.0E-05	7.4E-06	7.3E-06	1.3E-05	2.1E-05	2.1E-05	0.5
0.6	1.4E-05	8.4E-06	1.0E-05	1.0E-05	1.1E-05	1.2E-05	9.2E-06	1.2E-05	1.2E-05	9.6E-06	7.6E-06	7.0E-06	6.5E-06	8.2E-06	1.4E-05	1.5E-05	0.6
0.7	1.2E-05	8.9E-06	1.0E-05	1.1E-05	1.0E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.0E-05	7.3E-06	5.2E-06	4.4E-06	8.3E-06	1.1E-05	1.2E-05	0.7
0.8	1.1E-05	7.3E-06	7.5E-06	7.7E-06	7.5E-06	8.9E-06	7.6E-06	9.9E-06	1.0E-05	7.5E-06	6.9E-06	5.8E-06	5.1E-06	7.1E-06	9.9E-06	1.2E-05	0.8
0.9	6.3E-06	6.0E-06	6.1E-06	6.1E-06	6.1E-06	6.2E-06	6.2E-06	6.4E-06	6.2E-06	5.9E-06	5.7E-06	5.2E-06	4.5E-06	5.6E-06	6.2E-06	8.3E-06	0.9
1.0	6.2E-06	5.6E-06	5.9E-06	5.8E-06	5.7E-06	6.1E-06	6.1E-06	7.0E-06	6.0E-06	5.3E-06	4.6E-06	4.1E-06	3.8E-06	4.3E-06	5.8E-06	7.6E-06	1.0
2.4	1.1E-05	1.0E-05	1.0E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.0E-05	8.9E-06	7.2E-06	8.9E-06	1.0E-05	1.1E-05	2.4
4.0	8.8E-06	8.6E-06	8.6E-06	8.8E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.7E-06	8.1E-06	7.8E-06	8.1E-06	8.6E-06	8.9E-06	4.0
5.6	7.3E-06	7.1E-06	7.3E-06	7.4E-06	7.5E-06	7.4E-06	7.4E-06	7.5E-06	7.5E-06	7.4E-06	7.2E-06	6.9E-06	6.5E-06	6.8E-06	7.2E-06	7.4E-06	5.6
7.2	6.3E-06	6.0E-06	6.3E-06	6.6E-06	6.7E-06	6.5E-06	6.5E-06	6.7E-06	6.8E-06	6.6E-06	6.2E-06	5.6E-06	5.1E-06	5.4E-06	6.1E-06	6.5E-06	7.2
12.1	4.4E-06	4.3E-06	4.5E-06	4.6E-06	4.7E-06	4.5E-06	4.5E-06	4.7E-06	4.7E-06	4.6E-06	4.4E-06	4.1E-06	3.8E-06	4.0E-06	4.4E-06	4.6E-06	12.1
24.1	2.8E-06	2.7E-06	2.9E-06	3.1E-06	3.0E-06	2.9E-06	2.9E-06	2.9E-06	3.0E-06	2.9E-06	2.8E-06	2.7E-06	2.5E-06	2.6E-06	2.9E-06	3.0E-06	24.1
40.3	1.8E-06	1.6E-06	1.9E-06	2.2E-06	2.1E-06	1.8E-06	1.8E-06	1.7E-06	1.9E-06	1.9E-06	1.7E-06	1.6E-06	1.5E-06	1.6E-06	1.9E-06	2.0E-06	40.3
56.3	1.5E-06	1.5E-06	1.6E-06	1.7E-06	1.6E-06	1.5E-06	1.5E-06	1.5E-06	1.6E-06	1.6E-06	1.5E-06	1.5E-06	1.4E-06	1.5E-06	1.6E-06	1.6E-06	56.3
72.4	1.3E-06	1.3E-06	1.3E-06	1.4E-06	1.4E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	72.4

TABLE H.5.5. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **Ground-Level** Releases from **200 Areas** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 200 Areas **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	3.0E-02	2.4E-02	3.4E-02	4.1E-02	4.5E-02	4.7E-02	4.3E-02	4.5E-02	5.9E-02	6.0E-02	3.9E-02	3.2E-02	3.2E-02	2.7E-02	3.0E-02	3.3E-02	0.1
0.2	9.1E-03	7.3E-03	1.0E-02	1.2E-02	1.4E-02	1.4E-02	1.3E-02	1.4E-02	1.8E-02	1.8E-02	1.2E-02	9.8E-03	9.7E-03	8.2E-03	9.0E-03	1.0E-02	0.2
0.3	4.6E-03	3.6E-03	5.1E-03	6.2E-03	6.8E-03	7.2E-03	6.5E-03	6.8E-03	9.0E-03	9.1E-03	5.9E-03	4.9E-03	4.9E-03	4.1E-03	4.5E-03	5.0E-03	0.3
0.4	2.8E-03	2.2E-03	3.2E-03	3.8E-03	4.2E-03	4.4E-03	4.0E-03	4.2E-03	5.5E-03	5.6E-03	3.7E-03	3.0E-03	3.0E-03	2.5E-03	2.8E-03	3.1E-03	0.4
0.5	1.9E-03	1.5E-03	2.2E-03	2.6E-03	2.9E-03	3.0E-03	2.8E-03	2.9E-03	3.8E-03	3.9E-03	2.5E-03	2.1E-03	2.1E-03	1.7E-03	1.9E-03	2.1E-03	0.5
0.6	1.4E-03	1.1E-03	1.6E-03	1.9E-03	2.1E-03	2.2E-03	2.0E-03	2.1E-03	2.8E-03	2.8E-03	1.9E-03	1.5E-03	1.5E-03	1.3E-03	1.4E-03	1.6E-03	0.6
0.7	1.1E-03	8.8E-04	1.2E-03	1.5E-03	1.6E-03	1.7E-03	1.6E-03	1.6E-03	2.2E-03	2.2E-03	1.4E-03	1.2E-03	1.2E-03	9.9E-04	1.1E-03	1.2E-03	0.7
0.8	8.8E-04	7.1E-04	9.9E-04	1.2E-03	1.3E-03	1.4E-03	1.3E-03	1.3E-03	1.7E-03	1.8E-03	1.1E-03	9.5E-04	9.4E-04	7.9E-04	8.8E-04	9.7E-04	0.8
0.9	7.3E-04	5.8E-04	8.2E-04	9.8E-04	1.1E-03	1.1E-03	1.0E-03	1.1E-03	1.4E-03	1.4E-03	9.4E-04	7.8E-04	7.8E-04	6.5E-04	7.2E-04	8.0E-04	0.9
1.0	6.1E-04	4.9E-04	6.8E-04	8.3E-04	9.1E-04	9.6E-04	8.7E-04	9.1E-04	1.2E-03	1.2E-03	7.9E-04	6.5E-04	6.5E-04	5.5E-04	6.0E-04	6.7E-04	1.0
2.4	1.6E-04	1.3E-04	1.7E-04	2.1E-04	2.3E-04	2.4E-04	2.2E-04	2.3E-04	3.1E-04	3.1E-04	2.0E-04	1.7E-04	1.7E-04	1.4E-04	1.5E-04	1.7E-04	2.4
4.0	7.6E-05	6.1E-05	8.5E-05	1.0E-04	1.1E-04	1.2E-04	1.1E-04	1.1E-04	1.5E-04	1.5E-04	9.9E-05	8.2E-05	8.1E-05	6.9E-05	7.6E-05	8.4E-05	4.0
5.6	4.9E-05	3.9E-05	5.4E-05	6.6E-05	7.2E-05	7.6E-05	6.9E-05	7.2E-05	9.6E-05	9.7E-05	6.3E-05	5.2E-05	5.2E-05	4.4E-05	4.8E-05	5.3E-05	5.6
7.2	3.5E-05	2.8E-05	3.9E-05	4.7E-05	5.2E-05	5.5E-05	5.0E-05	5.2E-05	6.9E-05	7.0E-05	4.5E-05	3.7E-05	3.7E-05	3.2E-05	3.5E-05	3.8E-05	7.2
12.1	1.8E-05	1.4E-05	2.0E-05	2.5E-05	2.7E-05	2.9E-05	2.6E-05	2.7E-05	3.6E-05	3.6E-05	2.4E-05	1.9E-05	1.9E-05	1.6E-05	1.8E-05	2.0E-05	12.1
24.1	7.7E-06	6.0E-06	8.6E-06	1.0E-05	1.1E-05	1.2E-05	1.1E-05	1.1E-05	1.5E-05	1.5E-05	1.0E-05	8.3E-06	8.2E-06	7.0E-06	7.7E-06	8.4E-06	24.1
40.3	4.1E-06	3.2E-06	4.6E-06	5.6E-06	6.1E-06	6.5E-06	5.9E-06	6.2E-06	8.2E-06	8.3E-06	5.4E-06	4.4E-06	4.4E-06	3.7E-06	4.1E-06	4.5E-06	40.3
56.3	2.8E-06	2.1E-06	3.1E-06	3.7E-06	4.1E-06	4.4E-06	3.9E-06	4.1E-06	5.5E-06	5.5E-06	3.6E-06	3.0E-06	3.0E-06	2.5E-06	2.8E-06	3.0E-06	56.3
72.4	2.1E-06	1.6E-06	2.3E-06	2.8E-06	3.1E-06	3.2E-06	2.9E-06	3.1E-06	4.0E-06	4.1E-06	2.7E-06	2.2E-06	2.2E-06	1.9E-06	2.0E-06	2.3E-06	72.4

TABLE H.5.6. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **30-m Stack** Releases from **200 Areas** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 200 Areas **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	7.1E-05	5.4E-05	9.4E-05	1.1E-04	9.8E-05	7.4E-05	3.8E-05	3.7E-05	3.7E-05	3.7E-05	3.2E-05	2.9E-05	1.7E-05	1.3E-05	3.1E-05	5.1E-05	0.1
0.2	1.5E-04	1.5E-04	1.5E-04	1.6E-04	1.5E-04	1.5E-04	1.1E-04	5.4E-05	6.2E-05	5.4E-05	5.1E-05	4.2E-05	3.0E-05	2.9E-05	5.2E-05	1.4E-04	0.2
0.3	1.2E-04	1.2E-04	1.4E-04	1.4E-04	1.3E-04	1.2E-04	8.0E-05	4.9E-05	5.0E-05	4.9E-05	4.7E-05	4.6E-05	4.5E-05	3.1E-05	4.9E-05	1.1E-04	0.3
0.4	9.7E-05	9.7E-05	9.8E-05	1.1E-04	9.8E-05	9.7E-05	9.3E-05	8.9E-05	8.9E-05	9.0E-05	6.7E-05	4.3E-05	3.3E-05	3.2E-05	7.7E-05	9.6E-05	0.4
0.5	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.0E-04	9.7E-05	1.0E-04	8.4E-05	5.7E-05	5.1E-05	4.1E-05	8.7E-05	1.1E-04	0.5
0.6	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.0E-04	1.0E-04	1.0E-04	9.5E-05	7.2E-05	6.7E-05	5.2E-05	9.4E-05	1.1E-04	0.6
0.7	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	9.8E-05	1.0E-04	9.5E-05	8.1E-05	7.9E-05	4.3E-05	9.2E-05	1.0E-04	0.7
0.8	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.5E-05	9.4E-05	9.6E-05	9.3E-05	8.7E-05	8.1E-05	5.9E-05	9.1E-05	9.7E-05	0.8
0.9	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.8E-05	8.8E-05	8.0E-05	4.8E-05	8.8E-05	8.9E-05	0.9
1.0	8.6E-05	8.6E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.6E-05	8.5E-05	8.6E-05	8.6E-05	8.5E-05	8.2E-05	8.0E-05	5.5E-05	8.3E-05	8.6E-05	1.0
2.4	4.7E-05	4.5E-05	4.9E-05	5.1E-05	5.2E-05	5.1E-05	5.1E-05	5.0E-05	5.3E-05	5.4E-05	5.0E-05	4.7E-05	4.3E-05	3.0E-05	4.3E-05	5.0E-05	2.4
4.0	3.3E-05	2.9E-05	3.4E-05	3.5E-05	3.5E-05	3.5E-05	3.5E-05	3.5E-05	3.5E-05	3.6E-05	3.5E-05	3.4E-05	3.1E-05	1.8E-05	2.9E-05	3.5E-05	4.0
5.6	2.2E-05	1.9E-05	2.5E-05	2.6E-05	2.6E-05	2.7E-05	2.6E-05	2.6E-05	2.8E-05	2.8E-05	2.6E-05	2.2E-05	2.0E-05	1.3E-05	1.9E-05	2.4E-05	5.6
7.2	1.7E-05	1.4E-05	1.9E-05	2.0E-05	2.1E-05	2.1E-05	2.0E-05	2.1E-05	2.2E-05	2.3E-05	2.0E-05	1.7E-05	1.5E-05	1.0E-05	1.4E-05	1.9E-05	7.2
12.1	9.4E-06	7.8E-06	1.1E-05	1.2E-05	1.2E-05	1.3E-05	1.2E-05	1.2E-05	1.4E-05	1.4E-05	1.2E-05	9.5E-06	8.4E-06	5.8E-06	7.8E-06	1.0E-05	12.1
24.1	3.5E-06	2.7E-06	4.8E-06	5.5E-06	5.8E-06	5.9E-06	5.6E-06	5.8E-06	6.8E-06	6.9E-06	5.4E-06	4.3E-06	4.2E-06	2.8E-06	3.4E-06	4.5E-06	24.1
40.3	2.0E-06	1.6E-06	2.7E-06	3.1E-06	3.3E-06	3.4E-06	3.2E-06	3.3E-06	3.9E-06	3.9E-06	3.0E-06	2.4E-06	2.4E-06	1.6E-06	1.9E-06	2.5E-06	40.3
56.3	1.4E-06	1.1E-06	1.8E-06	2.1E-06	2.2E-06	2.3E-06	2.2E-06	2.2E-06	2.7E-06	2.7E-06	2.0E-06	1.6E-06	1.6E-06	1.1E-06	1.3E-06	1.7E-06	56.3
72.4	1.0E-06	8.0E-07	1.4E-06	1.6E-06	1.7E-06	1.7E-06	1.6E-06	1.7E-06	2.0E-06	2.1E-06	1.5E-06	1.2E-06	1.2E-06	8.6E-07	1.0E-06	1.3E-06	72.4

TABLE H.5.7. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **60-m Stack** Releases from **200 Areas** Based on 1983 Through 1991 Meteorological Information

Distance	Sector (Wind from 200 Areas **Towards** Direction Indicated)																Distance
(km)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	(km)
0.1	1.3E-07	1.1E-07	1.4E-07	1.6E-07	1.5E-07	1.4E-07	1.1E-07	5.2E-08	5.2E-08	5.2E-08	4.1E-08	3.3E-08	2.0E-08	1.5E-08	3.6E-08	1.1E-07	0.1
0.2	2.6E-05	2.2E-05	2.8E-05	3.1E-05	3.0E-05	2.7E-05	2.1E-05	1.0E-05	1.0E-05	1.0E-05	6.3E-06	6.1E-06	4.3E-06	3.2E-06	6.2E-06	2.1E-05	0.2
0.3	4.4E-05	3.6E-05	5.0E-05	5.5E-05	5.3E-05	4.5E-05	3.2E-05	2.0E-05	2.3E-05	2.1E-05	1.3E-05	1.1E-05	8.3E-06	6.8E-06	1.3E-05	3.3E-05	0.3
0.4	4.0E-05	3.7E-05	4.3E-05	4.5E-05	4.3E-05	4.1E-05	2.8E-05	1.6E-05	1.6E-05	1.6E-05	1.2E-05	9.2E-06	7.6E-06	7.0E-06	1.4E-05	3.1E-05	0.4
0.5	3.0E-05	3.0E-05	3.4E-05	3.8E-05	3.4E-05	3.1E-05	2.5E-05	1.4E-05	1.6E-05	1.4E-05	8.7E-06	8.6E-06	5.6E-06	5.0E-06	1.0E-05	2.7E-05	0.5
0.6	2.7E-05	2.6E-05	3.7E-05	4.1E-05	3.8E-05	3.1E-05	1.6E-05	1.4E-05	1.4E-05	1.4E-05	7.4E-06	6.8E-06	5.9E-06	5.5E-06	1.1E-05	1.9E-05	0.6
0.7	1.6E-05	1.7E-05	2.7E-05	3.6E-05	2.9E-05	2.3E-05	1.4E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	8.5E-06	5.5E-06	4.4E-06	1.2E-05	1.4E-05	0.7
0.8	2.4E-05	2.5E-05	2.7E-05	3.1E-05	2.7E-05	2.6E-05	2.1E-05	1.7E-05	1.6E-05	1.7E-05	1.4E-05	7.6E-06	6.5E-06	6.0E-06	1.4E-05	2.3E-05	0.8
0.9	2.3E-05	2.3E-05	2.3E-05	2.7E-05	2.3E-05	2.3E-05	2.2E-05	2.0E-05	1.9E-05	2.1E-05	1.4E-05	7.4E-06	7.1E-06	7.1E-06	1.5E-05	2.2E-05	0.9
1.0	2.7E-05	2.7E-05	3.0E-05	3.1E-05	3.0E-05	2.8E-05	2.6E-05	2.3E-05	2.2E-05	2.3E-05	1.8E-05	8.3E-06	7.5E-06	7.3E-06	1.8E-05	2.6E-05	1.0
2.4	2.2E-05	2.2E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.2E-05	1.1E-05	9.6E-06	8.6E-06	1.7E-05	2.3E-05	2.4
4.0	1.5E-05	1.4E-05	1.7E-05	1.7E-05	1.7E-05	1.8E-05	1.7E-05	1.7E-05	1.8E-05	1.7E-05	1.6E-05	1.4E-05	1.3E-05	9.4E-06	1.4E-05	1.6E-05	4.0
5.6	1.3E-05	1.3E-05	1.4E-05	1.4E-05	1.4E-05	1.4E-05	1.4E-05	1.5E-05	1.5E-05	1.5E-05	1.4E-05	1.4E-05	1.1E-05	6.6E-06	1.1E-05	1.4E-05	5.6
7.2	1.0E-05	1.0E-05	1.2E-05	1.2E-05	1.2E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.2E-05	1.1E-05	8.3E-06	4.9E-06	8.1E-06	1.1E-05	7.2
12.1	6.5E-06	5.7E-06	6.6E-06	6.6E-06	7.1E-06	8.0E-06	8.6E-06	9.0E-06	9.3E-06	8.7E-06	6.8E-06	6.6E-06	6.5E-06	3.5E-06	5.7E-06	6.6E-06	12.1
24.1	3.0E-06	2.7E-06	4.5E-06	4.8E-06	5.4E-06	5.6E-06	5.7E-06	5.8E-06	5.8E-06	5.7E-06	5.1E-06	4.1E-06	3.5E-06	2.0E-06	2.5E-06	4.2E-06	24.1
40.3	1.7E-06	1.6E-06	2.7E-06	2.9E-06	3.3E-06	3.5E-06	3.8E-06	4.0E-06	4.1E-06	3.8E-06	3.1E-06	2.4E-06	2.0E-06	1.4E-06	1.6E-06	2.5E-06	40.3
56.3	1.1E-06	1.0E-06	1.3E-06	1.8E-06	2.3E-06	2.5E-06	2.8E-06	3.1E-06	3.1E-06	2.9E-06	2.1E-06	1.6E-06	1.7E-06	9.7E-07	1.1E-06	1.4E-06	56.3
72.4	8.6E-07	7.6E-07	1.1E-06	1.4E-06	1.8E-06	2.0E-06	2.2E-06	2.5E-06	2.5E-06	2.3E-06	1.6E-06	1.3E-06	1.3E-06	7.2E-07	8.5E-07	1.1E-06	72.4

TABLE H.5.8. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **90-m Stack** Releases from **200 Areas** Based on 1983 Through 1991 Meteorological Information

Distance	Sector (Wind from 200 Areas **Towards** Direction Indicated)																Distance
(km)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	(km)
0.1	2.1E-12	1.8E-12	2.3E-12	2.6E-12	2.5E-12	2.3E-12	1.8E-12	8.7E-13	8.6E-13	8.1E-13	6.7E-13	5.4E-13	3.1E-13	2.3E-13	5.8E-13	1.8E-12	0.1
0.2	1.6E-06	1.4E-06	1.8E-06	2.0E-06	1.9E-06	1.7E-06	1.3E-06	6.6E-07	6.5E-07	6.1E-07	5.0E-07	4.0E-07	2.3E-07	1.7E-07	4.4E-07	1.3E-06	0.2
0.3	1.9E-05	1.6E-05	2.1E-05	2.4E-05	2.3E-05	2.1E-05	1.6E-05	7.9E-06	7.7E-06	7.3E-06	6.0E-06	4.8E-06	2.9E-06	2.4E-06	5.3E-06	1.6E-05	0.3
0.4	1.9E-05	1.2E-05	2.4E-05	2.8E-05	2.7E-05	2.1E-05	1.2E-05	1.0E-05	1.0E-05	9.9E-06	7.6E-06	6.3E-06	3.8E-06	3.1E-06	7.2E-06	1.2E-05	0.4
0.5	2.1E-05	2.0E-05	2.1E-05	2.2E-05	2.2E-05	2.1E-05	1.8E-05	8.3E-06	1.1E-05	7.6E-06	6.8E-06	5.4E-06	3.8E-06	2.9E-06	6.8E-06	1.9E-05	0.5
0.6	1.5E-05	1.3E-05	1.8E-05	1.9E-05	1.8E-05	1.6E-05	1.1E-05	7.2E-06	7.7E-06	7.0E-06	4.9E-06	3.9E-06	2.9E-06	2.9E-06	5.3E-06	1.1E-05	0.6
0.7	1.2E-05	1.2E-05	1.3E-05	1.5E-05	1.3E-05	1.2E-05	1.0E-05	6.2E-06	7.5E-06	4.6E-06	3.8E-06	3.4E-06	2.0E-06	2.0E-06	4.3E-06	1.1E-05	0.7
0.8	1.1E-05	1.1E-05	1.5E-05	1.7E-05	1.5E-05	1.3E-05	7.5E-06	6.3E-06	7.0E-06	5.5E-06	2.6E-06	2.6E-06	2.0E-06	1.8E-06	4.6E-06	7.6E-06	0.8
0.9	7.4E-06	9.8E-06	1.6E-05	1.8E-05	1.5E-05	1.1E-05	6.2E-06	5.7E-06	5.7E-06	4.5E-06	2.3E-06	2.3E-06	1.8E-06	1.7E-06	4.5E-06	6.2E-06	0.9
1.0	6.9E-06	8.3E-06	1.4E-05	1.7E-05	1.4E-05	1.1E-05	6.1E-06	4.6E-06	4.7E-06	3.8E-06	2.9E-06	2.6E-06	2.3E-06	2.1E-06	3.8E-06	6.1E-06	1.0
2.4	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.0E-05	9.8E-06	9.0E-06	9.9E-06	7.8E-06	3.8E-06	3.7E-06	3.7E-06	6.2E-06	1.0E-05	2.4
4.0	8.9E-06	8.8E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.7E-06	8.5E-06	8.4E-06	8.6E-06	8.1E-06	3.8E-06	3.3E-06	3.0E-06	7.1E-06	8.7E-06	4.0
5.6	7.1E-06	7.1E-06	7.4E-06	7.4E-06	7.4E-06	7.4E-06	7.3E-06	7.3E-06	7.3E-06	7.3E-06	6.9E-06	4.4E-06	3.2E-06	2.7E-06	5.7E-06	7.2E-06	5.6
7.2	6.0E-06	6.0E-06	6.4E-06	6.5E-06	6.5E-06	6.5E-06	6.2E-06	6.3E-06	6.2E-06	6.3E-06	5.6E-06	4.2E-06	3.7E-06	3.0E-06	4.7E-06	6.1E-06	7.2
12.1	3.9E-06	3.9E-06	4.3E-06	4.4E-06	4.5E-06	4.5E-06	4.4E-06	4.5E-06	4.5E-06	4.5E-06	4.2E-06	3.6E-06	3.2E-06	2.4E-06	3.4E-06	4.2E-06	12.1
24.1	1.9E-06	1.7E-06	2.5E-06	2.6E-06	2.7E-06	2.8E-06	2.8E-06	2.9E-06	3.0E-06	2.9E-06	2.6E-06	2.1E-06	1.8E-06	1.1E-06	1.5E-06	2.5E-06	24.1
40.3	1.4E-06	1.2E-06	1.4E-06	1.4E-06	1.5E-06	1.7E-06	1.8E-06	2.0E-06	2.0E-06	1.9E-06	1.5E-06	1.4E-06	1.4E-06	9.4E-07	1.4E-06	1.4E-06	40.3
56.3	9.7E-07	8.3E-07	1.2E-06	1.3E-06	1.4E-06	1.5E-06	1.5E-06	1.6E-06	1.6E-06	1.6E-06	1.4E-06	1.2E-06	1.2E-06	6.8E-07	9.3E-07	1.2E-06	56.3
72.4	7.3E-07	6.3E-07	1.1E-06	1.2E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	9.8E-07	1.0E-06	5.3E-07	7.0E-07	1.1E-06	72.4

TABLE H.5.9. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **Ground-Level** Releases from **300 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 300 Area **Towards** Direction Indicated)																Distance (km)
	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	
0.1	3.0E-02	2.4E-02	3.0E-02	2.9E-02	3.4E-02	3.2E-02	3.3E-02	5.1E-02	4.9E-02	3.1E-02	3.0E-02	3.3E-02	6.3E-02	7.4E-02	5.6E-02	3.4E-02	0.1
0.2	9.2E-03	7.3E-03	9.2E-03	8.7E-03	1.0E-02	9.8E-03	1.0E-02	1.5E-02	1.5E-02	9.3E-03	9.0E-03	9.9E-03	1.9E-02	2.2E-02	1.7E-02	1.0E-02	0.2
0.3	4.6E-03	3.6E-03	4.6E-03	4.4E-03	5.1E-03	4.9E-03	5.1E-03	7.7E-03	7.5E-03	4.7E-03	4.5E-03	5.0E-03	9.5E-03	1.1E-02	8.4E-03	5.2E-03	0.3
0.4	2.8E-03	2.2E-03	2.8E-03	2.7E-03	3.2E-03	3.0E-03	3.1E-03	4.7E-03	4.6E-03	2.9E-03	2.8E-03	3.1E-03	5.9E-03	6.9E-03	5.2E-03	3.2E-03	0.4
0.5	2.0E-03	1.5E-03	2.0E-03	1.8E-03	2.2E-03	2.1E-03	2.1E-03	3.3E-03	3.2E-03	2.0E-03	1.9E-03	2.1E-03	4.0E-03	4.7E-03	3.6E-03	2.2E-03	0.5
0.6	1.4E-03	1.1E-03	1.4E-03	1.4E-03	1.6E-03	1.5E-03	1.6E-03	2.4E-03	2.3E-03	1.5E-03	1.4E-03	1.6E-03	3.0E-03	3.5E-03	2.6E-03	1.6E-03	0.6
0.7	1.1E-03	8.8E-04	1.1E-03	1.1E-03	1.2E-03	1.2E-03	1.2E-03	1.9E-03	1.8E-03	1.1E-03	1.1E-03	1.2E-03	2.3E-03	2.7E-03	2.0E-03	1.2E-03	0.7
0.8	8.9E-04	7.0E-04	8.9E-04	8.5E-04	9.9E-04	9.5E-04	9.8E-04	1.5E-03	1.4E-03	9.0E-04	8.7E-04	9.6E-04	1.8E-03	2.2E-03	1.6E-03	1.0E-03	0.8
0.9	7.3E-04	5.8E-04	7.3E-04	7.0E-04	8.2E-04	7.8E-04	8.1E-04	1.2E-03	1.2E-03	7.4E-04	7.2E-04	7.9E-04	1.5E-03	1.8E-03	1.3E-03	8.2E-04	0.9
1.0	6.2E-04	4.9E-04	6.2E-04	5.8E-04	6.9E-04	6.5E-04	6.8E-04	1.0E-03	1.0E-03	6.2E-04	6.0E-04	6.6E-04	1.3E-03	1.5E-03	1.1E-03	6.9E-04	1.0
2.4	1.6E-04	1.2E-04	1.6E-04	1.5E-04	1.7E-04	1.7E-04	1.7E-04	2.6E-04	2.5E-04	1.6E-04	1.5E-04	1.7E-04	3.3E-04	3.8E-04	2.9E-04	1.7E-04	2.4
4.0	7.7E-05	6.1E-05	7.7E-05	7.2E-05	8.5E-05	8.2E-05	8.4E-05	1.3E-04	1.3E-04	7.8E-05	7.6E-05	8.3E-05	1.6E-04	1.9E-04	1.4E-04	8.6E-05	4.0
5.6	4.9E-05	3.9E-05	4.9E-05	4.6E-05	5.4E-05	5.2E-05	5.4E-05	8.2E-05	8.0E-05	5.0E-05	4.8E-05	5.3E-05	1.0E-04	1.2E-04	9.0E-05	5.5E-05	5.6
7.2	3.5E-05	2.8E-05	3.5E-05	3.3E-05	3.9E-05	3.7E-05	3.9E-05	5.9E-05	5.7E-05	3.6E-05	3.5E-05	3.8E-05	7.3E-05	8.6E-05	6.5E-05	3.9E-05	7.2
12.1	1.8E-05	1.5E-05	1.8E-05	1.7E-05	2.0E-05	2.0E-05	2.0E-05	3.1E-05	3.0E-05	1.9E-05	1.8E-05	2.0E-05	3.8E-05	4.5E-05	3.4E-05	2.0E-05	12.1
24.1	7.8E-06	6.2E-06	7.8E-06	7.2E-06	8.6E-06	8.3E-06	8.5E-06	1.3E-05	1.3E-05	7.9E-06	7.6E-06	8.4E-06	1.6E-05	1.9E-05	1.4E-05	8.7E-06	24.1
40.3	4.2E-06	3.3E-06	4.2E-06	3.8E-06	4.6E-06	4.4E-06	4.6E-06	7.0E-06	6.8E-06	4.2E-06	4.1E-06	4.5E-06	8.7E-06	1.0E-05	7.7E-06	4.7E-06	40.3
56.3	2.8E-06	2.2E-06	2.8E-06	2.6E-06	3.1E-06	3.0E-06	3.1E-06	4.7E-06	4.5E-06	2.8E-06	2.7E-06	3.0E-06	5.8E-06	6.8E-06	5.1E-06	3.1E-06	56.3
72.4	2.1E-06	1.6E-06	2.1E-06	1.9E-06	2.3E-06	2.2E-06	2.3E-06	3.5E-06	3.4E-06	2.1E-06	2.0E-06	2.2E-06	4.3E-06	5.0E-06	3.8E-06	2.3E-06	72.4

TABLE H.5.10. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **30-m Stack** Releases from **300 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 300 Area **Towards** Direction Indicated)																Distance (km)
	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	
0.1	2.3E-05	3.5E-05	3.8E-05	5.4E-05	3.8E-05	3.6E-05	3.1E-05	3.6E-05	2.5E-05	2.5E-05	2.5E-05	2.8E-05	2.3E-05	1.9E-05	1.3E-05	1.5E-05	0.1
0.2	4.8E-05	5.3E-05	9.2E-05	1.4E-04	1.1E-04	5.3E-05	5.2E-05	5.4E-05	5.0E-05	3.7E-05	3.1E-05	4.2E-05	4.4E-05	4.9E-05	3.1E-05	4.2E-05	0.2
0.3	4.7E-05	4.8E-05	7.3E-05	1.1E-04	8.9E-05	4.9E-05	4.8E-05	4.9E-05	4.8E-05	4.7E-05	4.6E-05	4.7E-05	4.8E-05	4.9E-05	4.8E-05	4.8E-05	0.3
0.4	5.5E-05	6.6E-05	9.0E-05	9.6E-05	9.3E-05	7.9E-05	6.1E-05	8.9E-05	7.9E-05	5.0E-05	4.6E-05	6.3E-05	9.1E-05	9.2E-05	8.1E-05	7.7E-05	0.4
0.5	6.5E-05	6.7E-05	9.9E-05	1.1E-04	1.1E-04	8.7E-05	6.7E-05	9.9E-05	9.1E-05	6.6E-05	6.4E-05	7.7E-05	1.1E-04	1.1E-04	9.6E-05	8.7E-05	0.5
0.6	7.7E-05	7.7E-05	9.9E-05	1.1E-04	1.0E-04	9.5E-05	8.3E-05	1.0E-04	9.7E-05	8.3E-05	8.2E-05	9.1E-05	1.1E-04	1.1E-04	1.0E-04	9.6E-05	0.6
0.7	8.1E-05	8.1E-05	9.5E-05	1.0E-04	9.8E-05	9.3E-05	8.7E-05	9.9E-05	9.7E-05	8.8E-05	8.7E-05	9.3E-05	1.0E-04	1.0E-04	9.9E-05	9.5E-05	0.7
0.8	8.7E-05	8.7E-05	9.3E-05	9.6E-05	9.4E-05	9.2E-05	8.9E-05	9.4E-05	9.4E-05	9.0E-05	8.9E-05	9.2E-05	9.6E-05	9.7E-05	9.5E-05	9.3E-05	0.8
0.9	8.8E-05	8.8E-05	8.8E-05	8.9E-05	8.9E-05	8.8E-05	8.8E-05	8.9E-05	8.9E-05	8.8E-05	8.8E-05	8.8E-05	8.9E-05	8.9E-05	8.9E-05	8.8E-05	0.9
1.0	7.9E-05	7.4E-05	8.4E-05	8.5E-05	8.5E-05	8.4E-05	8.3E-05	8.6E-05	8.6E-05	8.3E-05	8.3E-05	8.5E-05	8.7E-05	8.7E-05	8.6E-05	8.4E-05	1.0
2.4	3.9E-05	3.7E-05	4.6E-05	4.7E-05	4.9E-05	4.6E-05	4.7E-05	5.2E-05	5.2E-05	4.6E-05	4.5E-05	4.8E-05	5.3E-05	5.4E-05	5.2E-05	4.8E-05	2.4
4.0	2.7E-05	2.6E-05	3.3E-05	3.3E-05	3.5E-05	3.2E-05	3.4E-05	3.5E-05	3.5E-05	3.3E-05	3.2E-05	3.4E-05	3.5E-05	3.6E-05	3.5E-05	3.5E-05	4.0
5.6	1.8E-05	1.7E-05	2.2E-05	2.3E-05	2.5E-05	2.2E-05	2.3E-05	2.7E-05	2.7E-05	2.2E-05	2.1E-05	2.4E-05	2.8E-05	2.9E-05	2.7E-05	2.5E-05	5.6
7.2	1.3E-05	1.2E-05	1.7E-05	1.7E-05	1.9E-05	1.6E-05	1.8E-05	2.1E-05	2.1E-05	1.6E-05	1.6E-05	1.8E-05	2.3E-05	2.4E-05	2.2E-05	1.9E-05	7.2
12.1	7.3E-06	6.7E-06	9.2E-06	9.5E-06	1.1E-05	9.1E-06	9.9E-06	1.3E-05	1.3E-05	9.1E-06	8.9E-06	1.0E-05	1.4E-05	1.6E-05	1.4E-05	1.1E-05	12.1
24.1	3.6E-06	2.8E-06	3.6E-06	4.3E-06	4.8E-06	4.3E-06	4.7E-06	6.2E-06	6.1E-06	3.7E-06	3.3E-06	4.4E-06	7.1E-06	7.8E-06	6.5E-06	4.9E-06	24.1
40.3	2.0E-06	1.6E-06	2.0E-06	2.3E-06	2.7E-06	2.4E-06	2.6E-06	3.5E-06	3.5E-06	2.1E-06	1.9E-06	2.5E-06	4.1E-06	4.6E-06	3.7E-06	2.7E-06	40.3
56.3	1.4E-06	1.1E-06	1.4E-06	1.6E-06	1.8E-06	1.6E-06	1.8E-06	2.4E-06	2.4E-06	1.5E-06	1.3E-06	1.7E-06	2.8E-06	3.2E-06	2.6E-06	1.8E-06	56.3
72.4	1.1E-06	8.4E-07	1.1E-06	1.2E-06	1.4E-06	1.2E-06	1.3E-06	1.8E-06	1.8E-06	1.1E-06	1.0E-06	1.3E-06	2.1E-06	2.4E-06	2.0E-06	1.4E-06	72.4

TABLE H.5.11. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **60-m Stack** Releases from **300 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 300 Area **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	2.5E-08	4.7E-08	1.0E-07	1.2E-07	1.2E-07	5.0E-08	4.2E-08	4.5E-08	2.9E-08	2.9E-08	3.0E-08	3.1E-08	2.5E-08	1.8E-08	1.4E-08	6.3E-09	0.1
0.2	5.4E-06	7.3E-06	2.1E-05	2.4E-05	2.5E-05	9.6E-06	7.4E-06	8.2E-06	6.0E-06	6.0E-06	6.0E-06	6.1E-06	5.6E-06	4.7E-06	3.1E-06	3.4E-06	0.2
0.3	1.1E-05	1.6E-05	3.0E-05	3.3E-05	3.3E-05	1.8E-05	1.6E-05	1.8E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	9.0E-06	6.7E-06	8.5E-06	0.3
0.4	1.0E-05	1.5E-05	2.1E-05	3.1E-05	2.9E-05	1.5E-05	1.5E-05	1.6E-05	1.2E-05	9.4E-06	8.7E-06	1.0E-05	1.1E-05	9.0E-06	7.5E-06	8.8E-06	0.4
0.5	8.8E-06	1.2E-05	2.1E-05	2.8E-05	2.5E-05	1.3E-05	1.2E-05	1.5E-05	8.8E-06	8.7E-06	8.2E-06	8.7E-06	8.8E-06	8.7E-06	6.7E-06	8.7E-06	0.5
0.6	7.7E-06	1.4E-05	1.5E-05	2.2E-05	1.6E-05	1.4E-05	1.4E-05	1.4E-05	7.7E-06	7.7E-06	7.3E-06	7.7E-06	7.7E-06	7.5E-06	7.4E-06	7.7E-06	0.6
0.7	1.2E-05	1.2E-05	1.3E-05	2.0E-05	1.4E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.1E-05	1.1E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	0.7
0.8	1.2E-05	1.4E-05	1.6E-05	2.3E-05	2.0E-05	1.6E-05	1.5E-05	1.7E-05	1.5E-05	1.0E-05	8.4E-06	1.2E-05	1.7E-05	1.7E-05	1.5E-05	1.5E-05	0.8
0.9	1.1E-05	1.4E-05	2.0E-05	2.3E-05	2.2E-05	1.8E-05	1.7E-05	2.0E-05	1.7E-05	8.8E-06	7.8E-06	1.0E-05	2.0E-05	2.1E-05	1.7E-05	1.6E-05	0.9
1.0	1.1E-05	1.4E-05	2.1E-05	2.6E-05	2.4E-05	2.2E-05	2.0E-05	2.3E-05	2.1E-05	1.1E-05	9.9E-06	1.1E-05	2.3E-05	2.3E-05	2.1E-05	2.0E-05	1.0
2.4	1.2E-05	1.4E-05	1.6E-05	2.3E-05	2.0E-05	1.6E-05	1.5E-05	1.7E-05	1.5E-05	1.0E-05	8.3E-06	1.1E-05	1.7E-05	1.8E-05	1.5E-05	1.5E-05	2.4
4.0	1.2E-05	1.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	1.8E-05	1.5E-05	2.2E-05	2.3E-05	2.3E-05	2.2E-05	2.2E-05	4.0
5.6	1.3E-05	1.3E-05	1.4E-05	1.4E-05	1.6E-05	1.6E-05	1.6E-05	1.7E-05	1.6E-05	1.4E-05	1.4E-05	1.5E-05	1.8E-05	1.8E-05	1.6E-05	1.5E-05	5.6
7.2	9.8E-06	9.6E-06	1.2E-05	1.3E-05	1.4E-05	1.4E-05	1.4E-05	1.4E-05	1.4E-05	1.3E-05	1.1E-05	1.4E-05	1.4E-05	1.5E-05	1.4E-05	1.4E-05	7.2
12.1	7.3E-06	7.1E-06	9.5E-06	1.0E-05	1.1E-05	1.2E-05	1.2E-05	1.3E-05	1.2E-05	9.9E-06	8.7E-06	1.1E-05	1.3E-05	1.3E-05	1.2E-05	1.1E-05	12.1
24.1	5.7E-06	5.0E-06	6.4E-06	6.5E-06	6.6E-06	7.6E-06	7.7E-06	8.5E-06	7.8E-06	6.5E-06	6.5E-06	6.5E-06	8.2E-06	9.1E-06	7.6E-06	6.6E-06	24.1
40.3	2.6E-06	2.3E-06	2.9E-06	3.2E-06	4.5E-06	5.5E-06	5.6E-06	5.7E-06	5.6E-06	3.6E-06	2.9E-06	3.9E-06	5.7E-06	5.8E-06	5.5E-06	4.4E-06	40.3
56.3	1.6E-06	1.6E-06	1.6E-06	1.8E-06	2.7E-06	3.4E-06	3.5E-06	3.8E-06	3.6E-06	2.1E-06	1.6E-06	2.2E-06	3.8E-06	3.9E-06	3.4E-06	2.6E-06	56.3
72.4	1.1E-06	1.0E-06	1.1E-06	1.1E-06	1.6E-06	2.4E-06	2.6E-06	2.8E-06	2.6E-06	1.2E-06	1.1E-06	1.2E-06	2.8E-06	3.0E-06	2.4E-06	1.8E-06	72.4

TABLE H.5.12. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **Ground-Level** Releases from **400 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 400 Area **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	3.4E-02	3.2E-02	3.3E-02	3.7E-02	4.6E-02	3.6E-02	3.2E-02	2.9E-02	2.9E-02	1.9E-02	3.1E-02	3.3E-02	3.4E-02	3.0E-02	2.7E-02	3.2E-02	0.1
0.2	1.0E-02	9.7E-03	9.9E-03	1.1E-02	1.4E-02	1.1E-02	9.7E-03	8.6E-03	8.9E-03	5.9E-03	9.2E-03	1.0E-02	1.0E-02	9.0E-03	8.2E-03	9.5E-03	0.2
0.3	5.1E-03	4.9E-03	5.0E-03	5.6E-03	7.0E-03	5.4E-03	4.9E-03	4.3E-03	4.5E-03	2.9E-03	4.6E-03	5.0E-03	5.2E-03	4.5E-03	4.1E-03	4.8E-03	0.3
0.4	3.2E-03	3.0E-03	3.1E-03	3.4E-03	4.3E-03	3.3E-03	3.0E-03	2.7E-03	2.7E-03	1.8E-03	2.8E-03	3.1E-03	3.2E-03	2.8E-03	2.5E-03	3.0E-03	0.4
0.5	2.2E-03	2.1E-03	2.1E-03	2.4E-03	3.0E-03	2.3E-03	2.1E-03	1.8E-03	1.9E-03	1.2E-03	2.0E-03	2.1E-03	2.2E-03	1.9E-03	1.7E-03	2.0E-03	0.5
0.6	1.6E-03	1.5E-03	1.6E-03	1.7E-03	2.2E-03	1.7E-03	1.5E-03	1.3E-03	1.4E-03	9.2E-04	1.4E-03	1.6E-03	1.6E-03	1.4E-03	1.3E-03	1.5E-03	0.6
0.7	1.2E-03	1.2E-03	1.2E-03	1.3E-03	1.7E-03	1.3E-03	1.2E-03	1.0E-03	1.1E-03	7.1E-04	1.1E-03	1.2E-03	1.3E-03	1.1E-03	9.9E-04	1.2E-03	0.7
0.8	9.9E-04	9.4E-04	9.6E-04	1.1E-03	1.4E-03	1.0E-03	9.4E-04	8.3E-04	8.6E-04	5.7E-04	8.9E-04	9.7E-04	1.0E-03	8.8E-04	7.9E-04	9.3E-04	0.8
0.9	8.2E-04	7.7E-04	7.9E-04	8.8E-04	1.1E-03	8.6E-04	7.7E-04	6.9E-04	7.1E-04	4.7E-04	7.3E-04	7.9E-04	8.3E-04	7.2E-04	6.5E-04	7.6E-04	0.9
1.0	6.9E-04	6.5E-04	6.7E-04	7.4E-04	9.4E-04	7.2E-04	6.5E-04	5.8E-04	5.9E-04	3.9E-04	6.2E-04	6.7E-04	6.9E-04	6.0E-04	5.5E-04	6.4E-04	1.0
2.4	1.7E-04	1.6E-04	1.7E-04	1.9E-04	2.4E-04	1.8E-04	1.7E-04	1.5E-04	1.5E-04	1.0E-04	1.6E-04	1.7E-04	1.8E-04	1.5E-04	1.4E-04	1.6E-04	2.4
4.0	8.5E-05	8.1E-05	8.3E-05	9.2E-05	1.2E-04	9.0E-05	8.1E-05	7.2E-05	7.5E-05	4.9E-05	7.7E-05	8.3E-05	8.6E-05	7.6E-05	6.9E-05	8.0E-05	4.0
5.6	5.4E-05	5.2E-05	5.3E-05	5.9E-05	7.5E-05	5.7E-05	5.2E-05	4.6E-05	4.8E-05	3.1E-05	4.9E-05	5.3E-05	5.5E-05	4.8E-05	4.4E-05	5.1E-05	5.6
7.2	3.9E-05	3.7E-05	3.8E-05	4.2E-05	5.4E-05	4.1E-05	3.7E-05	3.3E-05	3.4E-05	2.3E-05	3.5E-05	3.8E-05	4.0E-05	3.5E-05	3.2E-05	3.7E-05	7.2
12.1	2.0E-05	1.9E-05	2.0E-05	2.2E-05	2.8E-05	2.1E-05	1.9E-05	1.7E-05	1.8E-05	1.2E-05	1.8E-05	2.0E-05	2.1E-05	1.8E-05	1.6E-05	1.9E-05	12.1
24.1	8.6E-06	8.2E-06	8.4E-06	9.3E-06	1.2E-05	9.1E-06	8.2E-06	7.3E-06	7.5E-06	5.0E-06	7.8E-06	8.4E-06	8.7E-06	7.7E-06	7.0E-06	8.1E-06	24.1
40.3	4.6E-06	4.4E-06	4.5E-06	5.0E-06	6.4E-06	4.9E-06	4.4E-06	3.9E-06	4.1E-06	2.7E-06	4.2E-06	4.5E-06	4.7E-06	4.1E-06	3.7E-06	4.3E-06	40.3
56.3	3.1E-06	2.9E-06	3.0E-06	3.4E-06	4.3E-06	3.3E-06	2.9E-06	2.6E-06	2.7E-06	1.8E-06	2.8E-06	3.0E-06	3.1E-06	2.8E-06	2.5E-06	2.9E-06	56.3
72.4	2.3E-06	2.2E-06	2.2E-06	2.5E-06	3.2E-06	2.4E-06	2.2E-06	1.9E-06	2.0E-06	1.3E-06	2.1E-06	2.2E-06	2.3E-06	2.0E-06	1.9E-06	2.2E-06	72.4

TABLE H.5.13. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **10-m Stack** Releases from **400 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 400 Area Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	7.8E-04	7.9E-04	8.2E-04	1.0E-03	1.1E-03	1.0E-03	8.2E-04	6.8E-04	5.7E-04	4.3E-04	6.1E-04	7.6E-04	7.7E-04	6.3E-04	5.1E-04	7.5E-04	0.1
0.2	1.3E-03	1.2E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.2E-03	1.2E-03	8.9E-04	1.2E-03	1.3E-03	1.3E-03	1.2E-03	1.1E-03	1.3E-03	0.2
0.3	1.1E-03	1.0E-03	1.1E-03	1.1E-03	1.2E-03	1.2E-03	1.1E-03	9.6E-04	9.9E-04	8.9E-04	1.0E-03	1.1E-03	1.1E-03	1.1E-03	9.4E-04	1.1E-03	0.3
0.4	9.9E-04	9.4E-04	1.0E-03	1.1E-03	1.1E-03	1.0E-03	9.8E-04	8.0E-04	8.4E-04	6.8E-04	9.5E-04	1.0E-03	1.0E-03	9.4E-04	7.6E-04	9.6E-04	0.4
0.5	7.6E-04	7.2E-04	7.5E-04	8.8E-04	9.3E-04	8.2E-04	7.2E-04	7.0E-04	7.2E-04	6.2E-04	7.2E-04	7.9E-04	8.1E-04	7.2E-04	6.8E-04	7.2E-04	0.5
0.6	8.8E-04	7.8E-04	8.7E-04	9.0E-04	9.1E-04	8.9E-04	8.5E-04	5.5E-04	6.2E-04	4.9E-04	7.9E-04	8.8E-04	8.9E-04	7.4E-04	5.4E-04	7.8E-04	0.6
0.7	7.8E-04	6.4E-04	7.4E-04	8.1E-04	8.4E-04	8.1E-04	7.0E-04	4.5E-04	5.0E-04	4.1E-04	6.4E-04	7.6E-04	8.0E-04	6.1E-04	4.5E-04	6.6E-04	0.7
0.8	6.7E-04	5.5E-04	6.3E-04	7.1E-04	7.5E-04	7.1E-04	6.1E-04	3.8E-04	4.2E-04	3.6E-04	5.5E-04	6.6E-04	7.0E-04	5.2E-04	3.8E-04	5.7E-04	0.8
0.9	5.9E-04	4.8E-04	5.5E-04	6.2E-04	6.8E-04	6.2E-04	5.3E-04	3.2E-04	3.6E-04	3.2E-04	4.7E-04	5.7E-04	6.1E-04	4.5E-04	3.2E-04	4.9E-04	0.9
1.0	5.2E-04	4.3E-04	4.7E-04	5.5E-04	6.1E-04	5.4E-04	4.4E-04	2.9E-04	3.2E-04	2.8E-04	3.7E-04	4.8E-04	5.3E-04	3.4E-04	2.9E-04	4.2E-04	1.0
2.4	1.6E-04	1.4E-04	1.5E-04	1.7E-04	2.1E-04	1.7E-04	1.4E-04	1.2E-04	1.2E-04	9.5E-05	1.3E-04	1.5E-04	1.6E-04	1.3E-04	1.1E-04	1.4E-04	2.4
4.0	8.1E-05	7.5E-05	7.8E-05	8.7E-05	1.1E-04	8.5E-05	7.5E-05	6.3E-05	6.6E-05	4.9E-05	7.0E-05	7.8E-05	8.2E-05	6.8E-05	6.0E-05	7.3E-05	4.0
5.6	5.2E-05	4.8E-05	5.0E-05	5.6E-05	7.0E-05	5.5E-05	4.9E-05	4.2E-05	4.3E-05	2.8E-05	4.5E-05	5.0E-05	5.3E-05	4.4E-05	4.0E-05	4.8E-05	5.6
7.2	3.8E-05	3.5E-05	3.7E-05	4.1E-05	5.1E-05	4.0E-05	3.5E-05	3.1E-05	3.2E-05	2.1E-05	3.3E-05	3.7E-05	3.8E-05	3.2E-05	2.9E-05	3.5E-05	7.2
12.1	2.0E-05	1.9E-05	1.9E-05	2.2E-05	2.7E-05	2.1E-05	1.9E-05	1.6E-05	1.7E-05	1.1E-05	1.8E-05	1.9E-05	2.0E-05	1.7E-05	1.6E-05	1.8E-05	12.1
24.1	8.5E-06	8.0E-06	8.2E-06	9.2E-06	1.2E-05	8.9E-06	8.0E-06	7.0E-06	7.3E-06	4.8E-06	7.6E-06	8.3E-06	8.6E-06	7.4E-06	6.7E-06	7.9E-06	24.1
40.3	4.6E-06	4.3E-06	4.5E-06	5.0E-06	6.2E-06	4.8E-06	4.3E-06	3.8E-06	4.0E-06	2.6E-06	4.1E-06	4.5E-06	4.6E-06	4.0E-06	3.6E-06	4.3E-06	40.3
56.3	3.1E-06	2.9E-06	3.0E-06	3.3E-06	4.2E-06	3.2E-06	2.9E-06	2.6E-06	2.7E-06	1.8E-06	2.8E-06	3.0E-06	3.1E-06	2.7E-06	2.4E-06	2.9E-06	56.3
72.4	2.3E-06	2.2E-06	2.2E-06	2.5E-06	3.1E-06	2.4E-06	2.2E-06	1.9E-06	2.0E-06	1.3E-06	2.1E-06	2.2E-06	2.3E-06	2.0E-06	1.8E-06	2.1E-06	72.4

TABLE H.5.14. **95th Percentile E/Q** Values (sec m^{-3}) for Acute **30-m Stack** Releases from **400 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 400 Area Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	3.6E-05	3.7E-05	3.7E-05	5.9E-05	5.9E-05	6.8E-05	3.7E-05	3.2E-05	3.3E-05	2.7E-05	2.3E-05	3.0E-05	3.2E-05	2.1E-05	1.6E-05	2.6E-05	0.1
0.2	5.3E-05	5.4E-05	8.3E-05	1.5E-04	1.5E-04	1.5E-04	8.1E-05	5.2E-05	5.1E-05	4.0E-05	3.6E-05	5.1E-05	5.2E-05	3.6E-05	3.1E-05	5.0E-05	0.2
0.3	4.9E-05	4.9E-05	6.9E-05	1.1E-04	1.2E-04	1.1E-04	7.0E-05	4.8E-05	4.7E-05	4.6E-05	4.7E-05	4.8E-05	4.8E-05	4.7E-05	4.6E-05	4.8E-05	0.3
0.4	8.5E-05	8.1E-05	9.2E-05	9.6E-05	9.7E-05	9.5E-05	9.2E-05	6.3E-05	4.5E-05	3.5E-05	4.8E-05	6.7E-05	7.7E-05	5.3E-05	4.5E-05	7.4E-05	0.4
0.5	9.5E-05	8.8E-05	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	7.1E-05	5.5E-05	4.5E-05	6.6E-05	8.1E-05	8.9E-05	6.8E-05	5.8E-05	8.6E-05	0.5
0.6	9.9E-05	9.4E-05	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.0E-04	8.5E-05	7.0E-05	5.9E-05	8.2E-05	9.3E-05	9.6E-05	8.4E-05	7.4E-05	9.5E-05	0.6
0.7	9.6E-05	9.0E-05	1.0E-04	1.0E-04	1.0E-04	1.0E-04	9.9E-05	8.6E-05	8.0E-05	7.6E-05	8.6E-05	9.5E-05	9.6E-05	8.8E-05	8.1E-05	9.5E-05	0.7
0.8	9.3E-05	9.1E-05	9.6E-05	9.7E-05	9.7E-05	9.7E-05	9.5E-05	8.9E-05	8.4E-05	6.7E-05	8.9E-05	9.3E-05	9.3E-05	9.0E-05	8.6E-05	9.3E-05	0.8
0.9	8.8E-05	8.8E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.8E-05	8.5E-05	6.0E-05	8.8E-05	8.8E-05	8.8E-05	8.8E-05	8.8E-05	8.8E-05	0.9
1.0	8.4E-05	8.2E-05	8.5E-05	8.6E-05	8.7E-05	8.7E-05	8.4E-05	8.1E-05	8.1E-05	6.3E-05	8.2E-05	8.6E-05	8.5E-05	8.3E-05	7.7E-05	8.4E-05	1.0
2.4	4.7E-05	4.4E-05	4.8E-05	5.1E-05	5.2E-05	5.0E-05	4.6E-05	3.6E-05	3.9E-05	3.1E-05	4.5E-05	4.9E-05	4.9E-05	4.4E-05	3.4E-05	4.5E-05	2.4
4.0	3.4E-05	3.1E-05	3.4E-05	3.5E-05	3.5E-05	3.5E-05	3.4E-05	2.3E-05	2.5E-05	2.0E-05	3.1E-05	3.5E-05	3.5E-05	2.9E-05	2.2E-05	3.1E-05	4.0
5.6	2.5E-05	2.1E-05	2.3E-05	2.6E-05	2.6E-05	2.6E-05	2.2E-05	1.5E-05	1.7E-05	1.3E-05	2.0E-05	2.4E-05	2.5E-05	2.0E-05	1.5E-05	2.1E-05	5.6
7.2	1.9E-05	1.6E-05	1.8E-05	2.0E-05	2.1E-05	2.0E-05	1.7E-05	1.1E-05	1.2E-05	1.0E-05	1.5E-05	1.8E-05	1.9E-05	1.5E-05	1.1E-05	1.6E-05	7.2
12.1	1.1E-05	8.6E-06	1.0E-05	1.1E-05	1.2E-05	1.1E-05	9.5E-06	5.8E-06	6.4E-06	5.8E-06	8.5E-06	1.0E-05	1.1E-05	8.0E-06	5.8E-06	8.8E-06	12.1
24.1	4.8E-06	4.1E-06	4.5E-06	5.2E-06	5.9E-06	5.1E-06	4.2E-06	2.9E-06	3.2E-06	2.6E-06	3.6E-06	4.5E-06	5.0E-06	3.4E-06	2.8E-06	4.0E-06	24.1
40.3	2.7E-06	2.3E-06	2.5E-06	2.9E-06	3.3E-06	2.8E-06	2.4E-06	1.7E-06	1.8E-06	1.5E-06	2.1E-06	2.5E-06	2.8E-06	1.9E-06	1.6E-06	2.3E-06	40.3
56.3	1.8E-06	1.6E-06	1.7E-06	2.0E-06	2.3E-06	1.9E-06	1.6E-06	1.2E-06	1.3E-06	9.9E-07	1.4E-06	1.7E-06	1.9E-06	1.3E-06	1.1E-06	1.6E-06	56.3
72.4	1.4E-06	1.2E-06	1.3E-06	1.5E-06	1.7E-06	1.4E-06	1.2E-06	9.0E-07	9.7E-07	7.4E-07	1.1E-06	1.3E-06	1.4E-06	1.0E-06	8.7E-07	1.2E-06	72.4

APPENDIX H.6

ATMOSPHERIC DISPERSION FACTORS: 99.5TH PERCENTILE CENTER-LINE E/Q VALUES FOR ACUTE ATMOSPHERIC RELEASES FROM THE HANFORD AREAS BASED ON 1983 THROUGH 1991 METEOROLOGICAL INFORMATION

THIS PAGE BLANK INTENTIONALLY

APPENDIX H.6

ATMOSPHERIC DISPERSION FACTORS: 99.5TH PERCENTILE CENTER-LINE E/Q VALUES FOR ACUTE ATMOSPHERIC RELEASES FROM THE HANFORD AREAS BASED ON 1983 THROUGH 1991 METEOROLOGICAL INFORMATION

Atmospheric dispersion factors for acute releases from the four major Hanford Areas are presented in Tables H.6.1-14. The 99.5th percentile center-line E/Q values were calculated using the GENII code based on meteorological information averaged over the years 1983 through 1991. A description of the computation of the E/Q values is presented in Appendix H.1. It should be noted that these values are calculated differently from the 99.5th percentile sector values specified in U.S. Nuclear Regulatory Commission Guide 1.145[a].

---

[a] U.S. Nuclear Regulatory Commission. 1983. Atmospheric Dispersion Models for Potential Accident Consequences Assessments at Nuclear Power Plants. Regulatory Guide 1.145, Revision 1 (updated), Office of Nuclear Regulatory Research, Washington, D.C.

TABLE H.6.1. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **Ground-Level** Releases from **100 N Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 100 N Towards Direction Indicated)																Distance (km)
	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	
0.1	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	0.1
0.2	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	0.2
0.3	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	0.3
0.4	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	0.4
0.5	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	0.5
0.6	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	0.6
0.7	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	0.7
0.8	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	0.8
0.9	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	0.9
1.0	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.0
2.4	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	2.4
4.0	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	4.0
5.6	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	5.6
7.2	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	7.2
12.1	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	12.1
24.1	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	24.1
40.3	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	40.3
56.3	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	56.3
72.4	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	72.4

TABLE H.6.2. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **30-m Stack** Releases from **100 N Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 100 N Towards Direction Indicated)																Distance (km)
	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	
0.1	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	0.1
0.2	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	0.2
0.3	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	0.3
0.4	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.3E-04	1.4E-04	1.4E-04	1.4E-04	0.4
0.5	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	0.5
0.6	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	0.6
0.7	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	0.7
0.8	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	0.8
0.9	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	0.9
1.0	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	1.0
2.4	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	2.4
4.0	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	4.0
5.6	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	5.6
7.2	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	7.2
12.1	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	12.1
24.1	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	24.1
40.3	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	40.3
56.3	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	56.3
72.4	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	72.4

TABLE H.6.3. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **60-m Stack** Releases from **100 N Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 100 N **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	0.1
0.2	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	0.2
0.3	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	0.3
0.4	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.7E-05	4.8E-05	4.8E-05	4.8E-05	0.4
0.5	4.7E-05	4.7E-05	4.7E-05	4.7E-05	4.7E-05	4.7E-05	4.7E-05	4.7E-05	4.7E-05	4.7E-05	4.7E-05	4.6E-05	4.4E-05	4.7E-05	4.7E-05	4.7E-05	0.5
0.6	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	0.6
0.7	4.2E-05	4.2E-05	4.2E-05	4.2E-05	4.2E-05	4.2E-05	4.2E-05	4.2E-05	4.2E-05	4.2E-05	4.2E-05	4.1E-05	3.9E-05	4.2E-05	4.2E-05	4.2E-05	0.7
0.8	4.0E-05	4.0E-05	4.0E-05	4.0E-05	4.0E-05	4.0E-05	4.0E-05	4.0E-05	4.0E-05	4.0E-05	4.0E-05	3.9E-05	3.6E-05	4.0E-05	4.0E-05	4.0E-05	0.8
0.9	3.7E-05	3.7E-05	3.7E-05	3.7E-05	3.7E-05	3.7E-05	3.7E-05	3.7E-05	3.7E-05	3.7E-05	3.7E-05	3.7E-05	3.3E-05	3.7E-05	3.7E-05	3.7E-05	0.9
1.0	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.3E-05	3.4E-05	3.4E-05	3.4E-05	1.0
2.4	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.4
4.0	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	4.0
5.6	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	5.6
7.2	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	7.2
12.1	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	12.1
24.1	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	24.1
40.3	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	40.3
56.3	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	56.3
72.4	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	72.4

TABLE H.6.4. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **90-m Stack** Releases from **100 N Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 100 N **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	0.1
0.2	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	0.2
0.3	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	0.3
0.4	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	0.4
0.5	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	0.5
0.6	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.2E-05	2.3E-05	2.3E-05	2.3E-05	0.6
0.7	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.2E-05	2.1E-05	2.3E-05	2.3E-05	2.3E-05	0.7
0.8	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.0E-05	2.0E-05	2.1E-05	2.1E-05	2.1E-05	0.8
0.9	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	0.9
1.0	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.0
2.4	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	2.4
4.0	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	4.0
5.6	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	5.6
7.2	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	7.2
12.1	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	12.1
24.1	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	24.1
40.3	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	40.3
56.3	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	56.3
72.4	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	72.4

TABLE H.6.5. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **Ground-Level** Releases from **200 Areas** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 200 Areas **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	8.5E-02	8.4E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.1E-02	8.5E-02	8.5E-02	0.1
0.2	2.6E-02	2.5E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.4E-02	2.6E-02	2.6E-02	0.2
0.3	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.2E-02	1.3E-02	1.3E-02	0.3
0.4	8.0E-03	7.8E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	7.5E-03	8.0E-03	8.0E-03	0.4
0.5	5.5E-03	5.4E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.2E-03	5.5E-03	5.5E-03	0.5
0.6	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	3.8E-03	4.0E-03	4.0E-03	0.6
0.7	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	2.9E-03	3.1E-03	3.1E-03	0.7
0.8	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.4E-03	2.5E-03	2.5E-03	0.8
0.9	2.1E-03	2.0E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	1.9E-03	2.1E-03	2.1E-03	0.9
1.0	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.6E-03	1.7E-03	1.7E-03	1.0
2.4	4.4E-04	4.3E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.2E-04	4.4E-04	4.4E-04	2.4
4.0	2.2E-04	2.1E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.0E-04	2.2E-04	2.2E-04	4.0
5.6	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.3E-04	1.4E-04	1.4E-04	5.6
7.2	9.9E-05	9.8E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.4E-05	9.9E-05	9.9E-05	7.2
12.1	5.2E-05	5.1E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	4.9E-05	5.2E-05	5.2E-05	12.1
24.1	2.2E-05	2.1E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.1E-05	2.2E-05	2.2E-05	24.1
40.3	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.1E-05	1.2E-05	1.2E-05	40.3
56.3	7.9E-06	7.7E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.4E-06	7.9E-06	7.9E-06	56.3
72.4	5.8E-06	5.7E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.5E-06	5.8E-06	5.8E-06	72.4

TABLE H.6.6. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **30-m Stack** Releases from **200 Areas** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 200 Areas **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	8.7E-05	6.7E-05	1.1E-04	1.1E-04	0.1
0.2	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.5E-04	1.5E-04	1.6E-04	1.6E-04	0.2
0.3	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.4E-04	1.4E-04	1.3E-04	1.2E-04	1.5E-04	1.5E-04	0.3
0.4	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.3E-04	1.3E-04	1.3E-04	1.1E-04	1.0E-04	9.8E-05	9.7E-05	1.3E-04	1.4E-04	0.4
0.5	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	0.5
0.6	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	0.6
0.7	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	0.7
0.8	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	0.8
0.9	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	0.9
1.0	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	1.0
2.4	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	2.4
4.0	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	4.0
5.6	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	5.6
7.2	2.6E-05	2.5E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.5E-05	2.6E-05	2.6E-05	7.2
12.1	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.6E-05	1.7E-05	1.7E-05	12.1
24.1	8.7E-06	8.6E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.3E-06	8.7E-06	8.7E-06	24.1
40.3	5.1E-06	5.0E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	4.9E-06	5.1E-06	5.1E-06	40.3
56.3	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.4E-06	3.5E-06	3.5E-06	56.3
72.4	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.6E-06	2.7E-06	2.7E-06	72.4

TABLE H.6.7. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **60-m Stack** Releases from **200 Areas** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 200 Areas Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.4E-07	1.3E-07	1.6E-07	1.6E-07	0.1
0.2	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.1E-05	2.8E-05	2.6E-05	3.2E-05	3.2E-05	0.2
0.3	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.5E-05	4.9E-05	4.2E-05	5.6E-05	5.6E-05	0.3
0.4	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.7E-05	4.8E-05	4.8E-05	4.4E-05	4.4E-05	4.2E-05	4.1E-05	4.6E-05	4.8E-05	0.4
0.5	4.7E-05	4.7E-05	4.7E-05	4.7E-05	4.7E-05	4.7E-05	4.7E-05	4.4E-05	4.7E-05	4.5E-05	3.5E-05	3.7E-05	3.3E-05	3.0E-05	4.3E-05	4.7E-05	0.5
0.6	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	3.7E-05	2.7E-05	4.1E-05	4.1E-05	0.6
0.7	4.2E-05	4.2E-05	4.2E-05	4.2E-05	4.2E-05	4.2E-05	4.2E-05	4.1E-05	4.0E-05	4.1E-05	3.7E-05	3.7E-05	2.9E-05	2.1E-05	4.0E-05	4.2E-05	0.7
0.8	4.0E-05	4.0E-05	4.0E-05	4.0E-05	4.0E-05	4.0E-05	4.0E-05	3.9E-05	3.8E-05	3.8E-05	3.2E-05	3.2E-05	2.7E-05	2.6E-05	3.7E-05	4.0E-05	0.8
0.9	3.7E-05	3.7E-05	3.7E-05	3.7E-05	3.7E-05	3.7E-05	3.7E-05	3.6E-05	3.5E-05	3.5E-05	2.8E-05	2.8E-05	2.3E-05	2.3E-05	3.4E-05	3.7E-05	0.9
1.0	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.4E-05	3.3E-05	3.4E-05	3.3E-05	3.2E-05	3.1E-05	2.9E-05	3.3E-05	3.4E-05	1.0
2.4	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.4
4.0	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	4.0
5.6	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	5.6
7.2	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	7.2
12.1	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	12.1
24.1	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	24.1
40.3	4.6E-06	4.5E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.5E-06	4.6E-06	4.6E-06	40.3
56.3	3.7E-06	3.5E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.5E-06	3.7E-06	3.7E-06	56.3
72.4	3.0E-06	2.9E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	2.9E-06	3.0E-06	3.0E-06	72.4

TABLE H.6.8. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **90-m Stack** Releases from **200 Areas** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 200 Areas Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.7E-12	2.6E-12	2.4E-12	2.2E-12	2.7E-12	2.7E-12	0.1
0.2	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	1.8E-06	1.6E-06	2.0E-06	2.0E-06	0.2
0.3	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.4E-05	2.1E-05	2.0E-05	2.4E-05	2.4E-05	0.3
0.4	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.4E-05	1.9E-05	2.9E-05	2.9E-05	0.4
0.5	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.1E-05	2.1E-05	2.2E-05	2.2E-05	0.5
0.6	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.1E-05	2.3E-05	2.2E-05	1.9E-05	1.9E-05	1.7E-05	1.6E-05	2.1E-05	2.3E-05	0.6
0.7	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	1.9E-05	2.3E-05	2.1E-05	1.3E-05	1.3E-05	1.3E-05	1.2E-05	1.9E-05	2.3E-05	0.7
0.8	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	1.9E-05	2.1E-05	2.0E-05	1.6E-05	1.6E-05	1.5E-05	1.2E-05	1.9E-05	2.1E-05	0.8
0.9	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.8E-05	1.9E-05	1.9E-05	1.8E-05	1.7E-05	1.6E-05	1.0E-05	1.8E-05	1.9E-05	0.9
1.0	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.8E-05	1.7E-05	1.6E-05	1.6E-05	9.8E-06	1.8E-05	1.8E-05	1.0
2.4	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	2.4
4.0	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	8.9E-06	4.0
5.6	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	7.5E-06	5.6
7.2	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06	7.2
12.1	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	12.1
24.1	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06	24.1
40.3	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06	40.3
56.3	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06	56.3
72.4	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06	72.4

TABLE H.6.9. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **Ground-Level** Releases from **300 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 300 Area **Towards** Direction Indicated)																Distance (km)
	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	
0.1	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	0.1
0.2	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	0.2
0.3	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	0.3
0.4	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	0.4
0.5	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	0.5
0.6	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	0.6
0.7	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	0.7
0.8	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	0.8
0.9	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	0.9
1.0	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.0
2.4	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	2.4
4.0	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	4.0
5.6	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	5.6
7.2	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	7.2
12.1	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	12.1
24.1	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	24.1
40.3	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	40.3
56.3	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	56.3
72.4	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	72.4

TABLE H.6.10. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **30-m Stack** Releases from **300 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 300 Area **Towards** Direction Indicated)																Distance (km)
	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	
0.1	1.0E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.0E-04	1.1E-04	1.1E-04	8.1E-05	5.2E-05	8.6E-05	9.2E-05	1.1E-04	1.1E-04	1.0E-04	0.1
0.2	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.5E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	0.2
0.3	1.4E-04	1.4E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.4E-04	1.5E-04	1.5E-04	1.4E-04	1.2E-04	1.4E-04	1.5E-04	1.5E-04	1.5E-04	1.4E-04	0.3
0.4	1.2E-04	1.2E-04	1.4E-04	1.4E-04	1.4E-04	1.3E-04	1.3E-04	1.4E-04	1.3E-04	1.1E-04	9.8E-05	1.2E-04	1.3E-04	1.4E-04	1.3E-04	1.3E-04	0.4
0.5	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	0.5
0.6	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	0.6
0.7	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	0.7
0.8	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	0.8
0.9	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	0.9
1.0	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	1.0
2.4	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	2.4
4.0	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	4.0
5.6	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	5.6
7.2	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	7.2
12.1	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	12.1
24.1	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	24.1
40.3	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	40.3
56.3	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	56.3
72.4	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	72.4

TABLE H.6.11. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **60-m Stack** Releases from **300 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 300 Area Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	1.5E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.4E-07	1.3E-07	1.5E-07	1.4E-07	1.5E-07	1.6E-07	1.5E-07	0.1
0.2	3.0E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	3.2E-05	2.8E-05	2.7E-05	3.0E-05	2.8E-05	2.9E-05	3.1E-05	2.9E-05	0.2
0.3	5.2E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	5.6E-05	4.6E-05	3.8E-05	5.2E-05	5.1E-05	5.2E-05	5.5E-05	5.2E-05	0.3
0.4	4.6E-05	4.6E-05	4.8E-05	4.8E-05	4.8E-05	4.6E-05	4.7E-05	4.8E-05	4.6E-05	4.3E-05	4.1E-05	4.5E-05	4.7E-05	4.8E-05	4.6E-05	4.7E-05	0.4
0.5	4.3E-05	4.3E-05	4.7E-05	4.7E-05	4.7E-05	4.2E-05	4.4E-05	4.6E-05	4.3E-05	3.6E-05	3.2E-05	3.9E-05	4.6E-05	4.7E-05	4.3E-05	4.5E-05	0.5
0.6	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	3.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	4.1E-05	0.6
0.7	3.9E-05	3.7E-05	4.1E-05	4.2E-05	4.2E-05	4.1E-05	4.1E-05	4.1E-05	4.0E-05	3.5E-05	2.9E-05	3.5E-05	4.1E-05	4.2E-05	4.0E-05	3.9E-05	0.7
0.8	3.6E-05	3.3E-05	3.9E-05	4.0E-05	4.0E-05	3.9E-05	3.8E-05	3.9E-05	3.7E-05	2.9E-05	2.7E-05	3.0E-05	3.9E-05	4.0E-05	3.8E-05	3.7E-05	0.8
0.9	3.3E-05	3.0E-05	3.6E-05	3.7E-05	3.7E-05	3.6E-05	3.5E-05	3.6E-05	3.4E-05	2.5E-05	2.3E-05	2.6E-05	3.6E-05	3.7E-05	3.5E-05	3.3E-05	0.9
1.0	3.3E-05	3.2E-05	3.3E-05	3.4E-05	3.4E-05	3.4E-05	3.3E-05	3.4E-05	3.3E-05	3.2E-05	3.1E-05	3.2E-05	3.4E-05	3.4E-05	3.3E-05	3.3E-05	1.0
2.4	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.3E-05	2.4
4.0	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05	4.0
5.6	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	1.5E-05	5.6
7.2	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	7.2
12.1	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	9.9E-06	12.1
24.1	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	6.0E-06	24.1
40.3	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	4.6E-06	40.3
56.3	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	3.7E-06	56.3
72.4	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06	72.4

TABLE H.6.12. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **Ground-Level** Releases from **400 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 400 Area Towards Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	8.5E-02	0.1
0.2	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	0.2
0.3	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	0.3
0.4	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	7.9E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	8.0E-03	0.4
0.5	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03	0.5
0.6	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	4.0E-03	0.6
0.7	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	3.1E-03	0.7
0.8	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	0.8
0.9	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.0E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	0.9
1.0	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.7E-03	1.0
2.4	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	2.4
4.0	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	4.0
5.6	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	5.6
7.2	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	9.9E-05	7.2
12.1	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	5.2E-05	12.1
24.1	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	2.2E-05	24.1
40.3	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	40.3
56.3	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	7.9E-06	56.3
72.4	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	5.8E-06	72.4

TABLE H.6.13. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **10-m Stack** Releases from **400 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 400 Area **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	1.4E-03	1.5E-03	1.5E-03	1.5E-03	1.5E-03	1.5E-03	1.5E-03	1.4E-03	1.2E-03	1.2E-03	1.4E-03	1.3E-03	1.5E-03	1.3E-03	1.3E-03	1.4E-03	0.1
0.2	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	1.3E-03	0.2
0.3	1.2E-03	1.2E-03	1.2E-03	1.2E-03	1.2E-03	1.2E-03	1.2E-03	1.2E-03	1.2E-03	1.2E-03	1.2E-03	1.2E-03	1.2E-03	1.2E-03	1.2E-03	1.2E-03	0.3
0.4	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	0.4
0.5	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	0.5
0.6	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	0.6
0.7	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	0.7
0.8	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	9.3E-04	0.8
0.9	9.0E-04	9.0E-04	9.0E-04	9.0E-04	9.0E-04	9.0E-04	9.0E-04	9.0E-04	9.0E-04	9.0E-04	9.0E-04	9.0E-04	9.0E-04	9.0E-04	9.0E-04	9.0E-04	0.9
1.0	8.5E-04	8.5E-04	8.5E-04	8.5E-04	8.5E-04	8.5E-04	8.5E-04	8.5E-04	8.5E-04	8.5E-04	8.5E-04	8.5E-04	8.5E-04	8.5E-04	8.5E-04	8.5E-04	1.0
2.4	3.5E-04	3.5E-04	3.5E-04	3.5E-04	3.5E-04	3.5E-04	3.5E-04	3.5E-04	3.5E-04	3.5E-04	3.5E-04	3.5E-04	3.5E-04	3.5E-04	3.5E-04	3.5E-04	2.4
4.0	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	4.0
5.6	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	5.6
7.2	9.1E-05	9.1E-05	9.1E-05	9.1E-05	9.1E-05	9.1E-05	9.1E-05	9.1E-05	9.1E-05	9.1E-05	9.1E-05	9.1E-05	9.1E-05	9.1E-05	9.1E-05	9.1E-05	7.2
12.1	4.9E-05	4.9E-05	4.9E-05	4.9E-05	4.9E-05	4.9E-05	4.9E-05	4.9E-05	4.9E-05	4.9E-05	4.9E-05	4.9E-05	4.9E-05	4.9E-05	4.9E-05	4.9E-05	12.1
24.1	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05	24.1
40.3	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	40.3
56.3	7.7E-06	7.7E-06	7.7E-06	7.7E-06	7.7E-06	7.7E-06	7.7E-06	7.7E-06	7.7E-06	7.7E-06	7.7E-06	7.7E-06	7.7E-06	7.7E-06	7.7E-06	7.7E-06	56.3
72.4	5.7E-06	5.7E-06	5.7E-06	5.7E-06	5.7E-06	5.7E-06	5.7E-06	5.7E-06	5.7E-06	5.7E-06	5.7E-06	5.7E-06	5.7E-06	5.7E-06	5.7E-06	5.7E-06	72.4

TABLE H.6.14. **99.5th Percentile E/Q** Values (sec m^{-3}) for Acute **30-m Stack** Releases from **400 Area** Based on 1983 Through 1991 Meteorological Information

Distance (km)	Sector (Wind from 400 Area **Towards** Direction Indicated) S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Distance (km)
0.1	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.0E-04	1.1E-04	8.1E-05	1.0E-04	1.1E-04	1.1E-04	1.0E-04	6.6E-05	1.1E-04	0.1
0.2	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.5E-04	1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.5E-04	1.6E-04	0.2
0.3	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.4E-04	1.4E-04	1.3E-04	1.4E-04	1.4E-04	1.5E-04	1.4E-04	1.4E-04	1.4E-04	0.3
0.4	1.3E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.2E-04	1.0E-04	9.8E-05	1.2E-04	1.2E-04	1.3E-04	1.1E-04	1.1E-04	1.2E-04	0.4
0.5	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	0.5
0.6	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	0.6
0.7	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	0.7
0.8	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	9.7E-05	0.8
0.9	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	8.9E-05	0.9
1.0	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	8.7E-05	1.0
2.4	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	2.4
4.0	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	3.6E-05	4.0
5.6	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	3.0E-05	5.6
7.2	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.6E-05	7.2
12.1	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	12.1
24.1	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	8.7E-06	24.1
40.3	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	5.1E-06	40.3
56.3	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	56.3
72.4	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	2.7E-06	72.4

APPENDIX H.7

RECEPTOR LOCATIONS FOR MAXIMALLY EXPOSED INDIVIDUAL RESULTING FROM ATMOSPHERIC RELEASES FROM SPECIFIED HANFORD FACILITIES

THIS PAGE BLANK INTENTIONALLY

APPENDIX H.7

RECEPTOR LOCATIONS FOR MAXIMALLY EXPOSED INDIVIDUAL RESULTING FROM ATMOSPHERIC RELEASES FROM SPECIFIED HANFORD FACILITIES

Atmospheric dispersion values, based on 1983 through 1987 Hanford meteorological information, were used to determine the locations on or around Hanford that could conceivably have the highest concentrations of radionuclides in air as a result of atmospheric releases from three major facilities on the Site. The $\overline{\chi}/Q'$ (i.e., for chronic releases) and E/Q values (i.e., for acute releases) were superimposed on a map of Hanford to determine the locations adjacent to and/or on the Site at which members of the general public may reside or be in transit. The "residential" locations include farm houses or offsite industrial and/or office facilities. The "transient" locations may include members of the general public traveling on State Highway 240 or fishing on the Columbia River. Both acute and chronic release situations were evaluated.

The atmospheric dispersion factor values for each of the 16 compass sectors for each major operational area were overlaid on a Hanford map and examined to determine which "residential" or "transient" location had the highest corresponding $\overline{\chi}/Q'$ and E/Q value. This normally is the location that produces the highest potential radiation dose via the atmospheric routes. However, other routes such as the surface and subsurface water pathways may contribute to the potential dose and, in turn, may affect the location of the maximally exposed individual (MEI). Therefore, depending on the situation, all environmental pathways and all potential sources should be considered before determining the MEI location.

Atmospheric dispersion factors for each sector's nearest location to the boundary of the Site are presented in Tables H.7.1-3. The locations are listed as distances (km) and sector (i.e., direction) away from the facility. Sector-averaged $\overline{\chi}/Q'$ values were used for the chronic releases. The 95th percentile center-line E/Q values were used for the acute releases.

TABLE H.7.1. Site Boundary Locations and Corresponding Maximum Sector-Averaged $\overline{\chi}/Q'$ and 95th Percentile Center-Line E/Q Values for the PUREX Plant (200 East Area) Based on 1983-1987 Joint Frequency Distributions

Sector	Distance to Nearest Site Boundary (km)	Corresponding Atmospheric Dispersion Factor (sec m^{-3}) Chronic Releases ($\overline{\chi}/Q'$) Release Height: Ground-Level	Chronic Releases ($\overline{\chi}/Q'$) Release Height: 60-m Stack	Acute Releases (E/Q) Release Height: Ground-Level	Acute Releases (E/Q) Release Height: 60-m Stack
N	24.6	1.67E-08	7.85E-09	8.24E-06	4.75E-06
NNE	23.7	1.39E-08	5.86E-09	8.23E-06	4.57E-06
NE	18.1	2.59E-08	9.81E-09	1.02E-05	5.18E-06
ENE	15.2	4.82E-08	1.63E-08	1.01E-05	5.19E-06
E	**16.2**	**7.72E-08***	**2.69E-08***	9.26E-06	5.08E-06
ESE	20.0	5.72E-08	2.28E-08	4.32E-06	3.22E-06
SE	24.3	3.44E-08	1.71E-08	3.30E-06	2.61E-06
SSE	19.6	2.74E-08	1.30E-08	8.85E-06	4.78E-06
S	19.5	2.44E-08	1.30E-08	9.28E-06	4.68E-06
SSW	16.9	1.62E-08	9.00E-09	9.93E-06	5.24E-06
SW	**17.6**	1.29E-08	6.80E-09	**1.06E-05***	**5.47E-06***
WSW	21.2	9.21E-09	5.03E-09	9.10E-06	4.70E-06
W	20.8	1.54E-08	7.92E-09	9.29E-06	5.43E-06
WNW	21.4	1.60E-08	7.68E-09	9.75E-06	5.12E-06
NW	21.4	1.71E-08	8.77E-09	8.72E-06	5.44E-06
NNW	**21.6**	1.51E-08	7.35E-09	8.90E-06	**5.47E-06***

(*) Indicates the sector with the highest atmospheric dispersion factor for the given type of release.

TABLE H.7.2. Site Boundary Locations and Corresponding Maximum Sector-Averaged $\overline{\chi}/Q'$ and 95th Percentile Center-Line E/Q Values for PFP (200 West Area) Based on 1983-1987 Joint Frequency Distributions

Sector	Distance to Nearest Site Boundary (km)	Corresponding Atmospheric Dispersion Factor (sec m^{-3}) Chronic Releases ($\overline{\chi}/Q'$) Release Height Ground-Level	Chronic Releases ($\overline{\chi}/Q'$) Release Height 60-m Stack	Acute Releases (E/Q) Release Height Ground-Level	Acute Releases (E/Q) Release Height 60-m Stack
N	18.0	2.57E-08	1.09E-08	1.21E-05	6.35E-06
NNE	26.3	1.21E-08	5.26E-09	7.24E-06	4.12E-06
NE	27.2	1.49E-08	6.49E-09	6.17E-06	3.41E-06
ENE	24.4	2.52E-08	1.04E-08	5.54E-06	3.04E-06
E	**23.8**	**4.55E-08***	1.85E-08	5.70E-06	3.33E-06
ESE	29.5	3.35E-08	1.51E-08	2.61E-06	2.07E-06
SE	23.8	3.54E-08	1.74E-08	3.39E-06	2.68E-06
SSE	19.5	2.76E-08	1.31E-08	8.90E-06	4.80E-06
S	**14.2**	3.82E-08	**1.86E-08***	1.38E-05	6.43E-06
SSW	14.5	2.01E-08	1.08E-08	1.21E-05	6.12E-06
SW	14.5	1.69E-08	8.49E-09	1.35E-05	6.60E-06
WSW	12.3	1.98E-08	9.31E-09	1.80E-05	7.86E-06
W	**12.1**	3.30E-08	1.44E-08	1.83E-05	**8.72E-06***
WNW	**12.6**	3.38E-08	1.38E-08	**1.88E-05***	8.24E-06
NW	15.3	2.74E-08	1.25E-08	1.32E-05	7.34E-06
NNW	16.3	2.22E-08	9.84E-09	1.26E-05	7.04E-06

(*) Indicates the sector with the highest atmospheric dispersion factor for the given type of release.

TABLE H.7.3. Site Boundary Locations and Corresponding Maximum Sector-Averaged $\overline{\chi}/Q'$ and 95th Percentile Center-Line E/Q Values for FFTF (400 Area) Based on1983-1987 Joint Frequency Distributions

Sector	Distance to Nearest Site Boundary (km)	Corresponding Atmospheric Dispersion Factor (sec m^{-3}) Chronic Release ($\overline{\chi}/Q'$) from 10-m Stack	Acute Release (E/Q) from 10-m Stack
N	16.0	6.40E-08	5.74E-06
NNE	12.8	5.83E-08	7.48E-06
NE	8.8	5.44E-08	2.15E-05
ENE	7.2	4.63E-08	3.19E-05
E	**6.9**	7.95E-08	**3.44E-05***
ESE	7.1	8.92E-08	1.85E-05
SE	8.7	9.49E-08	1.27E-05
SSE	9.4	7.20E-08	2.08E-05
S	8.1	**1.15E-07***	2.72E-05
SSW	7.6	7.45E-08	3.03E-05
SW	7.5	5.41E-08	3.26E-05
WSW	12.5	1.92E-08	1.96E-05
W	20.1	1.40E-08	1.09E-05
WNW	33.9	6.31E-09	5.23E-06
NW	38.8	7.03E-09	3.56E-06
NNW	39.3	1.07E-08	1.78E-06

(*) Indicates the sector with the highest atmospheric dispersion factor for the given type of release.

APPENDIX I

RECOMMENDED SCENARIO DEFINITIONS FOR ATMOSPHERIC AND LIQUID RELEASES

THIS PAGE BLANK INTENTIONALLY

APPENDIX I

RECOMMENDED SCENARIO DEFINITIONS FOR ATMOSPHERIC AND LIQUID RELEASES

The scenarios, as recommended by the Hanford Environmental Dose Overview Panel, to be considered when evaluating atmospheric releases from facilities and operations on the Hanford Site are presented in Table I.1. The scenarios for liquid releases are presented in Table I.2.

TABLE I.1. Recommended Exposure Scenarios for Atmospheric Releases from the Hanford Site

Receptor(s)	Type of Dose	Location(s)	Exposure Pathway(s)	Duration of Exposure (Hours)		
				Inhalation	Air Submersion	Ground Surface
Chronic Releases:						
Onsite individual	Individual	At least 100 m from the source at the location with highest air concentration	Inhalation, air submersion & ground surface	2000	2000	2000
Offsite resident	Individual	Offsite location with highest air concentration	All (use conservative individual parameters)	8766	8766	4380
General population	Collective	The general population within 80 km of the release point	All (use average individual parameters)	8766	8766	2920
Acute Releases:						
Onsite individual	Individual	At least 100 m from the source at the location with highest air concentration	Inhalation, air submersion & ground surface	Same as plume-passage time or case-specific value	Same as plume-passage time or case-specific value	2000
Site-boundary individual	Individual	Location with highest air concentration at Site boundary	All (use conservative individual parameters)	Same as plume-passage time or case-specific value	Same as plume-passage time or case-specific value	2
Offsite resident	Individual	Offsite location with highest air concentration	All (use most conservative individual parameters)	Same as plume-passage time or case-specific value	Same as plume-passage time or case-specific value	4380
General population	Collective	The general population within 80 km of the release point in a single sector	All (use average individual parameters)	Same as plume-passage time or case-specific value	Same as plume-passage time or case-specific value	2920

TABLE I.2. Recommended Exposure Scenarios for Liquid Releases to the Columbia River from the Hanford Site

Receptor(s)	Type of Dose	Locations	Human Exposure Routes: Pathways	Human Exposure Routes: Number of Potentially Exposed Individuals	Parameter Category
Chronic Releases:					
Offsite resident	Individual	Riverview area of Franklin county	Ground surface	1	Maximum individual
			Recreation	1	
			Drinking water	1	
			Aquatic products	1	
			Terrestrial foodstuffs	1	
			Animal products	1	
General population	Collective	Downstream to Walla Walla River junction	Ground surface	2,000	Average individual
			Recreation	125,000	
			Drinking water	70,000	
			Aquatic products	(a)	
			Terrestrial foodstuffs	2,000	
			Animal products	2,000	
Acute Releases:					
Offsite resident	Individual	Riverview area of Franklin County when considering all pathways; however, locations on the Columbia River immediately downstream from the 100 Areas and the 300 Area should be evaluated for the "recreation" and the "aquatic products" pathways	Ground surface	1	Maximum individual (adjusted for the duration of the release)
			Recreation	1	
			Drinking water	1	
			Aquatic products	1	
			Terrestrial foodstuffs	1	
			Animal products	1	
General population	Collective	Downstream to Walla Walla River junction	Ground surface	2,000	Average individual (adjusted for the duration of the release)
			Recreation	125,000	
			Drinking water	70,000	
			Aquatic products	(a)	
			Terrestrial foodstuffs	2,000	
			Animal products	2,000	

(a) Assume consumption of 15,000 kg of fish by the general population.

THIS PAGE BLANK INTENTIONALLY

APPENDIX J

RECOMMENDED PARAMETERS FOR CALCULATING POTENTIAL ENVIRONMENTAL RADIATION DOSES AT HANFORD

THIS PAGE BLANK INTENTIONALLY

APPENDIX J

RECOMMENDED PARAMETERS FOR CALCULATING POTENTIAL ENVIRONMENTAL RADIATION DOSES AT HANFORD

The input parameters described below and listed in the tables at the end of this appendix are primarily those used in the version of the GENII code that has been approved by the Hanford Environmental Dose Overview Panel (see Appendix 4.1 for the most current Panel-approved version of the GENII code). Therefore, the Panel also recommends these parameters for use with other models and/or codes, as applicable, for calculating the potential radiation doses, or other measures of health and/or environmental effects, that could result from environmental releases of radioactive or other hazardous materials from facilities and/or operations on the Hanford Site. A more detailed description of the mathematical relationships and use of the parameters is presented by Napier et al. (1988).

Some of the tables list the recommended "average" and "maximum" default values. The "average" default values are those that normally produce the most realistic potential dose estimates and are normally used for population dose-type calculations. The "maximum" default values are those that are more conservative and typically produce the higher estimates. The "maximum" default values are normally used for calculations related to the "maximally exposed individual." Some of the tables list only one value without specifying "average" or "maximum." A single value usually denotes the most appropriate value, and a "maximum" value may not be germane for the particular parameter.

An explanation of some of the terms, equations, and relationships of the parameters presented in the tables is included below.

J.1 ATMOSPHERIC TRANSPORT

The parameters associated with the atmospheric transport, deposition, and resuspension of materials are summarized in Table J.1.

J.1.1 Atmospheric Dispersion Factors

The joint frequency tables for Hanford-specific meteorological observations, averaged for the years 1983 through 1991, are presented in Appendix H.3. The $\overline{\chi}/Q'$ values, for addressing chronic atmospheric releases, are presented in Appendix H.4. The 95th and 99.5th percentile E/Q values, for acute atmospheric releases, are listed in Appendixes H.5 and H.6, respectively.

J.1.2 Deposition

Default deposition velocity values are presented in Table J.1. Element-specific values are presented in Table J.9. The development and the use of the deposition velocity term are described in section J.4.3.5.

J.1.3 Fractional Intercept Values

As shown by Pinder, Ciravolo, and Bowling (1988), the unitless fractional interception (I) value can be estimated as a function of the standing biomass of the vegetation:

$$I = 1.0 - \exp[(-C)(Y)(R)]$$

where C = 1.9 for grasses, leafy vegetables, and grains

C = 3.6 for fruits and other types of vegetation

Y = standing biomass (kg wet m^{-2})

R = dry-to-wet weight ratio of the vegetation.

J.1.4 Resuspension

The resuspension factor as developed by Anspaugh et al. (1975) is calculated as a function of time following the deposition:

$$M = [(1.0E\text{-}4\ m^{-1})\ \exp(-0.15\ d^2\ t^{1/2})] + 1.0E\text{-}9\ m^{-1}$$

where M = resuspension factor (m^{-1})

t = elapsed days (d) following the deposition.

The value of M decreases from 1.0E-4 m^{-1} to 1.0E-9 m^{-1} as the time following the deposition increases.

Alternatively, the resuspension factor may be calculated based on the mass loading of the atmosphere:

$$M = S/\rho$$

where S = mass loading of soil in air (g m^{-3})

ρ = soil surface density (g m^{-2}).

J.2 SURFACE-WATER TRANSPORT

The parameters associated with the transport of materials via surface water are given in Table J.2.

J.3 SUBSURFACE SOURCES

Parameters associated with the exposure of subsurface sources of hazardous materials (e.g., buried waste) to humans and other biota are presented in Table J.3.

J.4 INGESTION PATHWAYS

The recommended values of the parameters used to evaluate the ingestion pathways are described below. The ingestion pathways include

- drinking water
- consumption of aquatic foodstuffs
- consumption of terrestrial food products
- consumption of terrestrial animal products.

J.4.1 Drinking Water

Parameters associated with the ingestion of drinking water are presented in Table J.4. The water treatment cleanup factors, listed by element, are presented in Table J.9.

J.4.2 Aquatic Foodstuffs

Various parameters associated with the consumption of aquatic foodstuffs are presented in Table J.5. The values of the concentration ratios (CR) that are used to quantify the transfer of material between tropic levels are presented in Table J.6. Descriptions of the CR values and the water treatment cleanup factors are presented below.

J.4.2.1 Concentration Ratios

The concentration ratio (CR) values (i.e., bioaccumulation factors) used with the GENII computer code are presented in Table J.6. The CR values have been updated from those used in the previous generation of Hanford dosimetry codes. The basic set of values for these parameters, taken from Ng et al. (1968), has been updated using more recent publications as available.

The data libraries have been supplied in the code package as text files covering 80 different elements. They may be adapted by the user as needed for specific environments or applications. The libraries, as supplied with the GENII code, should be used for standard applications at the Hanford Site. The use of other values should be justified for the particular situation.

The CR values for freshwater organisms were updated with information taken from Poston and Klopfer (1986) because they generally represented realistic rather than overly conservative estimates. Additional values were obtained preferentially from Jackson (1984), where the values were similar to those reported by the U.S. Nuclear Regulatory Commission (USNRC 1977), Miller et al. (1980), and Lawson and Smith (1985). Values from the latter reports were used in some cases where they provided a more conservative estimate and there was no other basis for choosing an alternative.

The CR values for marine organisms were based on those reported by Poston and Templeton (1986), which were judged to provide the most realistic data for field conditions. Additional estimates for elements not included in the primary reference were taken from Poston and Klopfer (1986) and Gomez et al. (1987).

Concentration ratios are simply a ratio of the observed quantity of an element or radionuclide per fresh weight of aquatic organism to the concentration of the material in the water

$$CR = \frac{Bq/kg\ Aquatic\ Product}{Bq/L\ Water}$$

The units of CR are actually L water per kg aquatic product. A given or projected concentration of a corresponding element or compound in water is multiplied by the particular CR value to provide an estimate of the level in

the aquatic organism, assuming that the water and organisms are in equilibrium conditions.

J.4.2.2 Water Treatment Cleanup Factors

Water treatment cleanup factors, such as those reported by Denham and Soldat (1975), are also listed in Table J.6. The water treatment cleanup factor denotes the fractional reduction in the concentration of an element in water as a result of water treatment operations. The unitless factor is calculated by dividing the measured concentration of material in the post-treated water (e.g., Bq ^{90}Sr L^{-1}) by the pre-treated water (e.g., Bq ^{90}Sr L^{-1}).

J.4.3 Terrestrial Food Products

Parameters associated with the ingestion of terrestrial food crops are presented in Table J.7. Parameters associated with the ingestion of terrestrial animal products are presented in Table J.8. Element-specific deposition velocities, concentration ratios, equilibrium transfer coefficients, and leaching factors are presented in Table J.9. An explanation of the uses, limitations, and descriptions of the parameters used to address the consumption of terrestrial food products listed in Table J.9 follows.

J.4.3.1 Chronic Releases

For a chronic release, one normally assumes that the environmental media reach an equilibrium value (i.e., the levels of material in the media asymptotically approach a value such that the loss from the media equals the input from the source). Applying the appropriate transfer factor provides an estimate of the concentration of radioactive or other hazardous material in the environmental media of interest (e.g., a concentration ratio value is multiplied by the measured or projected Bq ^{90}Sr kg^{-1} soil to project the concentration of ^{90}Sr in vegetation that grew on the contaminated soil). For radionuclides, the resulting concentration values are normally combined with other appropriate parameters to estimate the resulting dose rate (e.g., Gy yr^{-1}) received by the target organism.

J.4.3.2 Acute Releases

As described in Napier et al. (1988), these transfer factors are also used in the GENII code to address acute release situations. For an acute

release, the transfer factors are used to calculate a time-integrated value of the total amount of material transferred between the various environmental media. For radionuclides, these values, in turn, provide an estimate of the total dose that a target organism could receive over a specified time period based on the total amount of material released during the acute event.

J.4.3.3 Default Values

The values in Table J.9 that are listed as "9.9E-4" are actually default values. They represent specific situations where no appropriate literature values were found.

J.4.3.4 Carbon-14 and Tritium Models

Concentration ratio values for carbon (i.e., ^{14}C) and hydrogen (i.e., ^{3}H) are not listed in Table J.9 because they are evaluated by the GENII code in a manner that is different from that used for the other elements. Atmospheric dispersion models are used to project the concentration of ^{14}C or ^{3}H in air (e.g., Bq m^{-3}) at specified downwind locations. These values are then used to calculate corresponding isotopic air concentrations (e.g., Bq ^{14}C g^{-1} carbon and Bq ^{3}H g^{-1} hydrogen) based on an assumed or given concentration of carbon and hydrogen in the volume of air (e.g., 1.6E-4 kg carbon m^{-3} air or 8.9E-4 kg hydrogen m^{-3} air, respectively). The various terrestrial components (e.g., vegetation and meat products) are then assumed to equilibrate with the calculated isotopic air concentration values. The corresponding isotopic concentration values are combined with other appropriate parameters (e.g., kg carbon and hydrogen ingested via specified pathways) to calculate the total amount of ^{14}C and ^{3}H ingested and/or inhaled by the target organism to provide an estimate of the dose rate (e.g., Gy yr^{-1}). Recommended values for the concentration of hydrogen and carbon in various environmental media are presented in Table J.10.

J.4.3.5 Deposition Velocity

Deposition velocity has units of m sec^{-1} and expresses the rate at which material is deposited from the near-surface atmosphere onto surfaces (e.g., vegetation, soil surface, buildings). It is multiplied by a given or calculated air concentration (e.g., Bq m^{-3}) to provide an estimate of the rate at which the radionuclide is deposited per square meter of surface area

(e.g., m sec^{-1} by Bq m^{-3} = Bq m^{-2} sec^{-1}). The surface area includes the surface of the vegetation as well as the soil surface. The deposition rate, in turn, can be multiplied by the duration of the deposition (e.g., one year) to give the total amount deposited per m^2. This can then be converted to concentration in soil (e.g., Bq kg^{-1}) if one assumes the surface-deposited radionuclides are evenly mixed to a given depth (e.g., by plowing to a depth of 15 cm), and if one also knows the density of the soil (kg m^{-3}) and the rate at which the material is removed (i.e., weathered) from the surface of the vegetation and deposited onto the surface of the soil.

J.4.3.6 Concentration Ratio

Concentration ratio (CR) has units of kg soil kg^{-1} dry vegetation and is a measure of plants' affinity to take up elements from the soil. Multiplying a CR value by a given concentration of material in soil provides an estimate of the concentration that will occur in the plant at harvest (i.e., if one assumes an equilibrium condition exists between the plant and the soil). For example, multiplying a given concentration of material in soil (Bq kg^{-1} soil) by the corresponding CR value (kg soil kg^{-1} dry vegetation) gives an estimate of the concentration of the material in vegetation (Bq kg^{-1} dry vegetation).

The CR values used with the GENII computer code have been updated from those used in the previous generation of Hanford dosimetry codes. The basic set of values was taken originally from Ng et al. (1968) and then updated using more recent publications as available. Whenever possible, the values were selected from published results of experimental measurements. In some instances, values were selected on the basis of the values of other chemical elements that are expected to behave similarly in the environment.

J.4.3.7 Equilibrium Transfer Coefficients

Equilibrium transfer coefficients (ETC) for a given element are expressed in units of d kg^{-1} wet animal product and relates the concentration of material in an animal product at equilibrium to the rate at which the material is ingested by the animal. For example, multiplying the average daily rate that an animal is ingesting a radionuclide (e.g., Bq d^{-1}) by the corresponding ETC (i.e., d kg^{-1} wet animal product) gives an estimate of the

projected concentration of the material in the animal product at equilibrium (i.e., Bq kg^{-1} wet animal product).

The ETC values were taken primarily from a draft International Atomic Energy Agency document[a] to provide a consistent data set that had recently been updated and reviewed. When data were unavailable from the primary reference, these values were supplemented with information from Ward and Johnson (1985), Lawson and Smith (1985), Ng (1982), Haywood et al. (1980), Voilleque et al. (1985), and Miller et al. (1980). When more than one value was reported for a given element, the more conservative value (i.e., the one resulting in a higher dose via the ingestion pathway) was chosen when there was no other basis for discriminating between the alternatives.

J.4.3.8 Leaching Factor

The leaching factor is expressed in units of yr^{-1} and is the fractional rate at which material is moved beyond the root zone into the deeper soils each year. The downward movement of the material is usually associated with the percolation of water downward through the soil profile. The leaching factor values (λ_i) were calculated using the formula of Baes and Sharp (1981):

$$\lambda_i = \frac{P+I-E}{d[1+(\rho/\theta)Kd_i]}$$

where λ_i = annual leaching factor (yr^{-1}) for element or compound i

P = total annual precipitation (cm yr^{-1})

I = total annual irrigation (cm yr^{-1})

E = total annual evapotranspiration (cm yr^{-1})

d = depth of the rooting zone (cm)

ρ = soil bulk density (g cm^{-3})

θ = soil volumetric water content (mL cm^{-1})

Kd_i = distribution coefficient for element or compound i.

---

[a] International Atomic Energy Agency (IAEA). 1987 (draft). Handbook of Parameter Values for the Prediction of Radionuclide Transfer in the Terrestrial and Freshwater Environments. IAEA, Vienna.

As noted in Napier et al. (1988), the term "P + E - I" was approximated as an overwatering term and set at 15 cm yr^{-1} to represent the amount of water that percolates downward through the rooting zone to the deeper soil layers each year. The depth of the rooting zone (*d*) was assumed to be 15 cm. Baes and Sharp (1981) showed that the values of "ρ/θ" averaged about 3.0. Napier et al. (1988) also noted that the "Kd_i" values used to calculate the leaching factor for each element for the GENII code were based on the most conservative (i.e., largest) distribution coefficient value "identified in a wide range of literature."

J.5. EXTERNAL EXPOSURE

Parameters associated with calculating external exposure are presented in Table J.11.

J.6 MISCELLANEOUS PARAMETERS

Miscellaneous parameters are presented in Table J.12.

J.7 REFERENCES

Anspaugh, L. R., R. J. Shinn, P. L. Phelps, and N. C. Kennedy. 1975. "Resuspension and Redistribution of Plutonium in Soils." Health Physics 29:571-582.

Baes, C. F., and R. D. Sharp. 1981. Predicting Radionuclide Leaching From Root Zone Soil for Assessment Applications. CONF-81606, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Denham, D. H., and J. K. Soldat. 1975. "A Study of Selected Parameters Affecting the Radiation Dose From Radionuclides in Drinking Water Downstream of the Hanford Project." Health Physics 28:139-144.

Gomez, L. S., M. G. Marietta, and D. W. Jackson. 1987. Compilation of Selected Marine Radioecological Data for the U. S. Subseabed Disposal Project: Summaries of Available Radioecological Concentration Factors and Biological Half-lives. SAND-2674, Sandia National Laboratories, Albuquerque, New Mexico.

Haywood, S. M., J. R. Simmonds, and G. S. Linsley. 1980. The Development of Models for the Transfer of Cs-137 and Sr-90 in the Pasture-Cow-Milk Pathway Using Fallout Data. NRPB-R110, National Radiological Protection Board, Harwell, United Kingdom.

Jackson, D. 1984. Aquatic Organism and Terrestrial Plant Data for the Biosphere Code ECOS. ANS Report No. 376-1, Associated Nuclear Services, Epsom, Surrey, United Kingdom.

Lawson, G., and G. M. Smith. 1985. BIOS: A Model to Predict Radionuclide Transfer and Doses to Man Following Releases from Geological Repositories for Radioactive Wastes. NRPB-R169, National Radiological Protection Board, Chilton, United Kingdom.

Miller, C. W., C. F. Baes, III, D. E. Dunning, Jr., E. L. Etnier, K. K. Kanak, D. C. Kocher, C. A. Little, L. M. McDowell-Boyer, H. R. Meyer, E. M. Rupp, and R. W. Shor. 1980. Recommendations Concerning Models and Parameters Best Suited to Breeder Reactor Environmental Radiological Assessments. ORNL-5529, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Napier, B. A., D. L. Strenge, R. A. Peloquin, and J. V. Ramsdell. 1988. GENII - The Hanford Environmental Radiation Dosimetry Software System, Volume 1: Conceptual Representation. PNL-6584 Vol. 1, Pacific Northwest Laboratory, Richland, Washington.

Ng, Y. C., C. A. Burton, S. E. Thompson, R. K. Tandy, H. K. Kretner, and M. W. Pratt. 1968. Prediction of the Maximum Dosage to Man from the Fallout of Nuclear Devices. IV. Handbook for Estimating the Maximum Internal Dose from Radionuclides Released to the Biosphere. UCRL-50163, Pt. IV, Lawrence Radiation Laboratory, University of California, Livermore, California.

Ng, Y. C., C. S. Colsher, and S. E. Thompson. 1982. Transfer Coefficients for Assessing the Dose from Radionuclides in Meat and Eggs. NUREG/CR-2976, Lawrence Livermore National Laboratory, Livermore, California.

Pinder III, J. E., T. G. Ciravolo, and J. W. Bowling. 1988. "The Interrelationships Among Plant Biomass, Plant Species, Plant Surface Area, and the Interception of Particulate Deposition by Grasses." Health Physics 55:51-58.

Poston, T. M., and D. C. Klopfer. 1986. A Literature Review of the Concentration Ratios of Selected Radionuclides in Freshwater and Marine Fish. PNL-5484, Pacific Northwest Laboratory, Richland, Washington.

Poston, T. M., and W. E. Templeton. 1986. Review of Bioaccumulation Factors for Thirteen Elements in Selected Groups of Marine Organisms. Prepared for Pacific Gas and Electric Co. by Battelle, Pacific Northwest Laboratories, Richland, Washington.

U.S. Nuclear Regulatory Commission (USNRC). 1977. Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I. Regulatory Guide 1.109, Washington, D.C.

Voilleque, P. G., G. J. Duggan, P. R. Leonard, and L. J. Coe. 1985. Environmental Radiation Doses for Difficult-to-Measure Nuclides. PORI NP-3840, Science Applications International Corp., Rockville, Maryland.

Ward, G. M., and J. E. Johnson. 1985. Confirmation of Selected Milk and Meat Radionuclide Transfer Coefficients. Third Technical Progress Report, Colorado State University, Fort Collins, Colorado.

TABLE J.1. Recommended Parameter Values -- **Atmospheric Transport**

Parameter	Default Values Average	Default Values Maximum
Atmospheric Dispersion Factors:		
Chronic $\overline{\chi}/Q'$ value (sec m^{-3}) [see Appendix H.4]	UDV[a]	UDV
Acute E/Q value (sec m^{-3}) [see Appendix H.5 or H.6]	UDV	UDV
Population-weighted $\overline{\chi}/Q'$ or E/Q values (person sec m^{-3})	UDV	UDV
Building's Dimensions:		
Vertical cross-sectional area (m)	UDV	UDV
Height (m)	UDV	UDV
Deposition:		
Duration of air deposition prior to beginning of intake period (yr)	0	UDV
Deposition velocity (m sec^{-1}) [see Table J.4.4 for element-specific deposition velocity values]	UDV	0.001
Fractional intercept [see Section J.1.3 for mathematical relationship]	UDV	0.25
Distance to MEI from release point (m) [see Appendix H.7]	UDV	UDV
Effluent temperature (°C)	UDV	UDV
Humidity (absolute) (kg water m^{-3} air)	0.008	UDV
Population totals [see Appendix G.2]	UDV	UDV
Release duration (yr)	1	UDV

[a] UDV = user-defined value (i.e., the user must assign a value to the parameter).

TABLE J.1 (cont'd). Recommended Parameter Values -- **Atmospheric Transport**

Parameter	Default Values Average	Default Values Maximum
Resuspension:		
Duration of individual annual inhalation exposure due to resuspension (h)	8766	8766
Mass loading factor (g m^{-3}) [see Section J.1.4 for mathematical relationship]	1.0E-4	UDV[a]
Resuspension factor (m^{-1}) [see Section J.1.4 for mathematical relationship]	1.0E-9	UDV
Soil surface density (g m^{-2})	2.24E+3	2.24E+3
Top soil available for resuspension (cm)	1	UDV
Stack Dimensions:		
Height (m)	UDV	UDV
Flow rate (m sec^{-1})	UDV	UDV
Radius (m)	UDV	UDV

[a] UDV = user-defined value (i.e., the user must assign a value to the parameter).

TABLE J.2. Recommended Parameter Values -- **Surface-Water Transport**

Parameter	Default Values Average	Default Values Maximum
Dimensions of Columbia River:		
Average depth (m)	UDV[a]	UDV
Minimum flow rate (m^3 sec^{-1})	1.0E+3	UDV
Average flow rate (m^3 sec^{-1})	3.4E+3	UDV
Maximum flow rate (m^3 sec^{-1})	1.8E+4	UDV
Average velocity (m sec^{-1})	1	UDV
Average width (m)	UDV	UDV
Distances:		
Longshore distance from release point to usage location (m)	0	0
Offshore distance to water intake (m)	0	0
Effluents:		
Rate of effluent discharge to receiving water body (m^3 sec^{-1})	UDV	UDV
Depth of effluent discharge point to surface water (m)	0	0
Shoreline to width factors:		
River shore	0.2	0.2
Lake shore	0.3	0.3
Ocean Site	0.5	0.5
Tidal basin	1.0	1.0
Quantity of water ingested inadvertently while swimming (L h^{-1})	0.02	0.02
Surface-water mixing ratio	1	1

[a] UDV = user-defined value (i.e., the user must assign a value to the parameter).

TABLE J.2 (cont'd). Recommended Parameter Values -- **Surface-Water Transport**

Parameter	Default Values Average	Default Values Maximum
Transit time to irrigation withdrawal location (h from 100-N to Riverview area)	20	UDV[a]
Water to sediment transfer constant (L m^{-2} yr^{-1})	25295.0	25295.0

[a] UDV = user-defined value (i.e., the user must assign a value to the parameter).

TABLE J.3. Recommended Parameter Values -- **Subsurface Sources**

Parameter	Default Values Average	Default Values Maximum
Number of years prior to intake period that inventory was disposed	UDV[a]	0
Number of years prior to intake period that loss of institutional control occurred	UDV	0
Manual redistribution (i.e., mixing); deep-soil to surface soil-dilution factor	UDV	UDV
Waste form &/or package half-life (yr)	UDV	0
Waste form &/or contaminated soil thickness (m)	UDV	UDV
Depth of soil overburden (m)	UDV	UDV
Fraction of roots in top 15 cm of soil	1	UDV
Fraction of roots in deep soil	0	UDV
Biotic Transport:		
Arid Non-Agricultural Scenario -		
Vegetative production (kg wet m^{-2})	0.4	UDV
Quantity of soil excavated by burrowing animals (m^3 m^{-2} yr^{-1})	9.4E-4	UDV
Fraction of Soil in Layer Moved to Surface --		
Depth of Layer (m)		
0 - 0.15 m	1.0	1.0
0.15 - 0.5 m	0.8	UDV
0.5 - 1.0 m	0.2	UDV
1.0 - 1.5 m	0.02	UDV
1.5 - 2.0 m	0.009	UDV
>2m	0.002	UDV

[a] UDV = user-defined value (i.e., the user must assign a value to the parameter).

TABLE J.3 (cont'd). Recommended Parameter Values -- **Subsurface Sources**

Parameter	Default Values Average	Default Values Maximum
Humid Non-Agricultural Scenario -		
Vegetative production (kg wet m^{-2})	5	UDV[a]
Quantity of soil excavated by burrowing animals (m^3 m^{-2} yr^{-1})	7.5E-4	UDV
Fraction of Soil in Layer Moved to Surface --		
Depth of Layer (m)		
0 - 0.15 m	1.0	1.0
0.15 - 0.5 m	0.9	UDV
0.5 - 1.0 m	0.1	UDV
1.0 - 1.5 m	0.006	UDV
1.5 - 2.0 m	0.0005	UDV
>2m	0.0005	UDV
Agricultural Scenario -		
Vegetative production (kg wet m^{-2})	4	UDV
Quantity of soil excavated by burrowing animals (m^3 m^{-2} yr^{-1})	7.5E-4	UDV
Fraction of Soil in Layer Moved to Surface --		
Depth of Layer (m)		
0 - 0.15 m	1.0	1.0
0.15 - 0.5 m	0.9	UDV
0.5 - 1.0 m	0.1	UDV
1.0 - 1.5 m	0.006	UDV
1.5 - 2.0 m	0.0005	UDV
>2m	0.0005	UDV

[a] UDV = user-defined value (i.e., the user must assign a value to the parameter).

TABLE J.4. Recommended Parameter Values -- **Drinking-Water Ingestion**

Parameter	Default Values Average	Default Values Maximum
Holdup/transit time of drinking water (d)	1	1
Number of people ingesting drinking water	--	ND[a]
Per capita drinking water consumption rate (L yr^{-1})	440	730

[a] ND = no data presently available.

TABLE J.5. Recommended Parameter Values -- **Ingestion of Aquatic Foodstuffs**

Parameter	Default Values Average	Default Values Maximum
Number of people ingesting aquatic foods	UDV[a]	UDV
Fish:		
Transit time for release to reach harvest area (h)	0	0
Total production (kg wet yr^{-1})	1.5E+4	1.5E+4
Holdup between harvest and consumption (d)	1	1
Per capita consumption rate (kg wet yr^{-1})	6.9	40
Mollusc:		
Transit time for release to reach harvest area (h)	0	0
Total production (kg wet yr^{-1})	0	UDV
Holdup between harvest and consumption (d)	0	0
Per capita consumption rate (kg wet yr^{-1})	0	6.9
Crustacea:		
Transit time for release to reach harvest area (h)	0	0
Total production (kg wet yr^{-1})	0	UDV
Holdup between harvest and consumption (d)	0	0
Per capita consumption rate (kg wet yr^{-1})	0	6.9
Aquatic Plants.		
Transit time for release to reach harvest area (h)	0	0
Total production (kg wet yr^{-1})	0	UDV
Holdup between harvest and consumption (d)	0	0
Per capita consumption rate (kg wet yr^{-1})	0	6.9

(a) UDV = user-defined value (i.e., the user must assign a value to the parameter).

TABLE J.6. Recommended Parameter Values -- **Aquatic Transfer Factors**

Element	Concentration Ratio (L Water/kg Wet Aquatic Organism)								Water Treatment Cleanup Factor
	Marine Organisms				Fresh Water Organisms				
	Fish	Crustacea	Mollusks	Plants	Fish	Crustacea	Mollusks	Plants	
Ac	3.0E+1	1.0E+3	1.0E+3	1.0E+3	3.3E+2	1.0E+3	1.0E+3	1.0E+4	0.7
Ag	3.0E+2	3.5E+2	5.8E+2	1.0E+3	1.0E+2	2.0E+2	2.0E+2	1.0E+3	0.7
Am	2.5E+3	3.6E+2	2.9E+2	2.9E+3	1.0E+2	1.0E+2	1.0E+2	3.0E+3	0.7
Ar	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	0.0
As	3.0E+2	3.0E+2	3.0E+2	3.0E+2	3.0E+2	3.0E+2	3.0E+2	3.0E+2	0.7
Ba	1.0E+1	1.0E+0	2.0E+1	1.0E+2	2.0E+2	2.0E+2	2.0E+2	5.0E+2	0.4
Be	1.0E+3	1.0E+4	1.0E+4	1.0E+4	1.0E+1	5.0E+1	5.0E+1	2.0E+2	0.2
Bi	1.5E+1	1.0E+3	1.0E+3	1.0E+4	1.5E+1	1.0E+5	1.0E+5	1.5E+3	0.9
Bk	5.0E+1	5.0E+2	2.0E+4	1.0E+0	5.0E+1	5.0E+2	2.0E+4	1.0E+0	-
Br	1.0E+1	1.0E+1	1.0E+1	1.0E+1	4.2E+2	3.3E+2	3.3E+2	5.0E+1	-
C	2.0E+4	2.0E+4	2.0E+4	1.8E+3	9.0E+3	9.0E+3	9.0E+3	4.5E+3	1.0
Ca	2.0E+0	5.0E+0	1.0E+0	5.0E+1	2.0E+2	2.0E+3	2.0E+3	1.0E+3	0.2
Cd	2.0E+3	5.0E+3	1.0E+4	1.0E+3	2.0E+2	1.0E+4	1.0E+4	5.0E+2	0.6
Ce	1.0E+2	5.0E+2	5.0E+2	5.0E+3	5.0E+2	1.0E+3	1.0E+3	4.0E+3	0.2
Cf	5.0E+1	5.0E+2	2.0E+3	5.0E+3	2.5E+1	1.0E+3	1.0E+3	5.0E+3	-
Cl	1.0E+0	1.0E+0	1.0E+0	1.0E+0	5.0E+1	5.0E+1	5.0E+1	5.0E+1	1.0
Cm	2.5E+3	4.6E+2	4.6E+2	4.3E+4	3.0E+1	1.0E+3	1.0E+3	1.0E+4	0.7
Co	1.0E+2	2.0E+3	3.0E+3	4.0E+2	3.3E+2	2.0E+3	2.0E+3	1.0E+3	0.2
Cr	6.0E+2	5.0E+2	1.1E+3	4.0E+3	2.0E+1	2.0E+3	2.0E+3	4.0E+3	-
Cs	1.0E+2	3.0E+1	3.0E+1	7.0E+2	1.5E+4	5.0E+2	5.0E+2	1.0E+3	0.9

TABLE J.6 (cont'd). Recommended Aquatic Transfer Factor Values

Element	Concentration Ratio (L Water/Kg Wet Aquatic Organism)								Water Treatment Cleanup Factor
	Marine Organisms				Fresh Water Organisms				
	Fish	Crustacea	Mollusks	Plants	Fish	Crustacea	Mollusks	Plants	
Cu	1.0E+3	5.0E+3	5.0E+3	1.0E+3	2.5E+3	4.0E+2	4.0E+2	2.0E+3	-
Dy	5.0E+2	1.0E+3	5.0E+3	1.0E+0	2.5E+1	1.0E+3	5.0E+3	1.0E+0	-
Er	1.0E+2	5.0E+2	5.0E+2	5.0E+3	5.0E+2	1.0E+3	1.0E+3	4.0E+3	0.2
Eu	3.0E+2	1.0E+3	7.0E+3	5.0E+3	3.0E+2	3.0E+3	3.0E+3	5.0E+3	0.2
F	4.0E+0	4.0E+0	4.0E+0	1.0E+0	1.0E+1	1.0E+2	1.0E+2	2.0E+0	0.8
Fe	3.0E+3	5.0E+3	3.0E+4	5.0E+4	2.0E+3	1.0E+2	1.0E+2	1.0E+3	0.2
Ga	1.0E+3	1.0E+4	1.0E+4	1.0E+0	1.0E+3	1.0E+4	1.0E+4	1.0E+0	-
Gd	5.0E+2	2.0E+3	5.0E+3	1.0E+0	5.0E+2	2.0E+3	5.0E+3	1.0E+0	-
H	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0
Hf	4.0E+1	1.0E+3	3.0E+3	1.0E+0	4.0E+1	1.0E+3	3.0E+3	1.0E+0	-
Hg	2.0E+4	2.0E+4	1.0E+4	3.4E+4	2.0E+4	2.0E+4	2.0E+4	3.4E+4	-
Ho	3.0E+2	1.0E+3	1.0E+3	5.0E+3	3.0E+2	3.0E+3	3.0E+3	5.0E+3	0.2
I	1.0E+1	5.0E+1	5.0E+1	1.5E+3	5.0E+1	1.0E+2	1.0E+2	3.0E+2	0.8
In	1.0E+3	1.0E+4	1.0E+4	1.0E+0	1.0E+3	1.0E+4	1.0E+4	1.0E+0	-
Ir	2.0E+1	1.0E+2	1.0E+2	1.0E+2	5.0E+1	2.0E+2	2.0E+2	2.0E+2	-
Kr	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	-
La	3.0E+1	1.0E+2	1.0E+2	3.0E+2	2.5E+1	1.0E+3	1.0E+3	5.0E+3	0.2
Mn	4.0E+2	8.0E+2	6.0E+3	1.0E+4	4.0E+2	1.0E+5	1.0E+5	1.0E+4	0.5
Mo	4.0E+1	2.0E+1	2.0E+1	1.0E+2	1.0E+1	1.0E+2	1.0E+2	1.0E+3	0.9
N	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0
Na	1.0E+0	1.0E-1	3.0E-1	1.0E+0	7.0E+1	1.0E+2	1.0E+2	1.0E+2	0.9

TABLE J.6 (cont'd). Recommended Aquatic Transfer Factor Values

Element	Concentration Ratio (L Water/Kg Wet Aquatic Organism)								Water Treatment Cleanup Factor
	Marine Organisms				Fresh Water Organisms				
	Fish	Crustacea	Mollusks	Plants	Fish	Crustacea	Mollusks	Plants	
Nb	1.0E+2	5.0E+1	5.0E+1	5.0E+2	1.0E+2	5.0E+1	5.0E+1	5.0E+2	0.7
Nd	1.0E+2	1.0E+3	1.0E+3	1.0E+3	2.5E+1	1.0E+3	1.0E+3	5.0E+3	0.2
Ni	1.0E+2	5.0E+2	5.0E+2	3.0E+3	1.0E+2	5.0E+2	5.0E+2	5.0E+2	0.2
Np	2.5E+3	1.0E+1	1.5E+2	6.0E+0	2.5E+3	3.0E+1	3.0E+1	3.0E+2	0.7
P	2.8E+4	3.8E+4	4.5E+4	1.0E+5	6.7E+4	1.0E+5	1.0E+5	5.0E+5	0.4
Pa	3.0E+2	1.0E+1	1.0E+1	5.0E+1	3.0E+1	3.0E+1	3.0E+1	3.0E+2	0.7
Pb	2.0E+2	1.0E+3	1.0E+3	5.0E+4	2.0E+3	5.0E+2	5.0E+2	2.0E+3	0.9
Pd	5.0E+1	3.0E+2	3.0E+2	2.0E+4	5.0E+1	2.0E+3	2.0E+3	2.0E+3	0.5
Pm	5.0E+2	1.0E+3	5.0E+3	3.0E+3	3.0E+2	3.0E+3	3.0E+3	5.0E+3	0.2
Po	2.0E+3	5.0E+4	1.0E+4	1.0E+3	5.0E+1	2.0E+4	2.0E+4	2.0E+3	0.8
Pr	1.0E+2	1.0E+3	1.0E+3	1.0E+3	2.5E+1	1.0E+3	1.0E+3	5.0E+3	0.2
Pu	1.0E+3	3.0E+2	3.0E+3	3.6E+3	2.5E+2	1.0E+2	1.0E+2	8.9E+2	0.7
Ra	9.5E+2	1.0E+2	1.0E+2	1.0E+3	5.0E+1	1.0E+3	1.0E+3	3.0E+4	0.7
Rb	5.0E+2	2.0E+2	2.0E+2	1.0E+3	2.0E+3	1.0E+3	1.0E+3	1.0E+3	0.9
Rh	1.0E+1	1.0E+2	1.0E+2	1.0E+2	1.0E+1	3.0E+2	3.0E+2	2.0E+2	0.5
Rn	1.0E+0	1.0E+0	1.0E+0	1.0E+0	5.7E+1	1.0E+0	1.0E+0	1.0E+0	0.0
Ru	1.0E+1	1.0E+2	2.0E+3	1.0E+3	1.0E+2	3.0E+2	3.0E+2	2.0E+3	0.5
S	2.0E+0	1.0E+0	4.0E+0	5.0E+0	7.5E+2	1.0E+2	1.0E+2	1.0E+0	-
Sb	1.0E+3	1.0E+2	1.2E+3	1.0E+2	2.0E+2	1.0E+2	1.0E+2	1.0E+3	0.8
Sc	7.5E+2	3.0E+2	1.0E+5	1.0E+3	1.0E+2	1.0E+3	1.0E+3	1.0E+4	0.3
Se	6.0E+3	5.0E+3	6.0E+3	1.0E+3	1.0E+3	2.0E+3	2.0E+3	1.0E+2	0.8

TABLE J.6 (cont'd). Recommended Aquatic Transfer Factor Values

Element	Concentration Ratio (L Water/Kg Wet Aquatic Organism)								Water Treatment Cleanup Factor
	Marine Organisms				Fresh Water Organisms				
	Fish	Crustacea	Mollusks	Plants	Fish	Crustacea	Mollusks	Plants	
Si	5.0E+4	5.0E+4	5.0E+4	5.0E+4	1.0E+3	1.0E+4	1.0E+4	5.0E+4	0.7
Sm	5.0E+2	1.0E+3	5.0E+3	5.0E+3	3.0E+2	3.0E+3	3.0E+3	5.0E+3	0.2
Sn	5.0E+4	5.0E+4	5.0E+4	5.0E+4	1.0E+3	1.0E+4	1.0E+4	5.0E+4	0.7
Sr	4.0E+0	1.0E+0	4.0E+1	3.0E+2	5.0E+1	1.0E+2	1.0E+2	3.0E+3	0.2
Ta	6.0E+1	3.0E+3	3.0E+3	1.0E+0	6.0E+1	3.0E+3	3.0E+3	1.0E+0	-
Tb	6.0E+1	1.0E+3	3.0E+3	1.0E+3	2.5E+1	1.0E+3	1.0E+3	5.0E+3	0.2
Tc	3.0E+1	1.0E+1	2.0E+1	5.0E+3	1.5E+1	1.0E+2	1.0E+2	5.0E+3	0.7
Te	1.0E+3	1.0E+3	1.0E+3	4.0E+2	4.0E+2	6.1E+3	6.1E+3	1.0E+2	0.8
Th	6.0E+2	1.0E+3	1.0E+3	2.0E+3	1.0E+2	1.0E+2	1.0E+2	3.0E+3	0.7
Tl	5.0E+3	1.0E+3	5.0E+3	1.0E+0	5.0E+3	1.0E+3	5.0E+3	1.0E+0	-
Tm	5.0E+2	1.0E+3	5.0E+3	1.0E+0	5.0E+2	1.0E+3	5.0E+3	1.0E+0	-
U	5.0E+1	1.0E+1	3.0E+1	1.0E+3	5.0E+1	1.0E+2	1.0E+2	9.0E+2	0.7
W	1.0E+1	1.0E+1	1.0E+2	1.0E+2	1.2E+3	1.0E+1	1.0E+1	1.2E+3	-
Xe	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	1.0E+0	-
Y	2.0E+1	1.0E+3	1.0E+3	3.0E+2	2.5E+1	1.0E+3	1.0E+3	5.0E+3	0.2
Yb	2.0E+2	1.0E+3	3.0E+3	1.0E+0	2.0E+2	1.0E+3	3.0E+3	1.0E+0	-
Zn	1.0E+3	5.0E+4	3.0E+4	5.0E+4	2.5E+3	1.0E+4	1.0E+4	2.0E+4	0.4
Zr	5.0E+1	5.0E+1	5.0E+1	5.0E+3	2.0E+2	5.0E+1	5.0E+1	5.0E+3	0.7

TABLE J.7. Recommended Parameter Values -- **Ingestion of Food Crops**

Parameter	Default Values Average	Default Values Maximum
Duration of irrigation deposition prior to beginning of intake period (yr)	0	0
Interception fraction of irrigation water onto leaves	0.25	0.25
Weathering half-time (d)	14	14
Cereals:		
Growing time (d)	90	90
Irrigation rate (cm per irrigation season)	0	UDV[a]
Irrigation duration (mo yr^{-1})	0	UDV
Standing biomass (kg wet m^{-2})	1.6	1.6
Translocation factor -- plant surfaces to edible part	0.1	0.1
Yield (kg wet m^{-2})	0.8	0.8
Total production (kg wet yr^{-1})	--	ND[b]
Holdup between harvest and consumption (d)	180	180
Per capita consumption rate of cereal and bread (kg wet yr^{-1})	72	80
Dry to wet weight ratio (kg dry kg^{-1} wet)	0.88	0.88
Fruit:		
Growing time (d)	90	90
Irrigation rate (cm per irrigation season)	90	90
Irrigation duration (mo yr^{-1})	6	6
Standing biomass (kg wet m^{-2})	3	3
Translocation factor -- plant surfaces to edible part	0.1	0.1

[a] UDV = user-defined value (i.e., the user must assign a value to the parameter).

[b] ND = no data presently available.

TABLE J.7 (cont'd). Recommended Parameter Values -- **Ingestion of Food Crops**

Parameter	Default Values Average	Default Values Maximum
Yield (kg wet m^{-2})	2	2
Total production (kg wet yr^{-1})	--	ND[a]
Holdup between harvest and consumption (d)	14	5
Per capita consumption rate (kg wet yr^{-1})	64	330
Dry to wet weight ratio (kg dry kg^{-1} wet)	0.2	0.2
Vegetables -- Leafy:		
Growing time (d)	90	90
Irrigation rate (cm per irrigation season)	90	90
Irrigation duration (mo yr^{-1})	6	6
Standing biomass (kg wet m^{-2})	2	2
Translocation factor -- plant surfaces to edible part	1	1
Yield (kg wet m^{-2})	1.5	1.5
Total production (kg wet yr^{-1})	--	ND
Holdup between harvest and consumption (d)	14	1
Per capita consumption rate (kg wet yr^{-1})	15	30
Dry to wet weight ratio (kg dry kg^{-1} wet)	0.2	0.2
Vegetables -- Other:		
Growing time (d)	90	90
Irrigation rate (cm per irrigation season)	100	100
Irrigation duration (mo yr^{-1})	6	6
Standing biomass (kg wet m^{-2})	2	2
Translocation factor -- plant surfaces to edible part	0.1	0.1

[a] ND = no data presently available.

TABLE J.7 (cont'd). Recommended Parameter Values -- **Ingestion of Food Crops**

Parameter	Default Values Average	Default Values Maximum
Yield (kg wet m^{-2})	4	4
Total production (kg wet yr^{-1})	--	ND[a]
Holdup between harvest and consumption (d)	14	5
Per capita consumption rate (kg wet yr^{-1})	140	220
Dry to wet weight ratio (kg dry kg^{-1} wet)	0.2	0.2
Soil:		
Soil density (kg wet soil m^{-3})	1.5E+3	UDV[b]
Soil moisture content (kg water kg^{-1} dry soil)	0.1	UDV
Surface soil layer thickness (m)	0.15	UDV
Surface soil density thickness (kg wet soil m^{-2})	225	UDV
Deep soil layer thickness, below surface layer (m)	1	UDV
Deep soil density thickness (kg wet soil m^{-2})	1.5E+3	UDV
Inadvertent ingestion of soil (kg wet soil d^{-1})	4.1E+7	UDV

(a) ND = no data presently available.

(b) UDV = user-defined value (i.e., the user must assign a value to the parameter).

TABLE J.8. Recommended Parameter Values -- **Ingestion of Animal Products**

Parameter	Default Values Average	Default Values Maximum
Fraction of animal's diet that consists of fresh forage:		
Winter	0.0	0.0
Spring	0.8	0.8
Summer	1.0	1.0
Autumn	0.8	0.8
Translocation factor -- plant surfaces to edible portions of:		
Fresh feed	1.0	1.0
Stored feed	0.1	0.1
Meat (Beef and Pork):		
Holdup between harvest and consumption (d)	34	15
Per capita consumption rate of meat (kg wet yr^{-1})	70	80
Dry to wet weight ratio (kg dry kg^{-1} wet)	0.4	0.4
Total production of meat (kg wet yr^{-1})	--	ND[a]
Consumption rate of stored feed (kg wet d^{-1})	68	68
Consumption rate of fresh forage (kg wet d^{-1})	68	68
Fresh forage dry to wet weight ratio (kg wet kg^{-1} dry)	0.2	0.2
Fraction of drinking water that is contaminated	1	1
Consumption rate of drinking water (L d^{-1})	50	50
Fraction of diet consisting of contaminated grain	0.25	0.25
Grain growing time (d)	90	90
Grain irrigation rate (cm per irrigation season)	90	90
Grain irrigation duration (mo yr^{-1})	6	6

[a] ND = no data presently available.

TABLE J.8 (cont'd). Recommended Parameter Values -- **Ingestion of Animal Products**

Parameter	Default Values Average	Default Values Maximum
Grain standing biomass (kg wet m^{-2})	1.6	1.6
Grain yield (kg wet m^{-2})	0.8	0.8
Grain storage time (d)	180	180
Fraction of diet consisting of contaminated hay	0.75	0.75
Hay growing time (d)	45	45
Hay irrigation rate (cm per irrigation season)	120	120
Hay irrigation duration (mo yr^{-1})	6	6
Hay standing biomass (kg wet m^{-2})	1	1
Hay yield (kg wet m^{-2})	2	2
Hay storage time (d)	100	100
Poultry (Eggs):		
Holdup between harvest and consumption (d)	18	1
Per capita consumption rate of eggs (kg wet yr^{-1})	20	30
Dry to wet weight ratio (kg dry kg^{-1} wet)	0.25	0.25
Total production of eggs (kg wet yr^{-1})	--	ND[a]
Consumption rate of drinking water (L d^{-1})	0.3	0.3
Fraction of drinking water that is contaminated	1	1
Consumption rate of stored feed (kg wet d^{-1})	0.12	0.12
Fraction of diet consisting of contaminated grain	1	1
Grain dry to wet weight ratio (kg wet kg^{-1} dry)	0.18	0.18
Grain growing time (d)	90	90

[a] ND = no data presently available.

TABLE J.8 (cont'd). Recommended Parameter Values -- **Ingestion of Animal Products**

Parameter	Default Values Average	Default Values Maximum
Grain irrigation rate (cm per irrigation season)	0	UDV[a]
Grain irrigation duration (mo yr^{-1})	0	UDV
Grain standing biomass (kg wet m^{-2})	1.6	1.6
Grain yield (kg wet m^{-2})	0.8	0.8
Grain storage time (d)	180	180
Meat (Poultry):		
Holdup between harvest and consumption (d)	34	1
Per capita consumption rate of poultry (kg wet yr^{-1})	8.5	18
Dry to wet weight ratio (kg dry kg^{-1} wet)	0.3	0.3
Total production of poultry (kg wet yr^{-1})	--	ND[b]
Consumption rate of drinking water (L d^{-1})	0.3	0.3
Fraction of drinking water that is contaminated	1	1
Consumption rate of stored feed (kg wet d^{-1})	0.12	0.12
Fraction of diet consisting of contaminated grain	1	1
Grain dry to wet weight ratio (kg wet kg^{-1} dry)	0.18	0.18
Grain Growing time (d)	90	90
Grain irrigation rate (cm per irrigation season)	0	UDV
Grain irrigation duration (mo yr^{-1})	0	UDV
Grain standing biomass (kg wet m^{-2})	1.6	1.6

(a) UDV = user-defined value (i.e., the user must assign a value to the parameter).

(b) ND = no data presently available.

TABLE J.8 (cont'd). Recommended Parameter Values -- **Ingestion of Animal Products**

Parameter	Default Values Average	Default Values Maximum
Grain yield (kg wet m^{-2})	0.8	0.8
Grain storage time (d)	180	180
Milk:		
Holdup between harvest and consumption (d)	4	1
Per capita consumption rate of milk (L yr^{-1})	230	270
Dry to wet weight ratio (kg dry kg^{-1} wet)	0.12	0.12
Total production of milk (L yr^{-1})	--	ND[a]
Consumption rate of stored feed (kg wet d^{-1})	55	55
Consumption rate of fresh feed (kg wet d^{-1})	55	55
Consumption rate of drinking water (L d^{-1})	60	60
Fraction of drinking water that is contaminated	1	1
Fraction of diet consisting of contaminated hay	0.25	0.25
Hay dry to wet weight ratio (kg wet kg^{-1} dry)	0.18	0.18
Hay growing time (d)	45	45
Hay irrigation rate (cm per irrigation season)	120	120
Hay irrigation duration (mo yr^{-1})	6	6
Hay standing biomass (kg wet m^{-2})	1	1
Hay yield (kg wet m^{-2})	2	2
Hay storage time (d)	100	100
Fraction of diet consisting of contaminated fresh forage	0.75	0.75
Fresh forage dry to wet weight ratio (kg wet kg^{-1} dry)	0.2	0.2

[a] ND = no data presently available.

TABLE J.8 (cont'd). Recommended Parameter Values -- **Ingestion of Animal Products**

Parameter	Default Values Average	Default Values Maximum
Fresh forage growing time (d)	30	30
Fresh forage irrigation rate (cm per irrigation season)	120	120
Fresh forage irrigation duration (mo yr^{-1})	6	6
Fresh forage standing biomass (kg wet m^{-2})	1	1
Fresh forage yield (kg wet m^{-2})	1.5	1.5
Fresh forage storage time (d)	0	0

TABLE J.9. Recommended Parameter Values -- **Terrestrial Transfer Factors**

Element	Deposition Velocity (m sec^{-1})	CR (kg Wet Soil kg^{-1} Dry Veg.) Leafy Veg.	Root Veg.	Fruit	Grain	Equilibrium Transfer Coefficient (d kg^{-1} Wet Weight) Meat	Poultry	Milk	Eggs	Leaching Factor (yr^{-1})
Ac	1.0E-3	1.0E-2	1.0E-2	3.0E-3	3.0E-4	4.0E-4	4.0E-3	2.0E-5	2.0E-3	1.3E-3
Ag	1.0E-3	6.0E-1	6.0E-1	6.0E-1	6.0E-2	2.0E-3	9.9E-4	2.5E-2	9.9E-4	2.7E-1
Am	1.0E-3	2.0E-3	2.0E-3	2.0E-3	2.0E-4	2.0E-5	2.0E-4	3.0E-7	9.0E-3	1.3E-3
Ar	0	0	0	0	0	0	0	0	0	0.8E-1
As	1.0E-3	1.0E-2	1.0E-2	1.0E-2	1.0E-2	1.5E-3	8.3E-1	8.0E-5	9.9E-4	1.3E-3
Au	1.0E-3	4.0E-1	4.0E-1	4.0E-1	4.0E-2	5.0E-3	9.9E-4	1.0E-5	9.9E-4	1.1E-2
Ba	1.0E-3	4.0E-2	4.0E-2	4.0E-2	4.0E-3	5.0E-4	8.1E-4	4.8E-4	1.5E+0	9.5E-5
Be	1.0E-3	8.0E-3	8.0E-3	8.0E-3	3.3E-3	8.0E-4	4.0E-1	2.0E-6	2.0E-2	1.9E-4
Bi	1.0E-3	6.0E-1	6.0E-1	6.0E-1	6.0E-1	1.7E-2	9.9E-4	5.0E-4	9.9E-4	2.7E-5
Br	1.0E-2	7.6E-1	7.6E-1	7.6E-1	7.6E-1	2.0E-2	4.0E-3	2.0E-2	1.6E+0	1.1E-1
C[a]	-	-	-	-	-	-	-	-	-	8.0E-1
Ca	1.0E-3	2.0E+0	2.0E+0	2.0E+0	2.0E+0	1.6E-3	4.4E-2	8.0E-3	4.4E-1	1.9E-4
Cd	1.0E-3	2.0E+0	2.0E+0	2.0E+0	6.0E-1	4.0E-4	8.4E-1	1.2E-4	1.0E-1	6.3E-4
Ce	1.0E-3	2.5E-3	2.5E-3	2.5E-3	2.5E-3	5.0E-3	4.0E-3	7.5E-7	2.0E-3	4.1E-4
Cf	1.0E-3	4.0E-2	4.0E-2	4.0E-2	4.0E-3	2.0E-3	1.0E-2	4.0E-5	5.0E-3	5.0E-4
Cl	1.0E-3	5.0E+1	5.0E+1	5.0E+1	1.0E+0	3.0E-2	3.0E-2	2.0E-2	9.9E-4	8.0E-1
Cm	1.0E-3	2.0E-3	2.0E-3	2.0E-3	2.0E-4	5.0E-3	4.0E-3	3.0E-7	2.0E-3	1.3E-4
Co	1.0E-3	1.0E-1	1.0E-1	1.0E-1	4.0E-3	2.0E-2	5.0E-1	1.0E-4	1.0E-1	3.0E-2
Cr	1.0E-3	4.0E-2	4.0E-2	4.0E-2	4.0E-3	9.0E-3	9.9E-4	1.0E-5	9.9E-4	4.7E-3
Cs	1.0E-3	2.0E-2	2.0E-2	2.0E-2	1.0E-2	3.0E-2	4.4E+0	7.0E-3	4.9E-1	1.1E-3

[a] Carbon is evaluated uniquely by the GENII code. The model basically assumes that the isotopic concentration of ^{14}C (e.g., Bq ^{14}C g^{-1} carbon) in the terrestrial components equilibrate.

TABLE J.9 (cont'd). Recommended Terrestrial Transfer Factor Values

Element	Deposition Velocity (m sec^{-1})	CR (kg Wet Soil kg^{-1} Dry Veg.) Leafy Veg.	Root Veg.	Fruit	Grain	Equilibrium Transfer Coefficient (d kg^{-1} Wet Weight) Meat	Poultry	Milk	Eggs	Leaching Factor (yr^{-1})
Cu	1.0E-3	5.0E-1	5.0E-1	5.0E-1	5.0E-2	9.0E-3	5.1E-1	2.0E-3	4.9E-1	2.9E-3
Dy	1.0E-3	9.9E-4	9.9E-4	9.9E-4	9.9E-4	5.3E-3	9.9E-4	5.0E-6	9.9E-4	4.1E-4
Er	1.0E-3	1.0E-2	1.0E-2	1.0E-2	1.0E-2	4.0E-3	9.9E-4	2.0E-5	9.9E-4	4.1E-4
Eu	1.0E-3	1.0E-2	1.0E-2	1.0E-2	2.0E-3	6.0E-3	4.0E-3	2.0E-5	7.0E-3	5.0E-4
F	1.0E-2	2.0E-2	2.0E-2	2.0E-2	2.0E-2	2.0E-2	9.9E-4	7.0E-3	9.9E-4	8.0E-1
Fe	1.0E-3	2.0E-2	2.0E-2	2.0E-2	5.0E-3	2.0E-2	1.5E+0	5.0E-5	1.3E+0	1.8E-2
Ga	1.0E-3	1.0E-2	1.0E-2	1.0E-2	1.0E-3	3.0E-4	9.9E-4	1.0E-5	9.9E-4	1.8E-4
Gd	1.0E-3	5.0E-2	5.0E-2	5.0E-2	5.0E-3	2.0E-3	9.9E-4	6.0E-5	9.9E-4	4.1E-4
H[a]	-	-	-	-	-	-	-	-	-	8.0E-1
Hf	1.0E-3	1.0E-2	1.0E-2	1.0E-2	2.0E-3	4.0E-4	9.9E-4	2.0E-5	9.9E-4	1.8E-4
Hg	1.0E-3	1.0E+0	1.0E+0	1.0E+0	1.0E-1	1.0E-1	1.1E-2	4.0E-4	9.9E-4	4.6E-4
Ho	1.0E-3	1.0E-2	2.0E-2	1.0E-2	2.7E-3	5.0E-3	4.0E-3	2.5E-6	7.0E-3	4.1E-4
I	1.0E-2	4.0E-1	4.0E-1	4.0E-1	4.0E-1	2.0E-3	1.8E-2	1.2E-2	2.8E+0	8.0E-1
In	1.0E-3	1.0E-2	1.0E-2	1.0E-2	1.0E-3	4.0E-3	9.9E-4	2.0E-4	9.9E-4	1.8E-4
Ir	1.0E-3	1.0E-1	1.0E-1	1.0E-1	4.0E-3	2.0E-3	9.9E-4	2.0E-6	9.9E-4	1.8E-3
K	1.0E-3	3.0E+0	3.0E+0	3.0E+0	3.0E+0	1.8E-2	9.9E-4	7.0E-3	9.9E-4	5.0E-1
Kr	0	0	0	0	0	0	0	0	0	8.0E-1
La	1.0E-3	1.0E-2	1.0E-2	1.0E-2	3.0E-4	5.0E-3	1.0E-1	2.5E-6	9.0E-3	4.1E-4
Mg	1.0E-3	9.9E-4	9.9E-4	9.9E-4	9.9E-4	1.8E-2	9.9E-4	9.9E-4	1.6E+0	1.9E-4
Mn	1.0E-3	7.0E-1	7.0E-1	7.0E-1	2.0E-1	5.0E-4	5.0E-2	3.0E-4	6.5E-2	1.1E-2

[a] Tritium is evaluated uniquely by the GENII code. The model basically assumes that the isotopic concentration of ^{3}H (e.g., Bq ^{3}H g^{-1} hydrogen) in the terrestrial components equilibrate.

TABLE J.9 (cont'd). Recommended Terrestrial Transfer Factor Values

Element	Deposition Velocity (m sec^{-1})	CR (kg Wet Soil kg^{-1} Dry Veg.) Leafy Veg.	Root Veg.	Fruit	Grain	Equilibrium Transfer Coefficient (d kg^{-1} Wet Weight) Meat	Poultry	Milk	Eggs	Leaching Factor (yr^{-1})
Mo	1.0E-3	1.0E+0	1.0E+0	1.0E+0	1.0E-1	1.2E-3	1.9E-1	1.7E-3	7.8E-1	8.0E-1
N	1.0E-3	7.5E+0	7.5E+0	7.5E+0	7.5E+0	9.9E-4	9.9E-4	1.1E-2	9.9E-4	8.0E-1
Na	1.0E-3	1.0E+1	1.0E+1	1.0E+1	1.0E+1	8.0E-2	1.0E-2	2.0E-2	2.0E-1	5.0E-1
Nb	1.0E-3	4.0E-2	4.0E-2	4.0E-2	8.0E-3	2.6E-7	3.1E-4	4.1E-7	1.3E-3	2.7E-3
Nd	1.0E-3	1.0E-2	1.0E-2	1.0E-2	1.0E-3	5.0E-3	4.0E-3	2.0E-5	2.0E-4	4.1E-4
Ni	1.0E-3	1.0E-1	1.0E-1	1.0E-1	5.0E-2	2.0E-3	1.0E-3	1.0E-3	1.0E-1	4.6E-3
Np	1.0E-3	1.0E+0	1.0E+0	1.0E+0	1.0E-1	1.0E-3	4.0E-3	1.0E-5	2.0E-3	3.3E-3
P	1.0E-3	4.0E+0	4.0E+0	4.0E+0	4.0E+0	5.0E-2	1.9E-1	1.5E-2	1.0E+1	8.0E-1
Pa	1.0E-3	5.0E-2	5.0E-2	5.0E-2	2.0E-2	5.0E-3	4.0E-3	2.5E-6	2.0E-3	1.3E-3
Pb	1.0E-3	1.0E-1	1.0E-1	1.0E-1	1.0E-2	4.0E-4	9.9E-4	3.0E-5	9.9E-4	4.5E-4
Pd	1.0E-3	3.0E-1	3.0E-1	3.0E-1	5.0E-2	1.0E-3	3.0E-4	5.0E-3	4.0E-3	4.6E-3
Pm	1.0E-3	1.0E-2	1.0E-2	1.0E-2	1.0E-3	5.0E-3	2.0E-3	2.5E-6	2.0E-2	5.0E-4
Po	1.0E-3	1.0E-2	1.0E-2	1.0E-2	1.0E-3	4.5E-3	9.9E-4	1.2E-4	9.9E-4	2.7E-5
Pr	1.0E-3	1.0E-2	1.0E-2	1.0E-2	1.0E-3	5.0E-3	3.0E-2	2.5E-6	5.0E-3	5.0E-4
Pu	1.0E-3	4.0E-4	4.0E-4	4.0E-4	4.0E-5	2.0E-6	1.5E-4	1.0E-7	8.0E-3	1.3E-3
Ra	1.0E-3	1.0E-1	1.0E-1	1.0E-1	1.0E-2	9.0E-4	9.9E-4	2.0E-4	2.0E-5	5.9E-4
Rb	1.0E-3	3.0E-1	3.0E-1	3.0E-1	3.0E-1	1.0E-2	2.0E+0	1.0E-2	3.0E+0	4.4E-3
Re	1.0E-3	9.9E-4	9.9E-4	9.9E-4	9.9E-4	9.9E-4	9.9E-4	1.0E-3	9.9E-4	3.3E-2
Rh	1.0E-3	5.0E+1	5.0E+1	5.0E+1	5.0E+0	1.0E-3	3.0E-4	5.0E-3	4.0E-3	4.4E-3
Rn	0	0	0	0	0	0	0	0	0	8.0E-1
Ru	1.0E-3	2.0E-1	2.0E-1	2.0E-1	2.0E-1	2.0E-3	7.0E-3	6.0E-7	6.0E-3	7.6E-4
S	1.0E-3	2.0E+0	2.0E+0	2.0E+0	2.0E+0	2.0E-1	9.9E-4	1.5E-2	9.9E-4	3.4E-2
Sb	1.0E-3	5.0E-2	5.0E-2	5.0E-2	5.0E-2	1.0E-3	6.0E-3	7.5E-4	7.0E-2	4.2E-2

TABLE J.9 (cont'd). Recommended Terrestrial Transfer Factor Values

Element	Deposition Velocity (m sec^{-1})	CR (kg Wet Soil kg^{-1} Dry Veg.)				Equilibrium Transfer Coefficient (d kg^{-1} Wet Weight)				Leaching Factor (yr^{-1})
		Leafy Veg.	Root Veg.	Fruit	Grain	Meat	Poultry	Milk	Eggs	
Sc	1.0E-3	1.0E-2	1.0E-2	1.0E-2	1.0E-2	6.0E-3	4.0E-3	2.5E-6	9.9E-4	2.7E-4
Se	1.0E-3	5.0E-1	5.0E-1	5.0E-1	5.0E-2	1.0E+0	8.5E+0	2.3E-2	9.3E+0	1.7E-2
Si	1.0E-3	3.5E-1	3.5E-1	3.5E-1	3.5E-1	4.0E-5	9.9E-4	2.0E-5	9.9E-4	8.8E-3
Sm	1.0E-3	1.0E-2	1.0E-2	1.0E-2	2.0E-3	5.0E-3	4.0E-3	2.0E-5	7.0E-3	4.1E-4
Sn	1.0E-3	1.0E-1	1.0E-1	1.0E-1	1.0E-2	1.0E-2	9.9E-4	1.0E-3	9.9E-4	2.7E-3
Sr	1.0E-3	2.0E+0	2.0E+0	2.0E+0	2.0E-1	8.0E-4	3.5E-2	1.3E-3	3.0E-1	2.7E-3
Ta	1.0E-3	9.9E-4	9.9E-4	9.9E-4	9.9E-4	9.9E-4	9.9E-4	3.0E-6	9.9E-4	4.1E-4
Tb	1.0E-3	2.6E-3	2.6E-3	2.6E-3	2.6E-3	5.0E-3	4.0E-3	2.5E-6	7.0E-3	4.1E-4
Tc	1.0E-3	4.0E+1	4.0E+1	4.0E+1	4.0E+1	9.9E-4	3.0E-2	3.0E-4	3.0E+0	8.0E-1
Te	1.0E-3	5.0E+0	5.0E+0	5.0E+0	5.0E-1	7.0E-3	8.5E-2	4.5E-4	5.2E+0	8.0E-1
Th	1.0E-3	4.0E-3	4.0E-3	4.0E-3	4.0E-4	5.0E-3	4.0E-3	2.5E-6	2.0E-3	5.3E-4
Tl	1.0E-3	9.9E-4	9.9E-4	9.9E-4	9.9E-4	9.9E-4	9.9E-4	2.0E-3	9.9E-4	5.0E-1
U	1.0E-3	4.0E-3	4.0E-3	4.0E-3	2.0E-4	2.0E-4	1.2E+0	6.0E-4	9.9E-1	1.3E-3
W	1.0E-3	3.0E+0	3.0E+0	3.0E+0	3.0E-1	3.7E-2	9.9E-4	3.0E-4	9.9E-4	1.8E-3
Xe	0	0	0	0	0	0	0	0	0	8.0E-1
Y	1.0E-3	1.0E-2	1.0E-2	1.0E-2	1.0E-3	1.0E-3	1.0E-2	5.0E-6	2.0E-3	5.0E-4
Zn	1.0E-3	2.0E+0	2.0E+0	2.0E+0	2.0E+0	1.0E-1	6.5E+0	1.0E-2	2.6E+0	2.8E-4
Zr	1.0E-3	4.0E-2	4.0E-2	4.0E-2	4.0E-2	1.2E-6	6.4E-5	5.5E-7	1.9E-4	5.3E-4

TABLE J.10. Recommended Parameter Values -- **Carbon and Hydrogen Content of Selected Environmental Media** (modified from Napier et al. 1988)

Parameter	Default Values Average	Default Values Maximum
Carbon in air (kg m^{-3} air)	1.6E-4[a]	UDV[b]
Carbon in water (kg L^{-1})	2.0E-5[c]	UDV
Carbon in vegetation (kg C kg^{-1} dry material)	4.5E-1	UDV
Carbon in eggs (kg C kg^{-1} dry material)	6.0E-1	UDV
Carbon in milk (kg C kg^{-1} dry material)	5.8E-1	UDV
Carbon in beef (kg C kg^{-1} dry material)	6.0E-1	UDV
Carbon in poultry (kg C kg^{-1} dry material)	6.7E-1	UDV
Carbon in soil (kg C kg^{-1} dry material)	3.0E-2	UDV
Hydrogen in air (kg m^{-3} air)	8.9E-4	UDV
Hydrogen in water (kg L^{-1})	1.1E-1	1.1E-1
Hydrogen in vegetation (kg H kg^{-1} dry material)	6.2E-2	UDV
Hydrogen in eggs (kg H kg^{-1} dry material)	9.2E-2	UDV
Hydrogen in milk (kg H kg^{-1} dry material)	8.3E-2	UDV
Hydrogen in beef (kg H kg^{-1} dry material)	9.4E-2	UDV
Hydrogen in poultry (kg H kg^{-1} dry material)	8.7E-2	UDV
Hydrogen in soil (kg H kg^{-1} dry material)	1.2E-2[d]	UDV

(a) Assumes an atmospheric CO_2 concentration of 320 ppm_v.

(b) UDV = user-defined value (i.e., the user must assign a value to the parameter).

(c) Assumes a concentration of 100 mg bicarbonate L^{-1} water.

(d) Assumes 0.1 L water kg^{-1} wet soil.

TABLE J.11. Recommended Parameter Values -- External Exposure

Parameter	Default Values Average	Default Values Maximum
Duration of irrigation (mo yr^{-1})	6	6
Fraction of plume passage time spent in plume (acute release scenarios only)	1	1
Individual annual exposure time to plume (h)	8766	8766
Individual annual exposure time to contaminated soil (h)	2920	4380
Individual annual exposure time while swimming (h)	10	100
Individual annual exposure time while boating (h)	5	100
Individual annual exposure time from shoreline activities (h)	17	500
Irrigation water application rate (cm per irrigation season)	100	100
Source area for external dose modification factor (m^2)	1250	1250
Transit time for release to reach aquatic recreation area (h)	13	8

TABLE J.12. Recommended Parameter Values -- **Miscellaneous**

Parameter	Default Values Average	Default Values Maximum
Duration of intake (yr)	1	1
Duration of dose commitment (yr)	50	50
Breathing rates:		
Chronic releases -- offsite non-worker (cm^3 sec^{-1})	270	270
Acute releases -- onsite worker (cm^3 sec^{-1})	330	330

THIS PAGE BLANK INTENTIONALLY

APPENDIX K

GLOSSARY

THIS PAGE BLANK INTENTIONALLY

APPENDIX K

GLOSSARY

K.1. ABBREVIATIONS, ACRONYMS, AND DEFINITION OF TERMS

Absorbed Dose (D or D_t): The amount of energy deposited by ionizing radiation in a given mass of material (e.g., tissue, organ, whole body, metal, concrete). It is expressed in SI units of gray (Gy) or in rad (1 rad = 0.01 Gy) as a total dose over a specified time period (D) or as a function of time (D_t).

Acute Release: A release of radioactive or other hazardous material to the environment that occurs over a relatively short time periods (e.g., minutes or hours versus years).

Atmospheric Dispersion Factors: Parameter used to calculate the concentration of material in air at a specified location given the average long-term release rate or total quantity of material released from the source during a shorter time period. It is expressed in units of sec m^{-3} and is designated as $\overline{\chi}/Q'$ for chronic, and E/Q for acute, releases.

becquerel (Bq): The SI unit of measurement of radioactivity.

$$1 \text{ Bq} = 1 \text{ transformation sec}^{-1} = 2.7\text{E-}11 \text{ Ci}$$

Bioaccumulation Factor: See Concentration Ratio.

Bq: See "becquerel."

°C: Degrees celsius.

$\overline{\chi}/Q'$: Parameter used to calculate the average concentration of material in air at a specified location given the average rate (e.g., Bq sec^{-1}) at which the material is chronically released to the atmosphere. It has units of sec m^{-3}. See "Atmospheric Dispersion Factors."

Chronic Release: A release of radioactive or other hazardous material to the environment that continues for a sufficiently long time period (e.g., months or years) such that the levels of the material in the environmental media approach equilibrium (see "equilibrium").

Ci: See "curie."

cm: Centimeter (10^{-2} m).

Committed Dose Equivalent (H_{50}): As stated in DOE report EH-0071 (USDOE 1988), it is the predicted total dose equivalent to a tissue or organ over a 50-year period following the intake of a radionuclide(s) into the body. It does not include contributions from external dose. It is expressed in units of sievert (Sv) or in rem (1 rem = 0.01 Sv). It is described mathematically as

$$H_{50} = \int_0^{50} H(t)\ dt$$

Committed Effective Dose Equivalent ($H_{E,50}$): According to DOE report EH-0071 (USDOE 1988), it is the sum of the committed dose equivalents (H_{50}) to various tissues or organs in the body over a 50-year period, each multiplied by the appropriate weighting factor (W_T). It does not include contributions from external dose. It is expressed in SI units of sievert (Sv) or in rem (1 rem = 0.01 Sv). It is described mathematically as

$$H_{E,50} = \int_0^{50} H_E(t)\ dt = [H_{50}][w_T]$$

Concentration Ratio (CR): An experimentally determined ratio of the concentration of a specific material in a biological medium and the concentration of that material in an associated environmental medium (e.g., [Bq kg^{-1} vegetation]/[Bq kg^{-1} soil] = kg soil kg^{-1} vegetation). Multiplying a given concentration of material in soil (Bq kg^{-1} soil) by the corresponding CR value (kg soil kg^{-1} vegetation) gives an estimate of the concentration of the material in vegetation (Bq kg^{-1} vegetation). It can also be used to express the ratio of concentration of a specific material in fish to that in water (e.g., [Bq kg^{-1} fish]/[Bq L^{-1} water] = L water kg^{-1} fish).

CR: See Concentration Ratio.

Curie (Ci): A unit of measurement of radioactivity.

$$1\ Ci = 3.7E{+}10\ \text{transformation}\ sec^{-1} = 3.7E{+}10\ Bq$$

Cumulative Dose: Includes future doses that are projected to result from external exposure to, and ingestion and inhalation of, residual radionuclides in the environment over some specified time period in addition to the dose received during the period of the release.

D or D_t: See "Absorbed Dose."

d: Day.

Deposition Velocity: Expresses the rate at which material is deposited from the near-surface atmosphere onto surfaces. It has units of m sec^{-1} and, when multiplied times a given concentration of material in the near-surface atmosphere (e.g., Bq m^{-3}), provides an estimate of the rate at which the material is deposited per square meter of surface area (e.g., m sec^{-1} times Bq m^{-3} = Bq m^{-2} sec^{-1}).

DOE: U.S. Department of Energy.

Dose Equivalent (H or H_t): The product of the absorbed dose (D or D_t), the quality factor (Q), and any other modifying factors (N). It is also the product of the absorbed dose and the relative biological effectiveness (RBE). It is the quantity used to compare the relative biological effectiveness of different kinds of radiation on a particular tissue, organ, or the whole body. It is expressed in SI units of sievert (Sv) or in rem (1 rem = 0.01 Sv) as a total dose equivalent over a specified time period,

$$H\ (Sv) = [D\ (\text{in Gy})][Q][N] = [D][RBE]$$

or as a function of time,

$$H_t\ (Sv) = [D_t\ (Gy)][Q][N].$$

E/Q: Parameter used to calculate the time-integrated average concentration of material in air at a specified location given the total quantity (e.g., Bq) of material that is released acutely to the atmosphere. It is expressed in units of sec m^{-3}. See "Atmospheric Dispersion Factors."

Ecology: The study of the interactions of the biotic and abiotic components of the environment. Also a shortened term for the Washington State Department of Ecology (WDOE).

EDE: See "Effective Dose Equivalent."

Effective Dose Equivalent (EDE or H_E): An estimate of the total risk of potential health effects from radiation exposure to individual tissues or organs relative to the risk from irradiation of the whole body. According to DOE report EH-0071 (USDOE 1988), it is the summation of the products of the "dose equivalent (H_T)" received by specified tissues of the body and a tissue-specific "weighting factor (w_T)." It includes the committed effective dose equivalent (H_{50}) from radionuclides that were deposited internally during the year of exposure plus the dose equivalent (H) due to penetrating radiation from sources external to the body during the year of exposure. It is expressed in SI units of sievert (Sv) or in rem (1 rem = 0.01 Sv). It is described mathematically as:

$$H_E = \sum_T [H_T][w_T]$$

Environmental and Health Dose Assessment: Assessment of doses potentially received by humans and other biota due to the actual or projected release of radioactive and/or other hazardous materials to the environment.

EPA: U.S. Environmental Protection Agency.

Equilibrium: A condition in which the level of material in a particular environmental compartment remains constant over time because the loss of the material from the compartment equals the input into it.

Equilibrium Transfer Coefficient (ETC): Relates the concentration of material in an animal product at equilibrium to the rate at which the material is ingested by the animal. It is expressed in units of d kg^{-1} animal product.

erg = The unit of energy required to exert a force of 1 dyne through a distance of 1 cm.

ETC: See "Equilibrium Transfer Coefficient."

$$1 \text{ erg} = 1 \text{ dyne cm} = 1 \text{ g cm}^2 \text{ sec}^{-2} = 6.25\text{E+5 MeV} = 1\text{E-7 J}$$

g: Gram.

gray (Gy): The SI unit of "Absorbed Dose."

$$1 \text{ gray} = 1 \text{ Gy} = 1 \text{ joule kg}^{-1} = 100 \text{ rad} = 1.0\text{E+4 erg g}^{-1}$$

Gy: See "gray."

h: Hour.

H or H_t: See "Dose Equivalent."

H_E: See "Effective Dose Equivalent."

$H_{E,50}$: See "Committed Effective Dose Equivalent."

H_{50}: See "Committed Dose Equivalent."

HEDOP: Hanford Environmental Dose Overview Panel.

HEHF: Hanford Environmental Health Foundation.

HMS: Hanford Meteorological Station.

ICRP: International Commission on Radiological Protection.

Isotopic Concentration: The activity of a radioisotope divided by the mass of all the isotopes of the element in a sample (e.g., Bq ^{14}C kg^{-1} C in sample).

J: See "joule."

joule (J): The unit of work and energy that is required to exert a force of 1 newton (N) over a distance of 1 meter.

$$1 \text{ J} = [1 \text{ N}][1 \text{ m}]$$

°K: Degrees kelvin (°K = °C + 273.15).

kg: Kilogram (10^3 g).

km: Kilometer (10^3 m).

L: Liter.

lb: Pound (1 lb = 453.6 g).

Leaching Factor: The fractional rate at which material is moved beyond the root zone into the deeper soils each year. It is expressed in units of yr^{-1}.

m: Meter.

Maximally Exposed Individual (MEI): A hypothetical person whose location and lifestyle result in maximum exposure to radioactive or other hazardous material from all or specified credible pathways.

MEI: See "Maximally Exposed Individual."

mg: Milligram (10^{-3} g).

mi: Mile.

min: Minute.

mL: Milliliter (10^{-3} L).

mm: Millimeter (10^{-3} m).

mo: Month.

NCRP: National Council on Radiation Protection and Measurements.

oz: Ounce (1 oz = 28.35 g).

PA: See "Performance Assessment."

Performance Assessment (PA): As described in USDOE Order 5820.2A (1988), it is "a systematic analysis of the potential risks posed by waste management systems to the public and environment, and a comparison of those risks to established performance objectives."

PNL: Pacific Northwest Laboratory.

ppm_v: Concentration of a compound in air expressed in parts per million.

$$ppm_v = [C][24.4\ L\ mole^{-1}/W][T/273.15][760/P]$$

where C = concentration of compound in air (mg m^{-3} air)
W = gram molecular weight of compound (g $mole^{-1}$)
T = temperature (°K)
P = pressure (mm mercury).

Q: See "Quality Factor."

Quality Factor (Q): A numerical value for normalizing the absorbed dose produced by a given type of radiation according to the biological effectiveness of the radiation. It is based primarily on the linear energy transfer (LET) values for the radiation in question. The values of Q, as taken from ICRP Publication 42 (ICRP 1984), are given below.

Radiation Type	Q
Photons, negatrons, and positrons	1
Neutrons, protons, and singularly-charged particles of unknown energy with rest mass >1 amu	10
Alpha particles and multi-charged particles of unknown energy	20

rad (Radiation Absorbed Dose): Unit of "Absorbed Dose."

$$1 \text{ rad} = 100 \text{ erg g}^{-1} = 0.01 \text{ J kg}^{-1} = 0.01 \text{ Gy}$$

RBE: See "Relative Biological Effectiveness."

Relative Biological Effectiveness (RBE): An experimentally determined relative effectiveness of a given type of radiation on a particular biological system (e.g., whole body, organ, tissue) to produce a specified type of effect (e.g., death). It is the quotient of the dose from 250 keV X-rays to produce a given biological effect (e.g., mortality) divided by the dose from the radiation in question to produce the same effect. It has Si units of Sv/Gy or conventional units of rem/rad.

rem (Roentgen Equivalent Man): A unit of "Dose Equivalent."

$$1 \text{ rem} = 0.01 \text{ Sv}$$

RL: U.S. Department of Energy's Richland Field Office, located in Richland, Washington.

sec: Second.

SI: See "Systeme Internationale."

sievert (Sv): The SI units of "Dose Equivalent."

$$1 \text{ sievert} = 1 \text{ Sv} = [1 \text{ Gy}][Q][N] = 100 \text{ rem}$$

Systeme Internationale (SI): A system of units of measurement as recommended by the International Commission on Radiation Units and Measurements.

Sv: See "sievert."

USDOE: U.S. Department of Energy.

USEPA: U.S. Environmental Protection Agency.

WDOE: Washington State Department of Ecology.

Weighting Factor (w_T): Numerical representation of the total random risk to each tissue or organ resulting from uniform irradiation of the whole body. The values of w_T, as taken from ICRP Publication 42 (ICRP 1984), are given below.

Organ or Tissue	w_T
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lung	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder	0.30

The "Remainder" term consists of the 5 "other" organs with the highest dose. The "other" organs include the liver, kidney, spleen, thymus, adrenal glands, pancreas, stomach, small intestine, and upper and lower large intestine. (The skin, lens of the eye, and extremities are not included.) The weighting factor for each "other" organ is 0.06.

WHC: Westinghouse Hanford Company.

w_T: See "Weighting Factor."

yr: Year.

K.2. REFERENCES

International Commission on Radiological Protection (ICRP). 1984. "ICRP Publication 42, A Compilation of the Major Concepts and Quantities in use by ICRP." Annals of the ICRP, Vol. 14, No. 4, Pergamon Press, New York.

U.S. Department of Energy (USDOE). 1988. Internal Dose-Rate Conversion Factors for Calculation of Dose to the Public. DOE/EH-0071, DOE Assistant Secretary for Environment, Safety and Health, Washington, D.C.

U.S. Department of Energy (USDOE). 1988. Radioactive Waste Management. DOE Order 5820.2A (Issued 9-26-88), Washington, D.C.

THIS PAGE BLANK INTENTIONALLY

DISTRIBUTION

No. of Copies

OFFSITE

2 Office of Scientific and Technical Information

C. J. Card
MS 1025
Washington Public Power Supply System
POB 968
Richland, WA 99352

T. E. Chapman
MS 1020
Washington Public Power Supply System
POB 968
Richland, WA 99352

J. L. Erickson
Washington State Department of Health
POB 47827
Olympia, WA 98504-7827

D. E. Fields
Oak Ridge National Laboratory
POB 2009
Oak Ridge, TN 99831-6383

K. Fox-Williams
Washington State Department of Health
POB 47827
Olympia, WA 98504-7827

D. Jansen
Washington State Department of Ecology
POB 47600
Olympia, WA 98504-8711

No. of Copies

OFFSITE

D. Nylander
Washington State Department of Ecology
Suite 102
7601 W. Clearwater
Kennewick, WA 99336

R. W. Poeton
U.S. Environmental Protection Agency
1200 6th Ave.
Seattle, WA 98101

A. M. Raad
Washington State Department of Ecology
MS:PV-11
Olympia, WA 98504-8711

E. Still
4104 148th Ave. NE
Redmond, WA 98052

ONSITE

4 DOE Richland Field Office

E. M. Bowers (A5-90)
R. F. Brich (A5-55)
J. K. Erickson (A5-19)
E. D. Goller (A5-19)

4 Hanford Environmental Health Foundation

M. L. Dentler (H1-52)
R. Dowray (H1-02)
T. W. Henn (H1-02)
B. B. Milburn (B2-75)

No. of
Copies

ONSITE

22 Westinghouse Hanford Company

M. R. Adams (H6-01)
R. G. Britton (N1-19)
R. A. Carlson (H6-03)
J. S. Davis (N1-19)
R. P. Henckel (H6-03)
B. E. Hey (N1-19)
D. A. Himes (N1-19)
J. P. Hinckley (N1-24)
A. R. Johnson (H6-30)
T. J. Kelly (L8-20)
D. S. Leach (N1-19)
E. E. Leitz (N1-37)
L. D. Muhlestein (N1-28)
L. V. Nguyen (N1-19)
D. K. Oestreich (N1-19)
P. D. Rittmann (H4-14)
R. H. Ruben ((L8-20)
W. J. Rued (H6-26)
A. V. Savino (N1-19)
E. R. Selle (N1-19)
J. C. Van Keuren (N1-19)
J. R. Van Vleet (H4-62)

38 Pacific Northwest Laboratory

E. J. Antonio (K6-13)
D. A. Baker (K3-54)
W. T. Farris (K3-54)
S. L. Friant (K6-13)
C. S. Glantz (K6-96)
D. J. Hanley (K3-53)
T. A. Ikenberry (K3-54)
R. E. Jaquish (K1-30)
T. T. Jarvis (B1-34)
W. E. Kennedy, Jr. (K3-54)
C. T. Kincaid (K6-77)
D. L. Klages (P7-68)
B. A. Napier (K3-54)
I. C. Nelson (K3-54)
K. M. Probasco (K6-13)
J. V. Ramsdell (K6-03)
K. Rhoads (K3-54)

No. of
Copies

ONSITE

L. H. Sawyer (K3-54)
6 R. G. Schreckhise (K3-54)
D. B. Shipler (K1-25)
S. F. Snyder (K3-54)
J. K. Soldat (K3-54)
R. D. Stenner (K3-54)
D. L. Strenge (K3-51)
M. J. Sula (P7-78)
R. K. Woodruff (K6-13)
Publishing Coordination
5 Technical Report Files
HEDOP File

END

DATE FILMED

7/12/93