**A Research Report for
Rockwell Hanford Operations**

**Preliminary Examination of the
Impacts of Repository Site
Characterization Activities
and Facility Construction
and Operation Activities on
Hanford Air Quality**

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April 1986

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Rockwell Hanford Operations

PRELIMINARY EXAMINATION OF THE IMPACTS
OF REPOSITORY SITE CHARACTERIZATION
ACTIVITIES AND FACILITY CONSTRUCTION
AND OPERATION ACTIVITIES ON HANFORD
AIR QUALITY

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SUMMARY

Air quality impacts that would result from site characterization activities and from the construction and operation of a high-level nuclear waste repository at Hanford are estimated using two simple atmospheric dispersion models, HANCHI and CHISHORT. Model results indicate that pollutant concentrations would not exceed ambient air quality standards at any point outside the Hanford fenceline or at any publicly accessible location within the Hanford Site. The increase in pollutant concentrations in nearby communities due to site activities would be minimal. HANCHI and CHISHORT are documented in the appendices of this document. Further study of the repository's impact on air quality will be conducted when more detailed project plans and work schedules are available.

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CONTENTS

SUMMARY	iii
ACKNOWLEDGMENTS	v
INTRODUCTION	1
AMBIENT AIR QUALITY STANDARDS	3
BACKGROUND CONCENTRATIONS OF POLLUTANTS	4
METEOROLOGICAL DATA	7
EMISSIONS DATA	9
MODEL SELECTION	14
THE HANCHI MODEL	14
THE CHISHORT MODEL	16
ESTIMATES OF ANNUAL POLLUTANT CONCENTRATIONS USING THE HANCHI MODEL	17
ESTIMATES OF SHORT-TERM POLLUTANT CONCENTRATIONS USING THE CHISHORT MODEL	25
CONCLUSIONS	30
REFERENCES	31
APPENDIX A - DOCUMENTATION OF THE HANCHI MODEL	A.1
APPENDIX B - DOCUMENTATION OF THE CHISHORT MODEL	B.1

FIGURES

1	Reference Repository Location (RRL) in the West-Central Portion of the Hanford Site.	2
2	Map of the Hanford Site and Surrounding Region	8

TABLES

1	Ambient Air Quality Standards and Maximum Measured Background Concentrations for the Hanford Site and Surrounding Area, mg/m ³	6
2	Summary of Maximum Annual Emissions During Site Characterization, t/yr	11
3	Maximum Annual and Short-term Emission Rates for Site Characterization	12
4	Source Strength of Nonradiological Pollutants Emitted During Repository Construction and Operation	13
5	Maximum Annual and Short-term Emission Rates for Repository Construction and Operation	13
6	Joint Frequency Distribution of Wind Direction and Speed Near Ground-level at the Hanford Meteorology Station	18
7	Joint Frequency Distribution of Wind Direction, Wind Speed, and Atmospheric Stability at the Hanford Meteorology Station.	19
8	Annual Average χ/Q (s/m ³) Calculated Using a Sector-average Model and Three Years of Ground-level Measurements of Data	22
9	Maximum Annual Pollutant Concentrations at Key Locations Resulting from Site Characterization Activities	23
10	Maximum Annual Pollutant Concentrations at Key Locations from Construction and Operation Activities	24
11	Maximum Short-term χ/Q (s/m ³)	26
12	Maximum Short-term Pollutant Concentrations at Key Locations Resulting from Site Characterization	27
13	Maximum Short-term Pollutant Concentrations at Key Locations Resulting from Construction and Operation Activities	29

INTRODUCTION

This report discusses the air quality impacts of the nonradiological pollutants that would be routinely emitted during site characterization and during the construction and operation of a high-level nuclear waste repository at Hanford. The pollutants considered in this preliminary study are sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and total suspended particulates (TSP). Estimates of the maximum concentrations of these pollutants are obtained using two simple atmospheric dispersion models, HANCHI and CHISHORT.

The high-level nuclear waste repository at Hanford would be sited in an area designated as the reference repository location (RRL) (Figure 1). Within the RRL, initial shaft drilling and all major construction would occur in an area designated as the exploratory shaft location. It is assumed that nearly all emissions from construction and operation of the facility would occur within this area. A transportation corridor, Washington State Highway 240, crosses the Hanford Area, and a 4-km (2.5-mi) stretch of the 2-lane highway passes through the southwestern corner of the RRL. At its closest point, the highway lies 1.5 km (0.9 mi) to the west of the center of the exploratory shaft location.

To estimate the ground-level pollutant concentrations that would result from repository activities, data are needed on site meteorology and pollutant emission parameters. An atmospheric dispersion model would use these data to calculate maximum pollutant concentrations. The choice of an appropriate model or models is based on the quantity and quality of the available data and the ability of candidate models to efficiently utilize these data.

In this report, an analysis of the repository's potential impact on air quality is presented. Increases in pollutant concentrations due to site activities are compared with the pertinent ambient air quality standards. Meteorological data, regional air quality, emission parameters, and the atmospheric dispersion models used in this analysis are discussed.

Figure 1. The Reference Repository Location (RRL) in the West-Central Portion of the Hanford Site. The locations of the Hanford Meteorology Station (♦) and three nearby telemetry stations (o) are shown. The ESL is the exploratory shaft location.

AMBIENT AIR QUALITY STANDARDS

National ambient air quality standards (AAQS) have been set by the U.S. Environmental Protection Agency (EPA), as mandated in the 1970 Clean Air Act. "Ambient air" is defined in the U.S. Code of Federal Regulations (1985) as "that portion of the atmosphere, external to buildings, to which the general public has access." The standards define levels of air quality that are necessary, with an adequate margin of safety, to protect the public health (primary standards) and the public welfare (secondary standards). Standards exist for sulfur oxides (measured as sulfur dioxide), nitrogen dioxide, carbon monoxide, total suspended particulates, lead, and ozone. For the four pollutants of concern in this study,^(a) the standards specify the maximum pollutant concentrations and frequencies of occurrence that are allowed for specific averaging periods (e.g., the concentration of carbon monoxide averaged over 1 h is allowed to exceed 40 mg/m^3 only once per year). The averaging periods vary from 1 h to 1 year, depending on the pollutant.

State and local governments have the authority to impose AAQS that are stricter than the national standards. Washington State standards for sulfur dioxide and total suspended particulates differ from national standards and are referred to in this report as supplemental state standards. The state standards for carbon monoxide and nitrogen dioxide are identical to the national standards. At the local level, the Tri-County (Benton-Franklin-Walla Walla) Air Pollution Control Authority has the power to tighten AAQS in the vicinity of the Hanford Site, but has established no local standards.

(a) Lead and ozone are not discussed in this report because significant concentrations of these pollutants will not result from repository activities.

BACKGROUND CONCENTRATIONS OF POLLUTANTS

To estimate the total concentration of a pollutant, it is necessary to consider the impact of local sources of the pollutant and the background concentration of the pollutant. Background concentrations of pollutants are due to natural and anthropogenic emissions in an area and to pollutants transported into the area from outside the region. Background concentrations vary depending on the level of pollutant emission in the area of concern, the level of pollutant emission in the regions that the air mass has passed through before entering the area of concern, and the degree of activity of chemical and meteorological processes that cleanse the air. In urban and industrial areas of a region, where there are many local sources of pollution, background concentrations are generally higher than in the rural areas of the same region.

At present, the only sources of pollution in the immediate vicinity of the proposed repository are those associated with preliminary site characterization activities, which are producing only slight increases in pollutant concentrations above background levels. No major activities are scheduled in the immediate area other than those associated with the repository. As a result, in the absence of emissions from repository-related activities, the concentration of air pollutants near the repository should be approximately equal to background concentrations.

Currently, only background concentrations of total suspended particulates and nitrogen dioxide are monitored on the Hanford Site. However, periodically during the past 10 years, carbon monoxide, sulfur dioxide, and nitrogen dioxide have been monitored in communities and commercial areas southeast of Hanford (U.S. NRC 1982). The offsite measurements were used in this study to estimate maximum background concentrations for the repository site. However, maximum background concentrations at the repository site would probably be somewhat lower than maximum offsite measurements because these measurements were made near local sources of pollution and during periods when pollutant emission rates were higher than current or projected values.

Background levels of total suspended particulates are measured at the Hanford Meteorology Station at a site well removed from local sources of

pollution. Particulate concentrations can reach relatively high levels in eastern Washington State because of exceptional natural events (i.e. duststorms, sandstorms, volcanic eruptions, and large brushfires) that periodically occur in the region. Washington State ambient air quality standards do not consider "rural fugitive dust" from exceptional natural events when estimating the maximum background concentrations of particulates in the area east of the Cascade mountain crest. Similarly, the EPA also exempts the rural fugitive dust component of background concentrations when considering permit applications and the enforcement of air quality standards.

Table 1 summarizes the pertinent AAQS (federal and supplemental state standards) and the maximum background concentrations that have been measured in the vicinity of the Hanford Site.

TABLE 1. Ambient Air Quality Standards and Maximum Measured Background Concentrations for the Hanford Site and the Surrounding Area, $\mu\text{g}/\text{m}^3$

	<u>National Primary Standard</u>	<u>National Secondary Standard</u>	<u>Supplemental State Standard</u>	<u>Maximum Background Concentration</u>
Nitrogen Dioxide (NO_2)				
Annual arithmetic mean	100	100	--	36
Sulfur Dioxide (SO_2)				
Annual arithmetic mean	80	80	52	0.5
24-h maximum ^(a)	365	365	260	6
3-h maximum ^(a)	--	1,300	--	20
1-h maximum ^(a)	--	--	1018	49
1-h maximum ^(b)	--	--	655	49
Carbon Monoxide (CO)				
8-h maximum ^(a)	10,000	10,000	--	6,500
1-h maximum ^(a)	40,000	40,000	--	11,800
Total Suspended Particulates (TSP)				
Annual geometric mean	75	60	40 + back.	37/20 ^(c)
24-h maximum ^(a)	260	150	120 + back.	<150/30 ^(c)

(a) Not to be exceeded more than once per year.

(b) Not to be exceeded more than two times in any consecutive 7 days.

(c) The higher values represent concentrations due to the occurrence of exceptional natural events (i.e., duststorms, brushfires). In the absence of such events, the maximum annual background concentration would generally not exceed $20 \mu\text{g}/\text{m}^3$ and the maximum 24-h background concentration would generally not exceed $30 \mu\text{g}/\text{m}^3$. For siting and enforcement purposes the EPA uses these lower values for eastern Washington state.

METEOROLOGICAL DATA

Meteorological data for the Hanford Site are collected and archived at the Hanford Meteorology Station. The station is located in the northeastern corner of the RRL and has been in operation for over 40 years (Stone et al. 1983). The station is the equivalent of a National Weather Service facility and is currently operated for the Department of Energy by Pacific Northwest Laboratory. At least one professional meteorologist is always on duty at the station. Climatological data from the 30-year period prior to the construction of the station are available because during that period meteorological measurements were made near the Hanford townsite (located by the Columbia River, in the northeastern portion of the current Hanford Site) by cooperative observers for the National Weather Service.

Parameters currently measured at or determined from the Hanford Meteorology Station include wind direction, wind speed, atmospheric temperature, moisture and pressure, precipitation, sky cover, solar radiation, and soil temperature. Hourly averaged values of wind direction, wind speed, and temperature are determined for seven levels on the station's 122-m (400-ft) tower. An acoustic sounder is used to measure the height of the atmosphere's mixed layer and to estimate meteorological parameters between 122 m and 600 m (2000 ft) above the surface. Since March 1982, measurements of wind direction and speed have been made at a height of 9 m (30 ft) above the ground at 21 meteorological substations located throughout the Hanford Site and in neighboring locations outside the Hanford fenceline (Figure 2). In order to more accurately determine the surface winds within the exploratory shaft location, the meteorological substation that was initially located in the 200-W Area was moved to a site within the exploratory shaft location in late 1985.

As a result of the comprehensive meteorological measurement and research program at Hanford, a large quantity of high quality data is available for comprehensive studies of atmospheric dispersion. These data should provide more than adequate meteorological input for the estimation of air quality impacts from activities within the RRL.

Figure 2. The Hanford Site (dashed line) and the reference repository location (solid line) are outlined in this map of the Hanford Site and surrounding region. The locations of the Hanford Meteorology Station (◆) and supporting telemetry station (○) are plotted. Also depicted are the Columbia and Yakima rivers and area highways.

EMISSIONS DATA

Site characterization activities are expected to be conducted over a period of approximately 6 years. During the third year of these activities, the work force would reach a maximum, site preparation, exploratory shaft drilling, hydrologic testing, underground development and other field activities would be under way. Emission rates for all major pollutants would reach their maximum values in the third year and would be at lower levels during the succeeding years. The third year of these activities is therefore used to assess maximum air quality impacts.

During the preparation of the site for site characterization activities, selective land clearing and road construction would occur. The potential air quality impacts during this phase of site characterization would be due to the emission of combustion by-products and the generation of dust by construction equipment.

Exploratory shaft drilling would involve the use of electric motors and would not result in the local emission of air pollutants. The material removed from the shafts would be moved to a spoils pile using a diesel-powered dragline. The material would consist primarily of basalt chips 0.6 to 1.2 cm (0.25 to 0.50 in.) in diameter with some finer particles. Spoils from the shaft would be wet and remain wet while being moved to the spoils pile. As a result, dust emissions would be minimal.

After the shaft drilling is complete, a steel liner would be installed and the space between the liner and rock wall would be filled with cement grout. This grout would be provided by a portable, closed system. The dry materials for the grout would be obtained from offsite sources. Emissions to the atmosphere from this operation would be small.

When the first shaft is completed, a series of drifts would be constructed. The material from these drifts would be moved to a spoils pile by truck. The trucks used for this task are assumed to be similar to those used in site preparation. The potential air quality impacts of this operation are related to emissions from the trucks and fugitive dust.

Ten or more borehole sites may be required for site characterization. Typical drilling activity is assumed to involve drilling several boreholes at a time. This activity is expected to peak in the third year of site characterization. The borehole drilling rigs use diesel power.

Many of the field activities during site characterization would require the use of light-duty vehicles (most likely gasoline-powered trucks) for transportation of people and equipment. These activities are also expected to be at their maximum in the third year of site characterization.

The total emissions from internal combustion engines predicted for the third year of site characterization activities are summarized in Table 2. These emissions have been estimated using preliminary plans for site characterization activities and EPA emission factors (EPA 1977). Activity descriptions are biased toward the maximum likely activity; emissions estimates are similarly biased (i.e., they overestimate the actual emissions that would result from site characterization activities).

In addition to emissions from internal combustion engines, it is necessary to consider the contribution of dust generated by surface activities to completely define potential air quality impacts caused by site characterization activities. Fugitive dust emissions are likely to occur during several of the site characterization activities. These emissions are estimated by analogy with operations for which the EPA has published emission factors and are based on the peak month of activity. Transporting the material from the underground development to the spoils pile, dumping the material, and maintaining the spoils pile are assumed to result in fugitive dust emissions that are not greater than those from similar operations at locations that maintain aggregate storage piles. Fugitive dust emissions from the dragline operation are assumed to be no greater than those from sand and gravel processing, and the potential emissions from the preparation of the grout should be less than those associated with concrete batching.

A summary of the potential maximum annual particulate emissions from the third year of site characterization is presented in Table 2. The value shown for the underground development does not account for a reduction in dust that

TABLE 2. Summary of Maximum Annual Emissions During Site Characterization, t/yr

<u>Combustion Sources</u>	<u>Carbon Monoxide</u>	<u>Nitrogen Dioxide</u>	<u>Sulfur Dioxide</u>	<u>Particulates</u>
Bulldozers	3.18	13.6	1.01	0.88
Heavy trucks	3.65	20.8	1.23	0.70
Dragline	2.51	11.6	0.77	0.83
Borehole drilling	21.8	100	6.71	7.21
Trucks	1.27	0.24	0.01	0.02
TOTALS	32.4	147	9.73	9.64

<u>Sources of Fugitive Dust</u>	<u>Particulates</u>
Site Preparation	16.8
Underground Development	31.5
Dragline Operation	0.7
Grout Preparation	0.1
TOTAL	49.1

would result from combining the wet spoils material from the exploratory shaft with material from the drifts. Frequent watering of the spoils pile would assure that the dust is held to a minimum.

Maximum annual and short-term (periods of no more than 24-h) emission rates for site characterization activities are summarized in Table 3. Short-term emission rates were obtained assuming a uniform emission rate during 260 work days a year, each work day being 8-h long. This assumption would tend to overestimate emission rates for activities that involve more than one shift a day or weekend operations. By combining emission rates from various operations to obtain a single emission rate, we are combining activities that would probably be performed at different locations within the repository area. This assumption results in the simulation of overly dense pollution plumes, which causes significant overestimations of environmental impacts. Because exact locations for site activities are not currently available, this conservative assumption (involving biases that overestimate concentrations) was deemed appropriate.

TABLE 3. Maximum Annual and Short-term Emission Rates for Site Characterization

Pollutant	Annual		24-h ^(a)	8-h ^(b)	3- and 1-h ^(b)
	(t/yr)	($\mu\text{g/s}$)	($\mu\text{g/s}$)	($\mu\text{g/s}$)	($\mu\text{g/s}$)
CO	32.4	1.0×10^6	— — — — (c)	4.3×10^6	4.3×10^6
NO ₂	147	4.7×10^6	— — — — (c)	(c)	(c)
SO ₂	9.73	3.1×10^5	4.3×10^5	— — — — (c)	1.3×10^6
TSP	58.7	1.9×10^6	2.6×10^6	— — — — (c)	(c)

- (a) Assumes 260 work days per year. The use of a higher figure, which would be appropriate for some site characterization activities, would produce lower emission rates and lower maximum pollutant concentrations.
- (b) Assumes all emissions occur during one 8-hour shift per day. Uniform emissions are assumed during the period. The assumption of more than one shift per day, which would be appropriate for some site characterization activities, would produce lower emission rates and lower maximum pollutant concentrations.
- (c) A maximum emission rate is not computed because the pollutant does not have an ambient air quality standard for this period of time.

Plans for facility construction and operation activities are less well defined than those for site characterization. This phase of the project would follow site characterization and would last for many years. Morrison Knudsen Company (MKC) examined the available information on construction and operation activities for the proposed repository and provided preliminary estimates of annual emissions for each year of facility construction and operation (Larvie 1985). From these annual-emission figures, maximum annual, weekly, and daily emission rates for each pollutant were calculated assuming a typical work schedule. These values are summarized in Table 4. The emission rates in the table represent the best estimates of project emissions that could be made at the time of this study. More accurate estimates of emission rates and release locations will be possible after additional work is done in planning and scheduling project activities. The estimates of maximum emission rates derived by MKC engineers are conservative; these values may differ from future estimates by a significant percentage.

TABLE 4. Source Strength of Nonradiological Pollutants Emitted During Repository Construction and Operation. Maximum values are estimated from preliminary construction and operation plans.

Pollutant	Annual Max. (kg/yr)	Weekly Max. (kg/wk)	Daily Max. (kg/d)
Carbon Monoxide	25,000	490	100
Sulfur Dioxide	6,300	120	25
Nitrogen Dioxide	92,000	1,800	350
Total Suspended Particulates	650,000	13,000	2,600

Maximum emission rates for 1-, 3-, and 8-h periods could not be directly estimated from project plans; these values had to be determined from estimates of maximum daily emissions. As for site characterization activities, MKC conservatively assumed that all emissions during the work day would occur in an 8-h work period. MKC also assumed that the maximum 3-h and 1-h emission rates would equal the maximum 8-h emission rate. Annual and short-term maximum emission rates for facility construction and operation activities are presented in Table 5.

TABLE 5. Maximum Annual and Short-term Emission Rates for Repository Construction and Operation

Pollutant	Annual		24-h (a)	8-h (b)	3- and 1-h (b)
	(t/yr)	($\mu\text{g/s}$)	($\mu\text{g/s}$)	($\mu\text{g/s}$)	($\mu\text{g/s}$)
CO	25	7.9×10^5	(c)	4.3×10^6	3.3×10^6
NO ₂	92	2.9×10^6	(c)	(c)	(c)
SO ₂	6.3	2.0×10^5	2.8×10^5	(c)	8.4×10^5
TSP	650	2.1×10^7	2.9×10^7	(c)	(c)

- (a) Assumes 260 work days per year. The use of a higher figure, which would be appropriate for some construction and operation activities, would produce lower emission rates and lower maximum pollutant concentrations.
- (b) Assumes all emissions occur during one 8-hour shift per day. Uniform emissions are assumed during the period. The assumption of more than one shift per day, which would be appropriate for some construction and operation activities, would produce lower emission rates and lower maximum pollutant concentrations.
- (c) A maximum emission rate is not computed because the pollutant does not have an ambient air quality standard for this period of time.

MODEL SELECTION

Two types of computer models were available for analyzing atmospheric dispersion and calculating the resulting maximum pollutant concentrations: 1) a complex dispersion model that would take advantage of detailed emissions, meteorological, and terrain data, and 2) a simple dispersion model that requires only limited emission and meteorological data. Simple models do not simulate atmospheric processes as thoroughly as more complex models, but the small data set they require and the short amount of time they take to simulate air quality impacts make them the first choice in preliminary studies. For this reason, two simple dispersion models were selected for this preliminary study. A more complex dispersion model will be used in follow-up studies when improved estimates of emission parameters are available.

The two simple dispersion models used in this study are FORTRAN programs that use standard Gaussian straight-line parameterizations to compute pollutant concentrations. The first model, HANCHI, was used to compute annual pollutant concentrations of sulfur dioxide, nitrogen dioxide, and total suspended particulates. The meteorological data used by the model included hourly measurements of wind direction, wind speed, and atmospheric stability from the Hanford Meteorology Station. The second model, CHISHORT, determines short-term, maximum pollutant concentrations using simulated meteorological data input by the user. This model was used to estimate the maximum pollutant concentrations for periods of 1 and 8 h for carbon monoxide, 1, 3 and 24 h for sulfur dioxide, and 24 h for total suspended particulates.

THE HANCHI MODEL

The first version of HANCHI was developed in late 1982. The model provides estimates of average normalized pollutant concentrations ($\bar{x}/Q$). It can be used to study the short-term impact on air quality of actual releases or to determine the average impact of routine releases over the course of many years.

HANCHI has undergone testing to verify that it operates correctly using a variety of data sets. Model results have been published previously

(McCormick et al. 1984) and have been used in work conducted by Hanford radiological researchers. Documentation of the model is given in Appendix A of this report.

The model computes χ/Q values using both the sector average and centerline approaches. Both approaches assume a Gaussian distribution of pollutant concentration in vertical cross sections of the plume. They also assume a constant emission rate and total reflection of the pollutant by the ground. The centerline approach assumes a Gaussian distribution in the horizontal plane and a constant wind direction. The sector average approach assumes a meandering wind that leads to a horizontally uniform distribution within a 22.5° sector. Pollution concentrations can be determined by multiplying χ/Q values by estimated emission rates (Q).

$$(\chi/Q)_{\text{sector average}} = 2.032 / (\sigma_z * x * u)$$

$$(\chi/Q)_{\text{centerline}} = 1 / (\sigma_z * \sigma_y * u * \pi)$$

where χ = pollutant concentration ($\mu\text{g}/\text{m}^3$)

Q = emission rate ($\mu\text{g}/\text{m}^3$)

σ_z = vertical diffusion coefficient (m)

σ_y = horizontal diffusion coefficient (m)

x = distance downwind (m)

u = wind speed at time of release (m/s)

π = approximately 3.14

The diffusion coefficients are computed using the approach adopted by the U.S. Nuclear Regulatory Commission and described in Ramsdell et al. (1983, p. 163).

To compute χ/Q values, HANCHI reads meteorological information from two files, a file of surface observations from Hanford wind measurement stations and a file of meteorological measurements from the 122-m (400-ft) weather tower. Winds are categorized into 16 direction sectors, with the first 22.5° sector centered at true north. Wind speeds are categorized into eight categories. Atmospheric stability is given in terms of the seven

Pasquill-Gifford stability categories (U.S. Atomic Energy Commission 1968). The model uses the meteorological information to compute a joint frequency distribution of wind direction, wind speed, and atmospheric stability for the period being studied. After computing the joint frequency distribution, the model calculates intermediate χ/Q values for all possible combinations of wind direction category, wind speed class, atmospheric stability class, and user-specified downwind distances. A maximum of 10 downwind distances may be input by the user. The intermediate χ/Q values are multiplied by their corresponding frequency of occurrence (from the joint frequency distribution) and summed to give an average χ/Q for each model grid point.

In the current version of the model, intermediate χ/Q values and frequencies of occurrence can be used to determine the χ/Q values that are exceeded 50%, 10%, 5%, and 1% of the time during the simulation period at each grid point.

THE CHISHORT MODEL

CHISHORT is a simple model developed in early 1985 to quickly perform calculations previously done using a hand-held calculator. The model is designed to provide estimates of pollutant concentration for short averaging periods (24 h or less). The CHISHORT model calculates pollutant concentration using the same sector average and centerline formulas as are used in the HANCHI model. Meteorological conditions are input by the user and are assumed to persist throughout the simulation. CHISHORT has undergone testing to verify that it operates correctly using a variety of data sets. Model results have been used in work conducted by Hanford radiological researchers. Documentation of the model appears in Appendix B of this report.

ESTIMATES OF ANNUAL POLLUTANT CONCENTRATIONS USING THE HANCHI MODEL

Annual normalized pollutant concentrations (χ/Q) were computed using three years of hourly meteorological measurements that were made within the RRL at the Hanford Meteorology Station. The meteorological data were collected between April 1, 1982, and March 31, 1985. The joint frequency distribution of wind direction (using the direction the wind comes from) and wind speed for this 3-year period is given in Table 6. The joint frequency distribution of wind direction, wind speed, and atmospheric stability (using the Pasquill-Gifford categorization) for the period is given in Table 7. The HANCHI model was run assuming emitted pollutants were chemically inactive and nondepositing. Model results were later multiplied by maximum emission rates to convert normalized concentrations into actual pollutant concentrations. Concentrations were computed at eight distances from the repository in each of 16 transport sectors. The eight distances were chosen because each represents the closest publicly accessible location in at least one of the 16 transport sectors. An effective release height of 3 m (10 ft) was assumed for all pollutant emissions. Releases were conservatively chosen to occur at one location, rather than from scattered sites within the RRL (which would be more typical of the construction activities that would be the dominant sources of the pollutants). The annual average normalized concentrations for each transport sector and downwind distance are presented in Table 8.

The maximum annual air quality impact at a publicly accessible location (as indicated by the highest normalized pollutant concentration) would occur 1.5 km (0.9 mi) to the west of the repository along Highway 240. The largest air quality impact along the Columbia River on the eastern border of the Hanford Site would occur 22.5 km (13.9 mi) to the east of the repository and would be less than 6% of the maximum impact along Highway 240. The largest air quality impact near the 300 Area, just north of the city of Richland (44 km (27 mi) to the southeast of the repository), would be only 2% of the maximum impact along Highway 240.

TABLE 6. Joint Frequency Distribution of Wind Direction and Speed Near Ground-level at the Hanford Meteorology Station

WIND CLASS	WIND DIRECTION															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	.02020	.01333	.01090	.01020	.01419	.01516	.01408	.00981	.01193	.00861	.01035	.01303	.01803	.01877	.01640	.01892
2	.02667	.01505	.01229	.01059	.01582	.01493	.01881	.01617	.01982	.01501	.01865	.03133	.05991	.06135	.06146	.03509
3	.04733	.00613	.00411	.00252	.00182	.00178	.00461	.00613	.00527	.00779	.01183	.02431	.03389	.04832	.05042	.01346
4	.04110	.00182	.00147	.00081	.00088	.00000	.00027	.00124	.00198	.00469	.00981	.01206	.00830	.01567	.02462	.00330
5	.00010	.00012	.00039	.00023	.00000	.00000	.00000	.00016	.00035	.00213	.00365	.01325	.00109	.00252	.00061	.00039
6	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00004	.00004	.00039	.00043	.00066	.00047	.00023	.00120	.00000
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00004	.00008	.00000	.00000	.00000	.00000	.00000	.00000
8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

WIND CLASS 1 = WIND SPEEDS LESS THAN 4 MPH
WIND CLASS 2 = WIND SPEEDS GREATER THAN OR EQUAL TO 4 MPH AND LESS THAN 8 MPH
WIND CLASS 3 = WIND SPEEDS GREATER THAN OR EQUAL TO 8 MPH AND LESS THAN 13 MPH
WIND CLASS 4 = WIND SPEEDS GREATER THAN OR EQUAL TO 13 MPH AND LESS THAN 19 MPH
WIND CLASS 5 = WIND SPEEDS GREATER THAN OR EQUAL TO 19 MPH AND LESS THAN 25 MPH
WIND CLASS 6 = WIND SPEEDS GREATER THAN OR EQUAL TO 25 MPH AND LESS THAN 32 MPH
WIND CLASS 7 = WIND SPEEDS GREATER THAN OR EQUAL TO 32 MPH AND LESS THAN 39 MPH
WIND CLASS 8 = WIND SPEEDS GREATER OR EQUAL TO 39 MPH

TABLE 7. Joint Frequency Distribution of Wind Direction, Wind Speed, and Atmospheric Stability at the Hanford Meteorology Station (Based on Three Years of Ground-level Measurements)

STABILITY CLASS 1

WIND CLASS	N	NNE	NE	ENE	E	ESE	WIND DIRECTION SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	.00089	.00074	.00054	.00050	.00078	.00109	.00050	.00039	.00047	.00027	.00043	.00027	.00039	.00027	.00054	.00050
2	.00080	.00045	.00018	.00053	.00043	.00039	.00049	.00064	.00036	.00033	.00052	.00027	.00030	.00029	.00043	.00047
3	.00021	.00048	.00017	.00078	.00056	.00054	.00062	.00058	.00120	.00140	.00299	.00411	.00333	.00194	.00057	.00045
4	.00035	.00066	.00058	.00012	.00008	.00000	.00004	.00012	.00023	.00050	.00213	.00330	.00186	.00186	.00033	.00014
5	.00000	.00000	.00008	.00012	.00000	.00000	.00000	.00000	.00000	.00012	.00081	.00089	.00039	.00012	.00014	.00016
6	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00004	.00023	.00000	.00000	.00000	.00000
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

STABILITY CLASS 2

WIND CLASS	N	NNE	NE	ENE	E	ESE	WIND DIRECTION SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	.00186	.00174	.00085	.00151	.00116	.00112	.00101	.00066	.00097	.00054	.00058	.00039	.00074	.00066	.00050	.00120
2	.00000	.00007	.00018	.00174	.00240	.00198	.00159	.00194	.00260	.00182	.00198	.00178	.00174	.00221	.00030	.00049
3	.00119	.00035	.00058	.00050	.00023	.00008	.00039	.00027	.00027	.00105	.00074	.00225	.00132	.00081	.00186	.00124
4	.00004	.00012	.00016	.00008	.00000	.00000	.00000	.00012	.00004	.00027	.00054	.00078	.00039	.00031	.00101	.00047
5	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00031	.00004	.00000	.00000	.00000	.00000
6	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00012	.00012	.00000	.00000	.00000	.00000
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

STABILITY CLASS 3

WIND CLASS	N	NNE	NE	ENE	E	ESE	WIND DIRECTION SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	.00237	.00148	.00182	.00089	.00147	.00120	.00124	.00070	.00058	.00050	.00081	.00081	.00097	.00054	.00101	.00190
2	.00000	.00000	.00016	.00128	.00178	.00101	.00182	.00101	.00124	.00066	.00089	.00136	.00151	.00186	.00088	.00037
3	.00000	.00000	.00035	.00051	.00023	.00004	.00023	.00047	.00023	.00043	.00070	.00097	.00194	.00124	.00076	.00178
4	.00016	.00000	.00028	.00034	.00000	.00000	.00000	.00004	.00004	.00016	.00054	.00078	.00047	.00051	.00109	.00023
5	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00004	.00004	.00004	.00000	.00039	.00000
6	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00004	.00000	.00000	.00000
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

WIND CLASS 1 = WIND SPEEDS LESS THAN 4 MPH
WIND CLASS 2 = WIND SPEEDS GREATER THAN OR EQUAL TO 4 MPH AND LESS THAN 8 MPH
WIND CLASS 3 = WIND SPEEDS GREATER THAN OR EQUAL TO 8 MPH AND LESS THAN 13 MPH
WIND CLASS 4 = WIND SPEEDS GREATER THAN OR EQUAL TO 13 MPH AND LESS THAN 19 MPH
WIND CLASS 5 = WIND SPEEDS GREATER THAN OR EQUAL TO 19 MPH AND LESS THAN 25 MPH
WIND CLASS 6 = WIND SPEEDS GREATER THAN OR EQUAL TO 25 MPH AND LESS THAN 32 MPH
WIND CLASS 7 = WIND SPEEDS GREATER THAN OR EQUAL TO 32 MPH AND LESS THAN 39 MPH
WIND CLASS 8 = WIND SPEEDS GREATER OR EQUAL TO 39 MPH

TABLE 7. (Continued)

STABILITY CLASS 4

WIND CLASS	WIND DIRECTION															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	.00450	.00562	.00461	.00465	.00605	.00628	.00640	.00388	.00442	.00275	.00322	.00438	.00620	.00822	.00725	.00803
2	.00548	.00348	.00207	.00260	.00384	.00337	.00465	.00419	.00403	.00283	.00322	.00558	.01276	.01665	.02260	.01086
3	.00215	.00190	.00097	.00054	.00054	.00058	.00132	.00198	.00163	.00318	.00427	.00803	.01105	.02164	.02255	.00399
4	.00047	.00250	.00047	.00054	.00000	.00000	.00019	.00074	.00109	.00326	.00485	.00543	.00392	.01043	.01412	.00140
5	.00000	.00000	.00000	.00012	.00000	.00000	.00000	.00000	.00016	.00155	.00206	.00116	.00058	.00229	.00547	.00023
6	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00035	.00023	.00031	.00035	.00023	.00047	.00000
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

STABILITY CLASS 5

WIND CLASS	WIND DIRECTION															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	.00302	.00171	.00163	.00140	.00240	.00271	.00240	.00256	.00318	.00244	.00264	.00372	.00481	.00477	.00388	.00392
2	.00310	.00101	.00101	.00085	.00178	.00287	.00279	.00318	.00473	.00268	.00333	.00845	.01850	.01764	.01260	.00514
3	.00101	.00023	.00031	.00031	.00012	.00043	.00097	.00104	.00128	.00109	.00237	.00473	.01092	.01656	.01140	.00194
4	.00010	.00050	.00012	.00010	.00000	.00000	.00004	.00012	.00050	.00050	.00163	.00143	.00140	.00271	.00489	.00035
5	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00012	.00035	.00043	.00012	.00000	.00023	.00097	.00000
6	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00004	.00004	.00000	.00000	.00000	.00016	.00000
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

WIND CLASS 1 = WIND SPEEDS LESS THAN 4 MPH
 WIND CLASS 2 = WIND SPEEDS GREATER THAN OR EQUAL TO 4 MPH AND LESS THAN 8 MPH
 WIND CLASS 3 = WIND SPEEDS GREATER THAN OR EQUAL TO 8 MPH AND LESS THAN 13 MPH
 WIND CLASS 4 = WIND SPEEDS GREATER THAN OR EQUAL TO 13 MPH AND LESS THAN 19 MPH
 WIND CLASS 5 = WIND SPEEDS GREATER THAN OR EQUAL TO 19 MPH AND LESS THAN 25 MPH
 WIND CLASS 6 = WIND SPEEDS GREATER THAN OR EQUAL TO 25 MPH AND LESS THAN 32 MPH
 WIND CLASS 7 = WIND SPEEDS GREATER THAN OR EQUAL TO 32 MPH AND LESS THAN 39 MPH
 WIND CLASS 8 = WIND SPEEDS GREATER OR EQUAL TO 39 MPH

TABLE 7. (Continued)

STABILITY CLASS 6

WIND CLASS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	.00237	.00097	.00043	.00081	.00143	.00209	.00225	.00124	.00167	.00147	.00194	.00252	.00403	.00283	.00225	.00260
2	.00132	.00047	.00031	.00097	.00120	.00302	.00226	.00260	.00322	.00438	.00534	.01629	.01346	.01660	.02496	
3	.00019	.00004	.00027	.00008	.00012	.00074	.00124	.00050	.00047	.00047	.00287	.00423	.00450	.00535	.00112	
4	.00004	.00000	.00000	.00000	.00000	.00000	.00000	.00012	.00008	.00000	.00012	.00035	.00027	.00004	.00016	.00012
5	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00004	.00004	.00000	.00000	.00000	.00000	.00000	.00000	.00000
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

STABILITY CLASS 7

WIND CLASS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	.00089	.00054	.00031	.00043	.00081	.00066	.00027	.00059	.00054	.00062	.00074	.00093	.00089	.00147	.00097	.00078
2	.00062	.00047	.00031	.00019	.00074	.00050	.00124	.00116	.00155	.00147	.00233	.00310	.00609	.00523	.00434	.00171
3	.00012	.00004	.00000	.00000	.00000	.00000	.00035	.00050	.00016	.00019	.00031	.00136	.00112	.00153	.00217	.00043
4	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
5	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

WIND CLASS 1 = WIND SPEEDS LESS THAN 4 MPH
 WIND CLASS 2 = WIND SPEEDS GREATER THAN OR EQUAL TO 4 MPH AND LESS THAN 8 MPH
 WIND CLASS 3 = WIND SPEEDS GREATER THAN OR EQUAL TO 8 MPH AND LESS THAN 13 MPH
 WIND CLASS 4 = WIND SPEEDS GREATER THAN OR EQUAL TO 13 MPH AND LESS THAN 19 MPH
 WIND CLASS 5 = WIND SPEEDS GREATER THAN OR EQUAL TO 19 MPH AND LESS THAN 25 MPH
 WIND CLASS 6 = WIND SPEEDS GREATER THAN OR EQUAL TO 25 MPH AND LESS THAN 32 MPH
 WIND CLASS 7 = WIND SPEEDS GREATER THAN OR EQUAL TO 32 MPH AND LESS THAN 39 MPH
 WIND CLASS 8 = WIND SPEEDS GREATER OR EQUAL TO 39 MPH

TABLE 8. Annual average X/Q (s/m³) Calculated Using A Sector-Average Model and Three Years of Ground-level Measurements of Data from the Hanford Meteorology Station

RELEASE HEIGHT: 3 M

TRANSPORT SECTOR	1500.M	1800.M	3400.M	6000.M	9400.M	12000.M	22500.M	44000.M
S	1.26E-06	9.30E-07	4.07E-07 HAN 240	1.40E-07	7.15E-08	4.99E-08	2.02E-08	7.55E-09
SSW	7.36E-07	5.42E-07 HAN 240	2.36E-07	8.01E-08	4.07E-08	2.83E-08	1.13E-08	4.38E-09
SW	6.40E-07	4.42E-07	1.92E-07 HAN 240	6.53E-08	3.32E-08	2.31E-08	9.23E-09	3.55E-09
WSW	5.47E-07 HAN 240	4.03E-07	1.76E-07	6.00E-08	3.05E-08	2.13E-08	8.52E-09	3.29E-09
W	6.71E-07 HAN 240	6.44E-07	2.83E-07	9.79E-08	5.03E-08 HAN, BOR	3.52E-08	1.43E-08	5.60E-09
WNW	9.33E-07	6.90E-07	3.05E-07 HAN 240	1.06E-07	5.46E-08	3.83E-08	1.56E-08	6.14E-09
NW	1.01E-06	7.51E-07	3.32E-07	1.16E-07 YAK, BAR	5.46E-08	4.18E-08	1.71E-08	6.72E-09
WNW	8.17E-07	6.05E-07	2.69E-07	9.38E-08	4.85E-08	3.41E-08 VERNITA	1.40E-08	5.52E-09
N	9.69E-07	7.32E-07	3.25E-07	1.14E-07	5.91E-08	4.16E-08 VERNITA	1.71E-08	6.78E-09
NNE	8.44E-07	6.26E-07	2.79E-07	9.83E-08	5.12E-08	3.61E-08	1.49E-08 COLUMBIA	5.96E-09
NE	1.04E-06	8.00E-07	3.57E-07	1.26E-07	6.57E-08	4.64E-08	1.92E-08 COLUMBIA	7.69E-09
ENE	1.08E-06	1.24E-06	5.56E-07	1.97E-07	1.03E-07	7.27E-08	3.02E-08 COLUMBIA	1.21E-08
E	2.77E-06	2.01E-06	8.99E-07	3.19E-07	1.67E-07	1.18E-07	4.91E-08 COLUMBIA	1.97E-08
ESE	2.54E-06	2.14E-06	9.56E-07	3.37E-07	1.75E-07	1.23E-07	5.09E-08 WYE BAR,	2.02E-08
SE	2.54E-06	1.80E-06	8.36E-07	2.92E-07	1.51E-07	1.06E-07	4.34E-08	1.71E-08 300 AREA
SSE	1.54E-06	1.17E-06	5.17E-07 HAN 240	1.79E-07	9.25E-08	6.49E-08	2.65E-08	1.04E-08

Multiplying annual normalized concentrations (from Table 8) by the maximum annual emission rate for each pollutant (from Table 3 and Table 5), we obtain maximum annual pollutant concentrations. In Table 9 we present the maximum annual pollutant concentrations due to site characterization activities at three key locations. In Table 10 we present the same information for facility construction and operation emissions. At these key publicly accessible locations, all maximum annual pollutant concentrations are predicted to be well below the limits set in ambient air quality standards. The increase in pollutant concentrations in populated areas would be orders of magnitude below the limits set in the standards.

In this preliminary study, simple conservative assumptions were made because of model limitations and uncertainties in emission parameters. As a result, the maximum annual pollutant concentrations presented in Tables 9 and 10 are overestimated. By assuming pollutants are nondepositing, we are especially overestimating the annual impact of particulates. At distances of 22.5 km or more from the release point, annual particulate concentrations may be overestimated by an order of magnitude. Further study, using a more advanced dispersion model, would probably predict much lower particulate concentrations than have been obtained in this preliminary analysis.

TABLE 9. Maximum Annual Pollutant Concentrations at Key Locations Resulting from Site Characterization Activities

<u>Pollutant</u>	<u>Maximum Annual Emission Rate ($\mu\text{g/s}$)</u>	<u>Maximum Increase in Pollutant Concentration at Points of Public Access (Max. Annual Emission Rate) $\times$ (χ/Q)</u>		
		<u>1.5 km ($\mu\text{g/m}^3$)</u>	<u>22.5 km ($\mu\text{g/m}^3$)</u>	<u>44 km ($\mu\text{g/m}^3$)</u>
NO ₂	4.7×10^6	4.1	0.2	0.1
SO ₂	3.1×10^5	0.3	0.2	<0.1
TSP(a)	1.9×10^6	1.6	0.1	<0.1

(a) Dry deposition not assumed.

Note: CO does not have an annual ambient air quality standard.

TABLE 10. Maximum Annual Pollutant Concentrations At Key Locations
Resulting from Construction and Operation Activities

<u>Pollutant</u>	<u>Maximum Annual Emission Rate ($\mu\text{g/s}$)</u>	<u>Maximum Increase in Pollutant Concentrations at Points of Public Access (Max. Annual Emission Rate) x (χ/Q)</u>		
		<u>1.5 km ($\mu\text{g/m}^3$)</u>	<u>22.5 km ($\mu\text{g/m}^3$)</u>	<u>44 km ($\mu\text{g/m}^3$)</u>
NO ₂	2.9×10^6	2.5	0.1	<0.1
SO ₂	2.0×10^5	18	1.1	0.4
TSP(a)	2.1×10^7	0.2	<0.1	<0.1

(a) Dry deposition not assumed.

Note: CO does not have an annual ambient air quality standard .

ESTIMATES OF SHORT-TERM POLLUTANT CONCENTRATIONS USING THE CHISHORT MODEL

Maximum short-term normalized pollutant concentrations (χ/Q) were computed using the CHISHORT model. An effective release height of 3 m (10 ft) was assumed for all pollutant emissions. Releases were conservatively chosen to occur at one location, and pollutant concentrations were computed at the same eight distances downwind from the release point that were used in the analysis of annual impacts. The model assumed all pollutants were chemically inactive and nondepositing. Pollutant concentrations were computed for each Pasquill-Gifford classification of atmospheric stability using wind speeds of 0.5, 1.0, 1.5, 2.0, and 2.5 m/s (1.1, 2.2, 3.4, 4.5, and 5.6 mph). The lowest value, 0.5 m/s, represents the lowest non-zero wind speed archived in the Hanford meteorological data base. At lower speeds the direction of the wind tends to be unsteady, dispersing pollutants into more than one transport sector; these conditions result in lower pollutant concentrations than would be produced by a 0.5-m/s wind of constant direction.

Using the parameterizations discussed above, the model determined that the maximum short-term normalized concentrations would occur during very stable atmospheric stratifications (Class F stability). Computed values at each downwind distance, using five wind speeds and stability class F, are presented in Table 11. Results indicate that the maximum short-term air quality impact at a publicly accessible location would occur 1.5 km (0.9 mi) to the west of the repository along Highway 240. The maximum short-term air quality impact outside the Hanford fenceline would occur 9.4 km (5.8 mi) from the repository and would be less than 7% of the maximum impact along Highway 240. The largest air quality impact along the Columbia River at the eastern border of the Hanford Site would occur 22.5 km (13.9 mi) to the east of the repository and would be about 2% of the impact along Highway 240. The maximum impact near the 300 Area, just north of the city of Richland (44 km (27 miles) southeast of the repository), would be less than 1% of the impact along Highway 240.

TABLE 11. Maximum Short-Term χ/Q (s/m^3)

Distance Downwind (m)	χ/Q (s/m^3) assuming stability class F and a wind speed (u) of :				
	2.5 m/s	2.0 m/s	1.5 m/s	1.0 m/s	0.5 m/s
1500	2.9×10^{-5}	3.6×10^{-5}	4.8×10^{-5}	7.3×10^{-5}	1.4×10^{-4}
1800	2.1×10^{-5}	2.7×10^{-5}	3.6×10^{-5}	5.3×10^{-5}	1.1×10^{-4}
6000	3.6×10^{-6}	4.5×10^{-6}	6.0×10^{-6}	8.9×10^{-6}	1.8×10^{-5}
9400	1.9×10^{-6}	2.4×10^{-6}	3.2×10^{-6}	4.8×10^{-6}	9.6×10^{-6}
12000	1.4×10^{-6}	1.7×10^{-6}	2.3×10^{-6}	3.4×10^{-6}	6.9×10^{-6}
22500	5.9×10^{-7}	7.4×10^{-7}	9.9×10^{-7}	1.5×10^{-6}	3.0×10^{-6}
44000	2.5×10^{-7}	3.1×10^{-7}	4.1×10^{-7}	6.2×10^{-7}	1.2×10^{-6}

Distance
Downwind
(m)

Corresponding Locations

1500	- Value for point of closest public access (along HW 240)
1800	- Maximum value along RRL fenceline
6000	- Value at the Yakima Barricade
9400	- Maximum value along the Hanford fenceline
12000	- Value at the Vernita Bridge
22500	- Value at the Wye Barricade and on the Columbia River at the eastern border of the Hanford Site
44000	- Value at the 300 Area

Multiplying normalized concentrations (from Table 11) by the maximum short-term emission rates for each pollutant (from Table 3 and Table 5), we obtain maximum short-term pollutant concentrations for nondepositing pollutants. To avoid unwarranted overestimations of particulate concentrations, the maximum short-term values for particulates were multiplied by a deposition factor to correct for depletion by dry deposition. This correction is especially warranted when large fugitive dust particles, with significant settling velocities, are the dominant particulates.

Deposition factors are a function of stability, wind speed, distance downwind from the source, and release height. Because the amount of material deposited by gravitational settling over a specific distance increases with increasing atmospheric stability and decreasing wind speed, the maximum short-term particulate concentration may not necessarily occur during class F stability and low wind speeds, as it does for nondepositing pollutants.

To ensure that maximum particulate concentrations are not underestimated, we used very conservative deposition factors in our analysis. These factors were based on the material presented in Meteorology and Atomic Energy (U.S. Atomic Energy Commission 1968).

In Table 12 we present the range of maximum potential short-term pollutant concentrations caused by site characterization emissions at three key locations. In Table 13 we present the same for emissions made during the facility construction and operation phase of project activities. At the key publicly accessible locations, the entire range of maximum pollutant concentrations are predicted to be well within ambient air quality standards. The increases in pollutant concentrations in populated areas would be orders of magnitude below the limits set in ambient air quality standards.

TABLE 12. Maximum Short-term Pollutant Concentrations at Key Locations Resulting from Site Characterization

USING THE HIGHEST WIND SPEED IN THE STUDIED RANGE: $u = 2.5$ m/s

Pollutant	Time Period (h)	Maximum Emission Rate ($\mu\text{g/s}$)	Maximum Increase in Pollutant Concentrations at Points of Public Access (Maximum Emission Rate) $\times$ (χ/Q)		
			at 1.5 km	at 22.5 km	at 44 km
			($\mu\text{g/m}^3$)	($\mu\text{g/m}^3$)	($\mu\text{g/m}^3$)
SO ₂	24(a)	4.3×10^5	3.1	0.1	<0.1
	3 and 1	1.3×10^6	38	0.8	0.3
CO	8(a)	4.3×10^6	93	1.9	0.8
	1	4.3×10^6	120	2.5	1.1
TSP	24(a)	2.6×10^6	7.5(b)	<0.1(b)	<0.1(b)

USING THE LOWEST WIND SPEED IN THE STUDIED RANGE: $u = 0.5$ m/s

Pollutant	Time Period (h)	Maximum Emission Rate ($\mu\text{g/s}$)	Maximum Increase in Pollutant Concentrations at Points of Public Access (Maximum Emission Rate) $\times$ (χ/Q)		
			at 1.5 km	at 22.5 km	at 44 km
			($\mu\text{g/m}^3$)	($\mu\text{g/m}^3$)	($\mu\text{g/m}^3$)
SO ₂	24(a)	4.3×10^5	15	0.3	<0.1
	3 and 1	1.3×10^6	180	3.9	1.6
CO	8(a)	4.3×10^6	450	9.7	3.9
	1	4.3×10^6	600	13	5.2
TSP	24(a)	2.6×10^6	9.1(b)	0.1(b)	<0.1(b)

- (a) Transport of the pollutant plume into a 22.5° sector is restricted to a maximum of 6 hours per day.
- (b) Concentrations are multiplied by very conservative dry deposition factors. For a wind speed of 2.5 m/s, it is assumed that 60% of the particulates are deposited within 1.5 km of source, and 90% at distances greater than or equal to 22.5 km. For a wind speed of 0.5 m/s, it is assumed that 90% of the particulates are deposited within 1.5 km of source, and 97% at distances greater than or equal to 22.5 km.

TABLE 13. Maximum Short-term Pollutant Concentrations At Key Locations Resulting from Construction and Operation Activities

USING THE HIGHEST WIND SPEED IN THE STUDIED RANGE: $u = 2.5 \text{ m/s}$

Pollutant	Time Period (h)	Maximum Emission Rate ($\mu\text{g/s}$)	Maximum Increase in Pollutant Concentrations at Points of Public Access (Maximum Emission Rate) $\times$ (y/Q) ^a		
			at 1.5 km	at 22.5 km	at 44 km
			($\mu\text{g/m}^3$)	($\mu\text{g/m}^3$)	($\mu\text{g/m}^3$)
SO ₂	24 ^(a)	2.8×10^5	2.0	<0.1	<0.1
	3 and 1	8.4×10^5	24	0.5	0.2
CO	8 ^(a)	3.3×10^6	72	1.5	0.6
	1	3.3×10^6	96	2.0	0.8
TSP	24 ^(a)	2.9×10^7	84 ^(b)	0.4 ^(b)	0.2 ^(b)

USING THE LOWEST WIND SPEED IN THE STUDIED RANGE: $u = 0.5 \text{ m/s}$

Pollutant	Time Period (h)	Maximum Emission Rate ($\mu\text{g/s}$)	Maximum Increase in Pollutant Concentrations at Points of Public Access (Maximum Emission Rate) $\times$ (y/Q) ^a		
			at 1.5 km	at 22.5 km	at 44 km
			($\mu\text{g/m}^3$)	($\mu\text{g/m}^3$)	($\mu\text{g/m}^3$)
SO ₂	24 ^(a)	2.8×10^5	9.8	0.2	<0.1
	3 and 1	8.4×10^5	120	2.5	1.0
CO	8 ^(a)	3.3×10^6	350	7.4	3.0
	1	3.3×10^6	460	9.9	4.0
TSP	24 ^(a)	2.9×10^7	100 ^(b)	0.7 ^(b)	0.3 ^(b)

- (a) Transport of the pollutant plume into a 22.5° sector is restricted to a maximum of 6 hours per day.
- (b) Concentrations are multiplied by very conservative dry deposition factors. For a wind speed of 2.5 m/s, it is assumed that 60% of the particulates are deposited within 1.5 km of source, and 90% at distances greater than or equal to 22.5 km. For a wind speed of 0.5 m/s, it is assumed that 90% of the particulates are deposited within 1.5 km of source, and 97% at distances greater than or equal to 22.5 km.

CONCLUSIONS

This study indicates that the nonradiological emissions from construction and operation activities of a high-level nuclear waste repository at Hanford should have minor impacts on regional air quality. Model predictions indicate that increases in ambient pollutant concentrations as a result of project activities would not cause ambient air quality standards to be exceeded at any publicly accessible location. Air quality impacts in populated areas would be minimal. More detailed modeling of air quality impacts will be performed in the future when improved estimates of emission parameters are available.

REFERENCES

- Larvie, F. C. 1985. "BWIP Exploratory Shaft Phase I, Calculations for Non-Radiological Pollutants." Morrison-Knudsen Company, Richland, Washington.
- McCormick, W. D., J. V. Ramsdell, and B.A. Napier. 1984. Hanford Dose Overview Program: Standardized Methods and Data for Hanford Dose Calculations. PNL-3777, Pacific Northwest Laboratory, Richland, Washington.
- Ramsdell, J. V., G. F. Athey, and C. S. Glantz. 1983. MESOI Version 2.0: An Interactive Mesoscale Lagrangian Puff Dispersion Model With Deposition and Decay. NUREG/CR-3344, U.S. Nuclear Regulatory Commission, Washington, D.C.
- 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. Atomic Energy Commission. 1968. Meteorology and Atomic Energy, ed. D.H. Slade, TID-24190, National Technical Information Service, Springfield, Virginia.
- U.S. Code of Federal Regulations, Title 40, Part 50, Washington, D.C.
- U.S. Department of Energy. 1986. Environmental Assessment: Reference Repository Location, Hanford Site, Washington. Washington, D.C.
- U.S. Environmental Protection Agency. 1977. Compilation of Air Pollution Emission Factors Third Edition, Including Supplements 1-7. AP-42, Research Triangle Park, North Carolina.
- U.S. Nuclear Regulatory Commission. 1982. Draft Environmental Impact Statement Related to the Construction of Skagit/Hanford Nuclear Project, Units 1 and 2. Docket Nos. STN 50-522 and STN 50-523. NUREG-0894, Washington, D.C., and Washington State Energy Facility Site Evaluation Council, Olympia, Washington.

APPENDIX A

DOCUMENTATION OF THE HANCHI MODEL

APPENDIX A

DOCUMENTATION OF THE HANCHI MODEL

In this appendix we briefly describe the major operations performed by HANCHI and its major subroutines. We then present a listing of the program and all its subroutines. The listing is followed by a description of each variable used in the model. Finally, the results from a test run of the model are presented.

MAJOR OPERATIONS PERFORMED

The seven key operations in HANCHI, in the order in which they occur, are listed below.

- STEP 1 The model is initialized. This step includes user specification of the release heights and telemetry stations to be used.
- STEP 2 If the user has activated the χ/Q % option, subroutine XOQINITC is called to compute all the χ/Q values that would be needed in subroutine XOQPRBI.
- STEP 3 Tower and telemetry station data are read from two files; files are checked so that dates and times match.
- STEP 4 Wind direction and wind speed categories are determined for each combination of release height and telemetry station. All joint frequency distribution counters are incremented. Steps 3 and 4 are repeated for each hour of meteorological data until the stop date and time are reached.
- STEP 5 After the stop date and time are reached, all counts are converted to frequencies and the joint frequency distributions are output.
- STEP 6 Using the joint frequency distributions, χ/Q values are determined using both the sector average and centerline formulations. Values are computed and output for each combination of release height and telemetry.
- STEP 7 If the user has specified the χ/Q % option, subroutine XOQPRBI is called for each release height and telemetry station being studied. The subroutine determines the χ/Q values that are exceeded 50%, 10%, 5%, and 1% of the time at each receptor location.

Subroutine XOQINITC computes the centerline χ/Q values for all the possible combinations of atmospheric stability, distance downwind (a maximum of 10 user-specified arc distances are allowed), release height, and wind speed category. Note that these values are independent of transport or wind direction and release site. The χ/Q values computed here are used only in Subroutine XOQPRBI and not in the main body of HANCHI.

Subroutine XOQPRBI computes the centerline χ/Q values that are exceeded 50%, 10%, 5%, and 1% of the time at each downwind distance in each of the 16 transport sectors. Subroutine XOQPRBI uses χ/Q values from Subroutine XOQINITC and frequencies of occurrence from HANCHI and calls subroutines SORT, CUMDIS, and PPTS.

Subroutine SORT reorders χ/Q values and the corresponding frequencies of occurrence in order from the largest to smallest the χ/Q values.

Subroutine CUMDIS converts each frequency of χ/Q occurrence to a frequency of there being a larger χ/Q value.

Subroutine PPTS selects the centerline χ/Q values that are exceeded 50%, 10%, 5%, and 1% of the time.

LISTING OF THE HANCHI PROGRAM AND ITS SUBROUTINES

```

C *****
C
C PROGRAM HANCHI
C   BY CS GLANTZ AND JV RAMSDELL
C   BATTELLE PACIFIC NORTHWEST LABORATORIES
C   P.O. BOX 999
C   RICHLAND, WA 99352
C   (509) 376-8753
C
C   CURRENT VERSION CREATED: 2/85
C   LAST UPDATE: 10/29/85
C
C A PROGRAM THAT COMPUTES JOINT FREQUENCY DISTRIBUTIONS AND
C CHI OVER Q (X/Q) VALUES USING SECTOR AVERAGE AND CENTERLINE
C FORMULAS. HANFORD TOWER AND TELEMETRY DATA IS USED IN THE
C CALCULATIONS.
C *****

C
C DIMENSION DIMWD(20,10,30),ROSE(20,10,30),IMWDC(10,10,30),
C + IR(8),ROLOSE(20,10,30),ATP(10),ICNTRS(10,30),ICNTLO(10,30),
C + ROLOAV(20,10,30),WINDC(20,10,10,30),WINDCL(20,10,10,30),
C + TFRN(10,10,30),STWDDR(20,10,10,10,30),IREHT(10),IDATA(30),
C + GXPQ(10,20,10,10),IIRK(30),XQDS(20,20,10,30),
C + XQDC(20,20,10,30),TOTAL(10,30),X(10),SZ(10,7),U(4),NAME(22),
C + A(7),DIRN(16),SY(10,7),IDYBOR(12)
C REAL AY(7), AZ(7,3), BZ(7,3), CZ(7,3)
C
C CHARACTER FILE1*31, FILE2*31
C
C DATA AY/ 0.3658, 0.2751,0.2089,0.1471,0.1046,0.0722,0.0481/
C DATA AZ/ 0.192, 0.156, 0.116, 0.079, 0.063, 0.053, 0.032,
C + 0.00066,0.0382,0.113, 0.222, 0.211, 0.086, 0.052,
C + 0.00024,0.055, 0.113, 1.26, 6.73, 18.05, 10.83 /
C DATA BZ/ 0.936, 0.922, 0.905, 0.881, 0.871, 0.814, 0.814,
C + 1.941, 1.149, 0.911, 0.725, 0.673, 0.74, 0.74,
C + 2.099, 1.098, 0.911, 0.516, 0.305, 0.18, 0.18 /
C DATA CZ/ 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
C + 0.27, 3.3, 0.0, -1.7, -1.3, -0.35, -0.21,
C + -9.6, 2.0, 0.0, -13., -34.0, -48.6, -29.2 /
C DATA U/ 0.78, 2.48, 4.49, 6.95, 9.63, 12.54, 15.67,
C + 17.88, 0.74/
C DATA X/ 805., 2414., 4023., 5632., 7241., 12068., 24135.,
C + 40225., 56315., 72405./
C DATA NAME/ 'ROS ', 'EOC ', 'ARMY', 'RSPG', 'EDNA', '200E',
C + '200W', 'WAHL', 'FFTF', 'YAKB', '300A', 'WYEB',
C + '100H', 'WPPS', 'FRNK', 'GABL', 'RING', 'RICH',
C + 'SAGE', 'RMTN', 'HMB ', 'PASC' /
C
C DIRECTION TRANSPORTED TO
C DATA DIRN/ ' N ', 'NNE', 'NE ', 'ENE', ' E ', 'ESE', 'SE ', 'SSE',
C + ' S ', 'SSW', 'SW ', 'WSW', ' W ', 'WSW', 'NW ', 'NNW' /
C DATA IB/ 4, 8, 13, 19, 25, 32, 39, 1000/
C DATA IDYBOR/0,31,59,90,120,151,181,212,243,273,304,334/
C IDF = 999
C SZLIM=5000.
C
C *****
C IN THE FOLLOWING SECTION THE USER INITIALIZES THE MODEL BY
C SPECIFYING THE TYPES OF CALCULATIONS NEEDED, DOWNWIND DISTANCE
C FOR RECEPTORS, MAXIMUM MIXING DEPTH, STATION(S) TO PROVIDE
C METEOROLOGICAL DATA, AND RELEASE HEIGHT(S). INPUT AND OUTPUT
C FILES ARE OPENED.
C
C WRITE(6,*)'INPUT A 1 IF YOU ONLY WANT X/Q VALUES'
C WRITE(6,*)'INPUT A 2 IF YOU ALSO WANT X/Q PERCENTAGE VALUES'
C READ(5,*)IXQUGD

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```

WRITE(6,*)'INPUT A *1* IF YOU WANT DEFAULT DOWNWIND DISTANCES'
READ(5,*)IDFAULT
IF (IDFAULT.EQ.1) THEN
    IXCOUNT=11
    GOTO 47
END IF
WRITE(6,*)' -- DOWNWIND DISTANCE (RECEPTOR)
*INFO MUST BE IN FILE "DIST.DAT" '
WRITE(6,*)'    10 DISTANCES MAX (F12.2)'
WRITE(6,*)' '
OPEN(UNIT=4,FORM='FORMATTED',FILE='DIST.DAT',STATUS='OLD')
49  IXCOUNT=IXCOUNT+1
    READ(4,48,ERR=800,END=47)X(IXCOUNT)
48  FORMAT(F12.2)
    GOTO 49
800  WRITE(6,*)'READ ERROR IN DIST.DAT FILE',X(IXCOUNT)
    STOP
47  IXCOUNT=IXCOUNT-1

312  WRITE(6,*)' INPUT STATION NUMBERS WANTED (999=STOP, 88=ALL)'
    READ(5,*)INUM
    IF (INUM.GE.99) GOTO 793
    IXCOUNT=IXCOUNT+1
    IF (INUM.EQ.88) THEN
        DO 311 ICDU=1,22
            IICK(ICDU)=ICDU
311    CONTINUE
        IXCOUNT=22
        GO TO 793
    END IF
    IICK(ICOUNT)=INUM
    GOTO 312

793  WRITE(6,*)' INPUT RELEASE HEIGHT IN METERS (I3) (999=STOP)'
    IRRH=IRRH+1
    READ(5,*)IREHT(IRRH)
    IF (IREHT(IRRH) .NE. 999) GO TO 793
    IRRH=IRRH-1

    WRITE(6,*)' INPUT YEAR,MONTH,DAY, HOUR TO START (4I2)'
    READ(5,6660)IYRSTART,IMOSTART,IDAYSTART,IHOURSTART
    JDATEBEG=IDYROR(IMOSTART)+IDAYSTART
    LYFLAG=FLOAT(IYRSTART)/4 - IYRSTART/4
    IF(LYFLAG.EQ.0 .AND. IMO.GE.3) JDATEBEG=JDATEBEG+1

    WRITE(6,*)' INPUT YEAR,MONTH,DAY, HOUR TO STOP (4I2)'
    READ(5,6660)IYRSTOP,IMOSTOP,IDAYSTOP,IHOURSTOP
6660  FORMAT(4I2)

    FILE1='DRA3:(HMT,TELENDATA) TELENDAT'
    FILE2='DPA3:(HMT,TOWERDATA) TOWERDAT'
    WRITE(FILE1(21:22),30) IYRSTART
    WRITE(FILE2(21:22),30) IYRSTART
30  FORMAT(I2)
    OPEN(UNIT=1,FILE='JOINTFO.OUT',STATUS='NEW')
    IF (IXORGO.EQ.2) OPEN(UNIT=17,FILE='Y04PEP.OUT',STATUS='NEW')
    OPEN(UNIT=1,FILE=FILE1,STATUS='OLD',READONLY)
    OPEN(UNIT=2,FILE=FILE2,STATUS='OLD',READONLY)

    IYINCI=IYRSTART
    IYINCP=IYRSTART

C    *** PERFORM INITIAL CALCULATIONS NEEDED FOR COMPUTATION OF ***
C    *** ELEVATED WIND SPEEDS AND FOR COMPUTATION OF X/O X VALUES ***
C    *** IF CALLED FOR ***
DO 340 IZ=1,IRRH
    IF (IREHT(IZ).GT.197)ATOP=400.
    IF (IREHT(IZ).GT.76.AND.IREHT(IZ).LE.107)ATOP=300.
    IF (IREHT(IZ).GT.45.AND.IREHT(IZ).LE.76)ATOP=200.
    IF (IREHT(IZ).LE.45)ATOP=100.
    ATP(IZ)=1.0/LOG(ATOP/50.0)
    IF (IXORGO.EQ.2)
        + CALL XORINTE (IZ,IREHT,GXOR,AY,AZ,RZ,CZ,X,IXCOUNT)
340  CONTINUE

```

```

C *****
C *** METEOROLOGICAL DATA PROCESSING BEGINS ***
C *****

C *** READ NEXT HOUR OF TOWER DATA: DATE, HOUR AND WIND SPEED ***
C *** (ISxxx) IN MPH AND WIND DIRECTION (IDxxx) AT VARIOUS ***
C *** HEIGHTS ABOVE GROUND (XXX = HEIGHT ABOVE GROUND) IN FEET ***

      WRITE(6,*) 'DATA PROCESSING WILL BEGIN'
110  CONTINUE
700  FORMAT(1X,4I2,' 5 speeds are: ',5(1X,I3))
100  FORMAT(4I2,5X,I3)
1117 READ(2,1100,END=1116,ERR=3400) IYR,IMO,IDAY,IHR,
+    ISS0,IS100,ID200,IS200,IS300,ID400,IS400
1100 FORMAT(4I2,5X,7I2)
      IF (I10H2.EQ.0) THEN
        WRITE(6,700) IYR,IMO,IDAY,IHR,ISS0,IS100,IS200,IS300,IS400
        I10H2=9
      END IF
      GO TO 1117

1116 CLOSE UNIT#2
      FILE2='DATA3:(HMT,TOWERDATA) TOWER.DAT'
      IYRINC1=IYRINC1+1
      IF (IYRINC1.GT.IYRSTOP) GOTO 2500
      WRITE(FILE2(21:22),30) IYRINC1
      OPEN(UNIT=2,FILE=FILE2,STATUS='OLD',READONLY)
      WRITE(6,*) ' HAVE JUST OPENED NEW UNIT 2 ',FILE2
      GOTO 1119

C *** CONVERT DATE TO JULIAN DATE ***
1117 JDATE=IDYBUP(IMO)+IDAY
      LYFLAG=FLOAT(IYR)/4 - IYR/4
      IF (LYFLAG.EQ.0 .AND. IMO.GE.3) JDATE=JDATE+1

C *** GO TO SECTIONS TO READ EITHER TOWER OR TELEMETRY DATA ***
C *** UP GOTO SECTION TO PROCESS THE DATA IF THE DATE AND ***
C *** TIME OF THE TOWER AND TELEMETRY DATA MATCH. ***
      IF ( IYR .GT. IYEAR ) GO TO 4750
      IF ( IYR .LT. IYEAR ) GO TO 1119
      IF ( JDATE .LT. IDDAY ) GO TO 1119
      IF ( JDATE .GT. IDDAY ) GO TO 4750
      IF ( IHR .LT. IHMP ) GO TO 1119
      IF ( IHR .GT. IHMP ) GO TO 4750
      GO TO 277

C *** READ NEXT HOUR OF TELEMETRY DATA: DATE, TIME, RECORD ***
C *** NUMBER, STABILITY, MIXING DEPTH, WIND VELOCITY FOR ***
C *** UP TO 30 STATIONS ***

4750 READ (1,120,ERR=3500,END=4700) IYEAR,IDDAY,IHHR,IDREC,
1  ISTARL,LDEPTH,
1  (IDATA(I),I=1,10)
120  FORMAT(12,I3,I2,I1,1X,I1,1X,I3,5X,10(1X,I5))
      READ (1,120,ERR=3500,END=4700) IYEAR,IDDAY,IHHR,IDREC,
1  ISTARL,LDEPTH,
1  (IDATA(I),I=11,20)
160  READ (1,120,ERR=3500,END=4700) IYEAR,IDDAY,IHHR,IDREC,
1  ISTARL,LDEPTH,
1  (IDATA(I),I=21,30)
      GO TO 4800

C STORE INITIAL DATE
4700 CLOSE UNIT#1
      FILE1='DATA3:(HMT,TELEMDATA) TELEM.DAT'
      IYRINC2=IYRINC2+1
      IF (IYRINC2.GT.IYRSTOP) GOTO 2500
      WRITE(FILE1(21:22),30) IYRINC2
      OPEN(UNIT=1,FILE=FILE1,STATUS='OLD',READONLY)
      WRITE(6,*) ' HAVE JUST OPENED NEW UNIT 1 ',FILE1
      GOTO 4750

4800 IF (IDREC.NE.3) THEN
      IFPRB=1
      GO TO 160
    END IF
    IF ( IPRBS .EQ. 1 ) THEN
      IFPRB=0
      GO TO 4750
    END IF

```



```

C    *** GO TO SECTIONS TO READ EITHER TOWER OR TELEMETRY DATA, ***
C    *** OR TO CONTINUE ON AND PROCESS THE DATA IF THE DATE AND ***
C    *** TIME OF THE TOWER AND TELEMETRY DATA MATCH, ***
IF ( IYR.EQ.IYRSTART .AND. JDATEBEG.GT.IDDAY ) GO TO 4750
IF ( IYR .GT. IYEAR ) GO TO 4750
IF ( IYR .LT. IYEAR ) GO TO 1119
IF ( JDATE .LT. IDDAY ) GO TO 1119
IF ( JDATE .GT. IDDAY ) GO TO 4750
IF ( IHR .LT. IDHR ) GO TO 1119
IF ( IHR .GT. IDHR ) GO TO 4750

277 IF ( IOF .EQ. 999 ) THEN
      IYRST=IYR
      IDYFST=IDAY
      IMHST=IMD
      IOF = 1
END IF

C    *** STOP PROCESSING HOURLY DATA AND GO TO SECTIONS TO DO ***
C    *** FINAL PROCESSING OF DATA IF THE DATE AND TIME OF THE ***
C    *** DATA EXCEEDS THE STOP DATE AND TIME ***

IF (IYR.GE.IYRSTOP.AND.IMD.GE.IMHSTOP.AND.
1  IDAY.GE.IDAYSTOP.AND.IHR.GE.IMHSTOP)GO TO 2500

IYOT=IYOT+1
IF (IDDAY.NE.IDDAYL) WRITE(6,*)IDDAY,IYEAR
IDDAYL=IDDAY

C    *** PROCESS DATA FOR EACH TELEMETRY STATION BEING EXAMINED ***
DO 5000 ISTAT=1,ICOUNT
  IK=IINK(ISTATION)

C    *** CONVERT 4-DIGIT WIND VELOCITY (00SS) INTO WIND DIRECTION ***
IF (IDATA(IK).GE. 6999 .OR. IDATA(IK) .LE. 0 ) GO TO 5000
C    CONVERT 4-DIGIT WIND VELOCITY INTO DEGREES (DDO)
  IDIRI = (IDATA(IK)/100) * 10

C    CHECK FOR CODES FOR CALM OR VARIABLE WINDS
IF ( IDIRI .EQ. 300 ) THEN
  IID = 16
  IU = 1
  GO TO 799
END IF
IF ( IDIRI .EQ. 500 ) THEN
  IU=1
  IID = 17
  GO TO 799
END IF

IF (IDIRI .GT. 360 .OR. IDIRI .LT. 0) THEN
  WRITE (6,*)' ***** ERROR IN WIND DIRECTION CLASS '
  GO TO 3500
END IF

C    *** CLASSIFY THE WIND DIRECTION INTO DIRECTION SECTORS ***
TEST = 31.0 * 3.1416 / 16.0
RADIAN = IDIRI/57.296
IF ( RADIAN .GE. TEST ) THEN
  IID = 0
  GO TO 799
END IF
DO 799 IID = 0,15
  BACK = ( 2.0 * IID + 1 ) * 3.1416 / 16.0
  FRONT = ( 2.0 * IID + 1 ) * 3.1416 / 16.0
  IF ( RADIAN .GE. BACK .AND. RADIAN .LT. FRONT ) GO TO 799
799 CONTINUE
WRITE (6,*)' ***** IID ERROR *****'
GO TO 3500

C    *** TAKE EACH RELEASE HEIGHT ***
799 DO 500 IZ=1,IRRH
  IF (IID.GE.16) GO TO 650

C    *** IF RELEASE HEIGHT IS < 15 M, USE GROUND-LEVEL DATA ***
IF (IREHT(IZ).LT.15) THEN
  ISP = IDATA(IK) - ( (IDATA(IK)/100) * 100 )
  GO TO 180
END IF

```

```

C      *** A POWER LAW APPROXIMATION IS USED TO ESTIMATE WIND ***
C      *** SPEEDS AT ELEVATIONS SIGNIFICANTLY ABOVE GROUND LEVEL ***
IF (IREHT(IZ).GT.107) THEN
  ISPOT=13400
  GOTO 1700
END IF
IF (IREHT(IZ).GT.76.AND.IREHT(IZ).LE.107) THEN
  ISPOT=13300
  IF (ISPOT.GT.90) THEN
    ISPOT=13400
    AK = 1.0/LOG(400./50.0)
  END IF
  GOTO 1700
END IF
IF (IREHT(IZ).GT.45.AND.IREHT(IZ).LE.76) THEN
  ISPOT=13200
  GOTO 1700
END IF
IF (IREHT(IZ).GT.15.AND.IREHT(IZ).LE.45) THEN
  ISPOT=13100
  IF (ISPOT.GT.80) THEN
    ISPOT=13200
    AK = 1.0/LOG(200./50.0)
  END IF
  GOTO 1700
END IF

1700  IF ( ISSO.LE.1 .OR. ISSO.GT.50 .OR. ISPOT.GE.80 ) THEN
      ISP = IDATA(IK) - ((IDATA(IK)/100)*100) *
        (IREHT(IZ)/8.2)**0.7
      GO TO 188
    END IF
    IF (ISPOT.LE.0) THEN
      ISP=0
      GO TO 188
    END IF
    IF ( AK.EQ.0.0 ) AK=ATP(IZ)
    ALPHA = AK * LOG( (ISPOT*1.0) / (ISSO*1.0) )
    AK=0.0
C      *** POWER LAW COMPUTATION OF WIND SPEED ***
    ISP = (IDATA(IK) - (IDATA(IK)/100) * 100)
      * ( (IREHT(IZ)*1.0) / 8.2 ) ** ALPHA
188  IF (ISP .GE. 80 .OR. ISP .LT. 0) GO TO 500

C      *** DETERMINE WIND SPEED CLASS ( 1 TO 8 ) ***
IF (ISP .LT. 4) THEN
  IU = 1
  GO TO 650
END IF

DO 600 J = 1,7
  IF ( ISP .GE. IR(J) .AND. ISP .LT. IR(J+1) ) THEN
    IU = J + 1
    GO TO 650
  END IF
600  CONTINUE

C      *** INCREMENT COUNTERS ***
650  INNOCL(IU,IZ,IK) = INNOCL(IU,IZ,IK) + 1
750  DIRWD(IID+1,IZ,IK) = DIRWD(IID+1,IZ,IK) + 1.0
  WINDC(IID+1,IU,IZ,IK) = WINDC(IID+1,IU,IZ,IK) + 1.0
  STWDCR(IID+1,IU,ISTABL,IZ,IK) =
    STWDCR(IID+1,IU,ISTABL,IZ,IK) + 1.0
  ICHTRS(IZ,IK) = ICHTRS(IZ,IK) + 1

C      *** DO SEPERATE, ADDITIONAL ANALYSIS FOR LOW SPEED WINDS ***
IF ( IU .EQ. 1 ) THEN
  ROLOSE(IID+1,IZ,IK) = ROLOSE(IID+1,IZ,IK) + 1.0
  ICHTLO(IZ,IK) = ICHTLO(IZ,IK) + 1
END IF

C      *** TAKE NEXT RELEASE HEIGHT ***

500  CONTINUE
C      *** TAKE NEXT TELEMETRY STATION ***
5000 CONTINUE

C      *** TAKE NEXT HOUR OF DATA ***
GO TO 110

```

```

C *****
C ***** FINAL COMPUTATIONS *****
C *****

2500 DO 4799 I=1, ICOUNT
      IK=I*IKK(I,STATION)
      DO 2501 IZ=1, IRRR
C      *** FOR EACH STATION AND RELEASE HEIGHT ***
C      *** CONVERT COUNTS TO FREQUENCIES ***
      DO 1111 I=1, 18
        IF (ICNTRS(IZ,IK).EQ. 0) THEN
          ICNTRS(IZ,IK) = -1
        END IF
        IF (ICNTLO(IZ,IK).EQ. 0) ICNTLO(IZ,IK) = -1
        POSE(I,IZ,IK) = DIRWD(I,IZ,IK)/ICNTRS(IZ,IK)
        POLOAV(I,IZ,IK) = ROLOSE(I,IZ,IK)/ICNTLO(IZ,IK)
        DO 1122 J = 1, 9
          WHDCL(I,J,IZ,IK)=WINDC(I,J,IZ,IK)/ICNTRS(IZ,IK)
          DO 1144 IS = 1, 7
            STWDDR(I,J,IS,IZ,IK) = STWDDR(I,J,IS,IZ,IK)
              / ICNTPS(IZ,IK)
          +
1144      CONTINUE
1122      CONTINUE
1111      CONTINUE

C      *** DISTRIBUTE CALM AND VARIABLE WIND DATA THE SAME AS ***
C      *** FOR LOW WIND SPEED CASES ***
      DO 1210 IS = 1, 7
        DO 1220 I = 1, 16
          TFREQ1(IS,IZ,IK) = TFREQ1(IS,IZ,IK)
            + STWDDR(I,1,IS,IZ,IK)
        +
1220      CONTINUE
1210      CONTINUE
        DO 1230 IS = 1, 7
          DO 1240 I = 1, 16
            IF (TFREQ1(IS,IZ,IK).EQ.0.0)
              +
              TFREQ1(IS,IZ,IK) = 0.0000001
            STWDDR(I,9,IS,IZ,IK) = STWDDR(I,1,IS,IZ,IK) * (1.0 +
              +
              (STWDDR(17,1,IS,IZ,IK) + STWDDR(18,1,IS,IZ,IK)) /
              +
              TFREQ1(IS,IZ,IK) )
          +
1240      CONTINUE
1230      CONTINUE

C *****
C ***** JOINT FREQUENCY DISTRIBUTION OUTPUT *****
C *****

      WRITE(8,1960)NAME(IK)
      WRITE(8,2033)IREHT(IZ)
      WRITE(8,955)IMDSTART, IDAYSTART, IYFSTART, INHURSTART,
        +
        TODAY, IYEAR
      WRITE(8,967)ICNTRS(IZ,IK), ICNTLO(IZ,IK)
      WRITE(8,960)(I,I=1,18)
      WRITE(8,965)(I,WHDCL(I,IZ,IK),I=1,8)
      WRITE(8,*)' WIND DIRECTION (16 SECTORS + CALM + VARIABLE)'
      WRITE(8,970)(DIRN(I),I=1,16)
      WRITE(8,975)(DIRWD(I,IZ,IK),I=1,16)

      WRITE(8,980)(ROSE(I,IZ,IK),I=1,18)
      WRITE(8,985)(POLOAV(I,IZ,IK),I=1,18)
      WRITE(8,950)
      WRITE(8,1951)
      WRITE(8,*)'
      DO 1130 J = 1, 8
        WRITE(8,990)J, WHDCL(I,J,IZ,IK), I=1, 16)
      +
1130      CONTINUE
      WRITE(8,950)
      WRITE(8,1950)
      WRITE(8,*)'
      WRITE(8,971)(DIRN(I),I=1,16)
      DO 1550 IS = 1, 7
        WRITE(8,995)IS
        DO 1660 J = 1, 9
          WRITE(8,970)J, (STWDDR(I,J,IS,IZ,IK),I=1,16)
        +
1660      CONTINUE
1550      CONTINUE
      WRITE(8,*)'
      WRITE(8,*)' W1 = WIND SPEEDS LESS THAN 4 MPH
      DO 17 IP=1,6
        WRITE(8,1907)IP+1,IB(IP),IB(IP+1)
      +
17      CONTINUE

```

```

WRITE(8,*)' W8 = WIND SPEEDS GREATER OR EQUAL TO 39 MPH'
WRITE(8,*)' W9 = WIND SPEEDS LESS THAN 4 MPH '
WRITE(8,*)' INCLUDING CALM AND VARIABLE WINDS'

IF (IXCOUNT,LT,1)GOTO 2501

C *****
C *** COMPUTE CENTERLINE AND SECTOR AVERAGE X/Q VALUES ***
C *****

DO 301 IS = 1,7
DO 310 IX = 1,IXCOUNT

C COMPUTE STABILITIES USING THE NRC METHOD
SY(IX,IS) = AY(IS) * X(IX)**0.9031

IF ( X(IX) .LE. 100.0 ) THEN
  SZ(IX,IS) = AZ(IS,1) * X(IX) ** 0Z(IS,1)
ELSE IF ( X(IX) .LE. 1000.0 ) THEN
  SZ(IX,IS) = AZ(IS,2) * X(IX) ** 0Z(IS,2) + CZ(IS,2)
ELSE IF ( X(IX) .GT. 1000.0 ) THEN
  SZ(IX,IS) = AZ(IS,3) * X(IX) ** 0Z(IS,3) + CZ(IS,3)
END IF
IF (SZ(IX,IS) .GT. SZLIM) SZ(IX,IS) = SZLIM

EE = EXP( -0.5 * ( IREHT(IZ) / SZ(IX,IS) ) **2 )

DO 320 IU = 2,9

  SEC = 2.032 / ( SZ(IX,IS) * X(IX) * U(IU) )
  C = 1.0 / ( SZ(IX,IS) * SY(IX,IS) * 3.1416 * U(IU) )

  DO 330 IN = 1,16

    XQGS(IN,IX,IZ,IK) = XQGS(IN,IX,IZ,IK) + SEC *
      EE * STWDRP(IN,IU,IS,IZ,IK)
    XQGC(IN,IX,IZ,IK) = XQGC(IN,IX,IZ,IK) + C *
      EE * STWDRP(IN,IU,IS,IZ,IK)
    IF (IX .EQ. 1) TOTAL(IZ,IK) = TOTAL(IZ,IK) +
      STWDRP(IN,IU,IS,IZ,IK)

330 CONTINUE
320 CONTINUE
310 CONTINUE
301 CONTINUE

C *****
C ***** X/Q OUTPUT *****
C *****

WRITE(8,1960)NAME(IX)
WRITE(8,11)
WRITE(8,2033)IREHT(IZ)
WRITE(8,610)TOTAL(IZ,IK)
WRITE(8,950)
WRITE(8,520)(X(IX),IX=1,IXCOUNT)
WRITE(8,521)
DO 409 IN = 1,16
  IF (IN,LT,9) THEN
    WRITE(8,507)DIRN(IN+8)
  ELSE
    WRITE(8,507)DIRN(IN-8)
  END IF
  WRITE(8,510)(XQGS(IN,IX,IZ,IK),IX=1,IXCOUNT)
409 CONTINUE
WRITE(8,1960)NAME(IX)
WRITE(8,12)
WRITE(8,2033)IREHT(IZ)
WRITE(8,610)TOTAL(IZ,IK)
WRITE(8,950)
WRITE(8,520)(X(IX),IX=1,IXCOUNT)
WRITE(8,521)
DO 1409 IN = 1,16
  IF (IN,LT,9) THEN
    WRITE(8,507)DIRN(IN+8)
  ELSE
    WRITE(8,507)DIRN(IN-8)
  END IF
  WRITE(8,510)(XQGC(IN,IX,IZ,IK),IX=1,IXCOUNT)
1409 CONTINUE

```

```

C      *****
C      ***** CALCULATE X/Q PERCENTAGES IF CALLED FOR *****
C      *****

      IF (IX0000.EQ.2) THEN
        CALL X00PRBIC (I7,IK,I9EHT,GX00,STWDD,X,IXCOUNT)
      END IF

2501      CONTINUE
9999      CONTINUE

      GO TO 4000

955      FORMAT(1X,' STARTING DATE ',I2,'/',I2,'/',I2,2X,I2,':00',
+ ' ENDING JULIAN DAY=',I3,' YEAR=',I3/)
967      FORMAT(1X,' TOTAL # OF HOURS',I7,' # OF 104 SPEED CLASS
+ ONE WINDST',I7)
960      FORMAT(1X,' WIND SPEED CLASS',8X,A(4X,I2,4X))
965      FORMAT(1X,' # OF OCCURRENCES',8X,A(1X,I7,2X)/)
970      FORMAT(20X,16(2X,A3,1X),' CH VR ')
975      FORMAT(1X,' WIND DIR OCCURANCE',18(F6,0))
980      FORMAT(1X,' WIND ROSE ',14(F6,3))

985      FORMAT(1X,' LOW SPD WIND ROSE ',18(F6,3)/)
1951     FORMAT(25X,'FREQUENCY DISTRIBUTION OF THE WIND
+AS A FUNCTION OF WIND SPEED AND WIND DIRECTION ' )
990      FORMAT(1X,' W',I1,18(1X,F6,5))
995      FORMAT(1X,' STABILITY CLASS',I2 )
971      FORMAT(4X,16(3X,A3,1X),' CALM VAR')
1950     FORMAT(25X,'FREQUENCY DISTRIBUTION OF THE WIND
+AS A FUNCTION OF WIND SPEED, WIND DIRECTION AND STABILITY' )
1907     FORMAT(6X,'W',I1,' # WIND SPEEDS GREATER THAN OR EQUAL TO
+',I2,' MPH AND LESS THAN ',I2,' MPH')
1964     FORMAT (101,40X,'***** MESOI WIND STATION: ',A4,
+ ' AVERAGE X/Q ((SEC/M**3) ) *****')
11      FORMAT (40X,' **** SECTOR-AVERAGE MODEL ****')
2033     FORMAT (1X,' RELEASE HEIGHT: ',I3,' M')
950      FORMAT(1X/)
610      FORMAT(1X,' TOTAL FREQUENCY IS ',F9,5)
520      FORMAT(1X,10(2X,F6,0,'M '))
521      FORMAT(1X,10(2X,' -----'))
507      FORMAT(1X,' TRANSPORTED INTO SECTOR: ',A3)
510      FORMAT(1X,10(2X,F10,2)/)
12      FORMAT(40X,' **** CENTERLINE MODEL ****')

C      READ ERROR OUTPUT
3400     WRITE(6,*)'ERROR DETECTED IN TOWER DATA'
        WRITE(6,700)IYR,IMO,IDAY,IHR,
1      I1950,IS100,IS200,IS300,IS400
121      FORMAT(1X,I2,1X,I3,1X,I2,1X,I1,1X,I1,1X,I3,10(1X,I5))
        IERROR=IERROR+1
        IF (IERROR.EQ.100)GOTO 4000
        GOTO 1110
3500     WRITE(6,*)'ERROR DETECTED IN MESOI NETWORK DATA'
        WRITE (6,121)IYEAR,IDDAY,IDHR,IDREC,ISTABL,LDEPTH,
1      (IDATA(1),I=1,10)
        WRITE (6,121)IYEAR,IDDAY,IDHR,IDREC,ISTABL,LDEPTH,
1      (IDATA(1),I=11,20)
        WRITE (6,121)IYEAR,IDDAY,IDHR,IDREC,ISTABL,LDEPTH,
1      (IDATA(1),I=21,30)
        IERROR=IERROR+1
        IF (IERROR.EQ.100)GOTO 4000
        GO TO 4750
C      *** PROGRAM TERMINATION ***
4000     STOP
        END

```

```

C*****
C*****

```

```

C *****
C SUBROUTINE XDRINITC LAST UPDATE 10/85
C
C BY JV RAMSDALL AND CS GLANTZ
C HATTELLE PACIFIC NORTHWEST LABORATORY
C
C COMPUTES VALUES TO BE USED IN CALCULATION OF X X/Q
C*****

```

```

SUBROUTINE XDRINITC (IZ,IREHT,GXUQ,AY,AZ,BZ,CZ,X,IXCOUNT)
DIMENSION DIST(10),GXUQ(10,20,10,10),SPD(0),IREHT(10),
1 SY(10,7),SZ(10,7),AY(7),AZ(7,3), BZ(7,3), CZ(7,3), X(10)

DATA SPD/0.78,2.98,4.49,6.95,9.63,12.54,15.67,17.86,0.78/

C *** COMPUTE CENTERLINE X/Q VALUES AS A FUNCTION OF ***
C *** STABILITY, DOWNWIND DISTANCE, AND WIND SPEED ***

C *** CONSIDER ALL STABILITY CATEGORIES ***
DO 100 IS = 1,7
C *** CONSIDER ALL DISTANCES DOWNWIND ***
DO 99 IX = 1,IXCOUNT

C *** COMPUTE STABILITIES USING THE HRC METHOD ***
SY(IX,IS) = AY(IS) * X(IX)**0.9031

IF ( X(IX) .LE. 100.0 ) THEN
SZ(IX,IS) = AZ(IS,1) * X(IX) ** BZ(IS,1)
ELSE IF ( X(IX) .LE. 1000.0 ) THEN
SZ(IX,IS) = AZ(IS,2) * X(IX) ** BZ(IS,2) + CZ(IS,2)
ELSE IF ( X(IX) .GT. 1000.0 ) THEN
SZ(IX,IS) = AZ(IS,3) * X(IX) ** BZ(IS,3) + CZ(IS,3)
END IF
IF (SZ(IX,IS) .GT. 5000.) SZ(IX,IS) = 5000.

GXUQ = 1 / (SZ(IX,IS)*SY(IX,IS)*3.1416)
EE = EXP(-0.5* ( IREHT(IZ) / SZ(IX,IS) )**2 )
C *** CONSIDER ALL 8 WIND SPEED CATEGORIES ***
DO 98 IW = 2,9
GXUQ(IW,IX,IS,IZ) = GXUQ/SPD(IW)
C *** RELEASE ABOVE 5 M REQUIRES USE OF "EE" TERM ***
IF ( IREHT(IZ).GT.5 ) GXUQ(IW,IX,IS,IZ) =
+ GXUQ(IW,IX,IS,IZ) * EE
98 CONTINUE
99 CONTINUE
100 CONTINUE

RETURN
END

```

```

C*****
C*****
C
C *****
C
C SUBROUTINE XQPRBIC LAST UPDATE 10/85
C
C BY JV KAMSDOLL AND CS GLANTZ
C BATTELLE PACIFIC NORTHWEST LABORATORY
C
C PROGRAM XQPRBIC CALCULATES, FOR TEN DISTANCES
C DOWNWIND OF A RELEASE, THE X/Q VALUES THAT WILL
C BE EXCEEDED 5 PERCENT OF THE TIME. IN XPROB THIS
C IS DONE FOR RELEASE HEIGHTS INPUTTED BY USER
C
C *****
C SUBROUTINE XQPRBIC(IZ,IK,IREFH,GXQD,STWDR,X,IXCOUNT)
C
C DIMENSION STWDR(20,10,10,10,30),GXQD(10,20,10,10),
C + DGXQD(2,63,10),PTS(10),PGXQD(10,10,10),X(10),
C + SPD(7),TRANS(16),IIM(27),IREFH(10)
C
C DATA PTS/0.01,0.05,0.10,0.50,6*0.0/
C DATA SPD/0.75,2.48,4.47,6.95,9.63,12.54,15.67,17.88,0.78/
C DATA TRANS/'S','SSH','SH','WSH','W','HWH','HW','NNH',
C + 'N','HNE','NE','ENE','E','ESE','SE','SSE',
C DATA IIM/'NOS','EOC','ARNY','RSPG','EDNA','ZONE','ZOW',
C + 'HML','FFTF','YAKB','300A','HYER','100N','WPPS',
C + 'FRNK','GABL','RING','RICH','SAGE','RMTN','HMS','PABC'/
C
C NPTS=4
C
C *** THE VARIABLE GXQD IS SET IN SUBROUTINE YDQINITC ***
C
C *** TREAT EACH DIRECTION ***
C DO 400 IDIR = 1,16
C   N = 0
C   *** TREAT EACH STABILITY CLASS ***
C   DO 190 ISTR = 1,7
C     *** TREAT EACH WIND SPEED CATEGORY ***
C     DO 200 ISPD = 2,9
C       IF ( STWDR(IDIR,ISPD,ISTR,IZ,IK) .GT. 0.0 ) THEN
C         N=N+1
C         *** ASSOCIATE EACH X/Q WITH A PROBABILITY
C         DO 180 IDIST = 1,IXCOUNT
C           DGXQD(1,N,IDIST) = GXQD(ISPD,IDIST,ISTR,IZ)
C           DGXQD(2,N,IDIST) = STWDR(IDIR,ISPD,ISTR,IZ,IK)
C         180 CONTINUE
C         END IF
C         200 CONTINUE
C       190 CONTINUE
C     *** SORT X/Q VALUES (AND ASSOCIATED PROBABILITIES) FROM ***
C     *** FROM LARGEST X/Q TO SMALLEST X/Q ***
C     CALL SORT(DGXQD,N,IXCOUNT)
C
C     *** CONVERT PROBABILITIES OF X/Q OCCURENCE INTO ***
C     *** PROBABILITY OF THERE BEING A LARGE X/Q ***
C     CALL CUMDIS(DGXQD,N,IXCOUNT)
C
C     *** DETERMINE X/Q VALUE THAT WOULD BE EXCEEDED ONLY ***
C     *** 50, 10, 5, AND 1 % OF THE TIME ( 50, 90, 95, ***
C     *** AND 99 % X/Q VALUES, RESPECTIVELY ***
C     CALL PRTG(DGXQD,N,PTS,NPTS,IDIR,PGXQD,IXCOUNT)
C
C     DO 300 K = 1,IXCOUNT
C       DO 290 J = 1,56
C         DO 280 I = 1,2
C           DGXQD(I,J,K)=0.0
C         280 CONTINUE
C       290 CONTINUE
C     300 CONTINUE
C
C 400 CONTINUE

```

C ***** OUTPUT RESULTS *****

```

      WRITE(17,10000)
      WRITE(17,10001)IIN(IK)
      IF (IPRNT(IZ).GT.2) THEN
        WRITE(17,10005)IREWT(IZ)
      ELSE
        WRITE(17,10001)
      END IF

      WRITE(17,10002)(X(IXX),IXX=1,IXCOUNT)
      DO 500 IDIR = 1,16
        WRITE(17,10003)TRANSD(IDIR)
        DO 490 N1=1,NPTS
          WRITE(17,10004)PTS(N1), (PGXOR(N2,N1,IDIR),N2=1,IXCOUNT)
490      CONTINUE
500      CONTINUE

10000 FORMAT(IH1)
10001 FORMAT(T11,/T16,'THE CENTERLINE X00 VALUE FOR A GROUND LEVEL
      RELEASE THAT HAS THE SPECIFIED PROBABILITY OF BEING EXCEEDED '///)
10002 FORMAT(T5,'PROBABILITY',T51,'DISTANCE(METERS)')
      1 T4,' OF EXCEEDING',T22,F6.0,T33,F6.0,T44,F6.0,T55,F6.0,
      1 T66,F6.0,T77,F6.0,T88,F6.0,T99,F6.0,T110,F6.0,T121,F6.0//)
10003 FORMAT(T11,5X,'TRANSPORT DIRECTION: ',A3)
10004 FORMAT (T9,UPF3.2,T16,10(IPE9.2,2X)/)
10005 FORMAT (/T11,/T16,'THE CENTERLINE X00 VALUE FOR A ',I3,' M
      RELEASE THAT HAS THE SPECIFIED PROBABILITY OF BEING EXCEEDED '///)
11000 format (t56,' MESOI SITE ',A9/)

201  RETURN
     END

```

```

      SUBROUTINE SORT(X,N,IXCOUNT)
      DIMENSION X(2,63,10),T(2)
      DO 300 K=1,IXCOUNT
        DO 200 J=1,N
          DO 100 J1=J+1,N
            IF ( X(1,J,K).LT.X(1,J1,K) ) THEN
              DO 50 I = 1,2
                T(I) = X(I,J,K)
                X(I,J,K)=X(I,J1,K)
                X(I,J1,K)=T(I)
50          CONTINUE
              END IF
            CONTINUE
100        CONTINUE
200      CONTINUE
300    CONTINUE

      RETURN
     END

```



```

SUBROUTINE CUMDIS(X,N,IXCOUNT)
DIMENSION X(2,63,10)
DO 300 K = 1,IXCOUNT
  SUM = 0
  DO 100 J = 1,N
    SUM = SUM + X(2,J,K)
    IF ( J .EQ. 1 ) THEN
      CARRY1 = X(2,J,K) / 2.0
      X(2,J,K) = CARRY1
    ELSE
      CARRY2 = X(2,J,K)/2.0
      X(2,J,K) = X(2,J-1,K) + CARRY1 + CARRY2
      CARRY1 = CARRY2
    END IF
  CONTINUE
100  DO 200 J = 1,N
    IF (SUM .EQ. 0) GO TO 300
    X(2,J,K) = X(2,J,K) / SUM
200  CONTINUE
300  CONTINUE

RETURN
END

SUBROUTINE PPTS (X,NX,Y,NY,ND,XOUT,IXCOUNT)
DIMENSION X(2,63,10),Y(10),XOUT(10,10,16)
DO 300 K = 1,IXCOUNT
  DO 200 N = 1,NY
    DO 100 J = 1,NX
      IF ( X(2,J,K).GT.Y(N) ) THEN
        IF ( J .EQ. 1 ) THEN
          XOUT(K,N,ND)=X(1,J,K)
        ELSE
          XOUT(K,N,ND)=X(1,J,K) + ( X(1,J-1,K)
+          -X(1,J,K) ) * ( X(2,J,K) - Y(N) ) /
+          ( X(2,J,K) - X(2,J-1,K) )
        END IF
        GOTO 200
      END IF
    CONTINUE
200  CONTINUE
300  CONTINUE
RETURN
END

```

HANCHI VARIABLES

Name	Content
AK	- factor based on the height above ground of tower measurements, used in the calculation of ALPHA
ALPHA	- exponent in power law approximation of wind speed
ATOP	- height of elevated wind used in computation of ALPHA
ATP	- factor based on release height, used in the calculation of ALPHA
AY	- factor that is a function of stability and is used in the calculation of Sigma Y
AZ	- factor that is a function of stability and distance and is used in the calculation of Sigma Z
BACK	- minimum wind direction in radians for the current 22.5° direction sector
BZ	- factor that is a function of stability and distance and is used in the calculation of Sigma Z
C	- factor used in calculating centerline χ/Q
CZ	- factor that is a function of stability and distance and is used in the calculation of Sigma Z
DIRN	- sector direction in which material is transported
DIRWD	- counter of number of hours of each combination of wind direction, release height, and station
EE	- term involving release height and Sigma Z that is used in χ/Q calculation
FRONT	- minimum wind direction in radians for the next 22.5° direction sector
GXOQ	- centerline χ/Q values used in probability calculation
IB	- maximum wind speed (mph) for each speed class
ICNTLO	- counter of number of hours of low wind speed for each combination of release height and station
ICNTRS	- counter of number of hours of data processed for each combination of release height and station
ICOUNT	- number of stations to be studied
ID200	- wind direction at 200 feet
ID400	- wind direction at 400 feet
IDATA	- four-digit code for wind velocity [DDSS, where DD x 10 = wind direction (in degrees), SS = wind speed (mph)]
IDAY	- day of the month for tower data
IDAYSTART	- day of the month to start processing data
IDAYSTOP	- day of the month to stop processing data
IDDAY	- Julian day from telemetry data
IDDAYL	- day of the month from previous record of tower data
IDEFAULT	- flag to indicate use of default downwind distances
IDF	- flag to indicate first date-time match of telemetry and tower data

IDHR	-	hour from telemetry data
IDIRI	-	wind direction (in degrees)
IDREC	-	line number of telemetry data entry (1, 2, or 3)
IDYBOR	-	number of days in the year that come before current month
IDYFST	-	first day of month that telemetry and tower data match
IERROR	-	error flag
IGLOB2	-	flag to print the first line of tower data that is encountered
IHOURLSTART-		hour of the day to start processing data
IHOURLSTOP	-	hour of the day to stop processing data
IHR	-	hour of the day from telemetry data
IID	-	wind direction sector and calm or variable indicator
IIKK	-	array of station numbers
IK	-	current station number
IMO	-	month of the year from telemetry data
IMOFST	-	first month that telemetry and tower data match
IMOSTART	-	month to start processing data
IMOSTOP	-	month to stop processing data
IN	-	wind direction sector
INUM	-	number of stations to be analyzed
IPROB	-	problem flag
IREHT	-	release height at station
IRRR	-	number of release heights being studied at each station
IS	-	stability category
IS50	-	wind speed at 50 feet (mph)
IS100	-	wind speed at 100 feet (mph)
IS200	-	wind speed at 200 feet (mph)
IS300	-	wind speed at 300 feet (mph)
IS400	-	wind speed at 400 feet (mph)
ISP	-	wind speed corrected to release height using power law approximation
ISPDT	-	wind speed on the tower from the measurement height closest to the release height, used in determination of ALPHA
ISTABL	-	atmospheric stability
ISTATION	-	station number
IU	-	wind speed category
IWNDCL	-	counter of number of hours of each combination of wind speed category, release height, and station
IX	-	counter of distances downwind
IXCOUNT	-	number of distances downwind
IXOQGO	-	flag to determine whether χ/Q percentages need to be computed
IYEAR	-	year from telemetry data
IYR	-	year from tower data
IYRFST	-	first year that telemetry and tower data match
IYRINC1	-	year of tower data to use
IYRINC2	-	year of telemetry data to use
IYEARSTART-		year to start processing data
IYRSTOP	-	year to stop processing data

IZ	-	counter of release heights
JDATE	-	Julian date for tower data
JDATEBEG	-	Julian date to start simulation
LDEPTH	-	mixing depth in tens of meters (not used in current program)
LYFLAG	-	flag to indicate a leap year
NAME	-	array of station names
RADIAN	-	wind direction in radians
ROLOAV	-	frequency during low-speed winds of each combination of wind direction, release height, and station
ROLOSE	-	counter of number of hours of low-speed wind for each combination of wind direction, release height, and station
ROSE	-	frequency of winds for each combination of wind direction, release height, and station
SEC	-	factor used in calculating sector average χ/Q
STWDDR	-	counter/frequency of hours of each combination of wind direction, wind speed, stability, release height, and station
SY	-	Sigma Y for distance downwind and stability
SZ	-	Sigma Z for distance downwind and stability
SZLIM	-	maximum Sigma Z value
TEST	-	radian direction that, if equaled or exceeded, indicates bad data
TFREQ1	-	frequency during low-speed winds of each combination of wind speed, release height, and stability
TOTAL	-	total frequency; should equal 1 at program completion
U	-	average speed (m/s) of wind in each wind speed category
WINDC	-	frequency of hours of each combination of wind direction, wind speed, release height, and station
WNDCL	-	counter of number of hours of each combination of wind direction, wind speed, release height, and station
X	-	distance downwind
XOQC	-	annual-average centerline χ/Q as a function of wind direction, downwind distance, release height, and station
XOQS	-	annual-average sector average χ/Q as a function of wind direction, downwind distance, release height, and station

TEST RUN OF THE HANCHI MODEL

The test was run using simulated data. 18 hours of data were processed.

TOWER.DAT file:

89010101	0101270101270101
89010102	0101270101270101
89010103	0101270101270101
89010104	0101270101270101
89010105	0101270101270101
89010106	0101270101270101
89010107	0101270101270101
89010108	0101270101270101
89010109	0101270101270101
89010110	0101270101270101
89010111	0101270101270101
89010112	0101270101270101
89010113	0101270101270101
89010114	0101270101270101
89010115	0101270101270101
89010116	0101270101270101
89010117	0101270101270101
89010118	0101270101270101
89010119	0101270101270101
89010120	0101270101270101
89010121	0101270101270101
89010122	0101270101270101

TELEM.DAT file:

89001011 1 200	0902 0902 0902 0902 0902 0902 0902 0902 0902 0902
89001012 1 200	0902 0902 0902 0902 0902 0902 0902 0902 0902 0902
89001013 1 200	0902 0902 0902 0902 0902 0902 0902 0902 0902 0902
89001021 2 200	0902 0902 0902 0902 0902 0902 0902 0902 0902 0902
89001022 2 200	0902 0902 0902 0902 0902 0902 0902 0902 0902 0902
89001023 2 200	0902 0902 0902 0902 0902 0902 0902 0902 0902 0902
89001031 3 200	0902 0902 0902 0902 0902 0902 0902 0902 0902 0902
89001032 3 200	0902 0902 0902 0902 0902 0902 0902 0902 0902 0902
89001033 3 200	0902 0902 0902 0902 0902 0902 0902 0902 0902 0902

[illegible]

HANCHI output

***** MESOI WIND STATION: HNS AVERAGE X/3 ((SEC/H**3)) *****

RELEASE HEIGHT: 10 M
STARTING DATE: 1/ 1/49 1100 ENDING: JULIAN DAY-- 1 YEAR-- 89

TOTAL # OF HOURS: 18 # OF LOW SPEED CLASS ONE WINDS: 17
WIND SPEED CLASS 1 2 3 4 5 6 7 8
OF OCCURRENCES 17 0 1 0 0 0 0 0

WIND DIRECTION (16 SECTORS + CALM + VARIABLE)

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	CM	VM
WIND DIR OCCURRENCE	1.	1.	0.	0.	10.	0.	0.	0.	0.	0.	1.	1.	1.	1.	1.	1.	0.	0.
WIND ROSE	0.056	0.056	0.000	0.000	0.556	0.000	0.000	0.000	0.000	0.000	0.056	0.056	0.056	0.056	0.056	0.056	0.000	0.000
LOW SPD WIND ROSE	0.059	0.000	0.000	0.000	0.556	0.000	0.000	0.000	0.000	0.000	0.059	0.059	0.059	0.059	0.059	0.059	0.000	0.000

FREQUENCY DISTRIBUTION OF THE WIND AS A FUNCTION OF WIND SPEED AND WIND DIRECTION

W1	.05556	.00000	.00000	.00000	.55556	.00000	.00000	.00000	.00000	.05556	.05556	.05556	.05556	.05556	.05556	.00000	.00000
W2	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W3	.00000	.05556	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W4	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W5	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W6	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

FREQUENCY DISTRIBUTION OF THE WIND AS A FUNCTION OF WIND SPEED, WIND DIRECTION AND STABILITY

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	CALM	VAR
STABILITY CLASS 1																		
W1	.00000	.00000	.00000	.00000	.05556	.00000	.00000	.00000	.00000	.05556	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W2	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W3	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W4	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W5	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W6	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W9	.00000	.00000	.00000	.00000	.05556	.00000	.00000	.00000	.00000	.05556	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
STABILITY CLASS 2																		
W1	.00000	.00000	.00000	.00000	.05556	.00000	.00000	.00000	.00000	.00000	.05556	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W2	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W3	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W4	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W5	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W6	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W9	.00000	.00000	.00000	.00000	.05556	.00000	.00000	.00000	.00000	.00000	.05556	.00000	.00000	.00000	.00000	.00000	.00000	.00000

HANCHI output (cont.)

STABILITY CLASS 7

W1	.05556	.00000	.00000	.00000	.22222	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W2	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W3	.00000	.05556	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W4	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W5	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W6	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
W9	.05556	.00000	.00000	.00000	.22222	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

W1 ■ WIND SPEEDS LESS THAN 4 MPH
 W2 ■ WIND SPEEDS GREATER THAN OR EQUAL TO 4 MPH AND LESS THAN 8 MPH
 W3 ■ WIND SPEEDS GREATER THAN OR EQUAL TO 8 MPH AND LESS THAN 13 MPH
 W4 ■ WIND SPEEDS GREATER THAN OR EQUAL TO 13 MPH AND LESS THAN 19 MPH
 W5 ■ WIND SPEEDS GREATER THAN OR EQUAL TO 19 MPH AND LESS THAN 25 MPH
 W6 ■ WIND SPEEDS GREATER THAN OR EQUAL TO 25 MPH AND LESS THAN 32 MPH
 W7 ■ WIND SPEEDS GREATER THAN OR EQUAL TO 32 MPH AND LESS THAN 39 MPH
 W8 ■ WIND SPEEDS GREATER OR EQUAL TO 39 MPH
 W9 ■ WIND SPEEDS LESS THAN 4 MPH
 INCLUDING CALM AND VARIABLE WINDS

HANCHI output (cont.)

***** MESOI WIND STATION: HMB AVERAGE X/1 ((SEC/M**3)) *****

**** SECTOR-AVERAGE MODEL ****

RELEASE HEIGHT: 10 M
TOTAL FREQUENCY IS 1.00000

	500.M	1000.M	1500.M	2000.M	2500.M	3000.M	3500.M	4000.M	4500.M	5000.M
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
TRANSPORTED INTO SECTOR: S	7.63E-06	8.49E-06	5.78E-06	4.10E-06	3.08E-06	2.43E-06	1.98E-06	1.66E-06	1.42E-06	1.23E-06
TRANSPORTED INTO SECTOR: SSW	1.33E-06	1.48E-06	1.00E-06	7.11E-07	5.35E-07	4.22E-07	3.44E-07	2.88E-07	2.46E-07	2.14E-07
TRANSPORTED INTO SECTOR: SW	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: WSW	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: W	9.38E-05	5.64E-05	3.48E-05	2.37E-05	1.75E-05	1.36E-05	1.10E-05	9.13E-06	7.76E-06	6.71E-06
TRANSPORTED INTO SECTOR: WNW	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: NW	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: NNW	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: N	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: NNE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: NE	2.33E-06	3.23E-07	9.07E-08	3.71E-08	1.86E-08	1.05E-08	8.27E-09	7.24E-09	6.43E-09	5.79E-09
TRANSPORTED INTO SECTOR: ENE	5.51E-06	1.31E-06	5.64E-07	3.09E-07	1.94E-07	1.33E-07	9.61E-08	7.27E-08	5.68E-08	4.55E-08
TRANSPORTED INTO SECTOR: E	8.50E-06	2.34E-06	1.08E-06	6.27E-07	4.10E-07	2.90E-07	2.16E-07	1.67E-07	1.34E-07	1.09E-07
TRANSPORTED INTO SECTOR: ESE	1.36E-05	4.37E-06	2.24E-06	1.40E-06	9.77E-07	7.29E-07	5.69E-07	4.60E-07	3.82E-07	3.23E-07
TRANSPORTED INTO SECTOR: SE	1.66E-05	6.24E-06	3.17E-06	2.02E-06	1.43E-06	1.08E-06	8.59E-07	7.03E-07	5.90E-07	5.05E-07
TRANSPORTED INTO SECTOR: SSE	1.68E-05	6.03E-06	4.47E-06	2.93E-06	2.12E-06	1.63E-06	1.31E-06	1.09E-06	9.20E-07	7.94E-07

HANCHI output (cont.)

***** MESOT WIND STATION: HPS AVERAGE X/U ((SEC/MAX3)) *****

***** CENTERLINE MODEL *****

RELEASE HEIGHT: 10 M
TOTAL FREQUENCY IS 1.00000

	500.M	1000.M	1500.M	2000.M	2500.M	3000.M	3500.M	4000.M	4500.M	5000.M
TRANSPORTED INTO SECTOR: S	4.54E-05	5.40E-05	3.83E-05	2.79E-05	2.14E-05	1.72E-05	1.42E-05	1.21E-05	1.04E-05	9.16E-06
TRANSPORTED INTO SECTOR: SSW	7.89E-06	9.38E-06	6.65E-06	4.84E-06	3.72E-06	2.98E-06	2.47E-06	2.10E-06	1.81E-06	1.59E-06
TRANSPORTED INTO SECTOR: SW	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: WSW	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: W	3.39E-04	2.82E-04	1.90E-04	1.36E-04	1.03E-04	8.22E-05	6.78E-05	5.73E-05	4.93E-05	4.33E-05
TRANSPORTED INTO SECTOR: WNW	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: NW	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: NNW	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: N	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: NNE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TRANSPORTED INTO SECTOR: NE	1.83E-06	2.70E-07	7.89E-08	3.32E-08	1.70E-08	9.81E-09	7.81E-09	6.92E-09	6.22E-09	5.66E-09
TRANSPORTED INTO SECTOR: ENE	5.73E-06	1.45E-06	6.52E-07	3.68E-07	2.36E-07	1.64E-07	1.21E-07	9.24E-08	7.30E-08	5.92E-08
TRANSPORTED INTO SECTOR: E	1.16E-05	3.42E-06	1.65E-06	9.83E-07	6.56E-07	4.72E-07	3.57E-07	2.80E-07	2.26E-07	1.87E-07
TRANSPORTED INTO SECTOR: ESE	2.64E-05	9.08E-06	4.85E-06	3.12E-06	2.22E-06	1.69E-06	1.34E-06	1.09E-06	9.18E-07	7.85E-07
TRANSPORTED INTO SECTOR: SE	4.54E-05	1.77E-05	9.65E-06	6.11E-06	4.57E-06	3.52E-06	2.84E-06	2.35E-06	2.00E-06	1.73E-06
TRANSPORTED INTO SECTOR: SSE	6.65E-05	3.40E-05	1.97E-05	1.13E-05	9.83E-06	7.70E-06	6.27E-06	5.26E-06	4.51E-06	3.93E-06

HANCHI output (cont.)

MESOI SITE MMS

THE X00 VALUE FOR A 10 M RELEASE THAT HAS THE SPECIFIED PROBABILITY OF BEING EXCEEDED

PROBABILITY OF EXCEEDING	500.	1000.	1500.	DISTANCE(METERS)							5000.
				2000.	2500.	3000.	3500.	4000.	4500.		
TRANSPORT DIRECTION: S											
.01	8.17E-04	9.72E-04	6.89E-04	5.01E-04	3.85E-04	3.09E-04	2.56E-04	2.17E-04	1.88E-04	1.65E-04	
.05	8.17E-04	9.72E-04	6.89E-04	5.01E-04	3.85E-04	3.09E-04	2.56E-04	2.17E-04	1.88E-04	1.65E-04	
.10	8.17E-04	9.72E-04	6.89E-04	5.01E-04	3.85E-04	3.09E-04	2.56E-04	2.17E-04	1.88E-04	1.65E-04	
.50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
TRANSPORT DIRECTION: SSW											
.01	1.42E-04	1.69E-04	1.20E-04	8.71E-05	6.70E-05	5.37E-05	4.45E-05	3.77E-05	3.26E-05	2.86E-05	
.05	1.42E-04	1.69E-04	1.20E-04	8.71E-05	6.70E-05	5.37E-05	4.45E-05	3.77E-05	3.26E-05	2.86E-05	
.10	1.42E-04	1.69E-04	1.20E-04	8.71E-05	6.70E-05	5.37E-05	4.45E-05	3.77E-05	3.26E-05	2.86E-05	
.50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
TRANSPORT DIRECTION: SW											
.01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
.05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
.10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
.50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
TRANSPORT DIRECTION: WSW											
.01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
.05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
.10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
.50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
TRANSPORT DIRECTION: W											
.01	1.20E-03	9.72E-04	6.89E-04	5.01E-04	3.85E-04	3.09E-04	2.56E-04	2.17E-04	1.88E-04	1.65E-04	
.05	1.20E-03	9.72E-04	6.89E-04	5.01E-04	3.85E-04	3.09E-04	2.56E-04	2.17E-04	1.88E-04	1.65E-04	
.10	1.12E-03	9.72E-04	6.89E-04	5.01E-04	3.85E-04	3.09E-04	2.56E-04	2.17E-04	1.88E-04	1.65E-04	
.50	8.16E-04	4.65E-04	2.64E-04	1.77E-04	1.30E-04	1.01E-04	8.20E-05	6.85E-05	5.85E-05	5.09E-05	

HANCHI output (cont.)

	TRANSPORT DIRECTION: ENE									
.01	1.03E-04	2.62E-05	1.17E-05	6.62E-06	4.25E-06	2.95E-06	2.17E-06	1.66E-06	1.31E-06	1.07E-06
.05	1.03E-04	2.62E-05	1.17E-05	6.62E-06	4.25E-06	2.95E-06	2.17E-06	1.66E-06	1.31E-06	1.07E-06
.10	1.03E-04	2.62E-05	1.17E-05	6.62E-06	4.25E-06	2.95E-06	2.17E-06	1.66E-06	1.31E-06	1.07E-06
.50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	TRANSPORT DIRECTION: E									
.01	2.09E-04	6.16E-05	2.97E-05	1.77E-05	1.18E-05	8.49E-06	6.42E-06	5.04E-06	4.07E-06	3.37E-06
.05	2.09E-04	6.16E-05	2.97E-05	1.77E-05	1.18E-05	8.49E-06	6.42E-06	5.04E-06	4.07E-06	3.37E-06
.10	2.09E-04	6.16E-05	2.97E-05	1.77E-05	1.18E-05	8.49E-06	6.42E-06	5.04E-06	4.07E-06	3.37E-06
.50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	TRANSPORT DIRECTION: ESE									
.01	4.75E-04	1.63E-04	8.72E-05	5.61E-05	4.00E-05	3.03E-05	2.41E-05	1.97E-05	1.65E-05	1.41E-05
.05	4.75E-04	1.63E-04	8.72E-05	5.61E-05	4.00E-05	3.03E-05	2.41E-05	1.97E-05	1.65E-05	1.41E-05
.10	4.75E-04	1.63E-04	8.72E-05	5.61E-05	4.00E-05	3.03E-05	2.41E-05	1.97E-05	1.65E-05	1.41E-05
.50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	TRANSPORT DIRECTION: SE									
.01	8.16E-04	3.18E-04	1.74E-04	1.14E-04	8.23E-05	6.34E-05	5.10E-05	4.23E-05	3.59E-05	3.11E-05
.05	8.16E-04	3.18E-04	1.74E-04	1.14E-04	8.23E-05	6.34E-05	5.10E-05	4.23E-05	3.59E-05	3.11E-05
.10	8.16E-04	3.18E-04	1.74E-04	1.14E-04	8.23E-05	6.34E-05	5.10E-05	4.23E-05	3.59E-05	3.11E-05
.50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	TRANSPORT DIRECTION: SSE									
.01	1.20E-03	6.13E-04	3.54E-04	2.39E-04	1.77E-04	1.39E-04	1.13E-04	9.47E-05	8.11E-05	7.07E-05
.05	1.20E-03	6.13E-04	3.54E-04	2.39E-04	1.77E-04	1.39E-04	1.13E-04	9.47E-05	8.11E-05	7.07E-05
.10	1.20E-03	6.13E-04	3.54E-04	2.39E-04	1.77E-04	1.39E-04	1.13E-04	9.47E-05	8.11E-05	7.07E-05
.50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

APPENDIX B

DOCUMENTATION OF THE CHISHORT MODEL

APPENDIX B

DOCUMENTATION OF THE CHISHORT MODEL

In this appendix we briefly describe the major operations performed by CHISHORT. We also present a listing of the program. The listing is followed by a description of each variable used in the model. Finally, results from a test run of the model are presented.

MAJOR OPERATIONS PERFORMED

The three key operations in CHISHORT, in the order in which they occur, are listed below.

- STEP 1 The model is initialized. This step includes user specification of release height, maximum mixing depth, downwind distances, and wind speeds. The pollutant source term, Q ($\mu\text{g/s}$), is input. A Q of "1" indicates that χ/Q values will be calculated, rather than pollutant concentrations (χ).
- STEP 2 Centerline and sector average χ/Q or χ values are determined for each of the seven Pasquill-Gifford stability classes for each possible combination of wind speed and downwind distance.
- STEP 3 Values are output. The user can examine these numbers to determine under what conditions and at what distance downwind maximum environmental impacts occur.

CHISHORT PROGRAM LISTING

```

C *****
C
C PROGRAM CHISHORT          CREATED: 3/85      LAST UPDATE: 10/85
C   BY   CS GLANTZ
C        BATTELLE PACIFIC NORTHWEST LABORATORY
C        P.O. BOX 999
C        RICHLAND, WA 99352
C        (509) 376-8753
C
C A PROGRAM THAT DETERMINES THE SHORT-TERM GROUND-LEVEL CHI
C (OR X/Q) VALUES POSSIBLE FOR USER SPECIFIED RANGES OF WIND
C SPEED, STABILITY AND DISTANCE DOWNWIND. USED TO DETERMINE
C MAXIMUM SHORT-TERM GROUND-LEVEL IMPACTS.
C *****
C
C REAL AY(7),AZ(7,3),BZ(7,3),CZ(7,3),XC(20,50,7),XS(20,50,7)
C
C DATA AY/ 0.3658, 0.2751, 0.2089, 0.1471, 0.1046, 0.0722, 0.0481/
C DATA AZ/ 0.192, 0.156, 0.116, 0.079, 0.063, 0.053, 0.032,
C + 0.00066, 0.0382, 0.113, 0.222, 0.211, 0.086, 0.052,
C + 0.00024, 0.055, 0.113, 1.26, 6.73, 18.05, 10.53 /
C DATA BZ/ 0.936, 0.922, 0.905, 0.881, 0.871, 0.814, 0.814,
C + 1.941, 1.149, 0.911, 0.725, 0.678, 0.74, 0.74,
C + 2.094, 1.098, 0.911, 0.516, 0.305, 0.18, 0.18 /
C DATA CZ/ 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
C + 9.27, 3.3, 0.0, -1.7, -1.3, -0.35, -0.21,
C + -9.0, 2.0, 0.0, -13., -34.0, -48.6, -29.2 /
C
C 793 WRITE(6,*)' INPUT RELEASE HEIGHT IN METERS '
C READ(5,*)REHT
C WRITE(6,*)' INPUT MIN DISTANCE IN METERS'
C READ(5,*)XMIN
C WRITE(6,*)' INPUT MAX DISTANCE IN METERS'
C READ(5,*)XMAX
C WRITE(6,*)' INPUT DISTANCE INTERVAL BETWEEN STEPS IN METERS'
C READ(5,*)XINTERVAL
C WRITE(6,*)' INPUT MIN WIND SPEED IN METERS/SECOND'
C READ(5,*)UMIN
C WRITE(6,*)' INPUT MAX WIND SPEED IN METERS/SECOND'
C READ(5,*)UMAX
C WRITE(6,*)' INPUT SPEED INTERVAL IN METERS/SECOND'
C READ(5,*)UINTERVAL
C WRITE(6,*)' INPUT MAX MIXING HEIGHT IN METERS'
C READ(5,*)SZLIM
C WRITE(6,*)' INPUT Q IN KG/S. INPUT *1* FOR X/Q OUTPUT.'
C READ(5,*)Q
C OPEN (UNIT=6,FILE='CHIS.OUT',STATUS='NEW')
C
C *** TREAT EACH STABILITY CATEGORY ***
C DO 310 IS=1,7
C *** TREAT EACH DOWNWIND RECEPTOR DISTANCE ***
C DO 310 X = XMIN,XMAX,XINTERVAL
C IF (X.EQ.XMIN) THEN
C IXCOUNT=1
C ELSE
C IXCOUNT=IXCOUNT+1
C END IF
C *** COMPUTE STABILITIES USING THE NRC METHOD ***
C SY = AY(IS) * X ** 0.9031
C IF ( X .LE. 100 ) THEN
C SZ = AZ(IS,1) * X ** BZ(IS,1)
C ELSE IF ( X .LE. 1000 ) THEN
C SZ = AZ(IS,2) * X ** BZ(IS,2) + CZ(IS,2)
C ELSE IF ( X .GT. 1000 ) THEN
C SZ = AZ(IS,3) * X ** BZ(IS,3) + CZ(IS,3)
C END IF
C IF (SZ .GT. SZLIM) SZ = SZLIM
C EF = EXP( -0.5 * ( REHT / SZ ) **2 )

```

```

C      *** TREAT EACH WIND SPEED ***
      DO 320 U=UMIN,UMAX,INTERVAL
      IF (U.EQ.UMIN) THEN
        IXCOUNT=1
      ELSE
        IXCOUNT=IXCOUNT+1
      END IF
C      *** CALCULATE SECTOR-AVERAGE AND CENTERLINE CHI ***
      SEC = Q * 2.032 / ( SZ * U * X )
      C = Q * 1. / ( SZ * SY * 3.1416 * U )
      XS(IXCOUNT,IXCOUNT,IS) = EE * SEC
      XC(IXCOUNT,IXCOUNT,IS) = EE * C
320  CONTINUE
310  CONTINUE
301  CONTINUE

C      ***** OUTPUT AT RUN COMPLETION *****
C      *****
C      *** OUTPUT ALL SECTOR-AVERAGE VALUES AND THEN FOLLOW ***
C      *** WITH ALL CENTERLINE VALUES ***

      I=1
      IF (Q.NE.1) THEN
        WRITE(8,11)
        WRITE(8,2033)REHT,SZLIM,Q
      ELSE
        WRITE(8,111)
        WRITE(8,2034)REHT,SZLIM
      END IF
      GOTO 699

698  I=2
      IF (Q.NE.1) THEN
        WRITE(8,12)
        WRITE(8,2033)REHT,SZLIM,Q
      ELSE
        WRITE(8,112)
        WRITE(8,2034)REHT,SZLIM
      END IF

699  DO 700 IS =1,7
      WRITE(8,703)IS
      WRITE(8,520) (UMIN+(IU-1)*INTERVAL, IU=1, IXCOUNT)
      WRITE(8,521)
      IXCOUNT=0
      DO 701 X = XMIN,XMAX,INTERVAL
        IXCOUNT=IXCOUNT+1
        IF (I.EQ.1) THEN
          WRITE(8,510)X, (XC(IU,IXCOUNT,IS), IU=1, IXCOUNT)
        ELSE
          WRITE(8,510)X, (XS(IU,IXCOUNT,IS), IU=1, IXCOUNT)
        END IF
      END DO
701  CONTINUE
700  CONTINUE
C      *** AFTER OUTPUTTING SECTOR-AVERAGE VALUES OUTPUT CENTERLINE ***
      IF (I.EQ.1) GOTO 698

111  FORMAT(1H,20X,' **** SECTOR-AVERAGE MODEL ****
+ X/G VALUES IN S/M**3 '/')
11  FORMAT(1H,20X,' **** SECTOR-AVERAGE MODEL ****
+ CHI VALUES IN KG/M**3 '/')
112  FORMAT(1H,20X,' **** CENTERLINE MODEL ****
+ X/G VALUES IN S/M**3 '/')
12  FORMAT(1H,20X,' **** CENTERLINE MODEL ****
+ CHI VALUES IN KG/M**3 '/')
2034  FORMAT (1X,' RELEASE HEIGHT: ',F4.0,' M',5X,' MIXING DEPTH: ',
+F7.1,' M')
2033  FORMAT (1X,' RELEASE HEIGHT: ',F4.0,' M',5X,' MIXING DEPTH: ',
+F7.1,' M',5X,' Q: ',1PE10.2,' KG/SEC')
703  FORMAT(1X,' STABILITY= ',I2)
950  FORMAT(1X/)
610  FORMAT(1X,' TOTAL FREQUENCY IS ',F9.5)
910  FORMAT(1X,' OF ',F7.0,' H ',3X,10(1X,1PE10.2))
920  FORMAT(1X,' SPEED (M/S): ',3X,10(3X,F6.2,2X))
921  FORMAT(1X,16X,10(2X,'-----')/1X,' DISTANCE')

4000  STOP
      END

```

CHISHORT VARIABLES

Name	Content
AY	- factor that is a function of stability and is used in the calculation of Sigma Y
AZ	- factor that is a function of stability and distance and is used in the calculation of Sigma Z
BZ	- factor that is a function of stability and distance and is used in the calculation of Sigma Z
C	- factor used in calculating centerline χ/Q
CZ	- factor that is a function of stability and distance and is used in the calculation of Sigma Z
EE	- term involving release height and Sigma Z that is used in χ/Q calculation
IS	- stability category
IUCOUNT	- counter of number of wind speeds being studied
IXCOUNT	- counter of number of downwind distances being studied
IXINTERVAL	- increment of downwind distance
IXMAX	- maximum downwind distance (m) being studied
IXMIN	- minimum downwind distance (m) being studied
Q	- source term (kg/s)
REHT	- release height
SEC	- factor used in calculating sector average χ/Q
SY	- Sigma Y for distance downwind and stability
SZ	- Sigma Z for distance downwind and stability
SZLIM	- maximum Sigma Z value
U	- wind speed (m/s)
UINTERNAL	- increment of wind speed
UMAX	- maximum wind speed (m/s) being studied
UMIN	- minimum wind speed (m/s) being studied
X	- distance downwind
XC	- centerline χ (or χ/Q) value as a function of downwind distance, wind speed, and stability
XS	- sector average χ (or χ/Q) value as a function of downwind distance, wind speed, and stability

CHISHORT output

**** CLITERLINE MODEL **** X/O VALUES IN S/M**3

RELEASE HEIGHT: 10. M MIXING DEPTH: 100.0M

STABILITY# 1 SPEED (M/S):	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	6.32E-05	3.16E-05	2.11E-05	1.58E-05	1.26E-05	1.05E-05	9.03E-06	7.91E-06	7.03E-06	6.32E-06
OF 1000. M	3.38E-05	1.69E-05	1.13E-05	8.45E-06	6.76E-06	5.64E-06	4.83E-06	4.23E-06	3.74E-06	3.38E-06
OF 1500. M	2.34E-05	1.17E-05	7.82E-06	5.86E-06	4.69E-06	3.91E-06	3.35E-06	2.93E-06	2.61E-06	2.34E-06
OF 2000. M	1.81E-05	9.04E-06	6.03E-06	4.52E-06	3.62E-06	3.01E-06	2.58E-06	2.26E-06	2.01E-06	1.81E-06

STABILITY# 2 SPEED (M/S):	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	1.61E-04	8.05E-05	5.37E-05	4.03E-05	3.22E-05	2.68E-05	2.30E-05	2.01E-05	1.79E-05	1.61E-05
OF 1000. M	4.50E-05	2.25E-05	1.50E-05	1.12E-05	8.99E-06	7.49E-06	6.42E-06	5.62E-06	5.00E-06	4.50E-06
OF 1500. M	3.12E-05	1.56E-05	1.04E-05	7.80E-06	6.24E-06	5.20E-06	4.45E-06	3.90E-06	3.46E-06	3.12E-06
OF 2000. M	2.40E-05	1.20E-05	8.02E-06	6.01E-06	4.81E-06	4.01E-06	3.44E-06	3.01E-06	2.67E-06	2.40E-06

STABILITY# 3 SPEED (M/S):	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	3.27E-04	1.63E-04	1.09E-04	8.17E-05	6.53E-05	5.44E-05	4.67E-05	4.08E-05	3.63E-05	3.27E-05
OF 1000. M	9.61E-05	4.81E-05	3.20E-05	2.40E-05	1.92E-05	1.60E-05	1.37E-05	1.20E-05	1.07E-05	9.61E-06
OF 1500. M	4.64E-05	2.32E-05	1.55E-05	1.16E-05	9.28E-06	7.73E-06	6.63E-06	5.80E-06	5.15E-06	4.64E-06
OF 2000. M	3.17E-05	1.58E-05	1.06E-05	7.92E-06	6.33E-06	5.28E-06	4.52E-06	3.96E-06	3.52E-06	3.17E-06

STABILITY# 4 SPEED (M/S):	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	7.41E-04	3.71E-04	2.47E-04	1.85E-04	1.48E-04	1.24E-04	1.06E-04	9.27E-05	8.24E-05	7.41E-05
OF 1000. M	2.55E-04	1.28E-04	8.50E-05	6.38E-05	5.10E-05	4.25E-05	3.64E-05	3.19E-05	2.83E-05	2.55E-05
OF 1500. M	1.36E-04	6.80E-05	4.54E-05	3.40E-05	2.72E-05	2.27E-05	1.94E-05	1.70E-05	1.51E-05	1.36E-05
OF 2000. M	8.75E-05	4.38E-05	2.92E-05	2.19E-05	1.75E-05	1.46E-05	1.25E-05	1.09E-05	9.73E-06	8.75E-06

CHISHORT output (cont.)

STABILITY# 5
SPEED (M/S):

	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	1.27E-03	6.37E-04	4.24E-04	3.10E-04	2.55E-04	2.12E-04	1.82E-04	1.59E-04	1.41E-04	1.27E-04
OF 1000. M	4.96E-04	2.48E-04	1.65E-04	1.24E-04	9.92E-05	8.26E-05	7.08E-05	6.20E-05	5.51E-05	4.96E-05
OF 1500. M	2.71E-04	1.35E-04	9.03E-05	6.77E-05	5.42E-05	4.92E-05	3.87E-05	3.39E-05	3.01E-05	2.71E-05
OF 2000. M	1.77E-04	8.86E-05	5.91E-05	4.43E-05	3.55E-05	2.95E-05	2.53E-05	2.22E-05	1.97E-05	1.77E-05

STABILITY# 6
SPEED (M/S):

	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	1.87E-03	9.33E-04	6.22E-04	4.67E-04	3.73E-04	3.11E-04	2.67E-04	2.33E-04	2.07E-04	1.87E-04
OF 1000. M	9.56E-04	4.78E-04	3.19E-04	2.39E-04	1.91E-04	1.59E-04	1.37E-04	1.19E-04	1.06E-04	9.56E-05
OF 1500. M	5.53E-04	2.76E-04	1.84E-04	1.38E-04	1.11E-04	9.22E-05	7.90E-05	6.91E-05	6.14E-05	5.53E-05
OF 2000. M	3.73E-04	1.87E-04	1.24E-04	9.33E-05	7.47E-05	6.22E-05	5.33E-05	4.67E-05	4.15E-05	3.73E-05

STABILITY# 7
SPEED (M/S):

	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	1.27E-03	6.37E-04	4.25E-04	3.19E-04	2.55E-04	2.12E-04	1.82E-04	1.59E-04	1.42E-04	1.27E-04
OF 1000. M	1.52E-03	7.58E-04	5.05E-04	3.79E-04	3.03E-04	2.53E-04	2.17E-04	1.90E-04	1.68E-04	1.52E-04
OF 1500. M	1.09E-03	5.44E-04	3.62E-04	2.72E-04	2.17E-04	1.81E-04	1.55E-04	1.36E-04	1.21E-04	1.09E-04
OF 2000. M	8.10E-04	4.05E-04	2.70E-04	2.03E-04	1.62E-04	1.35E-04	1.16E-04	1.01E-04	9.01E-05	8.10E-05

CHISHORT output (cont.)

*** SECTION-AVERAGE MODEL *** X/U VALUES IN S/M**3

RELEASE HEIGHT: 10. M MIXING DEPTH: 100.0M

STABILITY# 1 SPEED (M/S):	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	8.09E-05	4.04E-05	2.70E-05	2.02E-05	1.62E-05	1.35E-05	1.16E-05	1.01E-05	8.99E-06	8.09E-06
OF 1000. M	4.04E-05	2.02E-05	1.35E-05	1.01E-05	8.09E-06	6.74E-06	5.78E-06	5.05E-06	4.49E-06	4.04E-06
OF 1500. M	2.70E-05	1.35E-05	8.99E-06	6.74E-06	5.39E-06	4.49E-06	3.85E-06	3.37E-06	3.00E-06	2.70E-06
OF 2000. M	2.02E-05	1.01E-05	6.74E-06	5.05E-06	4.04E-06	3.37E-06	2.89E-06	2.53E-06	2.25E-06	2.02E-06

STABILITY# 2 SPEED (M/S):	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	1.55E-04	7.74E-05	5.16E-05	3.87E-05	3.10E-05	2.58E-05	2.21E-05	1.94E-05	1.72E-05	1.55E-05
OF 1000. M	4.04E-05	2.02E-05	1.35E-05	1.01E-05	8.09E-06	6.74E-06	5.78E-06	5.05E-06	4.49E-06	4.04E-06
OF 1500. M	2.70E-05	1.35E-05	8.99E-06	6.74E-06	5.39E-06	4.49E-06	3.85E-06	3.37E-06	3.00E-06	2.70E-06
OF 2000. M	2.02E-05	1.01E-05	6.74E-06	5.05E-06	4.04E-06	3.37E-06	2.89E-06	2.53E-06	2.25E-06	2.02E-06

STABILITY# 3 SPEED (M/S):	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	2.39E-04	1.19E-04	7.95E-05	5.96E-05	4.77E-05	3.98E-05	3.41E-05	2.98E-05	2.65E-05	2.39E-05
OF 1000. M	6.56E-05	3.28E-05	2.19E-05	1.64E-05	1.31E-05	1.09E-05	9.37E-06	8.20E-06	7.29E-06	6.56E-06
OF 1500. M	3.04E-05	1.52E-05	1.01E-05	7.61E-06	6.09E-06	5.07E-06	4.35E-06	3.81E-06	3.38E-06	3.04E-06
OF 2000. M	2.02E-05	1.01E-05	6.74E-06	5.05E-06	4.04E-06	3.37E-06	2.89E-06	2.53E-06	2.25E-06	2.02E-06

STABILITY# 4 SPEED (M/S):	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	3.81E-04	1.91E-04	1.27E-04	9.53E-05	7.62E-05	6.35E-05	5.45E-05	4.76E-05	4.24E-05	3.81E-05
OF 1000. M	1.23E-04	6.13E-05	4.09E-05	3.07E-05	2.45E-05	2.04E-05	1.75E-05	1.53E-05	1.36E-05	1.23E-05
OF 1500. M	6.29E-05	3.15E-05	2.10E-05	1.57E-05	1.26E-05	1.05E-05	8.99E-06	7.86E-06	6.99E-06	6.29E-06
OF 2000. M	3.94E-05	1.97E-05	1.31E-05	9.84E-06	7.87E-06	6.56E-06	5.62E-06	4.92E-06	4.37E-06	3.94E-06

CHISHORT output (cont.)

STABILITY= 5										
SPEED (M/S):										
	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	4.66E-04	2.33E-04	1.55E-04	1.16E-04	9.31E-05	7.76E-05	6.65E-05	5.82E-05	5.17E-05	4.66E-05
OF 1000. M	1.70E-04	8.48E-05	5.65E-05	4.24E-05	3.39E-05	2.83E-05	2.42E-05	2.12E-05	1.88E-05	1.70E-05
OF 1500. M	8.91E-05	4.45E-05	2.97E-05	2.23E-05	1.78E-05	1.48E-05	1.27E-05	1.11E-05	9.90E-06	8.91E-06
OF 2000. M	5.67E-05	2.83E-05	1.89E-05	1.42E-05	1.13E-05	9.45E-06	8.10E-06	7.08E-06	6.30E-06	5.67E-06

STABILITY= 6										
SPEED (M/S):										
	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	4.71E-04	2.36E-04	1.57E-04	1.18E-04	9.42E-05	7.85E-05	6.73E-05	5.89E-05	5.23E-05	4.71E-05
OF 1000. M	2.26E-04	1.13E-04	7.52E-05	5.64E-05	4.51E-05	3.76E-05	3.22E-05	2.82E-05	2.51E-05	2.26E-05
OF 1500. M	1.25E-04	6.27E-05	4.18E-05	3.14E-05	2.51E-05	2.09E-05	1.79E-05	1.57E-05	1.39E-05	1.25E-05
OF 2000. M	8.24E-05	4.12E-05	2.75E-05	2.06E-05	1.65E-05	1.37E-05	1.18E-05	1.03E-05	9.16E-06	8.24E-06

STABILITY= 7										
SPEED (M/S):										
	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
DISTANCE										
OF 500. M	2.14E-04	1.07E-04	7.14E-05	5.16E-05	4.29E-05	3.57E-05	3.06E-05	2.68E-05	2.38E-05	2.14E-05
OF 1000. M	2.38E-04	1.19E-04	7.95E-05	5.96E-05	4.77E-05	3.97E-05	3.41E-05	2.98E-05	2.65E-05	2.38E-05
OF 1500. M	1.64E-04	8.22E-05	5.48E-05	4.11E-05	3.29E-05	2.74E-05	2.35E-05	2.05E-05	1.83E-05	1.64E-05
OF 2000. M	1.19E-04	5.96E-05	3.97E-05	2.98E-05	2.38E-05	1.99E-05	1.70E-05	1.49E-05	1.32E-05	1.19E-05

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