Hanford Dose Overview Program:

Standardized Methods and Data for Hanford Environmental Dose Calculations

May 1984

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HANFORD DOSE OVERVIEW PROGRAM:
STANDARDIZED METHODS AND DATA
FOR HANFORD ENVIRONMENTAL
DOSE CALCULATIONS

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SUMMARY

The Hanford Dose Overview Program is a Hanford site-wide service administered by the Pacific Northwest Laboratory (PNL) for the U.S. Department of Energy (DOE). The program was established at the request of the DOE Richland Operations Office (DOE-RL) to provide a method of assuring internal consistency of Hanford-related environmental dose assessments.

This document serves as a guide to Hanford contractors for obtaining or performing Hanford-related environmental dose calculations. Because environmental dose estimation techniques are state-of-the-art and are continually evolving, the data and standard methods presented herein will require periodic revision. This document is scheduled to be updated annually, but actual changes to the program will be made more frequently if required. For this reason, PNL's Occupational and Environmental Protection Department should be contacted before any Hanford-related environmental dose calculation is performed.

This revision of the Hanford Dose Overview Program Report primarily reflects changes made to the data and models used in calculating atmospheric dispersion of airborne effluents at Hanford. The modified data and models are described in detail in the sections on atmospheric dispersion data and in Appendix B. In addition, discussions of dose calculation methods and the review of calculation results have been expanded to provide more explicit guidance to the Hanford contractors.

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INTRODUCTION

Environmental dose evaluations are required whenever an activity at the Hanford Site creates a potential for radiologic environmental impact. For future operations, evaluations are used to predict the adequacy of control systems and whether the operation will comply with environmental regulations. Evaluations of effluents from current operations are used to document potential impacts. Because these evaluations are sensitive to the models, data, and input assumptions used, the methods must be consistent.

The Hanford Dose Overview Program was established in response to DOE-RL's request that PNL provide a means of improving the consistency and accuracy of all documented Hanford-related environmental dose calculations. This program is funded through the service assessment pool and is administered by the Occupational and Environmental Protection Department at PNL. The program's decision-making body is the Hanford Dose Overview Committee, which is composed of people from PNL's Geosciences Research and Engineering, Radiological Sciences, and Occupational and Environmental Protection Departments, as well as representatives from each of the Hanford contractors involved in calculating environmental doses.

OBJECTIVES

The program's objective is to assure DOE-RL and the contractors that environmental dose calculations will be performed with comparable methods and data. The program serves as a focal point for Hanford environmental dose calculation activities and provides the following three services for Hanford contractors involved in calculating environmental doses.

First, a set of computer programs recommended for calculating Hanford environmental radiation doses is maintained on System B at Boeing Computer Services Richland (BCSR). These programs are documented and contain approved and internally consistent models and data files. They are accessible in a protected "use-only" mode and produce, as part of the program output, a quality assurance page that documents the primary data inputs, the program and

data files used, and their revision dates. The data files are updated and all modifications to the programs are controlled and documented. While alternate methods may be used to calculate Hanford environmental doses, their adequacy will be evaluated by comparison with the recommended programs and models.

Second, site-specific input data and assumptions have been compiled and are maintained for the contractors to use when calculating Hanford environmental doses. These data and assumptions should be used in Hanford calculations where applicable. These data are not all inclusive and will be modified by the Dose Overview Committee when appropriate.

Third, all environmental dose calculations are reviewed by a member of the Hanford Dose Overview Committee to verify that the methods, data, and assumptions used in the calculation are appropriate. The documentation generated by this review should become an integral part of the calculational results and should be included in any reporting of the doses.

SCOPE

The scope of the Hanford Dose Overview Program includes environmental dose calculations for Hanford's facilities, activities, or conditions both present and future. Dose calculations for routine operations and accident situations are included. Hanford environmental doses that have been calculated by using inappropriate methods or have not been subjected to review and documentation may not receive approval by DOE-RL.

Those aspects of an environmental impact evaluation that pertain to conditions within a facility and the generation of environmental releases are the responsibility of the facility contractor and are not within the scope of this program.

DOSE OVERVIEW SERVICES

Dose overview services (planning or review of calculated results) are obtained through the contractor's Dose Overview Program representative or by contacting the Occupational and Environmental Protection Department at PNL.

The Dose Overview Program representative must be involved in the planning phase of an environmental dose assessment to ensure that appropriate calculational methods and assumptions are used.

Review of calculated results is initiated by providing the Hanford Dose Overview Program representative or program manager with a description of the doses being calculated, a copy of the quality assurance page created by the computer program, and a copy of the calculational results. When dose calculations are performed manually, a description of the methods and equations used and the calculation results should be provided to the reviewer. Discrepancies discovered during this review will be resolved with the originator. A description of the review process is provided in Appendix A.

ENVIRONMENTAL DOSE CALCULATION METHODS

The preferred method of determining environmental dose impact is to measure radionuclide concentrations in air, water, and foodstuffs as close to the public as possible. However, when operations do not produce a measurable effect on background levels in the environment, or when an evaluation of future operations is required, calculations are performed to assess potential impacts.

Environmental dose calculations are used to estimate potential radiation doses to the public from all reasonable modes of exposure (pathways). These exposure pathways include inhalation of and submersion in airborne materials, ingestion of foodstuffs contaminated by deposition of airborne material or by irrigation with Columbia River water, direct exposure to facilities or to radionuclides that have been deposited on the ground, and exposure to radionuclides contained in the Columbia River. All pathways may not be appropriate for all environmental dose calculations. As will be discussed in sections that follow, the appropriate exposure pathways are identified within the exposure scenario.

The models used to perform these calculations are empirical and simulate as reasonably as possible various environmental and dosimetric processes including dispersion, pathway transfer and accumulation of pollutants, population exposure, and radiation dosimetry. Each model requires extensive site specific and generic data, and parameters that describe the exposure scenario. The accuracy of calculated doses is dependent largely on the correct application of these models to each exposure situation, the ability to acquire representative input data, and the validity of the assumed exposure scenario.

AIRBORNE EFFLUENTS

The dilution and transport of airborne effluents are calculated based on long-term onsite measurements of wind speed and direction and atmospheric stability (which affects the degree of mixing). Release rates (Ci/sec) of radionuclides contained in effluents are combined with the atmospheric dis-

persion model which is then used to calculate air concentrations (C_i/m^3) at specified locations in the environment. Radiation doses resulting from inhalation and air submersion are calculated directly from these air concentrations on the basis of an inhalation rate (m^3/sec) and duration of occupancy.

In order to estimate potential ingestion doses, the ground deposition rate ($C_i/m^2 \cdot sec$) of airborne materials is calculated using a deposition velocity (m/sec). The results of this calculation are used to estimate the amount of radionuclide activity (curies) deposited directly on plant surfaces and the ground. Translocation factors are used to calculate the fraction of deposited activity that transfers from plant surfaces and the ground to the edible portion of the crop. Consumption rates (kg/yr) for each foodstuff are used to estimate the intake of radionuclides for the purpose of calculating the resultant doses. For milk, eggs, meat, etc., animal consumption rates and additional translocation factors are included in the calculation.

An external dose from direct exposure to radioactivity is calculated by assuming exposure for an appropriate duration.

LIQUID EFFLUENTS

Radionuclides discharged to rivers are mixed with the river's flow. Concentrations at the point of public exposure are calculated on the basis of mixing at the mean annual flow rate.

Deposition of radionuclides on crops and farm land is estimated using an irrigation rate (ℓ/m^2) and the calculated concentrations in the river (C_i/ℓ). Translocation factors, consumption rates, and direct exposure time, as described for airborne effluents, are used to calculate potential ingestion and direct exposure doses.

Doses from drinking water are calculated by applying cleanup factors from the water treatment system to the estimated river concentrations. The consumption of drinking water (ℓ or ℓ/yr) is then used to calculate the intake of radionuclides from which dose is calculated.

External radiation doses are calculated for exposure to radionuclides in the river and from those deposited on the river shoreline. Calculated river concentrations are used to estimate the dose received from swimming (submersion) and boating (water surface). External doses received while on the shoreline are calculated assuming a narrow band of surface contamination deposited by the river.

Radionuclide concentrations in locally caught fish are estimated using bioaccumulation factors that account for the buildup of radionuclides in fish exposed to the calculated river concentrations. The amount (kg) of fish consumed by local residents is then used to estimate the ingestion of radionuclides.

CALCULATIONS OF HANFORD ENVIRONMENTAL IMPACTS

The offsite impacts of Hanford effluents are evaluated in terms of the potential radiation dose received by an assumed maximum exposed individual (MI) and the entire population residing within 80 km of the Hanford operating areas. While these two calculations have a common basis, their objectives and specific techniques are distinct.

The assessment of organ doses to the MI provides an estimate of the maximum radiation doses that a member of the public could receive from exposure to Hanford operations and effluents. The MI is an imaginary individual whose location and characteristics are chosen so as to maximize the combined potential doses from all realistically available exposure pathways.

The MI is hypothetical in that an actual offsite individual is not identified. However, the MI is realistic to the extent that all exposure pathways used in the calculations are credible. The MI's location and characteristics are defined within the exposure scenario.

The regional radiological impact of operations at Hanford is estimated by calculating the collective dose to the population residing within an 80-km radius of the release point. Collective population doses are expressed in units of man-rem and are the sum, for all possible pathways, of the product of the average individual dose and the number of persons potentially exposed.

Certain radionuclides inhaled or ingested with air, water, foods, etc., may be metabolically absorbed by the body and retained for some time. In addition, environmental retention of long-lived radionuclides may be modeled to become a source of long-term exposure. To fully account for the dose received in these cases, the environmental dose impact of Hanford effluents is expressed as a "50-year cumulative dose".

The 50-year cumulative dose is an estimate of the accumulated dose received by the public over a period of 50 years following radionuclide releases to the environment. The calculation considers exposure from radionuclides during the period of their release via inhalation, ingestion, and

external exposure as well as continued exposure (50 years) from long-lived radionuclides deposited on the ground, via external exposure, and by ingestion of locally grown crops. The cumulative dose thus considers the potential for long-term residency of the MI and the 80-km population.

EXPOSURE SCENARIOS

Hanford environmental dose calculations generally address one of two categories of radionuclide release to the environment: releases that continue for a relatively long period of time, as during normal operations; or short-term releases that could result from a facility upset or accident. The methods and assumptions used in calculating potential environmental doses are specific to each category of release and will be described separately in the sections that follow.

The specific assumptions and data used in an environmental dose calculation will also depend on the nature of the evaluation being performed. Calculations intended to predict potential impacts of future effluents would conservatively address possible future conditions while calculations performed to document the credible impacts of current or previous effluents would, to the extent practicable, address actual conditions.

CHRONIC RELEASES

Environmental dose impacts of chronic Hanford releases are evaluated on the basis of average annual conditions. Transport and dilution of airborne effluents are calculated using joint frequency distributions of wind speed, direction, and atmospheric stability, while effluents to the Columbia River are assumed to mix at the mean annual flow rate.

The MI doses from chronic releases are calculated for a long-term resident whose location and characteristics are such that the summed exposure from all credible pathways is maximized. Chronic release exposure pathways normally assumed for the MI are inhalation, air submersion, consumption of contaminated foodstuff, and direct exposure to deposited radionuclides. These pathways are illustrated in Figure 1.

Collective population doses (man-rem) due to chronic releases are calculated for the population residing within an 80-km radius of the release point. The same pathways considered for the MI are also assumed to be available to the population.

FIGURE 1. Environmental Dose Pathways

For releases to the Columbia River, only that portion of the full 80-km population using river water is considered to be potentially exposed. The river-related exposure pathways are drinking water, irrigated foodstuffs, fish consumption, and river recreation. The river-related pathways are described as follows:

- drinking water--The cities of Richland, Pasco, and Kennewick obtain all or some of their municipal water from the Columbia River downstream from Hanford. The total affected population was approximately 70,000 during 1983.
- irrigated foodstuffs--Columbia River water is withdrawn for irrigation of home vegetable gardens in the Riverview District of Franklin County. Approximately 2000 people are estimated to be affected.
- river recreation--These activities include swimming, boating, and shoreline recreation. The population assumed to be affected by these pathways is estimated to be 125,000.
- fish consumption--Population doses due to consumption of fish obtained locally from the Columbia River are calculated based on an estimated total annual catch of 15,000 kg/yr without reference to a specific population group.

ACUTE RELEASES

Environmental dose impacts of acute Hanford releases are based on potential short-term conditions. Because the occurrence of such releases cannot be predicted, assessments of postulated short-term effluents must be performed conservatively and potential impacts under possible worst-case conditions must be considered.

In addition to evaluating potential MI dose impacts for a long-term resident, as described for chronic releases, MI doses from acute releases are calculated at publicly accessible locations that would maximize short-term exposure during the release. For example, the short-term MI location for 200 Area acute releases could be Highway 240, or for acute releases from

100-N Area, the Columbia River. At these short-term locations, the potential pathways are assumed to be inhalation and external exposure.

Collective population doses from acute releases are calculated for the population residing within 80 km of the release point in the maximally exposed compass sector. The appropriate sector is the one for which the highest population weighted $\bar{X}/Q'$ value is calculated. The method of calculating weighted values is described in the atmospheric dispersion section. Exposure pathways available to the population within this sector include both short-term (inhalation and external) and long-term (ingestion of contaminated foodstuffs and direct exposure to deposited radionuclides) pathways.

COMPUTERIZED ENVIRONMENTAL DOSE CALCULATION PROGRAMS

The evaluation of potential environmental radiation dose impacts is facilitated through the use of computerized dose calculation programs. A set of programs has been established for doses from most environmental exposure pathways. These programs, listed in Table 1, are available on the UNIVAC 1100/44, System B at BCSR. The programs access a common set of standardized libraries which, to the extent they are available, contain Hanford-specific data. The programs and data libraries are maintained by the Dose Overview Program with all revisions or updates documented.

The computer programs have been documented separately as described in Table 1, and only a brief description of their application is given here.

TABLE 1. Programs for Calculating Radiation Doses

<u>Program</u>	<u>Description</u>	<u>Reference</u>
DACRIN	Individual and collective inhalation doses from chronic or acute releases, one-year doses, dose commitments, and cumulative doses	Houston, Streng and Watson 1974 Streng 1975
KRONIC	Individual and collective air submersion doses from chronic releases, one-year doses	Streng and Watson 1973
SUBDOS	Individual air submersion doses from acute release, one-year doses	Streng, Watson and Houston 1975
PABLM	Individual and collective doses from ingestion of contaminated foods and exposure to contaminated soils and sediments, one-year doses, dose commitments, and cumulative doses. Radionuclide releases may be either airborne or aquatic	Napier, Kennedy and Soldat 1980
MAXI	A package to calculate maximum annual dose to an individual from residual radioactivity following nuclear facility decommissioning	Murphy and Holter 1980 Napier et al. 1979 Kennedy et al. 1979

DACRIN

This program (Houston, Streng and Watson 1974; Streng 1975) is recommended for analyzing radiation doses from inhalation for Hanford operations. The program uses the model of the International Commission on Radiological Protection (ICRP) Task Group on Lung Dynamics (1966) to predict radionuclide movements through the respiratory system. Once radionuclides reach the blood stream, the doses to organs other than the lung are calculated using a single, exponential retention function (ICRP 1959).

DACRIN can also calculate atmospheric concentrations using the Gaussian, bivariate, normal distribution plume model, described further in Appendix B on atmospheric dispersion. However, externally calculated dispersion factors may also be entered.

Limitations to the DACRIN models include those applicable to all atmospheric dispersion models (i.e., terrain variability, wind patterns, etc.). In addition, data are often unavailable on the physical and chemical characteristics of the inhaled aerosols. Respirable particles are those below about 10 microns AMAD; particles much larger than this are not readily inhaled. In the absence of specific information concerning the characteristics of released particles, a default AMAD of 1 micron should be used in the calculations.

Doses calculated in DACRIN are dependent upon the values of the release time and dose time used as input. Therefore, the doses that can be calculated include a 1-yr dose, dose commitment, and cumulative dose for both an MI and the regional population.

KRONIC

This program (Streng and Watson 1973) is used to calculate air submersion doses from long-term releases to the atmosphere. The beta dose contribution is calculated using a semi-infinite cloud model because the range of beta particles in air is short compared to the dimensions of the plume. The gamma dose calculation is more complicated because of the relatively long range of photons in air. To properly determine the gamma contribution, a

space integration must be performed over the plume volume. Gamma doses are calculated as a tissue dose at the body surface, at a 1-cm depth, and at a 5-cm depth. The beta and gamma doses are reported separately; however, the beta dose and gamma surface dose may be combined and reported as a skin dose.

Calculations using KRONIC are normally based on annual releases, thus MI and regional population doses are reported as annual doses. Release times of less than a year may be used provided corresponding source term and joint frequency wind data are available. The reported doses then correspond to the release time used. If the release persists for periods longer than one year, the 1-yr dose is calculated and then multiplied by the number of years to obtain the cumulative dose.

SUBDOS

This program (Streng, Watson and Houston 1975) is used to calculate air submersion doses from accidental atmospheric releases of radionuclides. SUBDOS uses a space integration similar to that used in KRONIC. Dose results are reported for skin, male gonads, and total body. Corresponding tissue depths are 0.007, 1.0, and 5.0 cm, respectively. Doses are calculated for releases within each of several release time intervals. Up to six time intervals can be allowed, and separate radionuclide inventories and atmospheric dispersion conditions can be considered for each time interval. As in KRONIC, the dose results are normally a 1-yr dose for both the MI and for the regional population.

PABLM

The PABLM program (Napier, Kennedy and Soldat 1980) is used to calculate potential doses from environmental contamination pathways that include direct radiation from contaminated water, sediment, soil surfaces, and ingestion doses from contaminated drinking water, aquatic food products, terrestrial farm products and farm animal products. PABLM combines and enhances the pathway modeling capabilities of computer programs ARRRG and FOOD (Napier et al. 1980). It also can consider changing levels of environmental contamination with time from past or continuing deposition and includes radioactive

chain decay with daughter ingrowth. PABLM can be used to calculate dose commitments from one year of exposure and cumulative doses to either an MI or populations from multiple years of exposure.

MAXI

The MAXI program (Murphy and Holter 1980) is used to calculate a maximum annual dose to an individual from residual contamination after a nuclear facility has been decommissioned and returned to unrestricted use or converted from a nuclear installation. The individual can either be an office worker in a converted building, who is exposed to inhalation and direct radiation, or someone exposed to pathways as complex as those of a farmer growing crops and living on the site of a former nuclear facility. MAXI uses precalculated factors from versions of ARRRG, FOOD, and DACRIN. Exposure pathways that can be modeled include direct external exposure to contaminated soil or building surfaces, inhalation of resuspended material, and ingestion of contaminated foods and aquatic products. The time of the maximum dose rate to individual organs of reference is calculated and the annual dose for that organ is reported. Special options are available to tailor the program to simulate a variety of decommissioned facilities such as reactors, low-level waste burial grounds, or other nuclear material handling facilities.

DOSE CALCULATION INPUT DATA

The data used in performing dose calculations are extensive. Calculations based on effluent releases require data describing initial transport through the atmosphere or river, transfer or accumulation in terrestrial or aquatic pathways, public exposure, and dosimetry. While the bulk of these data are contained in computer files (libraries) automatically accessed by the programs during their operation, data must also be added directly to the programs. Table 2 contains a list of the data libraries maintained on the BCSR UNIVAC for use with the programs. Most of the libraries are used by more than one program, thus assuring consistent use of the basic data for all calculations.

The remaining data, which are entered directly, tailor the program to the exposure scenario under consideration. The specific data selected for use in an environmental dose calculation will depend on the nature of the evaluation being performed. Calculations intended to predict potential impacts of future effluents should use data selected to be conservatively representative of possible future conditions, while calculations performed to document the credible impacts of current or previous effluents should use data consistent with actual conditions.

For example, dose calculations for an environmental impact assessment of proposed routine effluents would be performed using historic atmospheric dispersion data while an assessment of prior calendar year operations at Hanford would be performed using data collected during that year. Assessments of current or previous acute releases would be performed using actual conditions during the release while an assessment of postulated short-term effluents must be performed conservatively and consider potential impacts under realistic worst-case conditions.

The data, which are entered directly, are selected to be consistent with the exposure scenario and to describe the population distributions, terrestrial and aquatic pathways, and public exposure, as well as atmospheric dispersion.

TABLE 2: Standard Data Libraries

<u>Library Name</u>	<u>Contents of Library</u>	<u>Reference Programs</u>
Radionuclide master list	The overall master list of available radionuclides, radioactive half-lives, radioactive decay schemes	DACRIN PABLM MAXI SUBDOSA KRONIC
Organ data	List of biological half-times, absorption and retention factors, and effective decay energies	DACRIN PABLM MAXI
Food transfer coefficient	Radionuclide-to-food transfer coefficients	PABLM MAXI
External dose factor	Dose factors for exposure to contaminated ground or water	PABLM
Bioaccumulation factor	Three versions exist, one generic one Hanford specific, and one with unit drinking water cleanup factors	PABLM MAXI
Inhalation dose increment	Incremental annual dose factors derived from DACRIN	MAXI
Energy probability	Photon energies, beta average energies, and probability distributions	SUBDOSA KRONIC

POPULATION DISTRIBUTIONS

Geographic distributions of population residing within an 80-km radius of the four operating areas are listed in Tables 3 through 6. These distributions are based on 1980 Bureau of Census data (Sommer, Rau and Robinson 1981).

TERRESTRIAL AND AQUATIC PATHWAYS

Following release and initial transport through the environment, radio-

active materials may enter terrestrial or aquatic pathways that lead to public exposure. These potential pathways include consumption of fish, drinking water and foodstuffs. Input parameters affecting the movement of radionuclides within potential exposure pathways include irrigation rates, growing period, holdup, etc. These parameters are listed in Table 7. Note that certain parameters are specific to MIs and others to average individuals.

PUBLIC EXPOSURE

Offsite radiation dose impact is related to the extent of public exposure to or consumption of radionuclides associated with Hanford effluents. Parameters describing assumed diet, residency and river recreation for maximum and average individuals are provided in Tables 8 through 10 respectively.

ATMOSPHERIC DISPERSION

Radioactive material released to the atmosphere becomes diluted as it is carried by the wind away from the point of release. The degree of dilution and the magnitude of resultant air concentrations are predicted through the use of the Gaussian plume model (Gifford 1968; USNRC 1977) and onsite measurements of atmospheric conditions.

Atmospheric dispersion data (wind speed, wind direction, and atmospheric stability) for the 200 Areas are collected at the Hanford Meteorology Station (HMS), which has been in operation since 1945. Data for the 100, 300, and 400 Areas are a composite of wind speed and direction data collected at each operating area and atmospheric stability data collected at the HMS. Atmospheric stability is classified as described in Appendix B, while the vertical and horizontal dispersion parameters, σ_z and σ_y are calculated using Brigg's formulations (Briggs 1973). A more detailed discussion of Hanford atmospheric dispersion data is provided in Appendix B.

Separate discussions are provided below for atmospheric dispersion data associated with chronic and acute releases. Additional atmospheric dispersion data, beyond that presented here, may be obtained by contacting the Hanford Dose Overview program manager.

TABLE 3. Distribution of Population in 80-km Radius of the 100-N Reactor by Population Grid Sector for 1980

Compass Direction	Number of People					Totals
	0-10 mi	10-30 mi	20-30 mi	30-40 mi	40-50 mi	
NORTH	36	953	420	1,492	7,583	10,484
NNE	5	285	561	18,531	1,350	20,732
NE	0	624	1,013	2,691	259	4,587
ENE	0	620	5,884	1,129	429	8,062
EAST	0	294	625	2,742	605	4,266
ESE	0	306	1,493	596	247	2,642
SE	0	54	2,113	28,922	5,001	36,090
SSE	0	0	35,127	50,292	3,354	88,773
SOUTH	0	127	4,592	2,041	176	6,936
SSW	0	258	1,676	12,603	625	15,162
SW	0	547	4,946	16,747	469	22,709
WSW	0	680	1,699	8,297	15,274	25,950
WEST	18	395	936	5,149	75,686	82,184
WNW	54	573	377	490	1,598	3,092
NW	74	277	425	515	683	1,974
NNW	64	277	438	1,030	4,696	6,505
TOTALS	251	6,270	62,325	153,267	118,035	340,148

TABLE 4. Distribution of Population in 80-km Radius of the 200 Area Hanford Meteorological Tower by Population Grid Sector for 1980

Compass Direction	Number of People					Totals
	0-10 mi	10-20 mi	20-30 mi	30-40 mi	40-50 mi	
NORTH	0	174	1,124	772	1,957	4,027
NNE	0	92	656	5,547	14,822	21,117
NE	0	262	5,930	2,963	596	9,751
ENE	0	235	773	2,366	435	3,809
EAST	0	340	1,329	1,659	588	3,916
ESE	0	283	1,374	230	652	2,539
SE	0	6,757	48,661	50,519	3,474	109,411
SSE	0	1,997	13,161	2,717	5,218	23,093
SOUTH	0	1,532	1,489	195	1,799	5,015
SSW	0	905	5,283	652	129	6,969
SW	0	1,190	19,786	2,182	459	23,617
WSW	5	1,840	5,063	15,088	4,573	26,569
WEST	32	648	949	6,874	78,635	87,138
WNW	73	444	802	833	2,833	4,985
NW	0	555	398	493	1,454	2,900
NNW	0	246	456	864	4,521	6,087
TOTALS	110	17,500	107,234	93,954	122,145	340,943

TABLE 5. Distribution of Population in 80-km Radius of the 300 Area by Population Grid Sector for 1980

Compass Direction	Number of People					Totals
	0-10 mi	10-20 mi	20-30 mi	30-40 mi	40-50 mi	
NORTH	289	241	989	5,655	5,317	12,491
NNE	307	475	841	1,950	2,269	5,842
NE	18	966	2,583	562	205	4,334
ENE	307	465	349	470	238	1,829
EAST	291	114	137	174	687	1,403
ESE	338	288	863	594	17,891	19,974
SE	2,549	26,150	2,922	877	1,235	33,733
SSE	7,161	30,357	1,114	1,117	1,113	40,862
SOUTH	15,561	6,651	96	17,223	5,127	44,658
SSW	11,124	4,034	99	1,209	2,038	18,504
SW	10,066	3,931	706	182	181	15,066
WSW	4,429	1,810	5,531	8,988	621	21,379
WEST	294	984	2,226	16,878	16,293	36,675
WNW	0	0	692	1,543	1,679	3,914
NW	0	0	74	923	785	1,782
NNW	0	0	8	875	1,212	2,095
TOTALS	52,734	76,466	19,230	59,220	56,891	264,41

TABLE 6. Distribution of Population in 80-km Radius of the 400 Area by Population Grid Sector for 1980

Compass Direction	Number of People					Totals
	0-10 mi	10-20 mi	20-30 mi	30-40 mi	40-50 mi	
NORTH	0	78	859	811	16,267	18,015
NNE	20	343	5,728	2,945	1,021	10,057
NE	114	377	760	1,033	217	2,501
ENE	211	1,041	2,644	492	451	4,839
EAST	229	600	183	169	183	1,364
ESE	229	442	544	292	1,060	2,567
SE	344	25,267	13,654	2,105	952	42,322
SSE	10,829	40,933	5,688	719	2,364	60,533
SOUTH	11,760	9,385	1,525	5,611	15,691	43,972
SSW	1,446	4,550	583	185	1,927	8,691
SW	179	1,538	5,234	535	239	7,725
WSW	0	1,206	7,748	14,956	481	24,391
WEST	0	190	3,339	6,089	17,171	26,789
WNW	0	0	932	1,221	3,176	5,329
NW	0	0	295	903	705	1,903
NNW	0	0	264	1,302	1,182	2,748
TOTALS	25,361	85,950	49,980	39,368	63,087	263,746

TABLE 7. Values of Parameters Affecting Ingestion Pathway Exposures

	Holdup, d ^(a)		Growing Period, d	Yield, kg/m ²	Irrigation Rate, t/m ² /month
	Maximum Individual	Average Individual			
Leafy vegetables	1	14	90	1.5	150
Other above-ground vegetables	1	14	60	0.7	160
Potatoes	10	14	90	4	180
Other root vegetables	1	14	90	5	150
Berries	1	14	60	2.7	150
Melons	1	14	90	0.8	150
Orchard fruit	10	14	90	1.7	0
Wheat	10	14	90	0.72	150
Other grains	1	14	90	1.4	150
Eggs	1	18	90	0.84	150
Milk	1	4	30	1.3	200
Beef	15	34	90	0.84	140
Pork	15	34	90	0.84	140
Poultry	1	34	90	0.84	140
Fish	1	1	-	-	-
Drinking water	1	1	-	-	-

(a) Holdup is the time between harvest and consumption.

TABLE 8. Dietary Parameters

	Consumption, kg/yr	
	Maximum Individual	Average Individual
Leafy vegetables	30	15
Other above-ground vegetables	30	15
Potatoes	110	100
Other root vegetables	72	17
Berries	30	6
Melons	40	8
Orchard fruit	265	50
Wheat	80	72
Other Grains	8.3	7.5
Eggs	30	20
Milk	274 ^(a, b)	230 ^(a)
Beef	40	40
Pork	40	30
Poultry	18	8.5
Fish	40	(c)
Drinking Water	730 ^(a, b)	438 ^(a)

(a) Units t/yr.

(b) 330 t/yr for infant.

(c) Radiation doses are calculated based on estimated total annual catch of 15,000 kg by the total population with 80 km.

TABLE 9. Residency Parameters

<u>Parameter</u>	<u>Exposure, h/d</u>	
	<u>Maximum Individual</u>	<u>Average Individual</u>
Ground contamination	12	8
Air submersion	24	24
Inhalation ^(a)	24	24

(a) Inhalation Rates:

Adult--250 cm³/sec routine; 350 cm³/sec acute.

Infant--44 cm³/sec.

TABLE 10. Recreational Activities

<u>Activity</u>	<u>Exposure, h/yr^(a)</u>	
	<u>Maximum Individual</u>	<u>Average Individual</u>
Shoreline	500	17
Boating	100	5
Swimming	100	10

(a) Assumes 8-h holdup for maximum individual and 13 h for average.

Chronic Releases.

For chronic releases, the annual average atmospheric dispersion is calculated using the sector-averaged Gaussian model and joint frequency distributions of wind speed, direction, and atmospheric stability. Values of the annual-average-air concentration per unit release rate ($\bar{X}/Q'$) with units of sec/m^3 (Ci/m^3 per Ci/sec released) calculated with this model for each operating area are provided in Tables 11 through 16. These values of $\bar{X}/Q'$ have been calculated from the extended record of atmospheric data for each operating area and as such should be used for calculations intended to predict the potential impacts of future effluents. Tables of $\bar{X}/Q'$ values calculated from atmospheric data collected during specific calendar years at each operating area (for use in evaluating calendar year effluents) and joint frequency distribution data from which the above $\bar{X}/Q'$ values were calculated are available upon request.

Regional population doses from chronic atmospheric releases are calculated through the use of population weighted $\bar{X}/Q'$ values. Weighted values are calculated by summing the products of $\bar{X}/Q'$ times population within each of 5 radial intervals for all 16 compass sectors. Although values of $\bar{X}/Q'$ are calculated at the midpoints of 10 radial intervals (as shown in Tables 11 through 16), the population distribution uses only 5 radial intervals (Tables 3 through 6). The $\bar{X}/Q'$ at 8 km is used for the first population interval.

Acute Releases.

For acute releases, atmospheric dispersion under short-term meteorologic conditions is estimated using the sector-averaged model for evaluating impacts on the regional population and the centerline model for impacts on the MI. Dispersion estimates for assessments of postulated acute releases of effluents are based on the extended record of atmospheric data collected at the operating areas. Assessments of impacts from actual releases would be based on actual atmospheric conditions during and following the release.

Because we cannot predict precisely when a postulated release would occur, we must assume that the release coincides with adverse atmospheric

conditions. This is accomplished by calculating dispersion based on 95th percentile atmospheric conditions. The 95th percentile conditions are derived from the recorded hourly measurements of wind speed, wind direction, and atmospheric stability, and are the conditions that predict short-term (1-hour average) air concentrations expected to be exceeded no more than 5 percent of the time. Calculated values of 95th percentile center-line $\bar{X}/Q'$, as a function of distance and direction, are provided in Tables 17 through 22 for each of the operating areas.

Population weighted values of 1-hour average $\bar{X}/Q'$ used in assessing postulated acute releases are calculated for a compass sector by summing the products of sector-averaged, 95th percentile $\bar{X}/Q'$ times population within 5 radial intervals out to 80 km ($\bar{X}/Q'$ at interval midpoint distance and uniform population distribution within interval). Sector-averaged, 95th percentile $\bar{X}/Q'$ values for each of the operating areas are provided in Tables 23 through 28.

TABLE 11. Annual Average Atmospheric Dispersion Parameters, $\bar{X}/Q'$ (sec/m³), for Ground Level Releases from the 100 Areas - Based on Historical Data^(a)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	4.85E-06	7.46E-07	3.36E-07	2.02E-07	1.44E-07	7.18E-08	3.01E-08	1.65E-08	1.13E-08	8.45E-09
NNE	4.55E-06	6.98E-07	3.16E-07	1.91E-07	1.36E-07	6.84E-08	2.90E-08	1.60E-08	1.10E-08	8.26E-09
NE	7.21E-06	1.11E-06	5.02E-07	3.02E-07	2.16E-07	1.08E-07	4.58E-08	2.52E-08	1.74E-08	1.30E-08
ENE	1.14E-05	1.75E-06	7.97E-07	4.80E-07	3.45E-07	1.74E-07	7.44E-08	4.13E-08	2.85E-08	2.14E-08
E	1.31E-05	2.02E-06	9.15E-07	5.51E-07	3.96E-07	1.99E-07	8.50E-08	4.71E-08	3.25E-08	2.44E-08
ESE	6.67E-06	1.02E-06	4.62E-07	2.78E-07	2.00E-07	1.00E-07	4.31E-08	2.39E-08	1.65E-08	1.24E-08
SE	4.73E-06	7.20E-07	3.25E-07	1.95E-07	1.40E-07	7.02E-08	3.00E-08	1.66E-08	1.15E-08	8.62E-09
SSE	3.44E-06	5.22E-07	2.34E-07	1.41E-07	1.01E-07	5.07E-08	2.16E-08	1.20E-08	8.26E-09	6.21E-09
S	3.71E-06	5.66E-07	2.55E-07	1.53E-07	1.10E-07	5.48E-08	2.32E-08	1.28E-08	8.80E-09	6.61E-09
SSW	1.92E-06	2.92E-07	1.32E-07	7.89E-08	5.65E-08	2.82E-08	1.20E-08	6.60E-09	4.55E-09	3.41E-09
SW	2.63E-06	4.01E-07	1.82E-07	1.09E-07	7.86E-08	3.95E-08	1.69E-08	9.38E-09	6.48E-09	4.88E-09
WSW	3.03E-06	4.64E-07	2.10E-07	1.27E-07	9.12E-08	4.59E-08	1.96E-08	1.09E-08	7.50E-09	5.65E-09
W	7.10E-06	1.09E-06	4.94E-07	2.98E-07	2.14E-07	1.07E-07	4.57E-08	2.53E-08	1.74E-08	1.31E-08
WNW	4.82E-06	7.44E-07	3.35E-07	2.01E-07	1.43E-07	7.11E-08	2.97E-08	1.62E-08	1.10E-08	8.25E-09
NW	4.89E-06	7.53E-07	3.40E-07	2.04E-07	1.46E-07	7.24E-08	3.04E-08	1.66E-08	1.14E-08	8.53E-09
NNW	3.46E-06	5.30E-07	2.39E-07	1.44E-07	1.03E-07	5.14E-08	2.17E-08	1.19E-08	8.19E-09	6.15E-09

(a) Data collected at the 100-N Area and the Hanford Meteorological Station during 1982 and 1983.

TABLE 12. Annual Average Atmospheric Dispersion Parameters, $\bar{X}/Q'$ (sec/m³) for Elevated Releases^(a) from the 100 Areas - Based on Historical Data^(b)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	1.60E-07	1.26E-07	8.39E-08	6.00E-08	4.54E-08	2.56E-08	1.14E-08	6.25E-09	4.23E-09	3.18E-09
NNE	1.21E-07	1.00E-07	6.91E-08	5.02E-08	3.84E-08	2.21E-08	1.00E-08	5.58E-09	3.81E-09	2.88E-09
NE	2.14E-07	1.66E-07	1.12E-07	8.06E-08	6.13E-08	3.50E-08	1.58E-08	8.72E-09	5.93E-09	4.48E-09
ENE	2.81E-07	2.10E-07	1.44E-07	1.05E-07	8.07E-08	4.72E-08	2.19E-08	1.23E-08	8.43E-09	6.41E-09
E	3.72E-07	2.52E-07	1.71E-07	1.24E-07	9.51E-08	5.53E-08	2.55E-08	1.43E-08	9.84E-09	7.48E-09
ESE	2.64E-07	1.37E-07	8.70E-08	6.18E-08	4.68E-08	2.70E-08	1.24E-08	6.96E-09	4.76E-09	3.62E-09
SE	2.33E-07	1.13E-07	6.94E-08	4.86E-08	3.66E-08	2.09E-08	9.50E-09	5.29E-09	3.62E-09	2.75E-09
SSE	1.91E-07	8.57E-08	5.17E-08	3.61E-08	2.71E-08	1.55E-08	7.08E-09	3.95E-09	2.71E-09	2.06E-09
S	1.73E-07	9.57E-08	5.97E-08	4.18E-08	3.14E-08	1.76E-08	7.80E-09	4.28E-09	2.90E-09	2.19E-09
SSW	9.16E-08	5.04E-08	3.17E-08	2.22E-08	1.67E-08	9.40E-09	4.19E-09	2.30E-09	1.56E-09	1.18E-09
SW	9.41E-08	5.69E-08	3.72E-08	2.67E-08	2.03E-08	1.17E-08	5.38E-09	3.02E-09	2.07E-09	1.58E-09
WSW	7.59E-08	6.05E-08	4.12E-08	3.00E-08	2.30E-08	1.33E-08	6.13E-09	3.43E-09	2.35E-09	1.79E-09
W	1.90E-07	1.58E-07	1.08E-07	7.90E-08	6.04E-08	3.50E-08	1.60E-08	8.94E-09	6.12E-09	4.64E-09
WNW	1.79E-07	1.38E-07	8.99E-08	6.34E-08	4.76E-08	2.63E-08	1.15E-08	6.18E-09	4.14E-09	3.09E-09
NW	1.69E-07	1.27E-07	8.41E-08	6.00E-08	4.54E-08	2.56E-08	1.14E-08	6.26E-09	4.24E-09	3.19E-09
NNW	1.29E-07	9.16E-08	6.07E-08	4.33E-08	3.28E-08	1.86E-08	8.30E-09	4.57E-09	3.11E-09	2.34E-09

(a) 89-m effective release height (61-m stack height and 28-m plume rise).

(b) Data collected at the 100-N Area and the Hanford Meteorological Station during 1982 and 1983.

TABLE 13. Annual Average Atmospheric Dispersion Parameters, $\bar{X}/Q'$ (sec/m³), for Ground Level Releases from the 200 Areas - Based on Historical Data^(a)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	6.41E-06	9.81E-07	4.51E-07	2.73E-07	1.99E-07	1.02E-07	4.50E-08	2.54E-08	1.78E-08	1.35E-08
NNE	5.02E-06	7.69E-07	3.54E-07	2.14E-07	1.56E-07	8.01E-08	3.54E-08	2.00E-08	1.40E-08	1.06E-08
NE	5.84E-06	8.93E-07	4.10E-07	2.48E-07	1.81E-07	9.27E-08	4.09E-08	2.32E-08	1.62E-08	1.23E-08
ENE	9.99E-06	1.53E-06	7.02E-07	4.25E-07	3.11E-07	1.60E-07	7.08E-08	4.02E-08	2.82E-08	2.14E-08
E	2.00E-05	3.05E-06	1.41E-06	8.52E-07	6.24E-07	3.21E-07	1.43E-07	8.10E-08	5.69E-08	4.31E-08
ESE	1.92E-05	2.93E-06	1.35E-06	8.18E-07	5.98E-07	3.07E-07	1.36E-07	7.71E-08	5.40E-08	4.10E-08
SE	1.71E-05	2.62E-06	1.20E-06	7.27E-07	5.30E-07	2.71E-07	1.19E-07	6.73E-08	4.71E-08	3.56E-08
SSE	8.78E-06	1.34E-06	6.15E-07	3.72E-07	2.70E-07	1.38E-07	6.02E-08	3.39E-08	2.36E-08	1.78E-08
S	6.78E-06	1.04E-06	4.72E-07	2.86E-07	2.06E-07	1.04E-07	4.49E-08	2.50E-08	1.73E-08	1.30E-08
SSW	3.76E-06	5.77E-07	2.61E-07	1.57E-07	1.13E-07	5.65E-08	2.39E-08	1.31E-08	9.02E-09	6.76E-09
SW	3.10E-06	4.76E-07	2.15E-07	1.30E-07	9.30E-08	4.67E-08	1.98E-08	1.09E-08	7.49E-09	5.61E-09
WSW	2.94E-06	4.51E-07	2.05E-07	1.24E-07	8.88E-08	4.47E-08	1.91E-08	1.05E-08	7.26E-09	5.45E-09
W	4.39E-06	6.75E-07	3.07E-07	1.86E-07	1.34E-07	6.79E-08	2.92E-08	1.63E-08	1.13E-08	8.48E-09
WNW	3.17E-06	4.86E-07	2.21E-07	1.34E-07	9.69E-08	4.92E-08	2.13E-08	1.19E-08	8.26E-09	6.23E-09
NW	5.01E-06	7.68E-07	3.51E-07	2.13E-07	1.55E-07	7.89E-08	3.45E-08	1.94E-08	1.35E-08	1.02E-08
NNW	5.03E-06	7.70E-07	3.53E-07	2.14E-07	1.56E-07	7.98E-08	3.51E-08	1.98E-08	1.39E-08	1.05E-08

(a) Data collected at the Hanford Meteorological Station from 1/76 through 1/84.

TABLE 14. Annual Average Atmospheric Dispersion Parameters, $\bar{X}/Q'$ (sec/m³), for Elevated Releases^(a) from the 200 Areas - Based on Historical Data^(b)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	5.59E-08	4.78E-08	3.80E-08	2.96E-08	2.36E-08	1.48E-08	7.32E-09	4.30E-09	3.02E-09	2.33E-09
NNE	3.82E-08	3.20E-08	2.50E-08	1.94E-08	1.55E-08	9.61E-09	4.75E-09	2.78E-09	1.94E-09	1.50E-09
NE	5.17E-08	3.75E-08	2.81E-08	2.14E-08	1.69E-08	1.03E-08	4.98E-09	2.89E-09	2.01E-09	1.55E-09
ENE	5.97E-08	4.91E-08	3.85E-08	2.99E-08	2.38E-08	1.48E-08	7.27E-09	4.26E-09	2.98E-09	2.30E-09
E	6.26E-08	7.19E-08	6.09E-08	4.91E-08	3.97E-08	2.57E-08	1.31E-08	7.83E-09	5.54E-09	4.31E-09
ESE	7.44E-08	8.62E-08	7.30E-08	5.84E-08	4.71E-08	2.99E-08	1.51E-08	8.94E-09	6.30E-09	4.89E-09
SE	1.23E-07	1.21E-07	9.55E-08	7.45E-08	5.93E-08	3.70E-08	1.83E-08	1.07E-08	7.50E-09	5.79E-09
SSE	1.15E-07	9.68E-08	7.34E-08	5.61E-08	4.43E-08	2.71E-08	1.31E-08	7.61E-09	5.30E-09	4.08E-09
S	1.54E-07	1.19E-07	8.74E-08	6.56E-08	5.12E-08	3.05E-08	1.44E-08	8.20E-09	5.66E-09	4.32E-09
SSW	1.22E-07	9.24E-08	6.37E-08	4.61E-08	3.53E-08	2.01E-08	8.99E-09	4.94E-09	3.35E-09	2.52E-09
SW	9.56E-08	6.68E-08	4.63E-08	3.37E-08	2.59E-08	1.48E-08	6.73E-09	3.74E-09	2.55E-09	1.92E-09
WSW	7.30E-08	5.93E-08	4.29E-08	3.17E-08	2.46E-08	1.43E-08	6.57E-09	3.68E-09	2.52E-09	1.91E-09
W	7.59E-08	6.71E-08	5.01E-08	3.76E-08	2.94E-08	1.73E-08	8.10E-09	4.59E-09	3.16E-09	2.40E-09
WNW	6.15E-08	5.54E-08	4.23E-08	3.21E-08	2.52E-08	1.51E-08	7.15E-09	4.09E-09	2.83E-09	2.16E-09
NW	6.75E-08	6.27E-08	4.80E-08	3.67E-08	2.89E-08	1.75E-08	8.41E-09	4.84E-09	3.37E-09	2.58E-09
NNW	5.33E-08	4.56E-08	3.63E-08	2.84E-08	2.27E-08	1.42E-08	7.07E-09	4.16E-09	2.92E-09	2.26E-09

(a) 89-m effective release height (61-m stack height and 28-m plume rise).

(b) Data collected at the Hanford Meteorological Station from 1/76 through 1/84.

TABLE 15. Annual Average Atmospheric Dispersion Parameters, $\bar{X}/Q'$ (sec/m³), for Ground Level Releases from the 300 Area - Based on Historical Data^(a)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	6.56E-06	1.01E-06	4.57E-07	2.76E-07	1.98E-07	9.95E-08	4.25E-08	2.35E-08	1.62E-08	1.22E-08
NNE	4.88E-06	7.49E-07	3.38E-07	2.03E-07	1.46E-07	7.27E-08	3.08E-08	1.69E-08	1.16E-08	8.73E-09
NE	6.31E-06	9.73E-07	4.41E-07	2.66E-07	1.91E-07	9.58E-08	4.07E-08	2.24E-08	1.54E-08	1.16E-08
ENE	3.79E-06	5.86E-07	2.66E-07	1.60E-07	1.15E-07	5.74E-08	2.43E-08	1.33E-08	9.16E-09	6.86E-09
E	4.76E-06	7.33E-07	3.33E-07	2.02E-07	1.45E-07	7.33E-08	3.14E-08	1.75E-08	1.21E-08	9.09E-09
ESE	3.42E-06	5.27E-07	2.40E-07	1.45E-07	1.05E-07	5.30E-08	2.28E-08	1.27E-08	8.82E-09	6.64E-09
SE	5.01E-06	7.75E-07	3.52E-07	2.13E-07	1.52E-07	7.64E-08	3.24E-08	1.79E-08	1.23E-08	9.21E-09
SSE	5.10E-06	7.92E-07	3.58E-07	2.16E-07	1.54E-07	7.64E-08	3.19E-08	1.74E-08	1.18E-08	8.84E-09
S	4.72E-06	7.25E-07	3.27E-07	1.97E-07	1.40E-07	6.97E-08	2.92E-08	1.60E-08	1.09E-08	8.19E-09
SSW	7.80E-07	1.15E-07	5.02E-08	2.97E-08	2.07E-08	1.01E-08	4.10E-09	2.20E-09	1.49E-09	1.11E-09
SW	7.05E-07	1.06E-07	4.68E-08	2.79E-08	1.98E-08	9.81E-09	4.11E-09	2.25E-09	1.53E-09	1.15E-09
WSW	4.65E-07	6.81E-08	2.96E-08	1.75E-08	1.21E-08	5.91E-09	2.39E-09	1.28E-09	8.67E-10	6.48E-10
W	1.51E-06	2.24E-07	9.86E-08	5.86E-08	4.13E-08	2.05E-08	8.59E-09	4.69E-09	3.22E-09	2.41E-09
WNW	3.05E-06	4.61E-07	2.07E-07	1.24E-07	8.86E-08	4.44E-08	1.89E-08	1.04E-08	7.20E-09	5.42E-09
NW	5.66E-06	8.66E-07	3.93E-07	2.36E-07	1.70E-07	8.54E-08	3.65E-08	2.02E-08	1.40E-08	1.05E-08
NNW	4.78E-06	7.31E-07	3.32E-07	2.00E-07	1.44E-07	7.28E-08	3.13E-08	1.75E-08	1.21E-08	9.11E-09

(a) Data collected at the 300 Area and the Hanford Meteorological Station during 1982 and 1983.

TABLE 16. Annual Average Atmospheric Dispersion Parameters, $\bar{X}/Q'$ (sec/m³), for Ground Level Releases from the 400 Area - Based on Historical Data^(a)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	7.19E-06	1.10E-06	4.98E-07	3.00E-07	2.15E-07	1.08E-07	4.61E-08	2.55E-08	1.76E-08	1.32E-08
NNE	5.57E-06	8.52E-07	3.84E-07	2.31E-07	1.65E-07	8.24E-08	3.48E-08	1.91E-08	1.31E-08	9.85E-09
NE	3.88E-06	5.99E-07	2.70E-07	1.62E-07	1.16E-07	5.75E-08	2.41E-08	1.31E-08	8.97E-09	6.71E-09
ENE	2.57E-06	3.96E-07	1.79E-07	1.08E-07	7.77E-08	3.91E-08	1.66E-08	9.21E-09	6.34E-09	4.76E-09
E	4.08E-06	6.32E-07	2.86E-07	1.72E-07	1.23E-07	6.12E-08	2.57E-08	1.40E-08	9.60E-09	7.18E-09
ESE	4.49E-06	6.98E-07	3.15E-07	1.90E-07	1.35E-07	6.73E-08	2.81E-08	1.53E-08	1.04E-08	7.76E-09
SE	4.43E-06	6.87E-07	3.11E-07	1.88E-07	1.34E-07	6.70E-08	2.82E-08	1.54E-08	1.06E-08	7.90E-09
SSE	3.54E-06	5.44E-07	2.46E-07	1.48E-07	1.06E-07	5.31E-08	2.25E-08	1.24E-08	8.49E-09	6.38E-09
S	5.01E-06	7.63E-07	3.46E-07	2.08E-07	1.50E-07	7.55E-08	3.24E-08	1.80E-08	1.25E-08	9.41E-09
SSW	2.73E-06	4.14E-07	1.87E-07	1.12E-07	8.07E-08	4.06E-08	1.74E-08	9.66E-09	6.68E-09	5.04E-09
SW	1.70E-06	2.58E-07	1.16E-07	6.96E-08	4.98E-08	2.49E-08	1.06E-08	5.87E-09	4.04E-09	3.04E-09
WSW	9.96E-07	1.50E-07	6.67E-08	3.97E-08	2.82E-08	1.39E-08	5.78E-09	3.14E-09	2.15E-09	1.61E-09
W	1.52E-06	2.30E-07	1.04E-07	6.24E-08	4.49E-08	2.27E-08	9.77E-09	5.45E-09	3.78E-09	2.85E-09
WNW	1.14E-06	1.73E-07	7.74E-08	4.64E-08	3.30E-08	1.64E-08	6.89E-09	3.77E-09	2.59E-09	1.94E-09
NW	1.79E-06	2.71E-07	1.22E-07	7.32E-08	5.23E-08	2.62E-08	1.11E-08	6.11E-09	4.22E-09	3.17E-09
NNW	3.30E-06	5.04E-07	2.27E-07	1.37E-07	9.78E-08	4.89E-08	2.08E-08	1.15E-08	7.88E-09	5.92E-09

(a) Data collected at the 400 Area and the Hanford Meteorological Station during 1982 and 1983.

TABLE 17. 95th Percentile^(a) Center-Line $\bar{X}/Q'$ (sec/m³) Values,
for Acute Ground Level Releases from the 100 Areas^(b)

Direction	Range, mi(km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	1.79E-03	2.97E-04	1.46E-04	9.25E-05	7.19E-05	4.19E-05	2.34E-05	1.62E-05	1.31E-05	1.11E-05
NNE	1.81E-03	3.00E-04	1.48E-04	9.34E-05	7.26E-05	4.23E-05	2.36E-05	1.63E-05	1.33E-05	1.12E-05
NE	1.60E-03	2.64E-04	1.29E-04	8.22E-05	6.37E-05	3.71E-05	2.07E-05	1.43E-05	1.16E-05	9.84E-06
ENE	1.61E-03	2.64E-04	1.29E-04	8.23E-05	6.37E-05	3.72E-05	2.07E-05	1.44E-05	1.16E-05	9.85E-06
E	1.41E-03	2.30E-04	1.12E-04	7.20E-05	5.55E-05	3.24E-05	1.80E-05	1.25E-05	1.01E-05	8.58E-06
ESE	1.92E-03	3.18E-04	1.57E-04	9.91E-05	7.71E-05	4.50E-05	2.51E-05	1.73E-05	1.41E-05	1.19E-05
SE	1.98E-03	3.30E-04	1.63E-04	1.03E-04	8.01E-05	4.67E-05	2.61E-05	1.80E-05	1.47E-05	1.24E-05
SSE	1.75E-03	2.90E-04	1.42E-04	9.02E-05	7.01E-05	4.08E-05	2.28E-05	1.57E-05	1.28E-05	1.08E-05
S	1.67E-03	2.75E-04	1.35E-04	8.58E-05	6.65E-05	3.88E-05	2.16E-05	1.50E-05	1.21E-05	1.03E-05
SSW	1.51E-03	2.47E-04	1.20E-04	7.69E-05	5.95E-05	3.47E-05	1.93E-05	1.34E-05	1.08E-05	9.19E-06
SW	1.86E-03	3.09E-04	1.52E-04	9.63E-05	7.49E-05	4.37E-05	2.44E-05	1.68E-05	1.37E-05	1.16E-05
WSW	1.92E-03	3.20E-04	1.58E-04	9.94E-05	7.74E-05	4.51E-05	2.52E-05	1.74E-05	1.42E-05	1.20E-05
W	2.09E-03	3.48E-04	1.72E-04	1.08E-04	8.45E-05	4.93E-05	2.75E-05	1.89E-05	1.55E-05	1.31E-05
WNW	1.49E-03	2.43E-04	1.19E-04	7.58E-05	5.86E-05	3.42E-05	1.90E-05	1.32E-05	1.07E-05	9.06E-06
NW	1.81E-03	3.00E-04	1.47E-04	9.33E-05	7.26E-05	4.23E-05	2.36E-05	1.63E-05	1.33E-05	1.12E-05
NNW	1.76E-03	2.91E-04	1.43E-04	9.06E-05	7.04E-05	4.10E-05	2.29E-05	1.58E-05	1.29E-05	1.09E-05

(a) One-hour average value with 5% probability of being exceeded.

(b) Based on data collected at 100-N Area and the Hanford Meteorological Station during 1982 and 1983.

TABLE 18. 95th Percentile^(a) Center-Line $\bar{X}/Q'$ (sec/m³) Values,
for Acute Elevated^(b) Releases from the 100 Areas^(c)

Direction	Range, mi(km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	4.63E-05	2.60E-05	1.95E-05	1.49E-05	1.22E-05	1.01E-05	6.73E-06	5.17E-06	4.28E-06	3.79E-06
NNE	4.42E-05	2.59E-05	1.94E-05	1.49E-05	1.22E-05	9.79E-06	6.39E-06	5.03E-06	4.16E-06	3.73E-06
NE	4.23E-05	2.54E-05	1.82E-05	1.44E-05	1.22E-05	9.35E-06	6.03E-06	4.88E-06	4.03E-06	3.65E-06
ENE	3.72E-05	2.46E-05	1.63E-05	1.40E-05	1.22E-05	8.99E-06	5.83E-06	4.80E-06	3.96E-06	3.62E-06
E	3.65E-05	2.46E-05	1.63E-05	1.39E-05	1.21E-05	8.65E-06	5.38E-06	4.62E-06	3.80E-06	3.53E-06
ESE	4.10E-05	2.49E-05	1.71E-05	1.40E-05	1.22E-05	9.16E-06	6.12E-06	4.92E-06	4.06E-06	3.67E-06
SE	4.45E-05	2.52E-05	1.78E-05	1.43E-05	1.22E-05	9.63E-06	6.50E-06	5.08E-06	4.20E-06	3.75E-06
SSE	4.47E-05	2.50E-05	1.73E-05	1.42E-05	1.22E-05	9.96E-06	6.74E-06	5.17E-06	4.28E-06	3.80E-06
S	4.47E-05	2.51E-05	1.75E-05	1.40E-05	1.22E-05	9.22E-06	6.08E-06	4.91E-06	4.05E-06	3.67E-06
SSW	4.35E-05	2.54E-05	1.81E-05	1.42E-05	1.22E-05	8.81E-06	5.65E-06	4.73E-06	3.89E-06	3.58E-06
SW	4.46E-05	2.57E-05	1.90E-05	1.48E-05	1.22E-05	9.97E-06	6.68E-06	5.15E-06	4.26E-06	3.79E-06
WSW	4.41E-05	2.60E-05	1.96E-05	1.50E-05	1.22E-05	1.00E-05	6.66E-06	5.14E-06	4.25E-06	3.78E-06
W	4.48E-05	2.60E-05	1.97E-05	1.50E-05	1.22E-05	1.02E-05	6.89E-06	5.24E-06	4.34E-06	3.83E-06
WNW	4.54E-05	2.56E-05	1.87E-05	1.45E-05	1.22E-05	9.36E-06	6.00E-06	4.87E-06	4.02E-06	3.65E-06
NW	4.50E-05	2.57E-05	1.89E-05	1.46E-05	1.22E-05	9.92E-06	6.62E-06	5.13E-06	4.24E-06	3.77E-06
NNW	4.60E-05	2.60E-05	1.96E-05	1.50E-05	1.22E-05	9.86E-06	6.44E-06	5.05E-06	4.18E-06	3.74E-06

(a) One-hour average value with 5% probability of being exceeded.

(b) Defined as 61 m.

(c) Based on data collected at 100-N Area and the Hanford Meteorological Station during 1982 and 1983.

TABLE 19. 95th Percentile^(a) Center-Line $\bar{X}/Q'$ (Sec/m³) Values,
for Acute Ground Level Releases from the 200 Areas^(b)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	9.63E-04	1.61E-04	7.95E-05	5.00E-05	3.90E-05	2.27E-05	1.27E-05	8.74E-06	7.15E-06	6.03E-06
NNE	9.88E-04	1.65E-04	8.12E-05	5.12E-05	3.99E-05	2.33E-05	1.30E-05	8.95E-06	7.30E-06	6.16E-06
NE	1.03E-03	1.71E-04	8.41E-05	5.32E-05	4.14E-05	2.41E-05	1.35E-05	9.29E-06	7.56E-06	6.39E-06
ENE	8.91E-04	1.50E-04	7.46E-05	4.66E-05	3.65E-05	2.13E-05	1.19E-05	8.16E-06	6.70E-06	5.64E-06
E	9.68E-04	1.62E-04	7.99E-05	5.02E-05	3.92E-05	2.29E-05	1.28E-05	8.79E-06	7.18E-06	6.06E-06
ESE	6.88E-04	1.16E-04	5.79E-05	3.60E-05	2.83E-05	1.65E-05	9.24E-06	6.32E-06	5.19E-06	4.37E-06
SE	4.70E-04	7.59E-05	3.71E-05	2.42E-05	1.84E-05	1.09E-05	6.01E-06	4.17E-06	3.37E-06	2.85E-06
SSE	8.70E-04	1.47E-04	7.32E-05	4.56E-05	3.58E-05	2.09E-05	1.17E-05	7.99E-06	6.57E-06	5.52E-06
S	9.33E-04	1.56E-04	7.75E-05	4.85E-05	3.80E-05	2.21E-05	1.24E-05	8.50E-06	6.96E-06	5.86E-06
SSW	7.06E-04	1.18E-04	5.82E-05	3.68E-05	2.86E-05	1.67E-05	9.33E-06	6.41E-06	5.24E-06	4.42E-06
SW	7.55E-04	1.26E-04	6.27E-05	3.94E-05	3.07E-05	1.80E-05	1.00E-05	6.89E-06	5.64E-06	4.75E-06
WSW	7.66E-04	1.28E-04	6.36E-05	4.00E-05	3.12E-05	1.82E-05	1.02E-05	6.99E-06	5.73E-06	4.82E-06
W	1.18E-03	1.93E-04	9.41E-05	6.01E-05	4.65E-05	2.71E-05	1.51E-05	1.05E-05	8.47E-06	7.18E-06
WNW	1.23E-03	2.01E-04	9.78E-05	6.28E-05	4.84E-05	2.82E-05	1.57E-05	1.09E-05	8.81E-06	7.48E-06
NW	1.22E-03	2.00E-04	9.73E-05	6.23E-05	4.81E-05	2.80E-05	1.56E-05	1.09E-05	8.76E-06	7.44E-06
NNW	1.04E-03	1.73E-04	8.50E-05	5.38E-05	4.18E-05	2.44E-05	1.36E-05	9.40E-06	7.65E-06	6.47E-06

(a) One-hour average value with 5% probability of being exceeded.

(b) Based on data collected at the Hanford Meteorological Station during 1982 and 1983.

TABLE 20. 95th Percentile^(a) Center-Line $\bar{X}/Q'$ (sec/m³) Values,
for Acute Elevated^(b) Releases from the 200 Areas^(c)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	4.10E-05	2.58E-05	1.92E-05	1.48E-05	1.22E-05	9.43E-06	5.74E-06	4.77E-06	3.93E-06	3.60E-06
NNE	3.66E-05	2.44E-05	1.58E-05	1.38E-05	1.21E-05	8.49E-06	5.29E-06	4.45E-06	3.65E-06	3.37E-06
NE	3.47E-05	2.39E-05	1.47E-05	1.29E-05	1.17E-05	7.68E-06	5.09E-06	4.09E-06	3.34E-06	3.03E-06
ENE	3.12E-05	2.36E-05	1.38E-05	1.30E-05	1.19E-05	7.78E-06	4.91E-06	3.77E-06	3.07E-06	2.73E-06
E	2.81E-05	1.80E-05	1.26E-05	1.09E-05	9.28E-06	6.17E-06	4.32E-06	3.08E-06	2.50E-06	2.15E-06
ESE	2.85E-05	1.84E-05	1.26E-05	1.01E-05	8.08E-06	5.12E-06	2.78E-06	2.04E-06	1.68E-06	1.46E-06
SE	2.15E-05	1.07E-05	1.17E-05	7.95E-06	5.82E-06	3.50E-06	1.86E-06	1.52E-06	1.25E-06	1.14E-06
SSE	3.99E-05	2.45E-05	1.60E-05	1.29E-05	1.18E-05	7.55E-06	4.89E-06	3.74E-06	3.05E-06	2.70E-06
S	4.42E-05	2.48E-05	1.69E-05	1.29E-05	1.16E-05	7.18E-06	4.65E-06	3.30E-06	2.68E-06	2.29E-06
SSW	4.52E-05	2.48E-05	1.69E-05	1.24E-05	1.05E-05	6.16E-06	3.83E-06	2.75E-06	2.24E-06	1.93E-06
SW	4.56E-05	2.51E-05	1.75E-05	1.33E-05	1.12E-05	6.98E-06	4.35E-06	3.10E-06	2.52E-06	2.16E-06
WSW	4.47E-05	2.52E-05	1.76E-05	1.32E-05	1.14E-05	7.05E-06	4.48E-06	3.19E-06	2.59E-06	2.22E-06
W	4.54E-05	2.58E-05	1.90E-05	1.46E-05	1.22E-05	9.11E-06	5.40E-06	4.63E-06	3.81E-06	3.53E-06
WNW	4.62E-05	2.59E-05	1.94E-05	1.49E-05	1.22E-05	9.54E-06	5.93E-06	4.85E-06	4.00E-06	3.64E-06
NW	4.48E-05	2.55E-05	1.85E-05	1.45E-05	1.22E-05	1.02E-05	6.98E-06	5.28E-06	4.37E-06	3.84E-06
NNW	4.27E-05	2.58E-05	1.90E-05	1.47E-05	1.22E-05	9.15E-06	5.69E-06	4.74E-06	3.91E-06	3.59E-06

(a) One-hour average value with 5% probability of being exceeded.

(b) Defined as 61 m.

(c) Based on data collected at the Hanford Meteorological Station during 1982 and 1983.

TABLE 21. 95th Percentile^(a) Center-Line $\bar{X}/Q'$ (sec/m³) Values,
for Acute Ground Level Releases from the 300 Area^(b)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	1.20E-03	1.97E-04	9.59E-05	6.14E-05	4.74E-05	2.76E-05	1.54E-05	1.07E-05	8.64E-06	7.33E-06
NNE	8.91E-04	1.50E-04	7.47E-05	4.66E-05	3.65E-05	2.13E-05	1.19E-05	8.17E-06	6.70E-06	5.64E-06
NE	9.31E-04	1.56E-04	7.73E-05	4.85E-05	3.79E-05	2.21E-05	1.24E-05	8.49E-06	6.95E-06	5.85E-06
ENE	1.18E-03	1.93E-04	9.44E-05	6.04E-05	4.66E-05	2.72E-05	1.51E-05	1.05E-05	8.50E-06	7.21E-06
E	1.92E-03	3.20E-04	1.57E-04	9.94E-05	7.74E-05	4.51E-05	2.52E-05	1.74E-05	1.42E-05	1.20E-05
ESE	2.12E-03	3.55E-04	1.75E-04	1.10E-04	8.60E-05	5.02E-05	2.80E-05	1.93E-05	1.58E-05	1.33E-05
SE	1.26E-03	2.05E-04	9.96E-05	6.40E-05	4.93E-05	2.88E-05	1.60E-05	1.11E-05	8.98E-06	7.63E-06
SSE	6.36E-04	1.07E-04	5.35E-05	3.33E-05	2.61E-05	1.52E-05	8.54E-06	5.84E-06	4.80E-06	4.04E-06
S	4.80E-04	8.06E-05	4.00E-05	2.51E-05	1.96E-05	1.15E-05	6.41E-06	4.39E-06	3.60E-06	3.03E-06
SSW	2.25E-04	3.68E-05	1.78E-05	1.14E-05	8.73E-06	5.03E-06	1.97E-06	1.37E-06	1.10E-06	9.39E-07
SW	4.73E-04	7.74E-05	3.80E-05	2.45E-05	1.88E-05	1.11E-05	6.14E-06	4.24E-06	3.44E-06	2.91E-06
WSW	4.31E-04	6.95E-05	3.37E-05	2.19E-05	1.68E-05	9.82E-06	5.44E-06	3.80E-06	3.05E-06	2.59E-06
W	4.73E-04	7.72E-05	3.79E-05	2.45E-05	1.88E-05	1.10E-05	6.12E-06	4.23E-06	3.43E-06	2.90E-06
WNW	6.32E-04	1.07E-04	5.31E-05	3.31E-05	2.60E-05	1.51E-05	8.48E-06	5.80E-06	4.77E-06	4.01E-06
NW	1.04E-03	1.72E-04	8.46E-05	5.35E-05	4.16E-05	2.43E-05	1.35E-05	9.35E-06	7.61E-06	6.43E-06
NNW	1.20E-03	1.97E-04	9.58E-05	6.14E-05	4.74E-05	2.76E-05	1.54E-05	1.07E-05	8.63E-06	7.32E-06

(a) One-hour average value with 5% probability of being exceeded.

(b) Based on data collected at the 300 Area and the Hanford Meteorological Station during 1982 and 1983.

TABLE 22. 95th Percentile^(a) Center-Line $\bar{X}/Q'$ (sec/m³) Values,
for Acute Ground Level Releases from the 400 Area^(b)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	6.00E-04	1.01E-04	5.05E-05	3.14E-05	2.47E-05	1.44E-05	8.06E-06	5.51E-06	4.53E-06	3.81E-06
NNE	4.74E-04	7.78E-05	3.83E-05	2.46E-05	1.89E-05	1.11E-05	6.17E-06	4.26E-06	3.46E-06	2.92E-06
NE	4.81E-04	8.10E-05	4.03E-05	2.52E-05	1.97E-05	1.15E-05	6.44E-06	4.41E-06	3.62E-06	3.05E-06
ENE	1.03E-03	1.71E-04	8.43E-05	5.33E-05	4.15E-05	2.42E-05	1.35E-05	9.32E-06	7.58E-06	6.41E-06
E	9.08E-04	1.53E-04	7.58E-05	4.74E-05	3.71E-05	2.16E-05	1.21E-05	8.30E-06	6.81E-06	5.73E-06
ESE	4.77E-04	7.90E-05	3.90E-05	2.48E-05	1.92E-05	1.13E-05	6.27E-06	4.32E-06	3.52E-06	2.97E-06
SE	4.79E-04	8.03E-05	3.98E-05	2.50E-05	1.95E-05	1.14E-05	6.38E-06	4.37E-06	3.58E-06	3.02E-06
SSE	9.62E-04	1.61E-04	7.94E-05	4.99E-05	3.90E-05	2.27E-05	1.27E-05	8.74E-06	7.14E-06	6.02E-06
S	1.15E-03	1.89E-04	9.25E-05	5.90E-05	4.57E-05	2.66E-05	1.48E-05	1.03E-05	8.33E-06	7.06E-06
SSW	1.27E-03	2.07E-04	1.00E-04	6.45E-05	4.97E-05	2.90E-05	1.61E-05	1.12E-05	9.05E-06	7.69E-06
SW	1.24E-03	2.01E-04	9.80E-05	6.29E-05	4.85E-05	2.83E-05	1.57E-05	1.10E-05	8.83E-06	7.50E-06
WSW	1.16E-03	1.88E-04	9.11E-05	5.88E-05	4.52E-05	2.64E-05	1.46E-05	1.02E-05	8.22E-06	6.99E-06
W	1.80E-03	2.98E-04	1.47E-04	9.29E-05	7.22E-05	4.21E-05	2.35E-05	1.62E-05	1.32E-05	1.12E-05
WNW	1.41E-03	2.30E-04	1.12E-04	7.18E-05	5.54E-05	3.23E-05	1.79E-05	1.25E-05	1.01E-05	8.56E-06
NW	1.15E-03	1.88E-04	9.20E-05	5.87E-05	4.54E-05	2.65E-05	1.47E-05	1.02E-05	8.28E-06	7.02E-06
NNW	6.42E-04	1.08E-04	5.40E-05	3.36E-05	2.64E-05	1.54E-05	8.62E-06	5.90E-06	4.85E-06	4.08E-06

(a) One-hour average value with 5% probability of being exceeded.

(b) Based on data collected at the 400 Area and the Hanford Meteorological Station during 1982 and 1983.

TABLE 23. 95th Percentile^(a) Sector-Averaged $\bar{X}/Q'$ (sec/m³) Values,
for Acute Ground Level Releases from the 100 Areas^(b)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	3.69E-04	5.66E-05	2.62E-05	1.57E-05	1.16E-05	5.98E-06	2.69E-06	1.53E-06	1.08E-06	8.21E-07
NNE	3.71E-04	5.68E-05	2.63E-05	1.58E-05	1.17E-05	6.01E-06	2.70E-06	1.54E-06	1.09E-06	8.25E-07
NE	3.51E-04	5.36E-05	2.46E-05	1.49E-05	1.10E-05	5.65E-06	2.53E-06	1.45E-06	1.02E-06	7.75E-07
ENE	3.51E-04	5.36E-05	2.47E-05	1.49E-05	1.10E-05	5.65E-06	2.53E-06	1.45E-06	1.02E-06	7.75E-07
E	3.33E-04	5.06E-05	2.31E-05	1.40E-05	1.03E-05	5.31E-06	2.38E-06	1.36E-06	9.57E-07	7.29E-07
ESE	3.81E-04	5.85E-05	2.72E-05	1.63E-05	1.21E-05	6.20E-06	2.78E-06	1.59E-06	1.12E-06	8.51E-07
SE	3.87E-04	5.95E-05	2.77E-05	1.66E-05	1.23E-05	6.32E-06	2.84E-06	1.62E-06	1.14E-06	8.67E-07
SSE	3.65E-04	5.59E-05	2.58E-05	1.55E-05	1.15E-05	5.91E-06	2.65E-06	1.51E-06	1.07E-06	8.11E-07
S	3.57E-04	5.46E-05	2.52E-05	1.52E-05	1.12E-05	5.76E-06	2.58E-06	1.48E-06	1.04E-06	7.91E-07
SSW	3.42E-04	5.20E-05	2.39E-05	1.45E-05	1.06E-05	5.47E-06	2.45E-06	1.41E-06	9.87E-07	7.51E-07
SW	3.76E-04	5.77E-05	2.67E-05	1.60E-05	1.19E-05	6.11E-06	2.74E-06	1.56E-06	1.10E-06	8.38E-07
WSW	3.82E-04	5.86E-05	2.72E-05	1.63E-05	1.21E-05	6.21E-06	2.79E-06	1.59E-06	1.12E-06	8.52E-07
W	3.97E-04	6.12E-06	2.85E-05	1.70E-05	1.26E-05	6.50E-06	2.92E-06	1.66E-06	1.18E-06	8.92E-07
WNW	3.40E-04	5.17E-05	2.37E-05	1.44E-05	1.06E-05	5.44E-06	2.43E-06	1.40E-06	9.81E-07	7.46E-07
NW	3.71E-04	5.68E-05	2.63E-05	1.58E-05	1.17E-05	6.01E-06	2.70E-06	1.54E-06	1.09E-06	8.25E-07
NNW	3.66E-04	5.60E-05	2.59E-05	1.56E-05	1.15E-05	5.92E-06	2.66E-06	1.52E-06	1.07E-06	8.13E-07

(a) One-hour average value with 5% probability of being exceeded.

(b) Based on data collected at 100-N Area and the Hanford Meteorological Station during 1982 and 1983.

TABLE 24. 95th Percentile^(a) Sector-Averaged $\bar{X}/Q'$ (sec/m³) Values,
for Acute Elevated^(b) Releases from the 100 Areas^(c)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	3.04E-05	1.06E-05	6.35E-06	4.57E-06	3.52E-06	2.03E-06	9.86E-07	6.03E-07	4.34E-07	3.39E-07
NNE	2.75E-05	1.06E-05	6.34E-06	4.55E-06	3.49E-06	2.02E-06	9.83E-07	5.98E-07	4.29E-07	3.35E-07
NE	2.21E-05	1.06E-05	6.21E-06	4.38E-06	3.32E-06	1.95E-06	9.79E-07	5.90E-07	4.22E-07	3.29E-07
ENE	1.86E-05	1.02E-05	6.02E-06	4.09E-06	3.03E-06	1.88E-06	9.75E-07	5.84E-07	4.16E-07	3.23E-07
E	1.90E-05	1.01E-05	6.01E-06	4.03E-06	3.01E-06	1.87E-06	9.72E-07	5.78E-07	4.11E-07	3.18E-07
ESE	2.70E-05	1.06E-05	6.09E-06	4.20E-06	3.14E-06	1.90E-06	9.77E-07	5.87E-07	4.19E-07	3.26E-07
SE	2.98E-05	1.06E-05	6.17E-06	4.31E-06	3.25E-06	1.93E-06	9.82E-07	5.95E-07	4.27E-07	3.33E-07
SSE	3.03E-05	1.06E-05	6.12E-06	4.24E-06	3.18E-06	1.92E-06	9.85E-07	6.01E-07	4.32E-07	3.38E-07
S	2.90E-05	1.06E-05	6.14E-06	4.27E-06	3.21E-06	1.89E-06	9.78E-07	5.88E-07	4.20E-07	3.27E-07
SSW	2.76E-05	1.06E-05	6.20E-06	4.36E-06	3.30E-06	1.91E-06	9.73E-07	5.81E-07	4.13E-07	3.20E-07
SW	2.91E-05	1.06E-05	6.29E-06	4.49E-06	3.43E-06	2.00E-06	9.85E-07	6.01E-07	4.32E-07	3.38E-07
WSW	2.70E-05	1.06E-05	6.35E-06	4.58E-06	3.52E-06	2.03E-06	9.85E-07	6.02E-07	4.33E-07	3.39E-07
W	2.86E-05	1.06E-05	6.37E-06	4.60E-06	3.54E-06	2.04E-06	9.87E-07	6.05E-07	4.36E-07	3.41E-07
WNW	2.93E-05	1.06E-05	6.27E-06	4.45E-06	3.40E-06	1.96E-06	9.79E-07	5.90E-07	4.22E-07	3.29E-07
NW	2.83E-05	1.06E-05	6.28E-06	4.48E-06	3.42E-06	1.98E-06	9.84E-07	6.00E-07	4.31E-07	3.37E-07
NNW	3.04E-05	1.06E-05	6.36E-06	4.58E-06	3.52E-06	2.03E-06	9.84E-07	5.99E-07	4.30E-07	3.36E-07

(a) One-hour average value with 5% probability of being exceeded.

(b) Defined as 61 m.

(c) Based on data collected at 100-N Area and the Hanford Meteorological Station during 1982 and 1983.

TABLE 25. 95th Percentile^(a) Sector-Averaged $\bar{X}/Q'$ (sec/m³) Values,
for Acute Ground Level Releases from the 200 Areas^(b)

Direction	Range, mi(km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	2.41E-04	3.64E-05	1.66E-05	1.02E-05	7.45E-06	3.86E-06	1.72E-06	9.88E-07	6.91E-07	5.27E-07
NNE	2.42E-04	3.65E-05	1.67E-05	1.02E-05	7.47E-06	3.87E-06	1.72E-06	9.90E-07	6.93E-07	5.28E-07
NE	2.25E-04	3.40E-05	1.55E-05	9.57E-06	6.96E-06	3.61E-06	1.61E-06	9.24E-07	6.46E-07	4.92E-07
ENE	2.00E-04	3.02E-05	1.38E-05	8.54E-06	6.19E-06	3.22E-06	1.43E-06	8.22E-07	5.75E-07	4.38E-07
E	2.01E-04	3.03E-05	1.39E-05	8.58E-06	6.22E-06	3.23E-06	1.44E-06	8.26E-07	5.77E-07	4.40E-07
ESE	1.65E-04	2.50E-05	1.15E-05	7.11E-06	5.16E-06	2.69E-06	1.20E-06	6.84E-07	4.80E-07	3.65E-07
SE	1.37E-04	2.10E-05	9.83E-06	5.91E-06	4.39E-06	2.26E-06	1.02E-06	5.76E-07	4.10E-07	3.10E-07
SSE	2.08E-04	3.14E-05	1.43E-05	8.87E-06	6.44E-06	3.35E-06	1.49E-06	8.54E-07	5.98E-07	4.55E-07
S	2.45E-04	3.70E-05	1.69E-05	1.04E-05	7.57E-06	3.92E-06	1.75E-06	1.00E-06	7.02E-07	5.35E-07
SSW	1.93E-04	2.91E-05	1.33E-05	8.26E-06	5.98E-06	3.11E-06	1.38E-06	7.94E-07	5.55E-07	4.23E-07
SW	2.17E-04	3.28E-05	1.50E-05	9.26E-06	6.73E-06	3.49E-06	1.55E-06	8.93E-07	6.24E-07	4.76E-07
WSW	2.22E-04	3.35E-05	1.53E-05	9.44E-06	6.87E-06	3.56E-06	1.59E-06	9.11E-07	6.37E-07	4.86E-07
W	2.92E-04	4.42E-05	2.01E-05	1.23E-05	9.02E-06	4.65E-06	2.07E-06	1.19E-06	8.35E-07	6.37E-07
WNW	3.09E-04	4.69E-05	2.13E-05	1.30E-05	9.55E-06	4.92E-06	2.20E-06	1.26E-06	8.85E-07	6.74E-07
NW	2.98E-04	4.51E-05	2.06E-05	1.26E-05	9.20E-06	4.74E-06	2.12E-06	1.22E-06	8.52E-07	6.50E-07
NNW	2.76E-04	4.18E-05	1.90E-05	1.17E-05	8.53E-06	4.40E-06	1.96E-06	1.13E-06	7.90E-07	6.02E-07

(a) One-hour average value with 5% probability of being exceeded.

(b) Based on data collected at the Hanford Meteorological Station during 1982 and 1983.

TABLE 26. 95th Percentile^(a) Sector-Averaged $\bar{X}/Q'$ (sec/m³) Values,
for Acute Elevated Releases^(b) from the 200 Areas^(c)

Direction	Range, mi(km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	2.28E-05	1.06E-05	6.32E-06	4.52E-06	3.47E-06	2.01E-06	9.80E-07	5.92E-07	4.23E-07	3.30E-07
NNE	1.85E-05	9.95E-06	5.96E-06	4.00E-06	2.94E-06	1.85E-06	9.70E-07	5.75E-07	4.08E-07	3.15E-07
NE	1.83E-05	9.93E-06	5.84E-06	3.83E-06	2.77E-06	1.74E-06	9.01E-07	5.36E-07	3.79E-07	2.93E-07
ENE	1.61E-05	9.53E-06	5.76E-06	3.71E-06	2.64E-06	1.74E-06	9.28E-07	5.49E-07	3.87E-07	2.99E-07
E	1.39E-05	8.98E-06	4.47E-06	3.34E-06	2.49E-06	1.48E-06	5.02E-07	3.54E-07	2.53E-07	2.11E-07
ESE	1.31E-05	9.18E-06	4.57E-06	3.35E-06	2.49E-06	1.38E-06	4.77E-07	2.95E-07	1.74E-07	1.40E-07
SE	1.25E-05	6.61E-06	2.77E-06	2.90E-06	2.41E-06	1.04E-06	4.21E-07	2.04E-07	1.33E-07	1.03E-07
SSE	1.85E-05	1.06E-05	5.98E-06	4.03E-06	2.97E-06	1.74E-06	8.65E-07	5.20E-07	3.68E-07	2.86E-07
S	2.92E-05	1.06E-05	6.07E-06	4.17E-06	3.11E-06	1.74E-06	7.67E-07	4.76E-07	3.37E-07	2.66E-07
SSW	3.02E-05	1.06E-05	6.07E-06	4.17E-06	3.11E-06	1.67E-06	5.01E-07	3.53E-07	2.44E-07	2.02E-07
SW	3.05E-05	1.06E-05	6.14E-06	4.26E-06	3.20E-06	1.78E-06	7.11E-07	4.50E-07	3.19E-07	2.54E-07
WSW	2.98E-05	1.06E-05	6.15E-06	4.28E-06	3.22E-06	1.78E-06	7.31E-07	4.59E-07	3.26E-07	2.58E-07
W	2.99E-05	1.06E-05	6.30E-06	4.50E-06	3.44E-06	1.98E-06	9.76E-07	5.86E-07	4.18E-07	3.25E-07
WNW	3.07E-05	1.06E-05	6.34E-06	4.56E-06	3.50E-06	2.02E-06	9.81E-07	5.94E-07	4.25E-07	3.31E-07
NW	2.87E-05	1.06E-05	6.24E-06	4.41E-06	3.36E-06	1.97E-06	9.88E-07	6.06E-07	4.37E-07	3.42E-07
NNW	2.14E-05	1.06E-05	6.30E-06	4.50E-06	3.44E-06	1.99E-06	9.77E-07	5.87E-07	4.19E-07	3.25E-07

(a) One-hour average value with 5% probability of being exceeded.

(b) Defined as 61 m.

(c) Based on data collected at the Hanford Meteorological Station during 1982 and 1983.

TABLE 27. 95th Percentile^(a) Sector-Averaged $\bar{X}/Q'$ (sec/m³) Values,
for Acute Ground Level Releases from the 300 Area^(b)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	2.97E-04	4.49E-05	2.05E-05	1.25E-05	9.17E-06	4.72E-06	2.11E-06	1.21E-06	8.49E-07	6.47E-07
NNE	2.30E-04	3.48E-05	1.59E-05	9.79E-06	7.13E-06	3.70E-06	1.65E-06	9.46E-07	6.62E-07	5.04E-07
NE	2.66E-04	4.03E-05	1.84E-05	1.12E-05	8.22E-06	4.25E-06	1.89E-06	1.09E-06	7.62E-07	5.81E-07
ENE	3.01E-04	4.56E-05	2.08E-05	1.27E-05	9.29E-06	4.79E-06	2.14E-06	1.23E-06	8.60E-07	6.56E-07
E	3.81E-04	5.86E-05	2.72E-05	1.63E-05	1.21E-05	6.21E-06	2.79E-06	1.59E-06	1.12E-06	8.52E-07
ESE	4.01E-04	6.17E-05	2.88E-05	1.72E-05	1.28E-05	6.56E-06	2.95E-06	1.68E-06	1.19E-06	9.00E-07
SE	3.10E-04	4.70E-05	2.14E-05	1.31E-05	9.58E-06	4.93E-06	2.20E-06	1.27E-06	8.87E-07	6.76E-07
SSE	1.66E-04	2.52E-05	1.16E-05	7.18E-06	5.20E-06	2.71E-06	1.20E-06	6.90E-07	4.84E-07	3.68E-07
S	1.43E-04	2.23E-05	1.05E-05	6.22E-06	4.63E-06	2.38E-06	1.08E-06	6.07E-07	4.33E-07	3.27E-07
SSW	1.00E-04	1.66E-05	7.35E-06	4.25E-06	3.02E-06	1.33E-06	5.76E-07	2.28E-07	1.59E-07	1.22E-07
SW	1.60E-04	2.45E-05	1.14E-05	6.94E-06	5.06E-06	2.63E-06	1.17E-06	6.69E-07	4.72E-07	3.58E-07
WSW	1.01E-04	2.17E-05	9.82E-06	4.27E-06	3.11E-06	1.49E-06	6.69E-07	3.82E-07	2.70E-07	2.05E-07
W	1.62E-04	2.47E-05	1.14E-05	7.01E-06	5.10E-06	2.65E-06	1.18E-06	6.75E-07	4.75E-07	3.61E-07
WNW	1.58E-04	2.42E-05	1.13E-05	6.84E-06	5.01E-06	2.60E-06	1.16E-06	6.61E-07	4.67E-07	3.54E-07
NW	1.99E-04	3.00E-05	1.37E-05	8.50E-06	6.16E-06	3.21E-06	1.42E-06	8.18E-07	5.72E-07	4.36E-07
NNW	2.91E-04	4.40E-05	2.00E-05	1.22E-05	8.98E-06	4.63E-06	2.06E-06	1.19E-06	8.31E-07	6.34E-07

(a) One-hour average value with 5% probability of being exceeded.

(b) Based on data collected at the 300 Area and the Hanford Meteorological Station during 1982 and 1983.

TABLE 28. 95th Percentile^(a) Sector-Averaged $\bar{X}/Q'$ (sec/m³) Values,
for Acute Ground Level Releases from the 400 Area^(b)

Direction	Range, mi (km)									
	0.5(0.8)	1.5(2.4)	2.5(4.0)	3.5(5.6)	4.5(7.2)	7.5(12)	15(24)	25(40)	35(56)	45(72)
N	1.55E-04	2.38E-05	1.11E-05	6.70E-06	4.93E-06	2.55E-06	1.14E-06	6.49E-07	4.60E-07	3.48E-07
NNE	1.40E-04	2.19E-05	1.03E-05	6.05E-06	4.51E-06	2.32E-06	1.05E-06	5.90E-07	4.21E-07	3.18E-07
NE	1.72E-04	2.59E-05	1.19E-05	7.40E-06	5.34E-06	2.79E-06	1.24E-06	7.10E-07	4.96E-07	3.78E-07
ENE	2.77E-04	4.20E-05	1.91E-05	1.17E-05	8.57E-06	4.42E-06	1.97E-06	1.13E-06	7.94E-07	6.05E-07
E	2.33E-04	3.52E-05	1.60E-05	9.88E-06	7.20E-06	3.73E-06	1.66E-06	9.54E-07	6.67E-07	5.09E-07
ESE	1.54E-04	2.37E-05	1.11E-05	6.69E-06	4.92E-06	2.55E-06	1.14E-06	6.48E-07	4.59E-07	3.48E-07
SE	1.49E-04	2.31E-05	1.09E-05	6.47E-06	4.80E-06	2.47E-06	1.11E-06	6.29E-07	4.48E-07	3.39E-07
SSE	2.23E-04	3.37E-05	1.54E-05	9.49E-06	6.91E-06	3.58E-06	1.59E-06	9.16E-07	6.41E-07	4.88E-07
S	2.78E-04	4.20E-05	1.92E-05	1.17E-05	8.58E-06	4.43E-06	1.97E-06	1.14E-06	7.95E-07	6.06E-07
SSW	3.11E-04	4.72E-05	2.15E-05	1.31E-05	9.61E-06	4.95E-06	2.21E-06	1.27E-06	8.90E-07	6.79E-07
SW	3.06E-04	4.64E-05	2.11E-05	1.29E-05	9.46E-06	4.87E-06	2.17E-06	1.25E-06	8.76E-07	6.68E-07
WSW	2.96E-04	4.48E-05	2.04E-05	1.25E-05	9.13E-06	4.70E-06	2.10E-06	1.21E-06	8.45E-07	6.45E-07
W	3.70E-04	5.67E-05	2.63E-05	1.58E-05	1.17E-05	6.00E-06	2.69E-06	1.54E-06	1.08E-06	8.23E-07
WNW	3.33E-04	5.06E-05	2.31E-05	1.40E-05	1.03E-05	5.31E-06	2.37E-06	1.36E-06	9.56E-07	7.28E-07
NW	2.97E-04	4.50E-05	2.05E-05	1.25E-05	9.17E-06	4.72E-06	2.11E-06	1.21E-06	8.49E-07	6.47E-07
NNW	1.59E-04	2.43E-05	1.13E-05	6.89E-06	5.03E-06	2.61E-06	1.17E-06	6.65E-07	4.69E-07	3.56E-07

(a) One-hour average value with 5% probability of being exceeded.

(b) Based on data collected at the 400 Area and the Hanford Meteorological Station during 1982 and 1983.

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APPENDIX A

REVIEW OF DOSE CALCULATION RESULTS

REVIEW OF DOSE CALCULATION RESULTS

When Hanford environmental dose calculations are completed, the calculational methods, input data, and results must be reviewed to verify consistency with the recommendations of the Hanford Dose Overview Program and to provide documentation of the calculations for future reference and reporting. This review, conducted by a member of the Dose Overview Committee according to the general outline provided in Table A.1, requires a description of the evaluation being performed, a copy of the quality assurance page generated by the computer program, and a copy of the calculational results.

Following resolution of review findings, documentation of the calculational methods and data should be prepared for inclusion with the doses when they are reported. This documentation should, as a minimum, include the information listed in Table A.2.

TABLE A.1. General Review Outline

<u>Review Point</u>	<u>Criteria</u>
Calculations	Consistent with intent of analysis - SAR, EIS, emergency planning, etc. Consistent with exposure scenario - chronic versus acute release
Models	Appropriate for calculations Appropriate for exposure scenario Current versions
Data Libraries	Current versions
Input	Accurate and appropriate for exposure scenario - population distribution - terrestrial and aquatic pathways - public exposure - atmospheric dispersion

TABLE A.2. Example of Dose Calculation Documentation^(a)

Facility name:	200 Area
Releases:	See Table 25
Meteorological conditions:	1983 annual average, calculated from data collected at the Hanford Meteorological Station from 1-82 through 12-82. See Table E.6
X/Q:	Maximum individual 3.1×10^{-9} sec/m ³ at 43 km SE for direct airborne pathways and 1.3×10^{-8} sec/m ³ at 32 km SE for food pathways, 80-km population 1.6×10^{-3} person-sec/m ³
Release height:	89.2 meters effective (60.96 meters actual stack height)
Population distribution:	341,000, see Table E.2
Computer code:	DACRIN, Rev. 1.2, 1980
Calculated dose:	Chronic inhalation, maximum individual and 80-km population, 50-yr dose commitment
Files addressed:	Organ Data Library, Rev. 2-5-81 Radionuclide Library, Rev. 1-15-81
Computer code:	PABLM, Rev. 2.2, 10-1-80
Calculated dose:	Chronic ingestion and ground contamination exposure, maximum individual and 80-km population, 50-year cumulative dose
Files addressed:	Radionuclide Library, Rev. 1-15-81 Food Transfer Library, Rev. 8-26-82 Organ Data Library, Rev. 2-5-81 Ground Dose Factor Library, Rev. 3-15-78
Computer code:	KRONIC, Rev. 3-11-83
Calculated dose:	Chronic air submersion, maximum individual and 80-km population, first year dose
Files addressed:	RNDBET GISLIB

(a) Taken from Price et al. 1984.

APPENDIX B
ATMOSPHERIC DISPERSION

APPENDIX B

ATMOSPHERIC DISPERSION

Hanford atmospheric dispersion is based on the joint frequency of occurrence of wind direction, wind speed and atmospheric stability. At Hanford, the sources of meteorological data used to generate the joint frequency tables are: 1) the wind and temperature data from the Hanford Meteorological Tower located near 200 W, 2) wind data from the stations of the telemetry system, and 3) surface weather observations made by the forecast staff at the HMS.

In compiling the joint frequency tables, 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 $\bar{X}/Q'$ values, the entries in the variable and calm classes are distributed in the lowest wind speed class in proportion to the original frequencies of occurrence of direction. Nine wind speed classes are used as defined below:

- W1 - <4 mph, but not variable or calm
- W2 - 4 to 8 mph
- W3 - 8 to 13 mph
- W4 - 13 to 19 mph
- W5 - 19 to 25 mph
- W6 - 25 to 32 mph
- W7 - 32 to 39 mph
- W8 - 39 mph and greater
- W9 - <4 mph, including distributed variables and calms.

In the summaries, the frequencies of occurrence of wind speeds and directions are given as functions of atmospheric stability class. Stability class 1 corresponds to extremely unstable (Pasquill A) conditions, and class 7 corresponds to extremely stable (Pasquill G) conditions. Atmospheric stabilities were determined at the Hanford Meteorological Station (HMS) using

the Pasquill-Gifford-Turner approach based on sky cover/wind speed prior to March 1983 (Gifford 1968, p. 101; or Turner 1969, p. 6). Since then they have been determined using the NRC temperature gradient method (Regulatory Guide 1.23, USNRC 1974).

The stability at the HMS is assumed to be representative for all sites at Hanford. This assumption is reasonable for estimating $\bar{X}/Q'$ 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 existing meteorological conditions.

Separate joint frequency distributions have been compiled for surface and elevated (89-m) releases. Both distributions at the 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 and a correction factor determined from the vertical profile of the winds on the tower at the HMS, and the HMS stability data. The wind speed correction factor is based on the assumption that the wind speed profile can be adequately represented by a power law. The correction further assumes that the wind speed shears at the HMS are representative for the entire area.

Values of $\bar{X}/Q'$ have been calculated for both routine and accidental releases using the joint frequency distributions. The models used for the computations are based on the Gaussian plume diffusion model. A sector-average model was used for routine release $\bar{X}/Q'$ estimates. Estimates of $\bar{X}/Q'$ were made for accidental releases using both the sector-average model and 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. The thickness of the atmospheric mixing layer was not used in the computations.

The sector-average model, described by Gifford (1968) and in USNRC Regulatory Guide 1.111 (USNRC 1977), is:

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

where σ_z = the vertical diffusion coefficient, m

x = the downwind distance, m

u = the wind speed, m/s

h_e = the effective release height, m

F = the frequency of occurrence of a joint wind direction,

wind speed, 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 wind speed 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. Wind speeds are converted from miles/hour to meters/second prior to computing $\bar{X}/Q'$. As a result of the double summation over atmospheric stability and wind speed, the values of routine release $\bar{X}/Q'$ are functions only of wind direction and distance from the source. They have dimensions of sec/m³.

The diffusion coefficients used in the $\bar{X}/Q'$ computations were developed by Briggs to represent diffusion over open country (Briggs 1973). 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 being defined graphically as are the Pasquill-Gifford curves. The Briggs coefficients are one of the options available in MESOI Version 2.0 (Ramsdell, Athey and Glantz 1983).

For accidental releases, the items of interest are specific points on the 1-hour average $\bar{X}/Q'$ frequency distribution, i.e., values of $\bar{X}/Q'$ that are exceeded no more than 1, 5, 10 and 50% of the time. When used to compute $\bar{X}/Q'$ 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 $\bar{X}/Q'$ 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 $\bar{X}/Q'$, and the required points in the frequency distribution are determined interpolation.

A centerline Gaussian plume model has also been used to estimate $\bar{X}/Q'$ for accidental releases. This model is:

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

where σ_y is the horizontal diffusion coefficient and the other variables remain as previously defined.

The constant has been adjusted to account for the differences between the sector-average and centerline models. After the initial computation of $\bar{X}/Q'$, the procedure used to obtain the accident $\bar{X}/Q'$ values with the centerline model was the same as with the sector-average model.

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