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Environmental Baseline File: Meteorology and Air Quality

Civilian Radioactive Waste Management System

Management & Operating Contractor

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Civilian Radioactive Waste Management System
Management & Operating Contractor

Environmental Baseline File for Meteorology and Air Quality

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March 1999

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Civilian Radioactive Waste Management System
Management & Operating Contractor

Environmental Baseline File for Meteorology and Air Quality

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March 1999

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ACRONYMS AND ABBREVIATIONS

CFR	Code of Federal Regulations
EBF	Environmental Baseline File
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
YMP	Yucca Mountain Site Characterization Project

1. BACKGROUND

This Working Draft Environmental Baseline File (EBF) is one in a series of reports on specific environmental topics being supplied by the Yucca Mountain Project (YMP) to the contractor tasked with writing the Draft Yucca Mountain Repository Environmental Impact Statement (EIS). These reports convey information on: relevant issues; methods used to acquire the information; descriptions of the current region of influence, resources and possible receptors; possible opposing views and hypotheses, and data needs for the EIS. The specific environmental topics addressed in this EBF are meteorology and air quality.

1.1 METEOROLOGY

Unlike most other environmental resources topics, meteorology is not an affected resource. That is, meteorological conditions are not affected by the alternatives related to the proposed repository. The meteorology information contained in this EBF is a description of current conditions. The description could be used to characterize atmospheric dispersion and to describe general climatic conditions in preparing the EIS. The atmospheric dispersion results could be used as dispersion mathematical model input to estimate both radiological and non-radiological impacts due to potential airborne releases. The general climatic data could be used in evaluating design and surface hydrology issues.

The Environmental Assessment for Yucca Mountain identified the possibility that airborne material released at the repository could reach populated areas, including nearby Amargosa Valley (about 25 kilometers south) and other nearby communities, such as Beatty and Las Vegas (DOE 1986, sec. 6.2.1.4). The Yucca Mountain area is comprised of complex terrain that significantly affects atmospheric dispersion. The transport pathways and corresponding diffusion of airborne material are controlled by the local topography and regional scale weather patterns. In addition to atmospheric dispersion, other meteorological conditions are also significantly controlled by local terrain and regional scale weather patterns. For example, extreme wind speed and precipitation events significant to design are also strongly influenced by the local topography (CRWMS M&O 1997a, sec. 4.2.2).

The Yucca Mountain region exhibits complicated local patterns of atmospheric dispersion and other meteorological conditions. Representative meteorological data are needed for the descriptions of existing conditions. To obtain these data, YMP began operating a network of meteorological stations in the immediate vicinity of Yucca Mountain to characterize the local conditions. The focus of the network was airflow toward Amargosa Valley from Midway Valley, the site of the proposed surface facilities.

The network provided detailed information on local conditions, as intended. However, other information requirements included characterizing conditions in the surrounding regional area, and over a longer span of time than that of operation of the network. Therefore, data from surrounding stations in the regional area, including those involved with operating the Nevada Test Site, were also obtained.

Surface flooding events are significant to site characterization and repository design activities. Estimates of potential maximum precipitation have been made. A recent related event is the

minor surface flooding that occurred in Fortymile Wash from the rainstorm on March 10 through 11, 1995. A portion of U.S. Highway 95 west of the community of Amargosa Valley was closed for a short time by floodwater and debris generated by surface water flow in Fortymile Wash. This event did not affect the area near the Exploratory Studies Facility or the proposed surface facilities area of the geologic repository.

Another meteorological topic in the YMP studies is climate. The currently arid, warm climate of Yucca Mountain is seen as a beneficial attribute to a geologic repository in unsaturated rock. Low precipitation amounts with frequent warm temperatures and wind contribute to low amounts of infiltration to underground rock, which most likely maximizes groundwater travel time. Long groundwater travel times could reduce the release rate of radionuclides to the accessible environment. On the other hand, higher precipitation amounts and cooler temperatures could increase infiltration, and subsequently decrease groundwater travel time, thereby increasing the release rate of radionuclides to the accessible environment. Thus, questions regarding the area becoming significantly wetter and cooler than current conditions are being addressed in the Climate Program portion of the YMP studies. In addition to groundwater travel time, another future climate question is the effects of potential changes in air temperature and precipitation on dissipation of heat emitted by spent fuel stored in the geologic repository. This question relates to the identified repository alternatives, namely, the density of underground spent nuclear fuel storage. The data regarding current meteorological conditions are used to provide a baseline to consider climate change.

1.2 AIR QUALITY

The second environmental topic addressed in this EBF is non-radiologic air quality. This includes current concentration levels of particulate matter and gaseous air pollutants. The air pollutants considered are the criteria pollutants, that is, those pollutants regulated by National or State regulations. The information on current air pollutant levels could be used to estimate potential air quality impacts due to construction and operation of the proposed repository.

Particulate matter could be generated as fugitive dust during construction and/or operations of a geologic repository. Depending on the type and size of support facilities, other criteria pollutants may require air quality analyses. A related topic is a concern for possible local air quality impacts resulting from surface disturbing activities performed during site characterization. An air quality monitoring program was implemented that included measurements of particulate matter and the criteria gaseous pollutants. Particulate matter includes Total Suspended Particulate matter and the inhalable particulate matter with an aerodynamic diameter less than 10 micrometers (10^{-6} meters) (PM_{10}). Results of this monitoring program are discussed in terms of compliance with the National Ambient Air Quality Standards, and air quality trends. The National Ambient Air Quality Standards are addressed in this EBF because they are the typical measure of the significance of health related impacts.

The National Ambient Air Quality Standards for Particulate Matter (40 Code of Federal Regulations (CFR) 50.6) included limitations on the 24-hour and annual averages of inhalable particulate matter PM_{10} from 1991 through the period of the monitoring being addressed in this report. The Standard applicable to the 24-hour samples basically allows one sample day per year to exceed the Standard level, which is 150 micrograms per cubic meter ($\mu g/m^3$). The method to

calculate compliance with the Standard is more complex than this, but a conservative approach is to use the second highest observed value as the measure of compliance with the Standard. The Standard for the annual average is 50 $\mu g/m^3$. The Nevada State Standards are the same levels as the National Ambient Air Quality Standards.

New National Ambient Air Quality Standards for particulate matter became effective on September 17, 1997 (40 CFR 50.7). The greatest difference for particulate matter is the change of the basic indicator of particulate matter from PM_{10} to $PM_{2.5}$, which are fine particles in the respirable range, with nominal aerodynamic diameters smaller than 2.5 micrometers. The particulate matter Standards involves specific calculations of the expected number of exceedance days during a three year period. The current Standards for particulate matter as inhalable particulate matter PM_{10} will remain in effect, with some revisions, until implementing actions are taken by the Environmental Protection Agency (EPA) and the State and local agencies.

The National Ambient Air Quality Standards for ozone (40 CFR 50.9) was based on the number of days with a 1-hour average exceeding 0.12 parts per million by volume. A new National Ambient Air Quality Standards for ozone also became effective on September 17, 1997. The new ozone standard will involve 8-hour averages in excess of 0.08 parts per million. Ozone is not currently being monitored, nor is it likely to be resumed to support the repository, because ozone analyses are typically initiated by planned emissions of volatile organic compounds. Significant volatile organic compounds emissions are not expected to be related to the planned repository surface facilities. Therefore, the change in this National Ambient Air Quality Standards should not impact the EIS.

The National Ambient Air Quality Standards for carbon monoxide (40 CFR 50.8), nitrogen dioxide (40 CFR 50.11), and sulfur dioxide (40 CFR 50.4) apply to the Yucca Mountain area. The monitoring program described in Section 2 indicates that these pollutants are virtually of no concern in an environmental analysis for the repository.

1.3 ISSUES OR CONCERNS

The regulatory requirements that call for descriptions of meteorological and air quality conditions for the environmental analyses related to the proposed geologic repository at Yucca Mountain are listed in this section. The relevant ambient air quality standards are also identified, as is the formal Notice of Intent document.

1.3.1 Notice of Intent

The Notice of Intent for the Repository Environmental Impact Statement included the plan to assess potential impacts of non radiological releases to the air resources (air quality) affecting the general public and on site workers. The impacts could result from the alternative of constructing and operating the geologic repository, or from the no action alternative of ceasing the site characterization activities and reclaiming the disturbed land.

1.3.2 Meteorology

The federal regulations in 10 CFR 960.5-2-3 include the need for information on the "meteorological setting during repository operation and closure," to determine the meteorological

affects on the transport of airborne emissions. This information is needed during the period of repository operation and closure to "estimate the potential effects on the transport of airborne emissions."

1.3.3 Environmental Quality

Further federal regulations 10 CFR 960.5-2-5 include the need for information on existing air quality and trends in order to estimate potential impacts on public health and welfare and on environmental quality.

1.3.4 National Ambient Air Quality Standards

The National Ambient Air Quality Standards 40 CFR 50 are addressed in this EBF because the National Ambient Air Quality Standards are the typical measures of the significance of health related impacts resulting from emissions of non radiologic air pollutants.

1.4 METHODS

Methods used to prepare data for this EBF are described in this section. Separate discussions are provided for the meteorology and air quality monitoring programs, and the atmospheric dispersion modeling activities.

1.4.1 Meteorology and Air Quality Monitoring Programs

Meteorological data from the Radiological and Environmental Programs Department site specific network of nine stations were analyzed to characterize local airflow and atmospheric dispersion, and to develop site specific representative values for design engineering and general climatological purposes. The locations of the sites are shown in Figure 1-1, and are identified in Table 1-1. The site locations were chosen to be representative of repository surface facilities, and to characterize local airflow, atmospheric dispersion, and current meteorological conditions.

The meteorological measurement program has evolved since its inception in December 1985. The network originally consisted of Sites 1 through 5; Sites 6 through 9 were added during 1992. Some atmospheric stability measurements were added during 1993 in response to changes in monitoring guidance for regulatory modeling applications (EPA 1995, sec. 6.4.4). The data summarized in this report are based on the measurements of:

- Wind at 10 meters above ground level (m-agl) at all sites, and at 60 meters at Site 1
- Air temperature and relative humidity (originally 10 m-agl, moved to 2 m-agl during 1993)
- Precipitation, barometric pressure, and solar radiation
- Vertical temperature gradient (delta-temperature) between 2 and 10 m-agl at all sites, and 10 and 60 m-agl at Site 1.

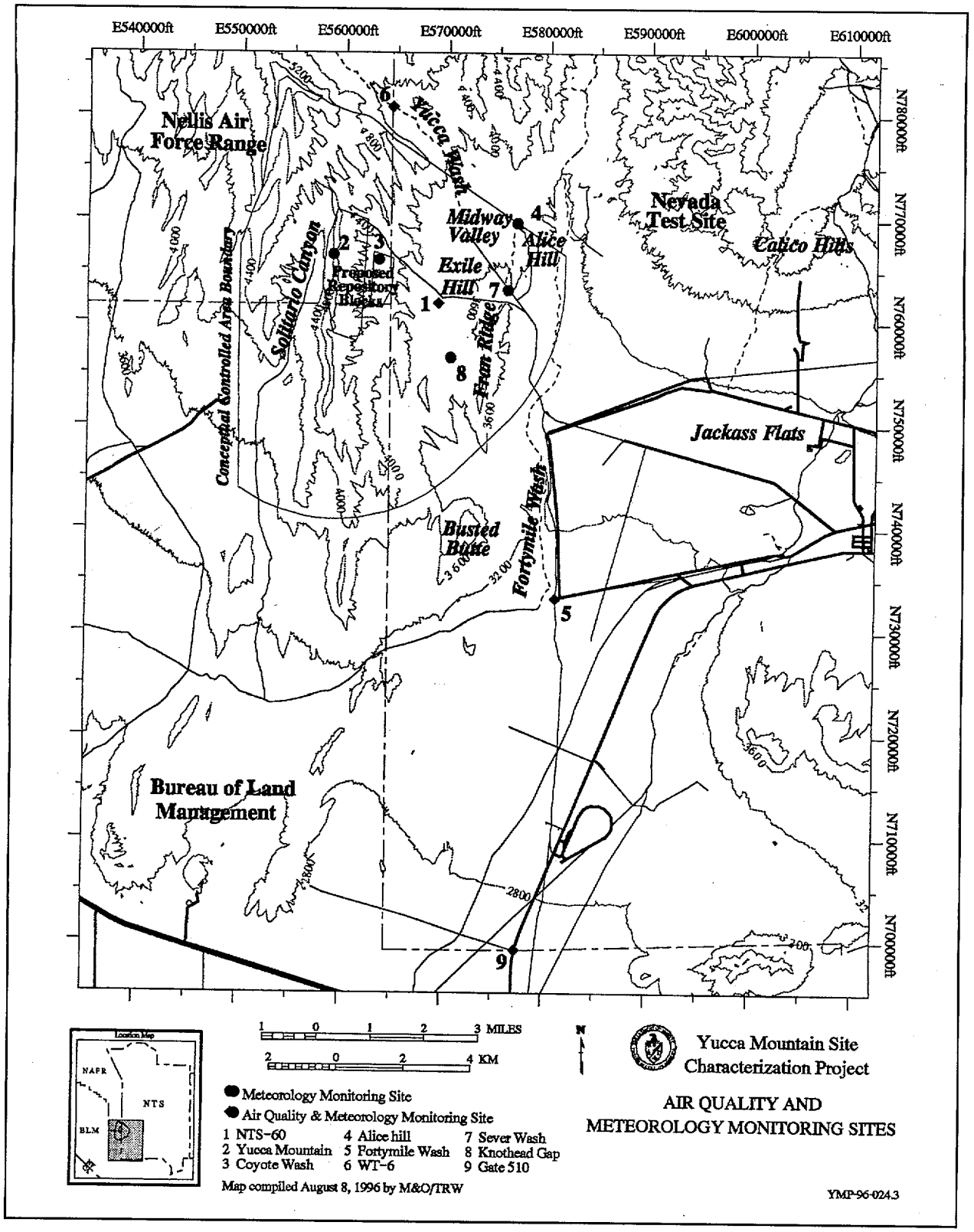


Figure 1-1. Locations of the Meteorological Monitoring Sites

Table 1-1. Coordinates of the Air Quality and Meteorological Monitoring Sites

Site	UTM Coordinates Zone 11 (meters)	Nevada Coordinates System Central Zone (feet)	Latitude-Longitude (deg° min' sec")	Elevation (above mean sea level)
Site 1 (NTS-60)	550,784E 4,077,374N	569,126E 761,795N	116° 25'50"W 36° 50'34"N	3750 ft 1143 m
Site 2 (Yucca Mountain)	547,646E 4,078,753N	558,844E 766,356N	116° 27'56"W 36° 51'19"N	4850 ft 1478 m
Site 3 (Coyote Wash)	548,874E 4,078,701N	562,874E 766,171N	116° 27'06"W 36° 51'17"N	4195 ft 1279 m
Site 4 (Alice Hill)	553,117E 4,079,779N	576,810E 769,661N	116° 24'15"W 36° 51'51"N	4050 ft 1234 m
Site 5 (Fortymile Wash)	554,385E 4,068,727N	580,843E 733,378N	116° 23'26"W 36° 45'52"N	3125 ft 953 m
Site 6 (WT-6)	549,388E 4,083,097N	564,612E 780,592N	116° 26'45"W 36° 53'40"N	4315 ft 1315 m
Site 7 (Sever Wash)	552,800E 4,077,847N	575,747E 763,324N	116° 24'28"W 36° 50'49"N	3545 ft 1081 m
Site 8 (Knothead Gap)	551,161E 4,075,773N	570,344E 756,538N	116° 25'35"W 36° 49'42"N	3710 ft 1131 m
Site 9 (Gate-510)	553,418E 4,058,398N	577,554E 699,491N	116° 24'08"W 36° 40'17"N	2750 ft 838 m

Data collected during the YMP meteorological monitoring program have been subjected to rigorous YMP quality assurance and quality control procedures. The monitoring program was designed to comply with EPA Prevention of Significant Deterioration (EPA 1995) and Nuclear Regulatory Commission monitoring guidance (ANSI 1984, NRC 1972, NRC 1987). Data from the Radiological Environmental Programs Department monitoring network were used to develop input for atmospheric dispersion modeling tasks.

Meteorological data from sources outside YMP were obtained to supplement the site specific network data, primarily to utilize data from stations with a longer period of record than that available from the network stations. These data have been used to analyze long term regional precipitation and wind characteristics.

The YMP ambient air quality monitoring program includes total suspended particulate matter and inhalable particulate matter (PM_{10}) sampling on the EPA every sixth day schedule. The criteria gaseous pollutants carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2) were monitored during the four year period from October 1991 through September 1995. The analyzer that measured nitrogen dioxide also measures nitric oxide (NO) and the oxides of nitrogen (NO_x), so these chemical compounds were monitored as well.

The primary particulate matter and gaseous pollutant monitoring location was Site 1, which includes the 60 meter meteorological tower and is located within a few kilometers south of the proposed locations for many of the repository surface facilities. The second particulate matter site was Site 5, which was intended to represent background conditions away from site

characterization activities. These measurements began in April 1989; two PM_{10} sites were added late in 1992. Site 9, with PM_{10} only, was installed at Gate 510, on the southern border of the Nevada Test Site immediately north of Amargosa Valley. Site 6, another PM_{10} site, was installed along the western border of the Nevada Test Site where it meets the Nellis Air Force Range land in upper Yucca Wash. Site 6 was sited to measure PM_{10} that might be transported from Midway Valley toward the northwest through Yucca Wash.

The data analyzed for this report include the results from the beginning of monitoring operations through calendar year 1997. In addition to environmental characterization applications, the PM_{10} results have been reported to the State of Nevada to comply with requirements to an air quality permit covering surface disturbance activities associated with site characterization activities.

1.4.2 Atmospheric Dispersion

Three steps in characterizing atmospheric dispersion are presented in this section. The first step is wind data summaries presented as three way joint frequency distributions of wind speed, wind direction, and atmospheric stability categories. These distributions are a fundamental step in performing many types of impact analyses due to airborne material. Detailed analyses (CRWMS M&O 1995a, 1997b) of the local wind characteristics in the study area led to the choice of Site 1 as the meteorological data source most representative of potential repository surface facilities. Site 1 is about one kilometer south of the proposed repository surface facility location in the western portion of Midway Valley. Like the proposed surface facility location, it is also near the eastern edge of the steeply rising terrain of the Yucca Mountain ridge. The similar topographic exposures between the two locations lead to similar prevailing northerly and southerly winds.

For completeness, wind data from both 10 and 60 meters above ground level at Site 1 were used for the mathematical model input, so data summaries from both levels are provided in Appendix B. The conventional way that meteorologists report wind direction data is the direction from which the wind was blowing. Conversely, atmospheric dispersion modelers describe corresponding results as transport toward a given direction. The joint frequency distribution wind summaries show dominance of southerly winds (winds blowing from the south toward the north) during about one half of the hours. These cases have been shown (CRWMS M&O 1997b, p. 3-2) to mostly occur during daytime hours. Conversely, the nighttime hours typically produce winds from the north at the 60 meter level, and from the northwest at the 10 meter level. The low level northwesterly winds are due to downslope airflow from the east side of Yucca Mountain, which tends to turn toward the south (becoming northerly wind) at distances corresponding to the Fortymile Wash area and beyond. Thus, the wind data from the 60 meter level are more representative of both elevated sources and surface level sources for transport beyond about 10 kilometers distance.

Atmospheric stability is the element in dispersion modeling that describes the rate of diffusion of airborne material. The stability categorization scheme used in these analyses is one recommended by the EPA for regulatory modeling applications (EPA 1995, Section 6). This scheme starts with the standard deviation of the horizontal wind direction (sigma-theta, σ_θ, or sigma-A, σ_A), and assigns stability categories considering wind speed and time of day.

Data from the years 1993 through 1997 were used for the summary to allow for optimal data availability for possible future modeling studies using more complex models and different stability categorization schemes. The last four sites began operating in 1993, and the on site data processing routines were modified in 1993 to include additional data that could be used to determine stability category.

The second modeling step is to use a conservative straight line Gaussian mathematical model to estimate dispersion factors for chronic (long term) exposures. Receptors were placed at 8 kilometer intervals from 8 to 80 kilometer distances. Although conservative straight line models do not describe actual plume pathways, they can be useful for preliminary screening results to indicate the maximum probable impacts. The GENII-S mathematical model software code was chosen for this step, because it is a widely used regulatory dispersion model for purposes of this level of analysis.

The third modeling step is analyses for possible worst case acute exposure (short term) releases. Hypothetical worst case meteorology data sets were created based on study of dispersion characteristics in the area. The worst case conditions appear to be steady nighttime drainage winds blowing toward the populated areas in Amargosa Valley from the proposed surface facility location in Midway Valley. The meteorological data used as software code input were constant conditions of common drainage wind conditions that typically occur at the nine sites in the Radiological and Environmental Programs Department network. The GENII-S and the PGEMS software codes were used in this step. PGEMS allows for airflow variations due to complex terrain.

Very limited information about the potential source type(s) and emission rate(s) was available for an analysis of possible radiological and non-radiological impacts due to airborne material because the design process has not produced this information yet. This information will be contained in Engineering Files. The anticipated area for the surface facility is near the current North Portal area of the Exploratory Studies Facility, which is approximately one kilometer north of the Radiological and Environmental Programs Department Site 1. For purposes of the software code, the source was located at Site 1, 550.8E kilometers and 4077.4N kilometers in Universal Transverse Mercator (Zone 11) coordinates. The structure may have a stack to vent released gas, or the releases could originate from a near surface height. Three possible source heights were used in separate model runs: near the surface, and at 60 and 100 meters above ground level.

1.5 RESULTS AND CONCLUSIONS

Information on current meteorological and non-radiological air quality conditions in the vicinity of Yucca Mountain is presented in Section 2 of this report. Summary statements about the meteorological and air quality conditions, and the atmospheric mathematical modeling results are given in this section.

Meteorological studies (CRWMS M&O 1997b, Section 5) indicate that airflow in valley areas in the vicinity of Yucca Mountain is channeled by local topography, particularly at night during stable conditions. Wind patterns also have a strong diurnal cycle of daytime winds from the south and nighttime winds from the north. Unstable atmospheric stability conditions typically

prevail during daytime hours. Strong vertical mixing occurs during daytime unstable conditions, and the transport direction is usually toward the north (in winds from the south). When daytime winds are from the north (and transport is toward the south), the atmosphere typically has neutral stability, frequently with large wind speeds, resulting in good atmospheric dispersion conditions. Nighttime conditions are usually very stable, with a complex layer structure. The lowest layers are typically associated with downslope or downvalley drainage winds that tend to follow the hydrographic gradient. Thus, nighttime airflow from Midway Valley is typically through Jackass Flats and into Amargosa Valley.

The Yucca Mountain area is characterized by an arid climate, with infrequent and generally small amounts of precipitation (CRWMS M&O 1997a, p. 4-1). The annual precipitation totals average between about four inches in Amargosa Valley to more than six inches in the upper elevations and northern portions of Yucca Mountain. Some rainfall events can bring high rainfall accumulation rates or long duration storms accumulating large totals. Twenty-four-hour totals between three and five inches are anticipated within the period of repository operation.

Air temperatures range between a minimum of about -15° Celsius to a maximum of about 45° Celsius. Freezing temperatures do not occur very frequently. The daily (diurnal) range of temperatures is about 10° Celsius. The relative humidity averages about 10 percent on summer afternoons, and about 53 percent on winter mornings.

The air quality monitoring program consistently showed concentration levels that were well below the applicable National Ambient Air Quality Standards. The highest PM_{10} concentration measured was 67 $\mu g/m^3$, which is 45 percent of the applicable standard concentration level.

Normalized dispersion results were produced using emission rates of one unit per second. The resulting concentration estimates (χ/Q) produced are expressed in the units seconds per cubic meter (sec/m^3). The highest estimated impact for the chronic (long term) exposures using the GENII-S software code was 2.67E-07 sec/m^3. (Note: concentrations are expressed in scientific notation, that is "n e-m," where "n" is a number multiplied by 10 raised to the power "m". Thus, 2.67E-07 is $2.67 \cdot 10^{-7}$). This result for the chronic exposure occurred in the runs using the 60-meter wind data and a release at one meter above ground level. The direction corresponds to transport toward the north, in the strongly prevailing southerly winds; the corresponding distance was the first receptor point at eight kilometers.

The highest estimated impact for the acute (short term) exposures using the GENII-S software code was 2.7E-06 sec/m^3; these runs were made independent of direction. The highest result occurred at a five kilometer distance. The estimated concentration at 20 kilometers was 3.8E-07 sec/m^3. The estimates near the five kilometer distance apply to a possible future restricted area boundary; the estimates for 20 kilometers apply to the nearest populated area. The highest result from the model that accounts for airflow in terrain (PGEMS) using hypothetical worst case drainage wind meteorological data was 1.8E-05 sec/m^3 at 5 kilometers, and 1.9E-06 sec/m^3 at 20 kilometers.

2. CURRENT UNDERSTANDING OF THE AFFECTED RESOURCES

Information currently available on meteorology and air quality that could be used in preparing the Repository Environmental Impact Statement is presented in this section. The information is presented following the concept of receptors and attributes, and is applicable within the defined region of influence. Possible opposing views and hypotheses are presented in Section 3, and the anticipated data needs for the Repository Environmental Impact Statement are presented in Section 4.

The meteorological and air quality data used to prepare this EBF have been reported in a series of Civilian Radioactive Waste Management System Management and Operating Contractor (and predecessor organization) reports, which are cited in Section 5.

2.1 REGION OF INFLUENCE

The regions of influence for both repository preclosure and postclosure periods include the immediate air basin area between Yucca Mountain and the populated areas in Amargosa Valley. Typical radiological analyses go at least to 50 miles (80 kilometers); Las Vegas is at least 12 miles (20 kilometers) further distant, but was considered during the airflow analysis to support possible dose estimate work.

2.2 RECEPTORS

The receptors and attributes for air quality issues include ambient air quality and annual emissions and are shown in Table 2-1.

Table 2-1. Receptors and Attributes for Ambient Air Quality and Emissions Receptors

Receptor	Attribute
Ambient Air Quality	Change in inhalable particulate matter (PM_{10}) and gaseous criteria pollutant concentrations
Annual Emissions	Tons/yr emissions of radon, tritium, PM_{10}, etc.; source information is to be included within the Engineering Files documents

The concept of receptors and affected attributes does not apply to the meteorology issues. The role of meteorology is twofold: input data for the impact assessments, and information used in describing local climate. The meteorological information supplied includes the data summaries shown in Table 2-2.

Table 2-2. Meteorological Data Summary Information

Meteorological Variable	Data Summary Information
Wind	Joint frequency distributions by speed, direction, and stability categories; and mean and extreme wind speeds
Precipitation	Average monthly and annual totals, and maximum 1-hr, 6-hr, and 24-hr totals
Temperature	Monthly means and extremes.
Humidity	Monthly means calculated for four hourly time periods (0400, 1000, 1600 and 2200 Pacific Standard Time).
Solar Radiation	Monthly and annual totals

2.3 CURRENT STATUS

2.3.1 Meteorology

The Yucca Mountain area currently has a relatively arid climate, with annual precipitation totals ranging between approximately four and six inches per year (CRWMS M&O 1995b, 1996a, 1997a [Section 4.1.4, et al.], 1997c, SAIC 1993a, 1993b, 1995). Precipitation at any given location depends upon nearby topographic features. The winter season is mild, with some periods of below freezing temperatures. Occasional periods of persistent rain have produced more than two inches of rainfall in daily periods. The summer season is typically hot and dry, with occasional periods of monsoon thunderstorms producing locally large amounts of rain. Storms can produce more than an inch of rain within a matter of hours.

Local and regional airflow patterns are largely controlled, and even produced, by topographic features such as mountain and valley systems or even canyons and washes such as those found on the east side of Yucca Mountain (CRWMS M&O 1995, 1997b). Daytime winds are typically from the south, with local direction changes due to topographic channeling through valleys or canyons along the topographic axis. Nighttime winds within the first few hundred meters of the ground are often from the north, which is a general downvalley direction in the area. Local airflow along the east side of Yucca Mountain and through Midway Valley is tightly constrained by topography; low level airflow generally follows the hydrologic gradient. Summaries of the wind data from REPD Site 1 are presented in the atmospheric dispersion analyses in this section. The region of the atmosphere from the surface up through the next few hundred meters above ground level often has complex vertical structure of wind and atmospheric stability.

Climatological summaries of data from whole years of operation through 1997 for the Radiological and Environmental Programs Department network sites are presented in Appendix A of this report. Thus, data periods were from 1986 through 1997 for Sites 1 through 5 and from 1993 through 1997 for Sites 6 through 9. Note the following important measurement changes that were made during the monitoring program:

- Air temperature and relative humidity data were taken at 10 m-agl from the beginning of site operation through August 1993, when the measurement height was changed to 2 m-agl.

- Some of the statistics were added during the program, such as the fastest 1-minute wind speed, and the 1-minute average temperature extremes. Thus, some of the statistics are based on a period shorter than the total operation of the sites.

The climatological summaries reflect the aridity of the area, with mild winters and hot summers. Annual average precipitation totals range from 8.30 inches at Site 6 in upper Yucca Wash to 3.59 inches at Site 9 near Gate 510 on the southern boundary of the Nevada Test Site near Amargosa Valley. Occasionally, storms can produce large precipitation totals in a short length of time. The maximum 24-hour totals range from 1.11 inches at Site 9 to 2.43 inches at Site 8 in the southern portion of Midway Valley. The average number of days with at least 0.01 inches of precipitation can be used as input to some dispersion models. In one calculation, precipitation occurrences at either Site 1 or Site 8 were used as representative of Midway Valley using the

data from 1993 through 1996; the result was 37.75 days. A similar calculation was also reported for only Site 1, using data from 1993 through 1997; this result was 34.2 days.

Air temperatures have a typical diurnal change of 10° Celsius. Summer afternoon temperatures average about 35° Celsius to 40° Celsius, and winter mornings average near 1.5° Celsius. Relative humidity averages range from near 10 percent in summer afternoons to about 53 percent during winter early mornings.

Wind speeds average between 2.6 and 4.3 meters per second (m/s) in the network. The fastest 1-minute wind speeds by site range between 18.6 and 33.2 m/s. The maximum peak gusts by site are between 26.7 and 38.2 m/s.

2.3.2 Air Quality

The YMP ambient air quality monitoring program and applicable National Ambient Air Quality Standards were described in Section 1. Four sites currently include inhalable particulate matter (PM_{10}) monitoring; two of these sites also include total suspended particulate matter monitoring. The criteria gaseous pollutants were monitored during the four year period from October 1991 through September 1995. The results of the gaseous and particulate matter air quality monitoring programs for the period through 1997 data are summarized in this section to provide information on background conditions in the area. The results reported in this document were calculated using consistent seasonal temperature and pressure values by site, a method consistent with EPA monitoring guidance. Further information on the sampling program and discussions of results are available in summary reports that are listed in Section 5 (CRWMS M&O 1996b, 1996c, 1997d, SAIC 1992a, 1992b).

The highest 24-hour PM_{10} sampling result was 67 $\mu g/m^3$, which was 45 percent of the Standard exceedance level, 150 $\mu g/m^3$. This measurement was made at Site 5 in 1995. The highest of the second highest values was 49 • g/m3, which was 33 percent of the standard. The annual averages range between 7 and 12 $\mu g/m^3$, which was less than 25 percent of the applicable annual standard. Summaries of the PM_{10} annual highest and second highest 24-hour samples and the annual averages are given in Table 2-3. These results show that the measured ambient particulate matter levels are well below applicable standards.

The results of the total suspended particulate matter sampling are also summarized in Table 2-3. There has not been a national total suspended particulate air quality standard since 1987, or a Nevada total suspended particulate standard since 1991. These results are presented as indicators of different aspects of ambient particulate matter levels in the area. The highest 24-hour sample result was an anomalous 310 $\mu g/m^3$, which was sampled at Site 5 during 1995. The corresponding second highest value that year at Site 5 was only 69 $\mu g/m^3$. The highest of the second highest values at Site 5 was 126 $\mu g/m^3$. The highest and highest of the second highest sampling results from Site 1 were 152 and 145 $\mu g/m^3$, respectively.

Table 2-3. Summary of Particulate Matter Sampling Results

Sampler	Item	1989	1990	1991	1992	1993	1994	1995	1996	1997	High
Site 1 PM_{10}	Highest	41	62	33	30	30	39	21	60	31	62
	2nd-hi	27	49	25	24	22	26	20	23	21	49
	Ann avg	12	12	10	12	10	10	10	10	9	12
Site 5 PM_{10}	Highest	40	51	45	49	21	42	67	57	26	67
	2nd-hi	38	43	33	27	20	23	21	35	19	43
	Ann avg	13	10	10	12	9	9	10	10	9	13
Site 9 PM_{10}	Highest	n/a	n/a	n/a	31	21	39	15	57	29	57
	2nd-hi	n/a	n/a	n/a	31	21	19	14	28	19	31
	Ann avg	n/a	n/a	n/a	n/a	9	8	7	10	8	10
Site 6 PM_{10}	Highest	n/a	n/a	n/a	n/a	21	25	14	32	59	59
	2nd-hi	n/a	n/a	n/a	n/a	21	20	13	21	18	21
	Ann avg	n/a	n/a	n/a	n/a	9	7	7	9	8	9
Site 1 TSP	Highest	88	152	63	73	86	99	56	147	78	152
	2nd-hi	88	145	62	67	61	74	53	77	50	145
	Ann avg	25	25	24	27	25	22	23	24	22	27
Site 5 TSP	Highest	90	103	103	130	56	98	310	148	57	310
	2nd-hi	62	90	87	73	54	41	69	126	46	126
	Ann avg	26	23	23	30	21	19	26	26	20	30

Note: Concentrations are shown in micrograms per standard cubic meter
"n/a" indicates that samples were not taken during the corresponding monitoring period.

The results of the gaseous criteria pollutant monitoring program are presented in Table 2-4 for each year of the four year monitoring period. The National Ambient Air Quality Standards are also shown in the table. The carbon monoxide and sulfur dioxide ambient concentrations did not register levels above the threshold of reliable detection of the analyzers. The values reported are approximately one half the range between zero and the threshold. The nitrogen oxides (NO, NO_2, and NO_x) occasionally registered values in the range of a few tens of parts per billion by volume, typically associated with nearby vehicle activity. The number of hours per operating quarter year period with measurements above the threshold ranged from 1 to 161, which occurred in the period October through December 1993. The applicable standard is an annual average of nitrogen dioxide (NO_2), so the results given in the table are the NO_2 annual averages. These values are barely above the threshold of reliable detection for that instrument.

The only criteria pollutant to routinely register ambient levels above the instrument threshold was ozone, O_3. Ozone levels never exceeded the regulatory limit of a 1-hour average of 0.12 parts per million by volume (ppm). The highest 1-hour average was 0.096 ppm. The ozone concentrations did not drop to near zero levels at night, which typically occurs in urban environments. The absence of ambient nitrogen oxides in the remote Yucca Mountain area allowed ambient ozone levels to persist near 0.030 ppm overnight. Ozone typically has the highest concentrations during the warm season months, because sunlight and warm temperatures are more conducive to higher ambient concentrations. Approximately 90 percent of the warm

season hours had concentrations between 0.020 and 0.060 ppm. Only 44 hours had concentrations in excess of 0.080 ppm.

Table 2-4. Maximum Gaseous Pollutant Monitoring Results Compared to Standards by Annual Periods

Pollutant	Standard	Year 1 (10/91-9/92)	Year 2 (10/92-9/93)	Year 3 (10/93-9/94)	Year 4 (10/94-9/95)
Carbon monoxide	1-hr: 35	0.2	0.2	0.2	0.2
	8-hr: 9	0.2	0.2	0.2	0.2
Nitrogen dioxide	Annual: 0.050	.00201	.00208	.00214	.00209
Ozone	1-hr: 0.120	.096	.093	.081	.083
Sulfur dioxide	3-hr: 0.500	.002	.002	.002	.002
	24-hr: 0.140	.002	.002	.002	.002
	Annual: 0.030	.002	.002	.002	.002

Note: Concentrations are shown in parts per million by volume (ppm)

2.3.3 Atmospheric Dispersion

Results from the three steps of atmospheric dispersion mathematical modeling are presented in this section. The mathematical modeling methods were described in Section 1 of this document. The first results are the wind summaries by joint frequency distributions of wind speed, wind direction, and atmospheric stability categories. These distributions are a fundamental step in performing many types of impact analyses. he results from the second step are the GENII-S straight line Gaussian calculations of chronic, or long term normalized concentrations. The results from the third step are the analyses using calculations for possible acute, or short term, releases.

The source heights in the software code runs were set to either surface (one meter), 60 meters, and 100 meters above ground level. Separate GENII-S runs were made using joint frequency distributions based on the 10 and 60 meter level wind data. The separate runs could allow for comparisons of results using the two meteorological data sources. The greater frequency of northerly winds in the 60 meter wind data would correspond to estimates of more frequent impacts in Amargosa Valley than would occur with northwesterly winds that prevail in the 10 meter data. The slower effective speeds calculated from the 60 meter data would increase the concentration estimates, since concentration is inversely proportional to wind speed in typical atmospheric dispersion models. Thus, the data taken from the 60 meter level at Site 1 would likely provide the more conservative (higher concentration levels) results compared to results based on data taken at the 10 meter level.

2.3.3.1 Joint Frequency Distributions

Tabular listings of the joint frequency distributions of wind speed, wind direction, and Pasquill atmospheric stability categories (A through F) for 10 and 60 m-agl at Site 1 are presented in Appendix B of this report. The scheme for assigning stability categories allows unstable through neutral (A through D) to occur during the daytime, and neutral through stable (D through F) to occur at night. The more unstable and stable periods (A, B and F) can only occur with slower

wind speeds, compared to the neutral category. For example, the A (extremely unstable) and F (very stable) categories do not occur with wind speeds greater than 3.3 m/s.

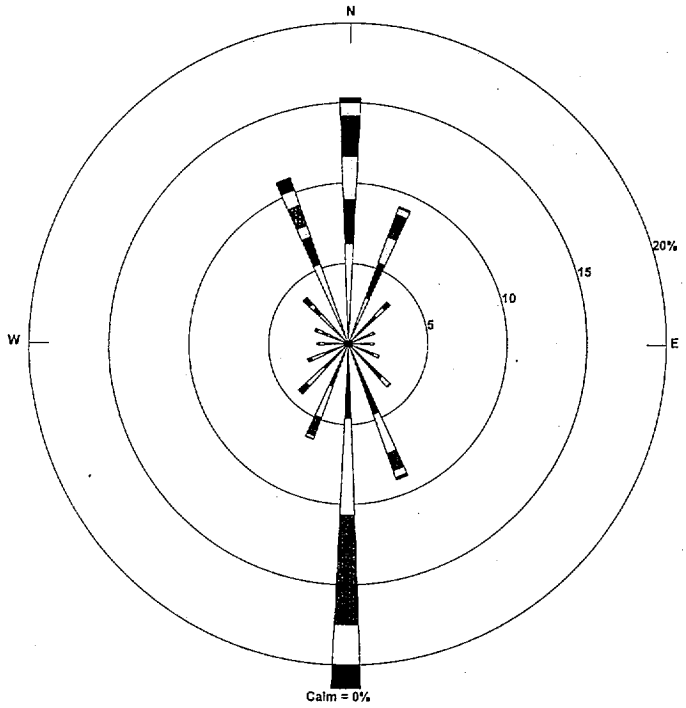
Most of the stable periods occur with winds from the northwest and north northwest directions at the 10 meter level, which are associated with the drainage winds from the east side of Yucca Mountain flowing into Midway Valley and on toward the Jackass Flats area and the Fortymile Wash. Similar winds at the 60 meter level are more from the north, which are flowing toward the south parallel to Yucca Mountain through Midway Valley. The neutral and unstable daytime periods are associated with winds from the south at many of the monitoring sites in the network. Wind rose diagrams of the joint frequency distributions of the 10 meter and 60 meter level wind data from 1993 through 1997 for all stability classes are shown in Figure 2-1. These wind roses show the bi-model predominant directions related to the topographic airflow constraints occurring at that location of REPD Site 1. Further discussion of local airflow is available in *Local and Regional Wind Patterns Near Yucca Mountain* (CRWMS M&O 1997b).

2.3.3.2 Chronic Exposure Mathematical Model Results

Tables showing the results of the GENII-S software code runs using the joint frequency distributions as input wind data are presented in Appendix C of this report. These results are being supplied for information purposes, since other mathematical modeling approaches may be taken during impact analyses. The maximum estimated impact consistently occurred in the first grid cell at a distance of eight kilometers to the north in Sector 9. The maximum estimated impact from each combination of source height and wind data are shown in Table 2-5. The highest estimated impact was 2.37E-07 sec/m^3, which occurred for a surface release using the 60 meter wind data from Site 1. Extrapolation of the 60 meter wind speed data down to the surface produced a low effective wind speed, 2.1 m/s. This low surface level wind speed contributed to the higher estimated impact than occurred with elevated release heights or wind data sources less affected by the extrapolation technique.

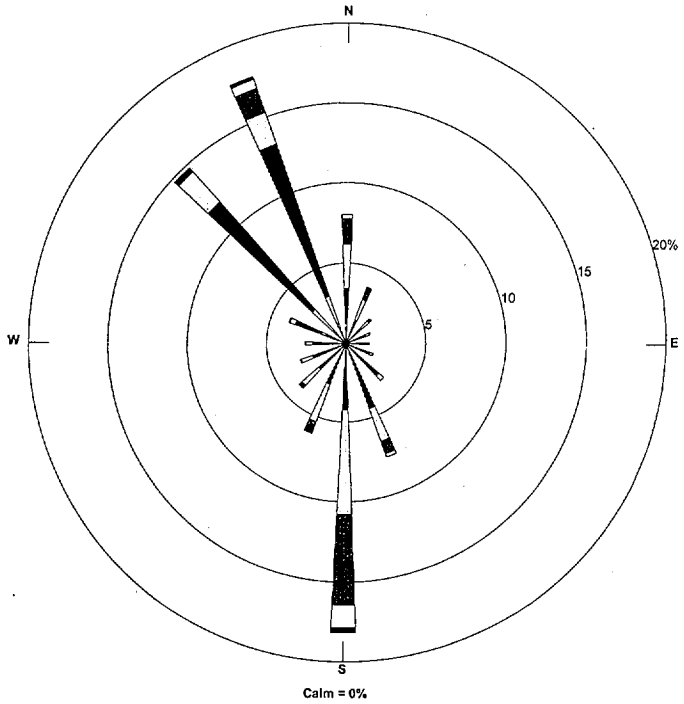
Table 2-5. Maximum Estimated Impacts from GENII-S Model Results for Chronic Exposure

Release Height (meters)	Wind Data Height (meters)	Normalized Concentration (χ/Q, in sec/m^3) (1E-06 = 1 • 10^{-6}) North direction, 8 km	Effective Wind Speed (meters/sec)
surface	10	4.70E-08	5.5
60	10	2.89E-08	7.7
100	10	2.29E-08	8.4
surface	60	2.37E-07	2.1
60	60	4.77E-08	7.0
100	60	3.22E-08	7.0



(b) Site 1: 60 m level

Note: Bar segment lengths are proportional to the frequency of occurrence for each combination of wind speed and direction categories..



(a) Site 1: 10 m level

Figure 2-1. Wind Rose Plots for Site 1: 10 and 60 meter levels, 1993-1997

The GENII-S software runs were also examined for an indication of possible impacts in the populated area of Amargosa Valley, which is over 20 kilometers south of the proposed source area. Table 2-6 shows the maximum estimated normalized concentrations for the combination of source heights and wind data sources for a distance of 24 kilometers for southerly three Sectors 16 (SSE), 1 (S), and 2 (SSW). The highest of these values is 1.98E-08 sec/m^3, which is more than a factor of ten lower than the highest estimate shown in the previous table. The corresponding effective speed was 3.6 m/s; this value is lower than the speeds associated with other release combinations. This low effective speed, again due to the model extrapolation process, may have contributed to the higher estimated concentration.

Table 2-6. Maximum Estimated Impacts from GENII-S Model Results for Chronic Exposure for the South Southeast, South, South Southwest Sectors at 24 Kilometers Distance

Release Height (meters)	Wind Data Height (meters)	Normalized Concentration (χ/Q, in sec/m^3) (1E-06 = 1 •10^{-6}) SSE, S, SSW sectors; 24 km	Effective Wind Speed (meters/sec)
surface	10	4.62E-09	8.9
60	10	3.18E-09	11.5
100	10	2.81E-09	12.1
surface	60	1.98E-08	3.6
60	60	4.62E-09	9.0
100	60	3.78E-09	9.5

2.3.3.3 Acute Exposure Mathematical Model Results

Three types of atmospheric dispersion analyses were performed to provide estimates of acute exposure impacts, that is, impacts occurring due to short term releases. Two of the analyses involved the GENII-S software code, and the third involved use of the PGEMS software code. PGEMS includes calculations to account for airflow variation in the presence of terrain, in contrast to the flat terrain dispersion of the GENII-S Gaussian method. The software code runs were all made to produce normalized concentration estimates using unity emission rates. These results could allow for simple impact calculations using actual emission rates. One of the analyses used the same full meteorological data used in the chronic exposure analyses; the other two used hypothetical worst case meteorology data sets.

For the first application with the GENII-S software code, three typical meteorological conditions used in regulatory screening mathematical model applications were identified that could produce maximum impacts due to short term airborne releases. The conditions were extremely unstable (A) and very stable (F) atmospheric stability, both with one meter per second (m/s) wind speed, and neutral stability (D) with four m/s wind speed. Unstable conditions (A) can impact the surface near the source for elevated releases; stable conditions (F) restrict vertical mixing, and neutral conditions (D) can be associated with persistent airflow conditions, which can produce high average concentrations compared to more concentrated but shorter duration exposures. The GENII-S input included a constant wind direction from the north, and the wind speed measurement at 10 meters.

The source was at the surface with a zero exit velocity, which causes the emission to occur at the source height, rather than to acquire plume rise due to momentum. One distance was set to five kilometers, the assumed nearest accessible distance. The other distance was 24 kilometers, which is near the populated area in Amargosa Valley. This distance was also used in the chronic exposure model runs. The results of these GENII-S code runs are summarized in Table 2-7. The maximum estimated normalized impact was a χ/Q value of 5.7E-05 sec/m^3, which occurred at the five kilometer distance during the F-stability case and a surface release. The highest estimated impact at 24 kilometers distance was 7.8E-06 sec/m^3, which occurred for the same release case conditions.

The second application of the GENII-S software code employed the "acute exposure" mode using the same five year meteorological data set used for the chronic exposure analysis. The only case run was the 60 meter wind data and a release height of one meter; this case gave the highest concentrations in the previous applications. The same distances and directions were used: 5 and 24 kilometers. These results are also presented in Table 2-7. The maximum impact at 5 kilometers was 4.8E-05 sec/m^3, and the impact at 24 kilometers was 6.6E-06 sec/m^3. These estimated impacts are similar to the estimates made using the hypothetical worst case meteorology as input.

The PGEMS software code was run using hypothetical meteorological data assuming steady nighttime drainage winds toward the populated areas in Amargosa Valley at each of the nine Radiological and Environmental Programs Department monitoring sites. The results of the PGEMS runs are also summarized in Table 2-7. The maximum estimated normalized impact was a χ/Q value of 1.79E-05 sec/m^3, which occurred at 5.4 kilometers distance during a release from 100 m-agl. The estimated impact at 20 kilometers was 1.92E-06 sec/m^3, which was during a release from 60 m-agl.

These impacts are slightly lower than those estimated by the GENII-S runs.

Table 2-7. Estimated Impacts from GENII-S and PGEMS Results for Acute Exposure

Model Run	Distance (kilometers)	Normalized Concentration (χ/Q, in sec/m^3) (1E-06 = 1 •10^{-6})
GENII-S (3 conditions)	5	5.7E-05
	24	7.8E-06
GENII-S (acute mode)	5	4.8E-05
	24	6.6E-06
PGEMS	5.4	1.79E-05
	20	1.92E-06

3. POTENTIAL OPPOSING VIEWS AND HYPOTHESES

Two potential opposing views were identified regarding how the meteorology and air quality information was compiled to support development of the Repository Environmental Impact Statement. The authors are not aware of any formal opposing views or hypotheses.

The first potential opposing view is that more air quality and meteorological data should have been collected. A potential response to such a view could be that scope of the monitoring program exceeds many other government or industrial studies in rural areas. The air quality and meteorological monitoring program is being accepted by the State of Nevada as adequate demonstration of environmental compliance with air quality permits related to site characterization activities. This acceptance does not necessarily imply universal acceptance for environmental analyses, though it is a good indication that the scope of the program might not be challenged by a regulatory agency.

Another potential opposing view is that more sophisticated meteorological analyses and atmospheric dispersion mathematical modeling should be performed. The intent of the data presentations in this EBF and in the YMP reports on wind patterns and regional meteorological conditions referenced in Section 5 is to demonstrate that the data collection and analyses performed provides adequate information to do the required impact assessments and engineering design tasks. If once the emissions data are available, the screening level of atmospheric dispersion analyses performed were to be too conservative, then more refined analyses could be performed.

4. DATA NEEDS FOR THE ENVIRONMENTAL IMPACT STATEMENT

The anticipated data needs for the Environmental Impact Statement are identified in this section. This EBF provides descriptions of current meteorological and air quality conditions.

Meteorological data from the site specific Radiological and Environmental Programs Department network of nine stations were used to describe local airflow and atmospheric dispersion conditions. The data are being made available for atmospheric dispersion analyses that could be used to assess impacts of radiological and nonradiological airborne emissions at receptors in the nearby vicinity of Yucca Mountain. Regional meteorological data from stations within about 100 miles of Yucca Mountain are provided for potential application with the site specific data to describe the local climatic conditions.

Ambient air quality data from the Radiological and Environmental Programs Department network is summarized in this EBF to describe current conditions in the Yucca Mountain study area.

4.1 ISSUES OR CONCERNS

The Project meteorological and air quality monitoring programs have collected a significant amount of data, partly to support the EIS. Some additional data collection includes acquiring existing data from outside sources. We do not anticipate being criticized for a lack of data (see section on potential opposing views and hypotheses). The analyses of impacts from nonradiological emissions are focused on the ambient environment.

4.2 REGION OF INFLUENCE

Same as in Section 2

4.3 RECEPTORS

Same as in Section 2

4.4 POTENTIAL ANALYSIS METHODS

The analysis methods for the meteorological data are primarily spatial and temporal statistical summaries. This work was accomplished in the Regional Meteorology Study, and was reported in two documents (CRWMS M&O 1997a and 1997b). The methods are mostly typical climatological data summaries, including identifying means and extremes of temperature, precipitation, wind, atmospheric humidity, with additional information provided on solar radiation and barometric pressure.

The analysis methods for the air quality data include both characterizing current ambient conditions, and estimating impacts of the proposed repository facility construction and operations. The ambient conditions include the on going monitoring of total suspended particulate matter and inhalable particulate matter less than 10 micrometers in aerodynamic

diameter, PM_{10}. The criteria gaseous pollutants were monitored for four years, between October 1991 and September 1995.

The ambient air quality impacts will be estimated using atmospheric dispersion models typically acceptable to regulatory agencies, such as the EPA, the U.S. Nuclear Regulatory Commission, and the State of Nevada. The models will most likely need to address the dispersion characteristics relevant to the complex terrain setting of Yucca Mountain. Should modeling identify potential unacceptable impacts, mitigating efforts will be addressed to reduce the emission factors through air pollution controls.

4.5 DESCRIPTION OF REGIONS OF INFLUENCE AND RECEPTORS

The material presented in Section 2 summarizes current meteorology and air quality information anticipated to be needed in preparation of the EIS.

5. REFERENCES

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STANDARDS AND REGULATIONS

10 CFR 960. *Title 10, Code of Federal Regulations, Part 960: General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories.* TIC 238500.

40 CFR 50. *Title 40, Code of Federal Regulations, Part 50: National Primary and Secondary Ambient Air Quality Standards.* TIC 221258.

APPENDIX A

CLIMATOLOGICAL SUMMARY TABLES FROM RADIOLOGICAL AND ENVIRONMENTAL PROGRAMS DEPARTMENT SITES

APPENDIX A

CLIMATOLOGICAL SUMMARY TABLES FROM RADIOLOGICAL AND ENVIRONMENTAL PROGRAMS DEPARTMENT SITES

The monthly and annual summary statistics of climatological data are presented for each of the nine Radiological and Environmental Programs Department meteorological monitoring sites. Hourly values are averages of 1-second observations for clock-hour periods. The site locations are described in Section 1. The summaries are based on data from 1985 through 1997 for Sites 1 through 5, from mid-1992 through 1997 for Sites 6 through 8, and from 1993 through 1997 for Site 9. The summary tables include the following parameters:

Temperature (degrees Celsius) extreme and mean values based on data calculated by period:

Temperature (degrees Celsius) for data from 1986-1993

Extreme Maximum:	highest daily maximum 1-hour average
Mean Maximum:	average of daily maximum 1-hour averages
Mean:	average of all 1-hour averages
Mean Minimum:	average of daily minimum 1-hour averages
Extreme Minimum:	lowest daily minimum 1-hour average

Temperature (degrees Celsius) for data from 1994-1997 (Site 1 is 1996-1997)

Extreme Maximum:	highest daily maximum 1-minute average
Mean Maximum:	average of daily maximum 1-minute averages
Mean:	average of all 1-hour averages
Mean Minimum:	average of daily minimum 1-minute averages
Extreme Minimum:	lowest daily minimum 1-minute average

Mean Relative Humidity (percent)

Hour (0400, etc)	average of the 1-hour averages ending at the hour shown

Precipitation (inches)

Max 1-hour total:	maximum 1-hour total
Max 6-hour total:	maximum running 6-hour total
Max 24-hour total:	maximum running 24-hour total
Mean:	average of the 1-hour total precipitation

Wind (meters per second)

Mean speed:	average of 1-hour averages
Fastest 1-minute (began in 1994)	
Speed:	maximum 1-minute average speed
Direction:	direction associated with maximum speed
Peak 1-sec gust:	maximum 1-second speed

Solar Radiation (Megajoules per square meter per day, began in 1992 and 1993)

Mean Daily:	average of the totaled 1-hour averages
Mean Monthly:	average of mean daily values

Table A-1. Site 1 (NTS-60) Climatological Data Summary

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Temperature (C)													
Extreme Maximum	20.5	26.3	27.1	31.7	36.6	39.8	40.9	40.5	37.3	34.7	26.4	20.4	40.9
Mean Maximum	10.8	13.4	16.5	21.1	25.4	31.0	34.2	33.8	29.0	23.3	15.6	10.6	22.1
Mean	6.3	8.6	11.6	15.8	19.8	25.2	28.5	28.0	23.5	17.9	10.4	5.9	16.8
Mean Minimum	2.3	4.2	6.5	10.0	13.5	18.5	21.9	21.6	17.7	12.5	5.8	1.8	11.4
Extreme Minimum	-9.2	-11.1	-5.2	-1.3	0.3	4.5	10.9	13.9	6.9	-0.3	-6.1	-11.7	-11.7
Mean Relative Humidity (%)													
Hour 0400 (PST)	46.1	44.8	40.1	32.6	30.9	23.5	23.5	25.6	27.4	29.2	38.2	45.8	34.0
Hour 1000	41.0	39.2	32.7	25.2	22.2	17.5	18.0	19.8	21.2	22.4	30.4	37.7	27.3
Hour 1600	34.0	30.1	24.9	18.5	16.3	12.6	13.2	14.1	15.2	17.9	24.7	31.3	21.1
Hour 2200	43.2	40.1	34.1	25.7	23.3	17.2	17.4	19.2	21.5	25.1	34.9	42.8	28.7
Precipitation (inches)													
Max 1-hour total	0.19	0.16	0.58	0.21	0.27	0.19	0.47	0.66	0.42	0.19	0.40	0.23	0.66
Max 6-hour total	0.77	0.49	0.84	0.71	0.42	0.52	0.86	1.18	0.75	0.48	0.66	0.70	1.18
Max 24-hour total	1.39	0.76	1.33	1.32	0.46	0.99	1.22	1.18	1.14	0.62	1.29	1.00	1.39
Average	0.88	0.57	0.83	0.23	0.36	0.16	0.24	0.49	0.25	0.23	0.26	0.48	4.98
Wind													
Mean Speed (m/s)	2.8	3.3	3.7	4.0	4.0	3.9	3.7	3.6	3.3	3.1	3.1	2.9	3.4
Fastest 1-minute													
Speed (m/s)	16.0	17.5	17.4	19.3	16.7	16.8	14.9	18.7	16.4	23.3	16.2	15.6	23.3
Direction (deg)	13.9	186.5	341.3	184.6	176.2	162.7	94.6	251.7	163.5	338.1	4.3	182.6	338.1
Peak 1-sec Gust (m/s)	19.1	22.9	21.7	23.2	20.6	22.1	18.4	18.9	18.9	27.1	21.1	21.11	27.1
Solar Radiation (MJ/m^2/day)													
Mean Daily	9.5	13.6	18.4	23.8	26.0	28.7	28.5	26.2	20.8	16.8	11.4	9.1	19.4
Mean Monthly	294.5	383.2	546.7	712.8	807.3	861.2	816.0	812.9	623.4	520.0	340.1	283.3	583.4

Period 1986 – 1997 (see legend page)

Table A-2. Site 2 (Yucca Mountain) Climatological Data Summary

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Temperature (C)													
Extreme Maximum	18.5	23.6	25.3	29.8	35.1	39.9	39.7	39.8	36.1	33.5	24.3	18.9	39.9
Mean Maximum	8.6	10.9	14.4	19.0	23.3	28.9	32.3	31.7	27.2	21.0	13.1	8.2	19.9
Mean	5.5	7.4	10.6	14.5	18.6	23.8	27.1	26.8	22.7	17.0	9.5	5.4	15.7
Mean Minimum	3.1	4.5	6.9	10.4	14.0	19.1	22.3	22.3	18.9	14.2	6.6	2.7	12.1
Extreme Minimum	-10.4	-12.5	-3.7	-2.2	-1.2	0.0	10.2	12.7	5.6	-1.5	-7.3	-12.3	-12.5
Mean Relative Humidity (%)													
Hour 0400 (PST)	47.1	41.5	38.2	28.7	26.8	17.8	18.9	22.5	25.1	27.7	37.1	41.5	31.1
Hour 1000	44.8	40.4	36.1	25.3	22.1	14.9	15.4	19.2	21.1	24.9	34.0	38.6	28.1
Hour 1600	40.1	32.3	27.7	18.0	15.9	10.0	11.2	13.0	14.9	19.7	28.3	34.2	22.1
Hour 2200	45.2	38.6	32.8	23.8	21.5	13.6	14.7	18.0	20.2	24.6	33.8	40.0	27.2
Precipitation (inches)													
Max 1-hour total	0.31	0.21	0.32	0.13	0.21	0.36	0.20	0.50	0.37	0.12	0.26	0.23	0.50
Max 6-hour total	0.63	0.64	0.92	0.22	0.37	0.58	0.26	0.56	0.68	0.42	0.71	1.03	1.03
Max 24-hour total	1.31	1.20	1.70	0.48	0.45	1.20	0.28	0.56	1.15	0.75	1.17	1.78	1.78
Average	1.20	1.27	1.36	0.12	0.19	0.27	0.12	0.18	0.32	0.18	0.30	0.68	6.19
Wind													
Mean Speed (m/s)	3.7	4.2	4.5	5.0	4.8	4.6	4.2	4.6	4.2	4.1	4.1	2.9	4.2
Fastest 1-minute													
Speed (m/s)	23.2	26.3	28.7	28.9	21.6	30.0	23.0	19.7	20.9	29.4	25.0	26.0	30.0
Direction (deg)	325.6	n/a	306.9	n/a	n/a	n/a	n/a	267.9	n/a	324.8	268.5	n/a	n/a
Peak 1-sec Gust (m/s)	27.2	32.7	34.8	38.2	28.9	34.0	28.5	24.1	24.1	33.3	32.3	32.3	38.2
Solar Radiation (MJ/m^2/day)													
Mean Daily	9.6	14.2	19.7	24.5	26.9	30.6	30.0	27.1	23.0	17.4	12.1	9.5	20.4
Mean Monthly	298.6	402.0	611.3	735.4	834.7	918.1	930.7	840.4	690.7	538.9	362.2	293.5	621.4

Period 1986 – 1997 (see legend page)

Table A-3. Site 3 (Coyote Wash) Climatological Data Summary

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Temperature (C)													
Extreme Maximum	19.5	24.9	26.3	30.9	35.3	40.4	39.9	39.6	36.6	33.5	25.2	19.7	40.4
Mean Maximum	9.9	12.5	15.5	20.2	24.3	29.9	33.1	32.7	28.2	22.2	14.4	9.5	21.0
Mean	6.3	8.5	11.1	15.5	19.4	24.7	27.9	27.5	23.3	17.6	10.3	5.8	16.5
Mean Minimum	3.0	5.0	7.0	10.9	14.0	18.9	22.1	22.1	18.5	13.7	6.7	2.4	12.0
Extreme Minimum	-10.1	-10.7	-4.3	-0.3	0.1	4.2	10.5	14.3	7.2	0.3	-5.9	-12.2	-12.2
Mean Relative Humidity (%)													
Hour 0400 (PST)	46.7	43.7	41.5	33.7	32.2	22.9	23.2	26.2	30.4	31.6	39.4	45.6	34.8
Hour 1000	41.0	38.8	35.4	26.6	24.0	17.7	17.6	21.1	23.1	24.8	31.7	38.0	28.3
Hour 1600	36.7	30.8	27.8	19.5	18.1	13.4	13.7	15.3	17.1	20.9	27.7	34.5	23.0
Hour 2200	44.4	40.0	36.1	26.7	24.5	17.3	17.6	20.7	23.9	27.8	35.5	42.9	29.8
Precipitation (inches)													
Max 1-hour total	0.32	0.20	0.43	0.14	0.23	0.29	0.18	0.31	0.38	0.17	0.57	0.26	0.57
Max 6-hour total	0.74	0.61	1.13	0.21	0.36	0.60	0.18	0.62	0.70	0.53	0.77	0.77	1.13
Max 24-hour total	1.53	1.22	1.89	0.31	0.41	1.18	0.18	0.67	1.14	0.79	1.60	1.12	1.89
Average	1.23	1.13	1.38	0.12	0.30	0.27	0.10	0.16	0.34	0.25	0.38	0.66	6.31
Wind													
Mean Speed (m/s)	2.3	2.5	2.7	2.9	2.8	2.8	2.6	2.5	2.4	2.4	2.6	2.9	2.6
Fastest 1-minute													
Speed (m/s)	16.3	15.9	16.0	19.3	13.7	17.3	18.6	11.7	13.9	18.0	15.2	14.9	18.6
Direction (deg)	n/a	n/a	309.2	n/a	n/a	n/a	n/a	170.7	n/a	307.4	309.7	303.8	n/a
Peak 3-sec Gust (m/s)	23.3	21.8	25.2	24.5	22.8	28.3	21.0	19.5	19.5	26.2	24.0	24.0	28.3
Solar Radiation (MJ/m^2/day)													
Mean Daily	9.3	13.8	19.1	23.7	26.1	30.0	29.6	26.5	22.2	16.9	11.5	9.1	19.8
Mean Monthly	288.3	389.4	591.2	704.9	808.6	901.1	917.7	822.2	666.6	523.6	346.0	278.9	603.2

Period 1986 – 1997 (see legend page)

Table A-4. Site 4 (Alice Hill) Climatological Data Summary

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Temperature (C)													
Extreme Maximum	20.6	25.3	27.3	32.3	36.8	42.3	41.6	41.7	38.0	34.8	26.5	20.4	42.3
Mean Maximum	10.3	12.8	16.2	20.6	24.8	30.5	33.8	33.6	28.9	22.7	14.8	9.8	21.6
Mean	6.4	8.5	11.5	15.5	19.6	25.1	28.4	28.1	23.6	17.5	10.3	6.1	16.7
Mean Minimum	3.0	4.6	6.9	10.7	14.1	19.3	22.7	22.5	18.2	12.9	6.3	2.3	12.0
Extreme Minimum	-8.5	-11.0	-4.1	0.0	-0.3	4.0	11.2	14.1	7.4	0.0	-6.0	-12.6	-12.6
Mean Relative Humidity (%)													
Hour 0400 (PST)	48.3	45.3	41.3	30.6	29.6	20.0	20.8	23.0	27.0	30.9	39.4	45.2	33.5
Hour 1000	45.4	41.8	35.9	24.2	21.7	16.5	17.0	18.8	22.0	24.8	34.0	39.9	28.5
Hour 1600	37.7	32.1	26.7	17.4	15.7	12.0	14.0	14.1	16.0	19.5	27.4	33.0	22.1
Hour 2200	45.7	41.3	35.5	24.3	21.9	15.2	16.5	18.1	21.6	26.8	35.0	42.5	28.7
Precipitation (inches)													
Max 1-hour total	0.29	0.22	0.33	0.17	0.14	0.18	0.33	0.38	0.50	0.19	0.42	0.23	0.50
Max 6-hour total	0.69	0.61	0.95	0.35	0.31	0.53	0.36	0.53	0.83	0.43	0.81	0.81	0.95
Max 24-hour total	1.19	1.13	1.76	0.53	0.50	0.89	0.37	0.56	1.14	0.74	1.51	1.86	1.86
Average	1.34	1.02	1.25	0.18	0.19	0.22	0.17	0.16	0.36	0.28	0.42	0.85	6.43
Wind													
Mean Speed (m/s)	3.8	4.3	4.6	5.3	5.1	4.8	4.3	4.1	4.1	4.2	4.4	2.9	4.3
Fastest 1-minute													
Speed (m/s)	27.0	25.3	27.8	19.3	24.6	26.8	25.1	19.9	22.9	33.2	25.6	25.2	33.2
Direction (deg)	19.1	n/a	2.4	n/a	9.8	n/a	37.2	n/a	n/a	344.7	n/a	21.0	344.7
Peak 1-sec Gust (m/s)	30.7	29.3	31.4	32.2	29.3	34.2	28.3	24.9	24.9	37.2	29.5	29.5	37.2
Solar Radiation (MJ/m^2/day)													
Mean Daily	9.7	14.3	19.7	24.1	26.8	30.3	29.7	26.8	22.7	17.4	11.9	9.4	20.2
Mean Monthly	300.1	402.7	610.2	717.9	831.9	907.5	919.3	831.9	681.3	540.9	356.7	292.1	616.0

Period 1986 – 1997 (see legend page)

Table A-5. Site 5 (Fortymile Wash) Climatological Data Summary

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Temperature (C)													
Extreme Maximum	22.9	27.9	29.6	34.6	39.0	43.6	43.5	43.2	39.9	36.9	28.3	22.2	43.6
Mean Maximum	12.6	15.4	18.8	23.4	27.6	33.1	36.3	35.9	31.4	25.5	17.6	12.2	24.2
Mean	6.8	9.5	12.7	16.9	21.2	26.4	29.6	29.0	24.5	18.7	11.2	6.4	17.7
Mean Minimum	2.0	4.3	6.7	10.4	14.1	18.5	21.8	21.5	17.6	12.9	6.0	1.4	11.4
Extreme Minimum	-7.1	-11.8	-6.7	-0.5	1.4	2.6	11.1	13.0	5.5	-0.7	-6.6	-13.1	-13.1
Mean Relative Humidity (%)													
Hour 0400 (PST)	50.5	46.6	44.3	33.2	33.1	22.3	22.7	25.4	27.5	29.6	38.7	45.0	34.9
Hour 1000	41.7	37.0	32.8	22.8	21.0	14.9	15.3	18.4	19.7	20.9	28.7	34.6	25.6
Hour 1600	32.9	27.7	24.7	16.2	15.0	9.7	10.3	12.1	13.4	15.7	22.0	26.7	18.9
Hour 2200	48.2	43.0	38.3	27.0	24.3	15.9	16.5	18.9	22.2	25.9	34.8	42.3	29.8
Precipitation (inches)													
Max 1-hour total	0.23	0.26	0.16	0.22	0.10	0.19	0.50	0.38	0.40	0.25	0.16	0.23	0.50
Max 6-hour total	0.50	0.59	0.53	0.26	0.25	0.50	0.72	0.53	0.74	0.49	0.70	0.78	0.78
Max 24-hour total	1.02	0.89	0.94	0.26	0.49	0.68	0.72	0.53	1.05	0.97	1.05	1.63	1.63
Average	1.04	0.83	0.78	0.11	0.19	0.17	0.20	0.09	0.34	0.20	0.25	0.68	4.88
Wind													
Mean Speed (m/s)	3.8	4.2	4.4	4.6	4.6	4.6	4.3	4.4	4.3	4.2	4.1	2.9	4.2
Fastest 1-minute													
Speed (m/s)	17.2	19.6	19.7	19.3	20.3	20.9	18.4	16.7	17.1	25.3	18.2	18.4	25.3
Direction (deg)	n/a	185.2	349.1	n/a	n/a	n/a	81.8	n/a	160.2	336.9	n/a	n/a	336.9
Peak 1-sec Gust (m/s)	20.7	23.1	24.9	26.4	24.8	25.5	26.5	20.6	20.6	30.4	22.1	22.1	30.4
Solar Radiation ($MJ/m^2/day$)													
Mean Daily	9.9	14.1	19.7	24.6	26.7	30.4	29.8	26.7	22.8	17.3	12.0	9.6	20.3
Mean Monthly	306.8	385.4	610.1	736.9	828.0	910.9	925.2	828.4	648.5	537.2	361.4	296.2	614.6

Period 1986 – 1997 (see legend page)

Table A-6. Site 6 (WT-6) Climatological Data Summary

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Temperature (C)													
Extreme Maximum	19.8	23.1	25.8	30.4	34.9	39.6	39.6	41.9	36.3	33.7	25.5	18.5	41.9
Mean Maximum	9.7	12.4	16.9	19.8	25.2	30.3	33.9	34.0	29.2	22.1	14.5	9.6	21.5
Mean	4.8	6.7	10.6	13.3	18.4	23.2	26.8	26.5	22.1	15.6	8.4	4.4	15.1
Mean Minimum	0.1	1.3	4.3	6.5	10.8	14.5	18.0	18.3	14.7	9.6	2.7	-0.6	8.3
Extreme Minimum	-11.1	-9.9	-6.9	-1.4	-0.3	2.3	11.1	12.0	6.2	-1.0	-7.8	-7.2	-11.1
Mean Relative Humidity (%)													
Hour 0400 (PST)	62.8	57.5	49.8	40.4	42.2	32.1	31.1	31.0	34.7	37.0	47.0	56.1	43.5
Hour 1000	50.8	42.5	34.4	25.4	24.0	19.4	18.0	18.0	20.8	24.2	32.1	40.5	29.2
Hour 1600	47.1	34.4	25.8	18.2	17.6	12.5	12.3	11.9	14.8	19.2	28.7	36.6	23.3
Hour 2200	60.3	53.6	42.2	32.4	32.1	23.2	21.8	21.8	26.4	31.7	43.2	52.5	36.8
Precipitation (inches)													
Max 1-hour total	0.44	0.27	0.25	0.19	0.34	0.27	0.31	0.28	0.55	0.17	0.25	0.31	0.55
Max 6-hour total	1.24	0.56	1.16	0.40	0.39	0.58	0.40	0.61	0.95	0.39	0.87	1.10	1.24
Max 24-hour total	1.54	1.27	2.14	0.51	0.41	1.16	0.40	0.64	1.12	0.76	1.45	1.78	2.14
Average	2.00	1.21	1.21	0.27	0.31	0.43	0.20	0.18	0.48	0.38	0.59	1.04	8.30
Wind													
Mean Speed (m/s)	3.5	3.9	4.1	4.6	4.2	4.2	4.0	4.0	3.9	3.9	3.8	2.9	3.9
Fastest 1-minute													
Speed (m/s)	20.1	18.5	20.2	19.3	19.7	22.6	17.5	16.4	19.1	19.8	19.9	20.8	22.6
Direction (deg)	358.4	346.0	346.2	n/a	n/a	n/a	n/a	154.7	n/a	345.1	n/a	n/a	n/a
Peak 1-sec Gust (m/s)	26.1	25.7	26.1	28.7	26.5	28.8	23.6	24.0	24.0	27.0	25.5	25.5	28.8
Solar Radiation ($MJ/m^2/day$)													
Mean Daily	8.9	13.2	18.6	24.1	26.7	29.9	29.7	26.7	22.4	16.7	11.8	9.0	19.8
Mean Monthly	274.8	372.6	577.1	724.4	827.4	896.4	920.2	773.7	570.4	518.9	353.5	277.9	590.6

Period 1986 – 1997 (see legend page)

Table A-7. Site 7 (Sever Wash) Climatological Data Summary

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Temperature (C)													
Extreme Maximum	22.2	25.3	28.7	33.3	38.3	42.3	42.8	42.4	39.3	36.1	27.8	20.5	42.8
Mean Maximum	11.9	14.8	19.6	22.6	28.2	33.2	36.8	36.8	31.9	24.5	16.5	11.7	24.1
Mean	5.2	7.4	11.4	14.6	19.8	24.4	27.9	27.6	22.8	15.8	8.4	4.5	15.8
Mean Minimum	-1.4	-0.1	2.8	5.5	9.7	13.2	16.6	16.9	12.7	7.0	0.3	-2.5	6.7
Extreme Minimum	-11.3	-10.8	-6.9	-3.5	-0.8	0.2	10.1	9.2	3.8	-5.0	-9.7	-12.8	-12.8
Mean Relative Humidity (%)													
Hour 0400 (PST)	67.8	63.5	54.4	43.4	44.6	34.4	32.5	31.7	36.7	41.5	52.2	62.2	47.1
Hour 1000	50.0	41.5	31.6	22.4	21.0	16.8	15.6	15.7	18.2	21.6	30.2	40.2	27.1
Hour 1600	42.5	31.2	22.4	15.9	14.9	10.1	9.9	9.7	12.4	16.6	25.0	32.9	20.3
Hour 2200	63.3	57.3	44.4	33.1	31.2	22.6	21.4	21.7	26.6	32.8	45.7	57.2	38.1
Precipitation (inches)													
Max 1-hour total	0.41	0.23	0.24	0.15	0.18	0.19	0.59	0.33	0.36	0.20	0.40	0.28	0.59
Max 6-hour total	0.97	0.52	0.94	0.26	0.24	0.52	0.60	0.50	0.73	0.48	0.81	0.93	0.97
Max 24-hour total	1.18	1.25	1.69	0.37	0.35	0.89	0.60	0.55	1.17	0.73	1.49	2.15	2.15
Average	1.62	1.06	0.89	0.24	0.23	0.25	0.35	0.13	0.35	0.35	0.50	1.06	7.04
Wind													
Mean Speed (m/s)	2.6	3.0	3.3	4.0	3.6	3.7	3.4	3.3	3.1	3.0	2.8	2.9	3.2
Fastest 1-minute													
Speed (m/s)	17.4	16.8	18.1	19.3	18.9	18.5	15.6	15.1	16.9	23.2	18.0	17.1	23.2
Direction (deg)	0.8	338.3	328.5	n/a	n/a	n/a	164.8	151.6	217.8	331.3	n/a	161.9	331.3
Peak 1-sec Gust (m/s)	20.7	20.7	22.3	25.5	23.0	25.5	23.5	26.9	26.9	27.7	20.6	20.6	27.7
Solar Radiation (MJ/m^2/day)													
Mean Daily	9.3	13.5	18.9	24.3	26.8	29.7	29.7	26.7	22.3	16.9	12.1	9.3	20.0
Mean Monthly	283.9	381.4	584.4	730.5	832.1	891.7	920.4	773.4	560.1	524.6	362.2	288.7	594.5

Period 1986 – 1997 (see legend page)

Table A-8. Site 8 (Knothead Gap) Climatological Data Summary

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Temperature (C)													
Extreme Maximum	21.2	24.7	28.1	32.8	37.4	41.9	42.0	41.4	38.2	35.6	27.2	19.6	42.0
Mean Maximum	11.4	14.2	19.0	21.9	27.6	32.6	36.2	36.2	31.3	24.0	16.0	11.2	23.5
Mean	5.4	7.5	11.5	14.6	19.8	24.6	28.1	27.9	23.1	16.1	8.7	4.9	16.0
Mean Minimum	-0.3	0.8	3.8	6.4	10.9	14.4	18.2	18.4	14.2	8.6	1.7	-1.1	8.0
Extreme Minimum	-9.9	-9.5	-6.6	-2.2	0.0	2.5	11.9	11.1	5.9	-3.1	-8.0	-9.6	-9.9
Mean Relative Humidity (%)													
Hour 0400 (PST)	63.8	59.9	51.4	40.5	41.2	31.6	29.8	29.9	34.4	38.5	48.9	58.1	44.0
Hour 1000	49.0	41.1	31.3	22.1	20.9	16.5	15.4	15.7	18.1	21.2	29.9	39.3	26.7
Hour 1600	42.0	31.0	22.6	15.3	14.8	9.9	9.8	9.6	12.2	16.4	25.0	33.2	20.1
Hour 2200	60.2	53.2	41.7	30.9	29.8	21.1	19.9	20.4	25.3	31.4	43.1	53.9	35.9
Precipitation (inches)													
Max 1-hour total	0.43	0.21	0.22	0.23	0.26	0.19	0.29	0.33	0.36	0.13	0.40	0.23	0.43
Max 6-hour total	1.06	0.47	0.84	0.23	0.31	0.58	0.31	0.69	0.71	0.53	0.76	1.02	1.06
Max 24-hour total	1.18	1.25	1.43	0.29	0.38	0.86	0.31	0.73	1.16	0.84	1.42	2.43	2.43
Average	1.64	1.09	0.91	0.20	0.26	0.32	0.16	0.18	0.36	0.24	0.44	0.99	6.80
Wind													
Mean Speed (m/s)	2.5	2.9	3.2	3.8	3.5	3.6	3.3	3.2	3.0	2.7	2.6	2.9	3.1
Fastest 1-minute													
Speed (m/s)	16.6	18.9	17.7	19.3	17.3	19.7	15.4	15.0	16.7	21.3	16.4	17.1	21.3
Direction (deg)	327.9	n/a	n/a	n/a	n/a	n/a	n/a	n/a	167.4	332.3	4.1	200.7	332.3
Peak 1-sec Gust (m/s)	20.5	22.6	25.0	27.6	20.6	24.9	21.5	21.4	21.4	27.3	20.8	20.8	27.6
Solar Radiation (MJ/m^2/day)													
Mean Daily	9.1	13.4	18.8	24.4	26.8	30.1	29.9	26.8	22.3	16.8	11.9	9.2	19.9
Mean Monthly	278.7	378.8	581.7	730.6	829.3	904.1	921.4	775.9	564.6	512.2	352.8	284.3	592.9

Period 1986 – 1997 (see legend page)

Table A-9. Site 9 (Gate-510) Climatological Data Summary

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Temperature (C)													
Extreme Maximum	22.9	26.6	30.7	35.4	39.5	45.1	44.7	43.8	40.5	37.8	28.5	22.5	45.1
Mean Maximum	13.5	16.6	21.5	24.6	30.1	35.3	39.2	38.9	33.7	26.0	18.3	13.9	26.0
Mean	7.1	9.6	13.6	16.7	22.1	27.4	31.0	30.5	25.4	17.7	10.6	6.9	18.2
Mean Minimum	1.3	3.1	6.1	8.1	13.1	18.4	21.5	20.9	16.7	10.0	3.6	0.8	10.3
Extreme Minimum	-7.6	-5.3	-6.0	0.0	1.2	2.5	12.1	13.8	7.5	0.6	-6.8	-7.7	-7.7
Mean Relative Humidity (%)													
Hour 0400 (PST)	61.9	55.2	48.3	37.9	38.7	27.9	23.7	24.2	30.7	33.2	47.6	54.4	40.3
Hour 1000	47.8	39.2	30.3	20.4	21.0	15.3	13.1	13.9	18.3	19.1	30.8	37.2	25.5
Hour 1600	39.0	27.6	19.9	13.7	14.2	8.7	7.3	8.0	11.4	13.8	23.5	28.0	17.9
Hour 2200	57.1	48.6	38.3	29.0	27.1	18.5	15.4	16.7	23.1	26.3	41.0	48.9	32.5
Precipitation (inches)													
Max 1-hour total	0.13	0.29	0.12	0.16	0.18	0.32	0.02	0.04	0.23	0.19	0.16	0.20	0.32
Max 6-hour total	0.39	0.57	0.40	0.16	0.43	0.68	0.03	0.05	0.71	0.44	0.50	0.42	0.71
Max 24-hour total	0.65	0.94	0.61	0.18	0.57	0.68	0.04	0.05	1.11	0.63	0.63	0.97	1.11
Average	0.92	0.67	0.46	0.12	0.22	0.30	0.02	0.01	0.36	0.21	0.28	0.46	3.59
Wind													
Mean Speed (m/s)	3.9	4.3	4.4	4.7	4.6	4.8	4.5	4.7	4.4	4.2	4.0	2.9	4.3
Fastest 1-minute													
Speed (m/s)	16.5	19.3	19.1	19.3	18.5	17.9	19.2	20.5	17.0	19.1	17.2	19.8	20.5
Direction (deg)	319.9	181.5	n/a	n/a	n/a	169.7	85.3	137.4	157.8	334.9	209.7	n/a	137.4
Peak 1-sec Gust (m/s)	20.2	24.7	22.7	25.4	23.6	26.7	23.2	21.4	21.4	23.1	23.2	23.2	26.7
Solar Radiation (MJ/m^2/day)													
Mean Daily	9.5	13.9	19.4	24.6	27.5	29.9	29.4	27.0	22.6	17.4	11.9	9.6	20.2
Mean Monthly	295.4	391.4	602.9	739.1	851.4	892.5	906.0	838.5	641.8	539.2	357.6	296.2	612.7

Period 1986 – 1997 (see legend page)

APPENDIX B

JOINT FREQUENCY DISTRIBUTIONS OF WIND DATA FROM RADIOLOGICAL AND ENVIRONMENTAL PROGRAMS DEPARTMENT SITE 1

APPENDIX B

JOINT FREQUENCY DISTRIBUTIONS OF WIND DATA FROM RADIOLOGICAL AND ENVIRONMENTAL PROGRAMS DEPARTMENT SITE 1

The summaries of joint frequency wind speed and wind direction data are presented for the six Pasquill stability categories for both the 10 meters above ground level (m-agl) and 60 m-agl data (separately) from Site 1. The stability categories are labeled A (extremely unstable) to F (very stable). The stability categories were determined by the standard deviation of the horizontal wind direction, with adjustments for wind speed and day or night occurrences. The summaries are based on hourly average wind data from 1993 through 1997.

The results shown in the tables are the relative frequency of occurrence in the corresponding wind speed and wind direction categories, expressed as decimal fractions of the hours with the given stability category. The percent of the total hours that the stability class occurred is shown in the header of the speed categories for each table.

Wind Speed Categories: (meters per second)	six categories as shown, with a summary column for all directions
Wind Direction: (compass directions)	direction from the indicated compass directions, with a summary column for all speeds

Table B-1. Site 1 (NTS-60) 10m Joint Frequency Wind Distributions for Stability Class A for Data from 1993 -1997

Wind Directions	Class A occurred during 15.0% of the total hours Speed Categories (m/s)						
	0.0 to <1.8	1.8 to <3.3	3.3 to <5.4	5.4 to <8.5	8.5 to <11.0	• 11.0	Sums
North	0.0287	0.0128	0.0000	0.0000	0.0000	0.0000	0.0416
North-Northeast	0.0260	0.0117	0.0000	0.0000	0.0000	0.0000	0.0377
Northeast	0.0412	0.0147	0.0000	0.0000	0.0000	0.0000	0.0559
East-Northeast	0.0497	0.0195	0.0000	0.0000	0.0000	0.0000	0.0692
East	0.0477	0.0232	0.0000	0.0000	0.0000	0.0000	0.0709
East-Southeast	0.0511	0.0324	0.0000	0.0000	0.0000	0.0000	0.0836
Southeast	0.0649	0.0765	0.0000	0.0000	0.0000	0.0000	0.1414
South-Southeast	0.0488	0.1318	0.0000	0.0000	0.0000	0.0000	0.1806
South	0.0272	0.0885	0.0000	0.0000	0.0000	0.0000	0.1157
South-Southwest	0.0147	0.0292	0.0000	0.0000	0.0000	0.0000	0.0439
Southwest	0.0100	0.0159	0.0000	0.0000	0.0000	0.0000	0.0260
West-Southwest	0.0105	0.0113	0.0000	0.0000	0.0000	0.0000	0.0218
West	0.0107	0.0059	0.0000	0.0000	0.0000	0.0000	0.0165
West-Northwest	0.0119	0.0045	0.0000	0.0000	0.0000	0.0000	0.0164
Northwest	0.0213	0.0079	0.0000	0.0000	0.0000	0.0000	0.0292
North-Northwest	0.0317	0.0181	0.0000	0.0000	0.0000	0.0000	0.0497
Sums	0.4962	0.5038	0.0000	0.0000	0.0000	0.0000	1.0000

Table B-2. Site 1 (NTS-60) 10m Joint Frequency Wind Distributions for Stability Class B for Data from 1993 -1997

	Class B occurred during 7.3% of the total hours Speed Categories (m/s)						
Wind Directions	**0 to <1.8**	**1.8 to <3.3**	**3.3 to <5.4**	**5.4 to <8.5**	**8.5 to <11.0**	**≥11.0**	**Sums**
North	0.0045	0.0093	0.0185	0.0000	0.0000	0.0000	0.0323
North-Northeast	0.0038	0.0099	0.0179	0.0000	0.0000	0.0000	0.0316
Northeast	0.0058	0.0125	0.0185	0.0000	0.0000	0.0000	0.0367
East-Northeast	0.0061	0.0125	0.0144	0.0000	0.0000	0.0000	0.0329
East	0.0026	0.0102	0.0064	0.0000	0.0000	0.0000	0.0192
East-Southeast	0.0022	0.0109	0.0099	0.0000	0.0000	0.0000	0.0230
Southeast	0.0051	0.0390	0.0243	0.0000	0.0000	0.0000	0.0684
South-Southeast	0.0102	0.1102	0.0994	0.0000	0.0000	0.0000	0.2198
South	0.0061	0.1022	0.1712	0.0000	0.0000	0.0000	0.2796
South-Southwest	0.0016	0.0288	0.0556	0.0000	0.0000	0.0000	0.0859
Southwest	0.0006	0.0182	0.0396	0.0000	0.0000	0.0000	0.0585
West-Southwest	0.0013	0.0070	0.0236	0.0000	0.0000	0.0000	0.0319
West	0.0013	0.0064	0.0118	0.0000	0.0000	0.0000	0.0195
West-Northwest	0.0022	0.0042	0.0077	0.0000	0.0000	0.0000	0.0141
Northwest	0.0032	0.0035	0.0115	0.0000	0.0000	0.0000	0.0182
North-Northwest	0.0054	0.0115	0.0115	0.0000	0.0000	0.0000	0.0284
Sums	0.0620	0.3962	0.5419	0.0000	0.0000	0.0000	1.0000

Note: Table is the decimal fraction of the hours with this stability that the average winds occurred jointly in the speed and direction categories.

Table B-3. Site 1 (NTS-60) 10m Joint Frequency Wind Distributions for Stability Class C for Data from 1993 -1997

	Class C occurred during 10.9% of the total hours Speed Categories (m/s)						
Wind Directions	**0 to <1.8**	**1.8 to <3.3**	**3.3 to <5.4**	**5.4 to <8.5**	**8.5 to <11.0**	**≥11.0**	**Sums**
North	0.0017	0.0045	0.0244	0.0083	0.0000	0.0000	0.0388
North-Northeast	0.0019	0.0045	0.0354	0.0076	0.0000	0.0000	0.0494
Northeast	0.0011	0.0030	0.0253	0.0034	0.0000	0.0000	0.0327
East-Northeast	0.0002	0.0021	0.0079	0.0011	0.0000	0.0000	0.0112
East	0.0006	0.0008	0.0042	0.0006	0.0000	0.0000	0.0064
East-Southeast	0.0000	0.0015	0.0064	0.0008	0.0000	0.0000	0.0087
Southeast	0.0017	0.0079	0.0132	0.0004	0.0000	0.0000	0.0231
South-Southeast	0.0019	0.0210	0.0930	0.0098	0.0000	0.0000	0.1256
South	0.0013	0.0231	0.2918	0.0866	0.0000	0.0000	0.4028
South-Southwest	0.0006	0.0053	0.0843	0.0183	0.0000	0.0000	0.1084
Southwest	0.0011	0.0019	0.0560	0.0068	0.0000	0.0000	0.0658
West-Southwest	0.0004	0.0017	0.0191	0.0011	0.0000	0.0000	0.0223
West	0.0006	0.0004	0.0083	0.0023	0.0000	0.0000	0.0117
West-Northwest	0.0015	0.0006	0.0144	0.0028	0.0000	0.0000	0.0193
Northwest	0.0019	0.0021	0.0174	0.0057	0.0000	0.0000	0.0272
North-Northwest	0.0021	0.0051	0.0265	0.0127	0.0000	0.0000	0.0465
Sums	0.0187	0.0855	0.7275	0.1683	0.0000	0.0000	1.0000