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FINAL REPORT
BASELINE METEOROLOGY AND AIR QUALITY IN THE FOLSOM DISTRICT

PART 1 - CHAPTERS 1-3
INTRODUCTION
PHYSICAL FEATURES
CLIMATOLOGY

Submitted to:

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ENVIRONMENTAL SCIENCE AND TECHNOLOGY

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1. INTRODUCTION

This document provides baseline data on meteorology and air quality impacting BLM lands in California, and specifically, in the Folsom District. Air quality considerations have become important factors in the establishment and execution of Federal land management policies. As with any resource, an assessment of current air quality and meteorological data must be performed to determine the present environmental baseline conditions.

BLM manages approximately 16.5 million acres in California as depicted in Figure 1-1. Figure 1-2 depicts BLM administered lands in the Folsom District. Figure 1-2 is also provided as Overlay A. In addition, gridded township and range locations for the Folsom District are provided on Figure 1-3. This map can be used directly with the color coded overlays provided for key parameters.

The purpose of this document is to provide information which can be used with other resource information to facilitate land use planning decisions for the Folsom District.

The specific objectives of this work effort include the following:

- Describe the climatology, dispersion meteorology and air quality in the Folsom District utilizing available historical data.
- Assess the emission sources which influence all BLM land areas in the Folsom District.
- Assess past and present air quality and meteorological monitoring activities and provide monitoring recommendations for the Folsom District.
- Provide a complete bibliography of available information and a glossary of all technical terms.

The above provides a brief synopsis of the objectives of this report. The document is intended for use by BLM personnel in all activities involved in the management of BLM administered lands.

This document uses a graphics intensive approach in the presentation of the meteorological and air quality baseline for BLM lands in the Folsom District. The data base which has been used to develop this document comprises that available in published form from governmental, academic, and private institutions within the state. These sources of data are summarized in the appropriate sections for dispersion meteorology, climatology, air quality, and emissions.

Figure 1-1
BLM Lands in the Folsom District
and the State of California

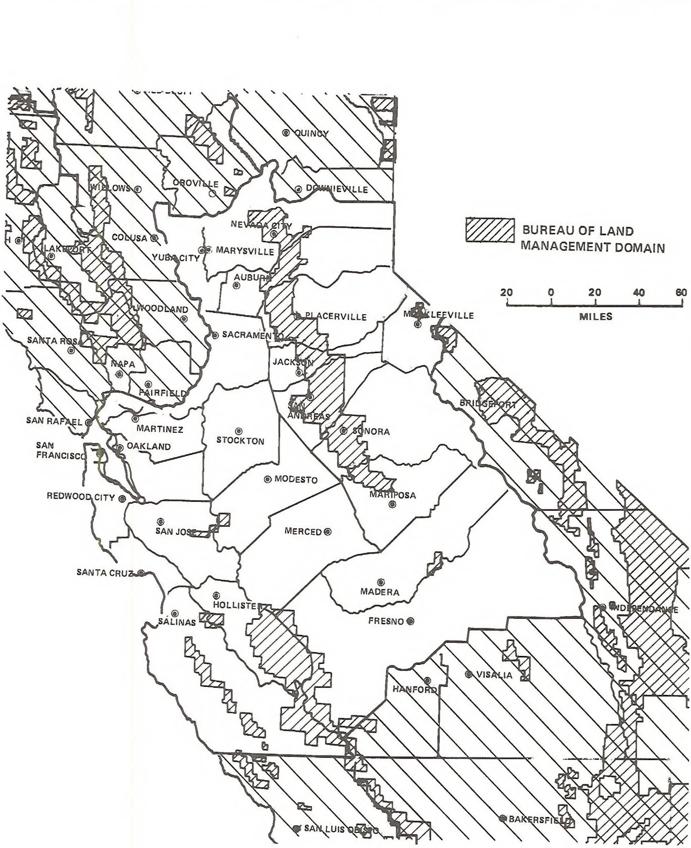


Figure 1-2
BLM Lands in the Folsom District

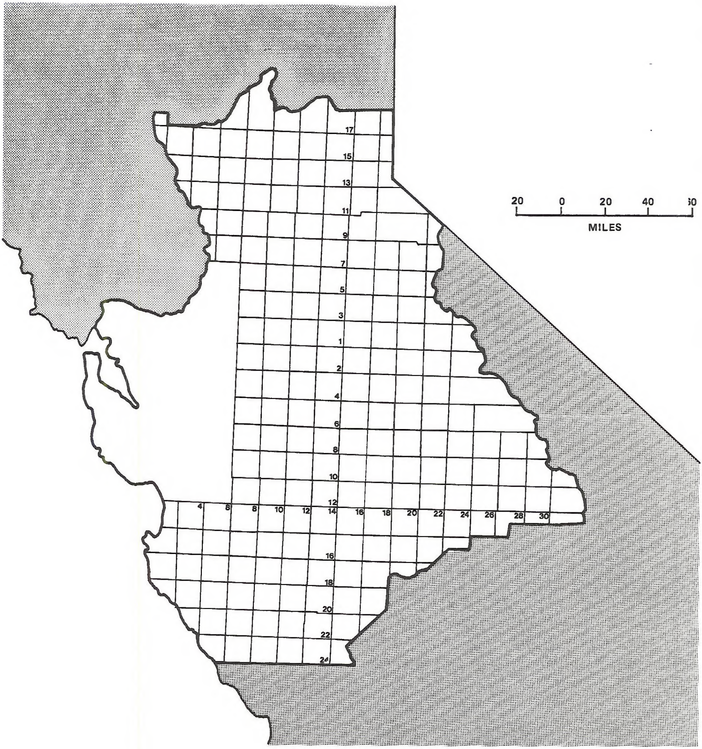


Figure 1-3
Gridded Township (N-S) and Range (E-W)
Locations in the Folsom District

The report presents data which represent meaningful (i.e., long-term) and representative time periods. The primary climatic parameters such as temperature and precipitation are based on a minimum of ten years of record and have been updated through 1976. For the secondary climatic parameter, e.g. evaporation, shorter periods of record were used due to poor data availability; however, the most recent available data are presented.

The dispersion meteorological analyses are based on five or more years of data for the primary parameters, i.e., wind speed, wind direction, atmospheric stability and mixing height. The actual period of record varies for many stations depending upon the period for which summarized data are available from the National Climatic Center (NCC). In addition, other sources of data which significantly contributed to the analysis were used although these consisted of shorter periods of record.

Baseline air quality levels in the Folsom District and pollutant attainment status are based on 1977 data. Emissions data presented in the report are based upon 1976 inventories.

Data are presented in the text in a graphics intensive manner with heavy dependence upon charts, tables, figures and overlays. The purpose of this manner of presentation is to facilitate the use of the data by BLM personnel. A key aspect of the graphical approach includes the use of color coded overlays for key parameters. Figures which depict conditions throughout the Folsom District are scaled such that they can be used in conjunction with the overlays provided in the report jacket, in order to better grasp the interactive nature of key parameters.

The results of the analyses provided in this document can be used by BLM personnel for a multitude of applications. The document has been written in straightforward and simplistic language such that it can be used by all levels of BLM technical personnel. A sufficient review of basic principles has been provided throughout the text such that it can also be used as a handbook for training purposes. It provides an excellent base for making a first cut analysis for specific air quality and climatological problems. In addition, the information contained in this document is suitable for use in the development of Environmental Statement sections. Some of the data provides background information suitable for the environmental setting and impact sections. However, the reader is cautioned that a detailed analysis of major problem areas, such as the potential impact of new pollutant sources, would require additional analysis and analytical review beyond that contained in this document.

Finally, in addition to its uses as a training handbook and for use in Environmental Statements, this document can be used for overall planning purposes by BLM land managers. This is one of the major intents for publishing the document. It is felt that the information contained herein will provide suitable information on which one can base judgments relative to the optimum utilization of BLM lands in terms of such potential alternatives as agriculture, forest management and energy development, as these relate to the air resource.

This report is intended as an environmental baseline document suitable for use in the administration of BLM lands. Recommendations have been provided in the text concerning the need for additional data to adequately describe the environmental baseline, i.e., air quality and meteorology in certain portions of the Folsom District. Monitoring would be required, as well as additional analyses, prior to making final decisions relative to major potential sources of air pollutants on BLM lands. Recommendations contained in this document for additional data collection and for additional analyses must be seriously considered by BLM planners during any final decision-making process. In addition, the information contained herein is current as of the publication date, but care must be taken while using the document, to ensure that all information and materials are up to date, particularly with regard to air quality regulations. For this reason, it is recommended that this document be updated on an annual basis by qualified technical personnel.

Separate reports have also been prepared for the Ukiah, Redding, Susanville, Bakersfield and Riverside Districts. Reference should be made to the appropriate reports for air quality and meteorological baseline conditions for BLM lands outside of the Folsom District in California.

2. PHYSICAL FEATURES

The following discussion provides a review of the major terrain and vegetation features in the Folsom District. Folsom is comprised of numerous terrain and vegetation types as indicated in the accompanying figures. Elevations range from sea level to approximately 12,600 feet above mean sea level (MSL) in the high Sierra. Vegetation types range from luxuriant Douglas Fir to marshes, grasslands and chaparral.

The major vegetation types as classified by Durrenberger (1967) are depicted in Figure 2-1. This figure, illustrates the variety of vegetation types found particularly in the coastal and interior mountainous regions. Between the coastline and the Diablo Range, vegetation types include Douglas Fir, sagebrush, marshlands, chaparral, grasslands and woodlands. Moving to the Central Valley, grass and marshlands dominate including some saltbush and woodlands. Along the lower foothills of the Sierra Nevada, the region becomes a combination of woodland and grassland. Progression up the western slopes of the Sierra Nevada involves a transition through woodland, chaparral, Lodgepole-Whitebark Pine, Pine, Douglas Fir, Fir, Pinon Pine-Juniper and True Alpine.

As indicated earlier, these vegetation types are distinctly influenced by terrain considerations. Figure 2-2 provides a review of major terrain features in the State of California. Figure 2-3 illustrates the Folsom District terrain. This figure is also included as Overlay B. The Folsom District is bordered on the west by the Pacific Ocean. Along the coastal areas, the terrain is a composite of hills and valleys rapidly rising into the Diablo Mountain Range. Smaller ranges along the coast include the Santa Cruz, Santa Lucia and the Gabilan Ranges. The larger Diablo Range is largely unbroken in the southern portion of the district, while towards the north, it is interrupted by the sea level entrance to the Central Valley through the Carquinez Straits, east of San Francisco. This major break in the Coast Range permits an abundant flow of maritime air into the interior sections of the state under certain synoptic conditions or climatological regimes. On the other hand, maritime flow toward the inland areas is greatly inhibited in the extreme southwestern portion of the Folsom District in the Big Sur area. Here, the San Lucia Range rises directly from the coast to elevations as high as 5,862 feet MSL (Junipero Sierra Peak). The Salinas Valley and the lowlands surrounding the southward extension of the San Francisco Bay into the Santa Clara Valley comprise the major lowland areas within the hilly coastal zone.

At a distance of approximately 60 miles inland, the Diablo Range and other coastal California ranges begin to slope downward toward the Central Valley floor. The San Joaquin valley separates the coastal mountain ranges from the towering Sierra

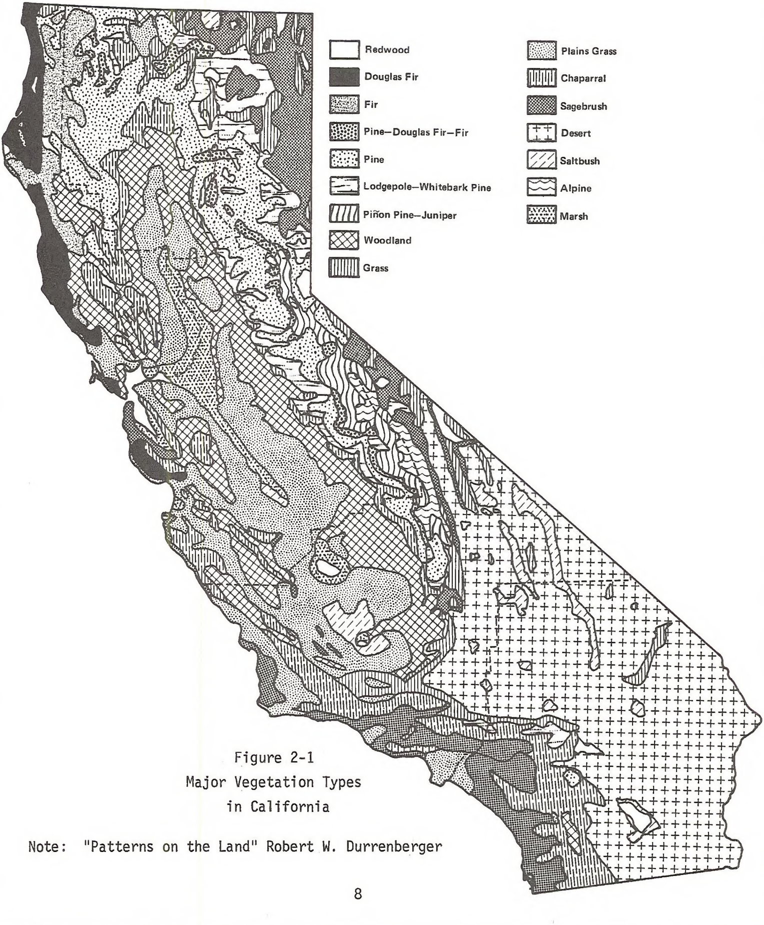


Figure 2-1
Major Vegetation Types
in California

Note: "Patterns on the Land" Robert W. Durrenberger

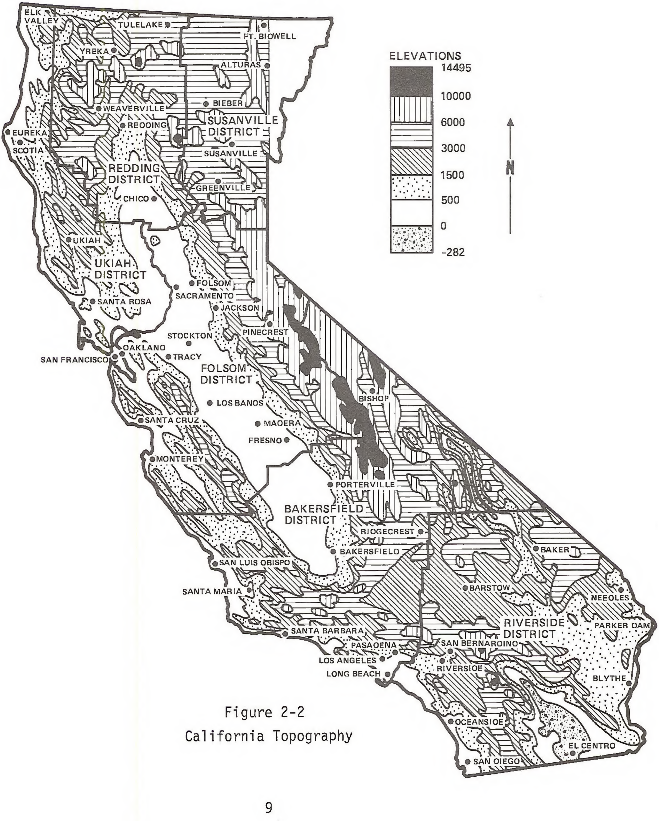


Figure 2-2
California Topography

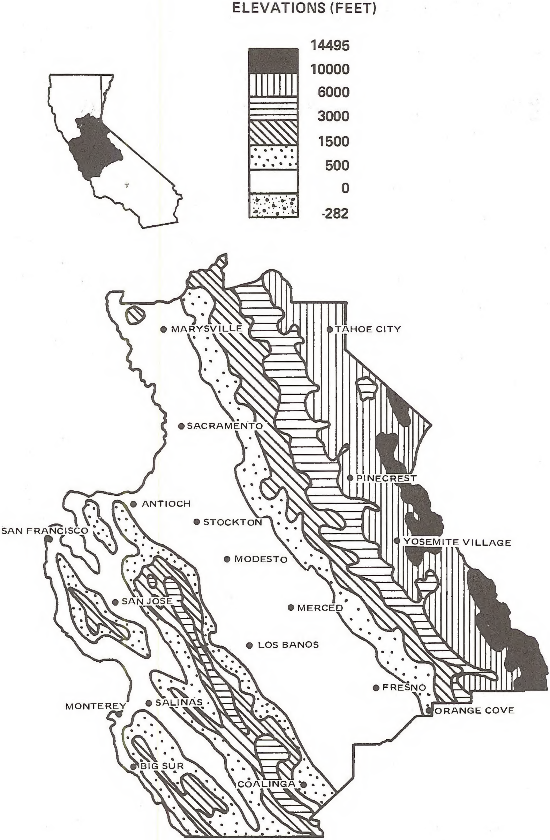


Figure 2-3
Folsom District Topography

Nevada located in the easternmost portion of the district. Elevations along the Central Valley floor range from 296 feet MSL at Fresno to 13 feet MSL at Stockton.

The Sierra Nevada foothills begin approximately 30 miles east of Sacramento and 40 miles east of Stockton. The range includes peaks as high as 12,600 feet MSL in the Folsom District. In other portions of the state, the Sierra rise as high as 13,495 feet MSL (Mount Whitney). As depicted in Figure 2-2, these slopes are extrememly steep and rugged and represent an abrupt barrier to the normal eastward flow of air. Preferred exit routes for eastward flow over the Sierra in the Folsom District are along the major basins associated with the Kings, San Joaquin, Tuolumne, Stanislaus, Mokelumne, American, Yuba, Merced, Truckee and Tahoe Rivers. The lower passes are in the northern part of the district, including the well-known Donner Pass.

Local terrain plays a major role in determining regional climatology. Therefore, a properly scaled overlay displaying the Folsom District topographic features is provided with this report in order that terrain features can be compared with averages (isopleths) of the important climatic parameters.

BIBLIOGRAPHY

1. Durrenberger, Robert W., Patterns on the Land, National Press Books, Palo Alto, California, Second Printing, 1967.

3. CLIMATOLOGY

This section is designed to characterize the prevailing climate of the Folsom District as well as to describe the physical processes that determine regional climate. Long-term manifestations of weather are best described by regional and local analyses of the numerous climatic parameters, i.e., temperature, precipitation, winds, evaporation and evapotranspiration, sky conditions, dew point and humidity, pressure distributions, severe weather and many others. The following sections shall describe the various climatic statistics pertinent to the area.

Color coded overlays for selected key climatic summaries are provided to facilitate the correlation of the primary climatic variables in particular geographic areas. Much of the enclosed graphical material is properly scaled to the overlay dimensions.

3.1 PRINCIPLES OF CLIMATOLOGY

Energy

The energy expended in atmospheric processes is originally derived from the sun. This transfer of energy from the sun to the earth and its atmosphere is the result of radiational heat by electromagnetic waves. The radiation from the sun has its peak of energy transmission in the visible range (0.4 to 0.7 microns) of the electromagnetic spectrum but releases considerable energy in the ultraviolet and infrared regions as well. The greatest part of the sun's energy is emitted at wave lengths between 0.1 and 30 microns. Some of this radiation is reflected from the tops of clouds and from the land and water surfaces of the earth. The general term for this reflectivity is the albedo. For the earth and atmosphere as a whole, the albedo is 36 per cent for mean conditions of cloudiness over the earth. This reflectivity is greatest in the visible range of wavelengths. When light (or radiation) passes through a volume containing particles whose diameter is smaller than the wavelength of the light, scattering of a portion of this light takes place. Shorter wavelengths scatter most easily, which is the reason the scattered light from the sky appears blue. Sunlight, near sunrise and sunset, passes through a greater path-length of the atmosphere and appears more red because of the increased scattering of shorter wave lengths. Absorption of solar radiation by some of the gases in the atmosphere (notably water vapor) also takes place. Water vapor, although comprising only 3 per cent of the atmosphere, on the average absorbs about six times as much solar radiation as all other gases combined. Consequently, the amount of radiation received at the earth's surface is considerably less than that received above the atmosphere.

The earth also radiates energy in proportion to its temperature according to Planck's law. Because of the earth's temperature, the maximum emission is about 10 microns, which is in the infrared region of the spectrum. The gases of the atmosphere absorb some wave length regions of this radiation. Water vapor absorbs strongly between 5.5 and 7 microns and at greater than 27 microns but is essentially transparent from 8 to 13 microns. Carbon dioxide absorbs strongly between 13 and 17.5 microns. Because the atmosphere absorbs much more of the terrestrial radiation than solar radiation, some of the heat energy of the earth is conserved. This is the "greenhouse" effect.

Figure 3.1-1 shows the amount of solar radiation absorbed by the earth and atmosphere compared to the long wave radiation leaving the atmosphere as a function of latitude. The sine of the latitude is used as the abscissa to represent area. It can be seen that if there were no transfer of heat poleward, the equatorial regions would continue to gain heat and the polar regions would continue to cool. However, temperatures do remain nearly constant because of this poleward transfer of heat. The required transfer of heat across various latitudes is given in Table 3.1-1.

Table 3.1-1

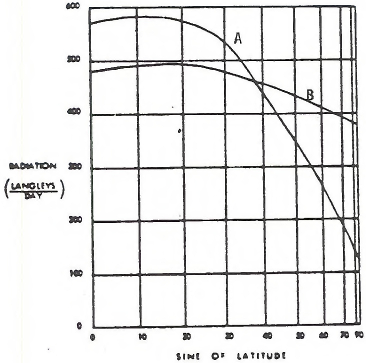
Required Flux of Heat Toward the Poles Across Latitudes (10^{19} calories per day) (1)

Latitude(°)	Flux
0	0
10	4.05
20	7.68
30	10.46
40	11.12
50	9.61
60	6.68
70	3.41
80	0.94
90	0

1. Source: H. G. Houghton, "On the Annual Heat Balance of the Northern Hemisphere."

The General Circulation

The previous section has indicated the necessity of transfer of heat from the warm equatorial regions to the cold polar regions in order to maintain the heat balance of the atmosphere. This thermal driving force is the main cause of atmospheric motion on the earth. The portion of the earth near the equator acts as a heat source and the polar regions as a heat sink. The atmosphere functions as a heat engine transforming the potential energy of heat difference between tropics and poles to kinetic energy of motion which transports heat poleward from source to sink.



A Solar Radiation Absorbed by Earth and Atmosphere

B Long Wave Radiation Leaving the Atmosphere

Figure 3.1-1
Global Radiation Balance

If the earth did not rotate, rising air above the equator would move poleward continually giving up some of its heat until the time it would sink and return toward the equator as a surface current. Since the earth does rotate, the Coriolis force deflects winds in the northern hemisphere to the right. Therefore flow from the tropics toward the poles become more westerly and flow from the poles toward the equator tends to become easterly. The result is that more of the motion is around the earth (zonal) with less than one-tenth of the motion between poles and equator. The meridional (along meridians, i.e., between poles and equator) circulation is broken into three cells shown in Figure 3.1-2 according to Palmen's (1951) model. Of considerable importance is the fact that the jet stream (i.e., a core of high winds usually 50 miles per hour or more embedded in the westerlies in the high troposphere) does not remain long in one position but meanders and is constantly changing position. This causes changes in the location of the polar front and perturbations along the front. The migrating cyclones (counterclockwise) and anticyclones (clockwise) resulting, play an important part in the heat exchange, transferring heat northward both as a sensible heat and also latent heat. Also, a small amount of heat is transferred poleward by the ocean currents.

Temperature

- Variation with Height

  In the lower region of the atmosphere extending from the surface to about 2 km. (6600 ft.), the temperature distribution varies considerably depending upon the character of the underlying surface and upon the amount of radiation at the surface. Within this region, the temperature may decrease with height or it may actually increase with height (inversion). This region, commonly called the lower troposphere, is the region of greatest interest in air pollution meteorology. The remainder of the troposphere is typified by a decrease of temperature with height on the order of 4 to 8°C per km. The stratosphere is a region with isothermal or slight inversion lapse rates. The layer of transition between the troposphere and stratosphere is called the tropopause. The tropopause varies in height from about 8 to 20 km (26,000 to 66,000 ft.), and is highest near the equator, lowest near the poles. Figure 3.1-3 and 3.1-4 indicate typical temperature variations with height for two latitudes for summer and winter in the troposphere and lower stratosphere.

  Above the stratosphere, the high atmosphere has several layers of differing characteristics. A rough indication of the variation of temperature with height including the high atmostphere is shown in Figure 3.1-5.

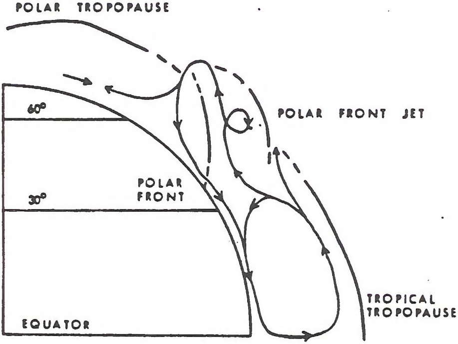
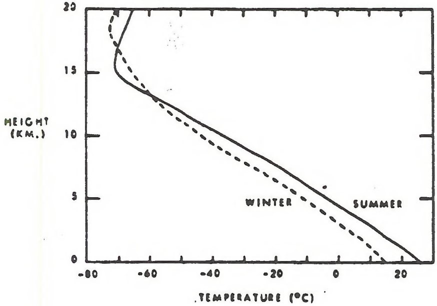
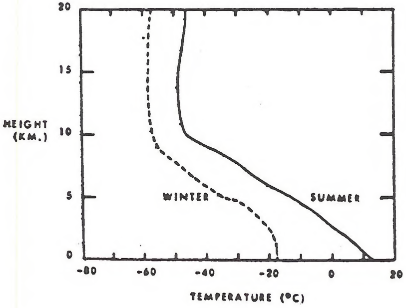


Figure 3.1-2
General Circulation Model (after Palmen)



VARIATION OF TEMPERATURE WITH HEIGHT AT 30° NORTH LATITUDE

Figure 3.1-3



VARIATION OF TEMPERATURE WITH HEIGHT AT 60° NORTH LATITUDE

Figure 3.1-4

- Horizontal Variation

  Temperature also varies horizontally particularly with latitude, being colder near the poles and warmer near the equator. However, the influence of continents and oceans have considerable effects on modifying temperatures. The continents have more extreme temperatures (continental climate) becoming warmer in summer and colder in winter, whereas the oceans maintain a more moderate temperature (marine or maritime climate) year-round.

Winds

Wind is nothing more than air in motion and although it is a motion in three dimensions, usually only the horiztontal component is considered in terms of direction and speed. In the free atmosphere (above the effects of the earth's friction), two forces are important. The first, the Coriolis force, is due to the tendency for the air to move in a straight path while the earth rotates underneath thereby deflecting the wind to the right in the northern hemisphere and to the left in the southern hemisphere. The deflection is proportional to the wind velocity, and decreases with latitude. The other force affecting the horizontal wind component is the pressure gradient force, which directs flow from high to low pressure. Above the friction layer, in regions where the lines of constant pressure (isobars) are straight and the latitude is greater than 20°, the two forces are in balance (See Figure 3.1-6) and the wind blows parallel to the isobars. Where isobars are curved, the forces are not in balance, their resultant producing a centripetal acceleration. In the lowest portion of the atmosphere frictional drag (not due to molecular friction but to eddy viscosity) slows down the wind speed, and because the Coriolis force is proportional to the wind speed, reduces the Coriolis force. The balance of forces under frictional flow is shown in Figure 3.1-7. It will be noted that under frictional flow the wind has a component across the isobars toward lower pressure.

Anticyclones and Cyclones

Migrating areas of high pressure (anticyclones) and low pressure (cyclones) and the fronts associated with the latter are responsible for the day to day changes in weather that occur over most of the mid-latitude regions of the earth. The low pressure systems in the atmospheric circulation are related to perturbations along the jet stream (the region of strongest horizontal temperature gradient in the upper troposphere and consequently the region of strongest winds) and form along frontal surfaces separating masses of air having different temperature and moisture characteristics. The evolution of a low pressure system is accompanied by the formation of a wave in the circulation pattern. This develops further into a warm front and a cold front both moving around the low in a counterclockwise (cyclonic)

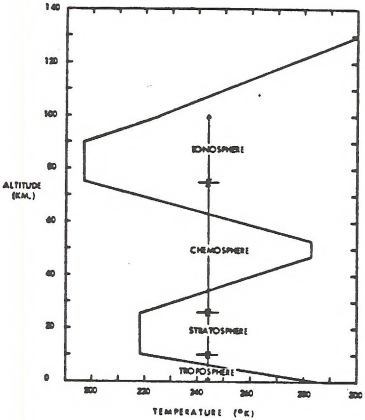


Figure 3.1-5
General Variation of Temperature with Height Throughout the Atmosphere

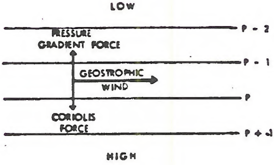


Figure 3.1-6
Balance of Forces in the Upper Atmosphere

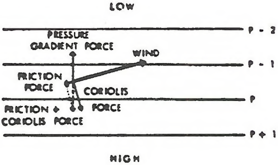


Figure 3.1-7
Balance of Forces in the Lower (Friction Layer) Atmosphere

sense. The life cycle of a typical cyclone is shown in Figure 3.1-8. The cold front is a transition zone between warm and cold air. The cold air typically is moving toward and over the area previously occupied by warm air. Cold fronts generally have slopes from 1/50 to 1/150. Warm fronts separate advancing warm air from retreating cold air and have slopes on the order of 1/100 to 1/300 due to the effects of friction on the trailing edge of the front. Figure 3.1-9 illustrates a vertical cross section through both a warm and a cold front.

Air Masses

Air masses are frequently divided by frontal systems and are usually classified according to the source region of their recent history. Air masses are classified as maritime or continental to indicate origin over the ocean or land, and arctic, polar, or tropical depending principally on the latitude of origin. Air masses are modified by vertical motions and radiation upon the surfaces over which they move.

Condensation, Clouds, and Precipitation

Condensation of water vapor upon suitable condensation nuclei in the atmosphere causes clouds. (Table 3.1-2 indicates the relative sizes of different particles.) Large hygroscopic nuclei will condense water vapor upon them even before saturation is reached, as opposed to crystallization nuclei which promote the growth of ice crystals, at the expense of small water droplets within a supercooled cloud. Of course, only a small proportion of all clouds produce rain. It is necessary that droplets increase in size so that they will have appreciable fall velocity and also to prevent complete evaporation of the drops before they reach the ground. Table 3.1-3 indicates the distance of fall for different size drops before evaporation occurs. Growth of water droplets into rain drops large enough to fall is thought to originate predominately with the large condensation nuclei which grow larger as they fall through the cloud. The presence of an electric field in clouds generally promotes the growth of raindrops.

Table 3.1-2

Sizes of Particles

Particles	Size (microns)*
Small ions	less than 10^{-3}
Medium ions	10^{-3} to 5×10^{-2}
Large ions	5×10^{-2} to 2×10^{-1}
Aitken nuclei	5×10^{-2} to 2×10^{-1}
Smoke, haze, dust	10^{-1} to 2

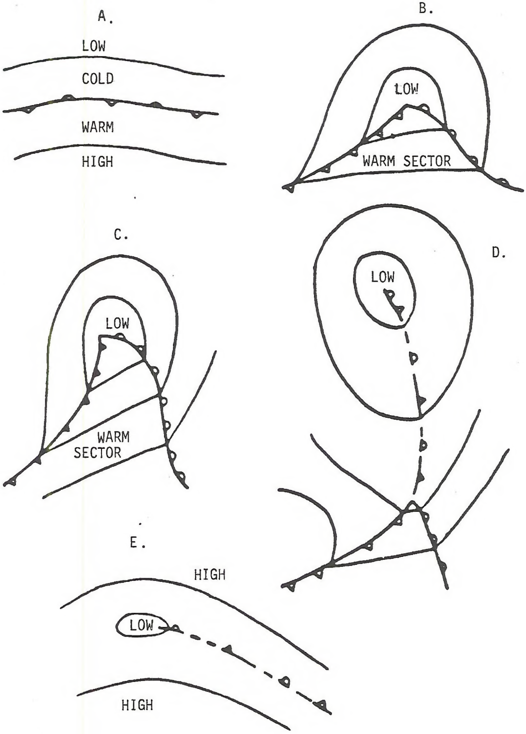
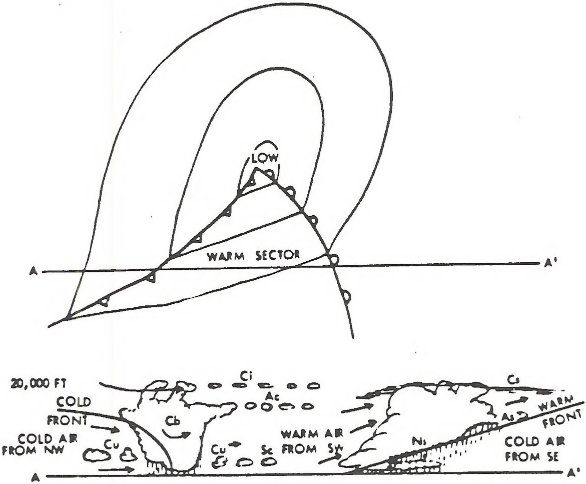


Figure 3.1-8
Idealized Development of a Low-Pressure (cyclone) System



Cross Section Through a Cold Front
and a Warm Front

Figure 3.1-9

Large condensation nuclei	2×10^{-1} to 10
Giant condensation nuclei	10 to 30
Cloud or fog droplets	1 to 100
Drizzle drops	100 to 500
Raindrops	500 to 4000

*1 Micron = 3.94×10^{-5} inches

Table 3.1-3

Distance of Fall Before Evaporation (Findeison 1939)

Radius (microns)*	Distance of Fall
1	1.3×10^{-4} inches
10	1.3 inches
100	492 feet
1000	26.1 miles
2500	174 miles

*1 Micron = 3.94×10^{-5} inches

3.2 CLIMATIC ZONES

California encompasses a vast amount of territory and offers a wide variety of climate types, ranging from hot, arid desert climates to cold, moist mountain climates. It is therefore advantageous to present the climatic analysis in terms of climatic zones. Figure 3.2-1 depicts the general climatic zones for California in each of the six BLM districts. Overlay C presents the climatic zones for the Folsom District. Regional topography as well as latitude plays a major role in the determination of the characteristic climate of the various California regions.

The Folsom District is comprised of a complete cross-section of the various types of topographic features present in California as described in Section 2 and includes four of the major climatic subdivisions or zones existing in the State. These include the Coastal, Coastal Mountain, Central Plain and Interior Mountain Climatic Zones (CZ).

The Coastal CZ includes most of the area between the coastline and the Diablo Range below elevations of approximately 1500 feet MSL. The Coastal CZ experiences a distinctly maritime

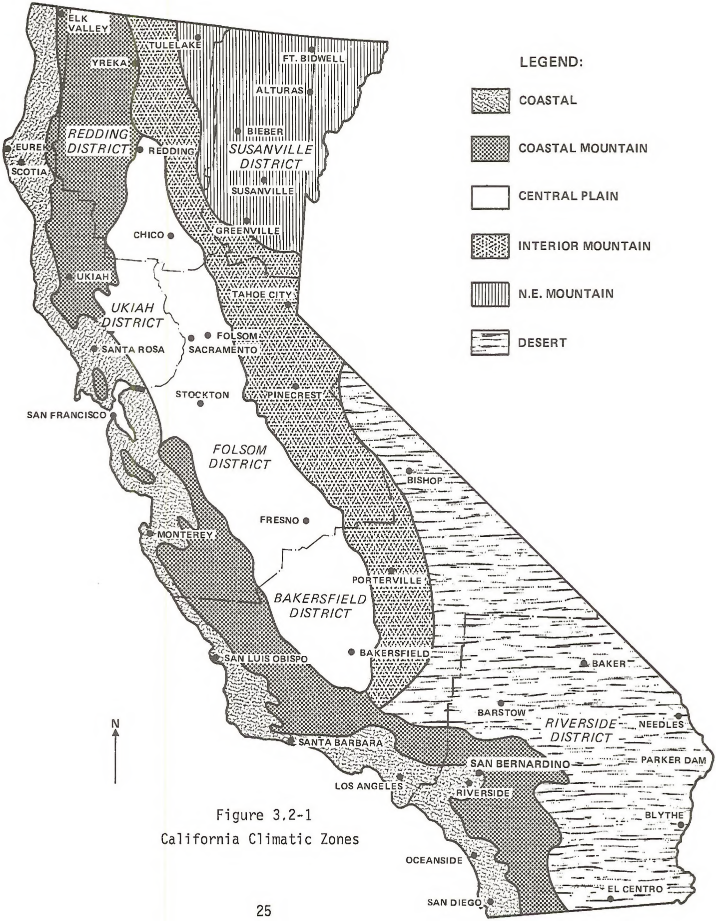


Figure 3.2-1
California Climatic Zones

climatic regime which is characterized by moderate annual precipitation, a modest range in the average and diurnal temperatures and fairly brisk onshore winds. In California, the Coastal CZ also experiences a Mediterranean style climate with a distinct winter rainy season.

The Coastal Mountain CZ experiences similar climatic conditions to those at lower coastal elevations. However, throughout the Coastal and Coastal Mountain CZ's, local terrain features play a distinct role in determining winds speeds as well as wind direction. Rainfall tends to be more variable depending upon the exposure of the higher terrain and the associated orographic enhancement or suppression of precipitation amounts. Westward facing slopes experience increased rainfall while eastward or leeward facing terrain experiences a distinct "rain-shadow" effect with lower rainfall amounts. Temperatures at higher elevations tend to be more variable than those along the immediate coastline. However, they can also be less variable than the range experienced in the more sheltered inland valley locations such as the Salinas and Santa Clara River Valleys. Finally, wind speeds tend to be higher in mountainous regions and become less influenced by local effects at the highest levels.

Much of the interior of the Folsom District comprises the Central Plain CZ. While some variability exists in terms of climatic conditions across this area, the region is generally characterized by modest rainfall, large seasonal and diurnal temperature ranges and moderate winds which are very dependent upon local terrain features. Portions of the Folsom District just east of the Bay Area such as Stockton and Sacramento, tend to exhibit a more maritime climate than portions of the Central Valley located further to the south such as Fresno. These former areas are characterized by the increased influence of the maritime sea breeze regime which includes slightly larger rainfall amounts, increased wind speeds, and decreased temperature ranges. The Bay Area represents the major break in the Coast Range in Central California and permits the greatest inland influence of the maritime, sea breeze regime.

The final major climatic zone in the Folsom District is the Interior Mountain CZ. Terrain plays a very important role in the climate of this area in the manner described for the Coastal Mountain CZ. Westward facing slopes of the Sierra experience increased rainfall with increasing elevation due to orographic lifting. Winds speeds tend to increase with elevation, while wind directions are greatly influenced by local terrain configurations. The temperature range actually decreases in the more exposed locations while ranges can be substantial in sheltered valley locations. East of the ridgeline of the Sierra, the Interior Mountain CZ characteristics are altered to those indicative of the leeward side of a major mountain range. That is, rainfall amounts decrease markedly due to the well known "rain-shadow" effect. This often occurs in the lee of major terrain obstacles as air is forced downward inhibiting the condensation process which relies on upward motion.

3.3 SOURCES OF CLIMATOLOGICAL DATA

It is necessary in the consideration of most climatological problems to obtain meteorological information. Frequently, a special observational program must be initiated as will be discussed in more detail in Section 7. However, there are also many situations where current or past meteorological records from a Weather Service station will suffice. The following outline provides a brief insight into the types of observations taken at Weather Service stations and some of the summaries compiled from this data. The discussion also serves to describe the bulk of the published data sources used in the Folsom District analysis. Many other data sources used in this report are noted in the bibliography as appropriate.

3.3.1 Observations and Records

Surface

- First Order Stations
  There are 100 Weather Bureau stations where 24 hourly observations are taken daily. The measurements taken are: dry bulb temperature and wet bulb temperature (from which dew point temperature and relative humdity are calculated), pressure, wind direction and speed, cloud cover and visibility. These observations are transmitted each hour on weather teletype circuits and are entered on a form with one day to each page. The original is sent to the National Climatic Center (NCC) in Asheville, North Carolina, and a duplicate is maintained in the station files. Each station also maintains a climatological record book where certain tabulations of monthly, daily, and hourly observations are recorded.

- Second Order Stations
  These stations usually take hourly observations similar to the first order stations above but not throughout the entire 24 hours of the day.

- Military Installations
  Many military installations, especially Air Force Bases, take hourly observations. These are transmitted on military teletype circuits and therefore not available for general use. No routine publications of these data is done. Records of observations are sent to NCC where special summaries can be made by use of punched cards.

- Supplementary Airways Reporting Stations
  These stations are located at smaller airports. Observations are not taken at regular intervals, usually being taken according to airline schedules. These observations are not published and are not available on punched cards. Original records, however, are sent to the NCC.

- Cooperative Stations
  There are about 10,000 of these stations manned, for the most part, by volunteer observers. The observations are taken once each day and consist generally of maximum and minimum temperatures and 24 hour rainfall. Observations are recorded on a form with one month to a page. The original is sent to NCC, a carbon sent to the state climatologist (prior to the termination of the State Climatologist Positions), and a carbon maintained at the station. A few cooperative stations have additional data on evaporation and wind. However, the wind observations are taken only a few inches off the ground and are of use mainly in connection with the evaporation measurements.

- Fire Weather Service Stations
  There are a number of special stations maintained during certain times of the year in forested regions where measurements of wind, relative humidity, and cloud cover are taken. These are generally not on punched cards nor are they summarized.

Upper Air

There are between 60 and 70 stations in the contiguous United States where upper air observations are taken twice daily (at 0000 GMT and 1200 GMT) by radiosonde balloon and radio direction-finding equipment. The measurements taken include temperature, pressure, relative humidity and wind speed and direction at several levels. These observations are transmitted to teletype and original records are sent to NCC where these data are published. Since these data are collected primarily to determine large scale meteorological patterns and have relatively little refinement in the lower 2 to 3 thousand feet of the atmosphere, they are of limited use in air pollution meteorology.

3.3.2 Climatological Data

There are a number of routine and special publications available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, that are useful in air pollution evaluation. A number of these are listed in Price List 48, available from the Superintendent of Documents.

Routinely Prepared Data

- Daily Weather Maps - Weekly Series
  The charts in this 4-page, weekly publication are a continuation of the principal charts of the former Weather Bureau publication, "Daily Weather Map." All of the charts for 1 day are arranged on a single page after being copied. They are copies from operational weather maps prepared by the National Meteorological Center, National Weather Service. The Surface Weather Map presents station data and the analysis for 7:00 a.m. EST.

The 500-Millibar Height Contour chart presents the height contours and isotherms of the 500-millibar surface at 7:00 a.m. EST.

The Highest and Lowest Temperatures chart presents the maximum and minimum values for the 24-hour period ending at 1:00 a.m., EST.

The Precipitation Areas and Amounts chart indicates by means of shading, areas that had precipitation during the 24 hour period ending at 1:00 a.m., EST.

- Local Climatological Data (LCD)
  These data are published individually for each station and include 3 issues discussed below.

  Monthly Issue LCD
  This issue gives daily information on a number of meteorological variables and monthly means of temperature, heating degree days, pressure and precipitation. Also tabulated are observations at 3-Hourly Intervals (observations for each hour of the day were discontinued after December 31, 1964). This publication is usually available between the 10th and 15th of the following month.

  LCD Supplement (monthly)
  This issue is available for stations having 24 hourly observations daily until December 31, 1964 when publication was discontinued. For air pollution investigations, Tables B, E, F, and G would be of greatest interest (Frederick, 1964). The Supplement is usually available from 20 to 40 days after the end of the month.

  LCD with Comparative Data (annual)
  This issue, published annually, has a table of climatological data for the current year and a table of normals, means, and extremes for a longer period of record. This issue is usually available between 45 and 60 days after the end of the year.

- Northern Hemisphere Data Tabulations
  This publication, issued daily, contains approximately 30 pages of surface synoptic observations and upper air observations. The surface data are for one hour only (1200 GCT). In this publication, the radisonde information is of principal interest in air pollution meteorology.

- Climatological Data - National Summary
  This publication of approximately 50 pages, issued monthly, contains a narrative summary of weather conditions, climatological data (similar to those given in each station's LCD) in both English and metric units,

mean monthly radiosonde data, and solar radiation data. Also included are a number of maps of the United States showing spatial distribution of temperature, precipitation, solar radiation and winds. The mean radiosonde and solar radiation data are of main interest in this publication for air pollution meteorology.

- <u>Climatological Data (by State)</u>
  This summary, issued monthly and annually, contains data primarily on temperature and precipitation. This will provide only limited information to the air pollution meteorologist.

- <u>Selected Climatic Maps</u>
  This publication consists of 30 U.S. maps of various meteorological parameters such as: maximum and minimum temperature, heating and cooling degree days, precipitation, relative humidity, solar radiation, and surface wind roses for January and July together with the annual wind rose. Wind data are presented for 74 locations within the contiguous U.S. A list of the basic Climatic Maps from which the generalized maps of this publication are taken is included.

Summaries

- <u>Summary of Hourly Observation</u>
  This series of publications, Climatography of the United States, No. 82-, Decennial Census of United States Climate, has been prepared for over 100 Weather Bureau stations where 24 hourly observations are recorded. One issue is prepared for each station, and where the period of record is sufficient, the ten year period 1951 - 1960 has been considered. For other stations, the 5 year period 1956 - 1960 has been summarized. This series supersedes the series, "Climatography of the United States" No 30-, a 5 year summary published in 1956.

- <u>Climatic Guide</u>
  This series of climatological publications contains a wealth of climatological information useful to the air pollution meteorologist fortunate enough to have had one prepared for his city. Of major interest to air pollution meteorologists, are tables of wind frequencies, solar radiation and degree days.

- <u>Climatic Summary of the United States-Supplement for 1931 - 1952.</u>
  This summary, issued by state, contains tables of monthly and annual precipitation, snowfall, and temperature for stations within the state.

- <u>Terminal Forecasting Reference Manual</u>
  This manual, published by station, describes the weather conditions at the station, and contains information on

local topography, visibility effects due to fog and smoke, ceiling, precipitation, special weather occurrences, and mean wind and visibility conditions. Numerous charts are included summarizing the above elements. Of special interest are surface wind roses by month and a wind rose chart related to restricted visibility conditions. A topographic and smoke source map for the station is included.

- <u>Key to Meteorological Records Documentation</u>
  This series of publications was established to provide guidance to those making use of observed data. A recent addition to this series No. 4.11, "Selective Guide to Published Climatic Data Sources prepared by U.S. Weather Bureau" (1969) is extremely useful to anyone contemplating use of climatic data.

  The series No. 1.1 title "Substation History" and issued by state contains information regarding history of station locations, type and exposure of measuring instruments, location of original meteorological records, where published, and dates of first and last observations.

3.4 TEMPERATURE

Temperature is a critical climatological parameter for land management activities. Temperature and related parameters, such as the length of the growing season, greatly influence the suitability of land areas for utilization in agriculture, forestry and grazing.

Ambient temperatures are determined by a multitude of factors, including the following:

- The intensity and duration of solar radiant energy
- The degree of depletion of this energy by reflection, scattering and absorption in the atmosphere
- The surface albedo
- The physical characteristics of the surface such as terrain types
- The local heat budget in terms of terrestrial and atmospheric radiation
- Heat exchanges involved in water phase changes
- Importation or advection of warm or cold air masses by horizontal air movement
- Transport of heat upward or downward by vertical air currents caused by natural convection and/or mechanical turbulence

In the United States, temperature is most commonly measured in degrees Fahrenheit (°F), however, there is an increasing trend towards the use of degrees Centigrade (°C). For this reason, temperature data and analyses presented in this report are in degrees Fahrenheit, with Table 3.4-1 providing a summary of temperature conversion information for aid in the usage of both systems.

Temperature data are available for numerous stations in California. For this reason, key stations have been used to represent the various climatic zones in the district in an effort to limit the amount of data analysis necessary to present the required information. Once again, the Folsom District has been divided into four key climatic zones in which temperature is fairly homogeneous. For each of these regions, data from the selected key stations has been used to describe temperature characteristics. Data provided for each of the key stations includes monthly and annual means, mean maximum, mean minimum as well as the record high and low temperatures.

Figure 3.4-1 presents the four climatic zones superimposed on the district map with selected station locations for which temperature data are available. Tables 3.4-2 through 3.4-5 summarize the temperature statistics for these stations in each climatic zone. Section 3.2 briefly summarizes temperature and other climatic characteristics of each climatic zone.

Table 3.4-1

TEMPERATURE CONVERSIONS

Temperatures in this publication are given in degrees Fahrenheit (°F). The Celsius (C) temperature scale, also called Centigrade, is used in most countries of the world. A temperature conversion scale is shown on the left, note that the values coincide only at the -40 degree mark.

°F	°C	
212	100	1. Water Boils
194	90	
176	80	
158	70	
140	60	
134	56.7	2. U.S. Record High
122	50	
104	40	
86	30	
68	20	
50	10	
32	0	1. Water Freezes
14	−10	
−4	−20	
−22	−30	
−40	−40	Scales Coincide
−58	−50	
−76	−60	
−94	−70	3. U.S. Record Low
−112	−80	
−130	−90	
−148	−100	

The standard formulas to convert °F to °C and °C to °F are shown below:

$$°F = 9/5\ °C + 32$$

$$°C = 5/9\ (°F - 32)$$

Atlernate, easy to remember conversion methods follow:

$$°F = 9/5\ (°C + 40) - 40$$

$$°C = 5/9\ (°F + 40) - 40$$

To use the alternate conversion formulas for converting from one scale to the other:

(a) add 40 to the value to be converted

(b) multiply that sum by the fraction:
(5/9 for °F to °C)
(9/5 for °C to °F)

(c) subtract 40 from the product

For example, to convert 68°F to °C:

(a) add 40: 68+40 = 108

(b) multiply the sum by 5/9 (°F to °C):
5/9x108 = 60

(c) subtract 40: 60-40 = 20

(d) answer: 68°F = 20°C

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1. Under Standard Sea Level Pressure
2. Greenland Ranch, CA - July 10, 1913
3. Rogers Pass, Montana - January 20, 1954

TEMPERATURE STATIONS FOR FOLSOM DISTRICT

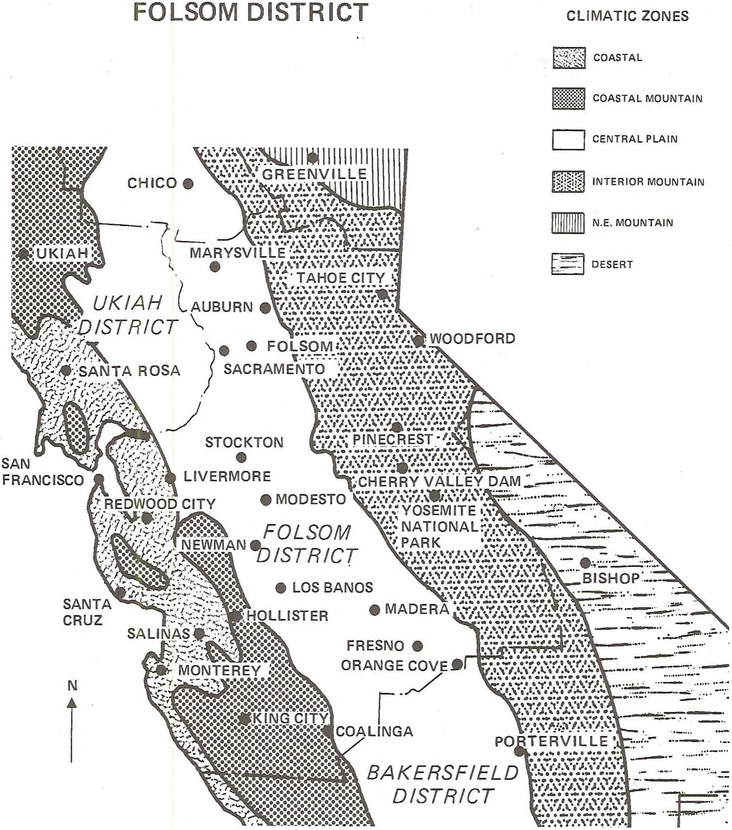


Figure 3.4-1

Table 3.4-2
Summarized Temperature (^{o}F) Data for Selected Stations in the Coastal Climatic Zone

		DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	HIGH	LOW
San Francisco	Mean	48.4	47.9	51.6	53.2	54.9	57.7	60.8	62.2	63.4	63.7	60.6	54.5	106	24
	Mean Max.	56.4	55.8	58.9	60.7	63.1	66.1	69.2	70.3	70.2	73.0	69.9	63.4		
	Mean Min.	41.9	40.8	43.4	45.1	46.2	49.0	51.3	52.5	53.5	52.8	50.4	45.6		
	Max.	75	72	78	85	88	96	106	104	98	103	95	85		
	Min.	20	24	25	30	31	36	41	43	42	38	34	25		
Redwood City	Mean	48.6	48.3	51.9	54.0	56.7	61.7	65.8	67.5	68.8	66.9	61.4	54.5	110	22
	Mean Max.	58.2	58.4	62.6	65.6	69.9	76.0	80.5	81.9	84.0	82.0	75.1	65.5		
	Mean Min.	38.9	38.2	41.1	42.2	43.4	47.5	51.1	53.1	53.5	51.8	47.7	43.4		
	Max.	75	75	78	86	90	101	104	110	100	106	95	87		
	Min.	22	24	26	30	35	38	39	44	44	42	33	29		
Santa Cruz	Mean	49.4	48.7	51.2	52.2	54.5	58.0	61.1	62.7	62.9	63.3	60.1	54.0	107	22
	Mean Max.	60.1	59.0	62.3	64.0	67.0	70.6	73.8	75.0	75.2	77.1	73.9	66.0		
	Mean Min.	38.7	38.3	40.1	40.4	41.9	45.3	48.4	55.4	50.6	49.5	46.2	42.0		
	Max.	87	81	85	88	91	98	104	105	103	107	102	92		
	Min.	23	22	25	28	31	34	36	40	39	38	30	27		
Monterey	Mean	51.0	51.2	52.6	53.0	53.6	55.7	58.1	59.5	60.9	62.1	60.5	56.1	101	23
	Mean Max.	59.3	59.7	60.8	61.1	62.0	63.5	66.2	67.2	68.8	71.1	69.8	64.6		
	Mean Min.	43.0	42.5	44.4	44.7	45.3	47.8	50.1	51.8	52.9	52.8	51.3	47.6		
	Max.	80	84	81	82	91	97	98	93	95	101	95	91		
	Min.	23	27	27	35	38	41	42	46	46	44	36	34		
Salinas	Mean	49.8	50.2	52.0	52.4	54.6	57.3	61.0	61.8	63.1	63.5	61.2	55.0	105	20
	Mean Max.	60.9	60.2	62.8	63.4	66.0	67.4	70.2	70.7	72.0	74.6	73.6	67.3		
	Mean Min.	39.8	38.6	41.4	41.6	44.4	48.3	51.4	53.1	53.6	52.9	49.0	44.0		
	Max.	83	81	85	86	93	99	104	95	98	105	102	93		
	Min.	20	20	25	27	33	34	41	44	45	36	31	29		

Table 3.4-3
Summarized Temperature (^{o}F) Data for Selected Stations in the Coastal Mountain Climatic Zone

		DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	HIGH	LOW
Livermore	Mean	47	46	49	52	56	61	66	71	71	69	64	53	115	16
	Mean Max.	58	57	61	65	71	76	82	89	87	86	77	67		
	Mean Min.	37	36	39	41	43	47	51	54	53	52	47	40		
	Max.	79	77	80	87	95	108	111	113	112	115	104	93		
	Min.	20	16	23	25	30	32	38	41	40	35	29	25		
Hollister	Mean	49	48	52	54	57	60	66	67	67	66	62	52	112	15
	Mean Max.	61	59	63	66	70	73	78	81	81	81	76	68		
	Mean Min.	37	37	40	41	44	46	49	51	51	50	46	40		
	Max.	88	84	82	91	93	104	108	112	103	111	105	92		
	Min.	19	15	19	26	28	31	35	37	36	31	22	20		
King City	Mean	49	49	52	54	56	61	66	68	68	66	62	54	111	15
	Mean Max.	63	63	67	69	73	78	82	85	85	84	79	69		
	Mean Min.	35	36	37	39	40	45	49	50	51	49	45	40		
	Max.	80	86	85	91	95	108	111	109	103	105	101	92		
	Min.	17	15	22	26	27	31	36	35	37	35	26	24		

Table 3.4-4
Summarized Temperature (^{O}F) Data for Selected Stations in the Central Plain Climatic Zone

		DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	HIGH	LOW
Sacramento	Mean	45.0	44.5	50.4	53.1	57.4	65.4	71.4	71.2	71.1	72.1	63.9	53.4	115	20
	Mean Max.	53.8	53.2	59.2	64.5	71.3	79.1	86.7	92.8	91.3	87.5	77.3	63.5		
	Mean Min.	33.8	37.4	40.5	42.1	45.3	50.0	55.0	58.0	57.0	55.3	49.5	42.2		
	Max.	72	70	76	86	93	104	115	114	108	108	101	87		
	Min.	22	20	25	26	32	34	41	49	46	43	31	26		
Marysville	Mean	46.1	45.4	50.8	54.5	60.1	67.1	74.0	78.9	77.4	73.3	64.6	53.7	113	20
	Mean Max.	54.3	53.5	60.5	66.0	73.2	81.5	89.9	96.8	95.1	90.1	79.2	64.8		
	Mean Min.	37.8	37.3	40.9	42.9	46.9	52.6	58.0	60.9	59.7	56.4	50.0	42.6		
	Max.	79	76	79	86	94	104	113	111	109	110	100	89		
	Min.	20	20	27	26	32	38	44	45	49	43	34	27		
Auburn	Mean	45.5	44.6	48.5	51.0	56.0	62.6	70.5	77.4	76.4	71.8	63.2	52.7	113	16
	Mean Max.	54.5	53.5	58.7	62.0	68.1	76.2	85.4	93.8	92.6	87.4	76.7	63.4		
	Mean Min.	36.4	35.7	38.3	39.9	43.8	48.9	55.5	60.9	60.2	56.1	49.6	42.0		
	Max.	76	81	78	85	90	98	110	113	108	106	99	89		
	Min.	16	20	21	25	30	32	36	42	46	41	31	29		
Modesto	Mean	45.5	45.5	50.5	54.2	59.4	65.5	71.8	76.8	75.3	71.3	63.3	52.8	112	22
	Mean Max.	53.7	53.7	60.7	66.5	73.1	80.7	88.2	94.6	92.6	87.7	77.9	64.2		
	Mean Min.	37.4	37.2	40.3	41.8	45.6	50.3	55.3	58.9	58.0	54.9	48.6	41.4		
	Max.	73	71	75	89	94	103	112	111	106	106	98	85		
	Min.	22	22	24	27	34	37	42	47	46	32	32	25		
Newman	Mean	44.5	44.0	50.1	53.5	58.0	66.6	72.2	76.5	75.2	71.2	62.9	52.7	109	8
	Mean Max.	54.0	53.9	61.1	67.3	73.2	83.9	90.0	95.4	93.2	88.5	78.6	63.9		
	Mean Min.	35.0	34.0	39.0	40.1	42.8	49.6	54.0	57.6	57.0	53.6	47.5	41.1		
	Max.	75	71	76	87	95	104	109	109	104	103	98	85		
	Min.	20	8	23	22	30	36	40	48	45	40	27	21		
Los Banos	Mean	45.6	45.4	50.6	54.5	60.0	66.5	73.0	78.5	77.1	72.7	64.0	53.1	112	19
	Mean Max.	54.9	54.9	62.2	68.1	75.1	82.7	90.3	97.5	95.8	90.5	80.0	65.7		
	Mean Min.	36.3	35.9	38.9	40.8	44.9	50.3	55.6	59.4	58.4	54.8	48.0	40.5		
	Max.	74	74	79	89	96	106	112	112	108	110	100	85		
	Min.	21	19	24	24	30	35	39	46	46	42	28	24		
Coalinga	Mean	46.5	46.0	50.7	54.1	59.9	67.7	75.1	81.6	80.0	74.3	64.7	53.5	112	18
	Mean Max.	57.4	56.9	62.7	67.9	74.8	83.8	91.8	99.1	97.3	91.5	80.6	66.9		
	Mean Min.	35.5	35.1	38.6	40.2	44.9	51.6	68.4	64.1	62.6	57.1	48.6	40.0		
	Max.	75	77	81	88	95	105	112	112	109	111	100	87		
	Min.	18	18	23	24	30	35	42	48	47	41	31	24		
Madera	Mean	44.4	44.3	49.9	53.8	58.8	67.3	74.4	80.2	78.6	73.0	64.0	53.3	116	4
	Mean Max.	55.5	53.9	61.0	66.1	73.8	83.1	92.0	99.0	97.0	88.0	79.3	65.9		
	Mean Min.	35.0	35.8	38.5	40.2	44.1	49.4	55.4	59.5	57.7	53.5	46.4	39.4		
	Max.	74	73	79	88	96	105	115	116	109	105	101	90		
	Min.	20	17	21	27	29	35	38	42	48	40	28	4		
Fresno	Mean	44.5	44.5	50.4	54.1	59.4	68.3	75.4	80.8	79.0	73.7	64.0	53.0	111	19
	Mean Max.	54.4	53.5	61.0	66.0	73.8	81.8	91.2	98.7	96.7	89.3	78.3	65.6		
	Mean Min.	37.4	37.3	40.0	43.4	47.4	52.9	59.0	64.6	62.8	57.8	50.5	42.7		
	Max.	73	75	76	90	95	104	110	111	108	107	99	88		
	Min.	21	19	25	26	32	36	45	52	49	41	27	26		
Orange Cove	Mean	44.8	44.4	49.8	53.7	58.7	67.2	74.0	-	78.8	68.1	64.4	54.0	111	9
	Mean Max.	53.9	54.1	60.5	66.4	72.7	83.0	90.4	-	95.6	84.1	79.7	65.8		
	Mean Min.	35.7	34.8	39.0	40.9	44.8	51.4	57.5	62.1	61.0	52.1	49.0	42.1		
	Max.	75	76	79	88	95	104	109	111	107	105	98	91		
	Min.	22	9	23	28	30	29	42	49	48	37	27	28		

Table 3.4-5
Summarized Temperature (^{0}F) Data for Selected Stations in the Interior Mountain Climatic Zone

		DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	HIGH	LOW
Tahoe City	Mean	30.1	28.8	30.5	32.6	36.8	46.4	53.5	61.1	60.2	54.3	44.9	36.6	90	-16
	Mean Max.	40.0	38.4	40.3	43.0	47.9	60.0	67.7	77.2	75.9	69.1	57.5	46.4		
	Mean Min.	20.2	19.2	20.7	22.2	25.7	32.8	39.2	45.0	44.4	39.5	32.2	26.7		
	Max.	57	54	59	61	67	78	85	90	90	82	75	66		
	Min.	-16	-3	-10	-1	6	9	26	30	31	18	9	4		
Woodford	Mean	34.5	33.3	36.3	39.2	45.1	53.2	61.7	69.2	68.1	61.4	51.6	41.2	98	-10
	Mean Max.	45.0	43.5	47.4	51.1	58.0	66.9	76.5	85.1	83.7	76.5	65.2	52.3		
	Mean Min.	24.0	23.0	25.2	27.2	32.0	39.4	46.8	53.3	52.4	46.3	38.0	30.0		
	Max.	73	68	71	75	81	88	97	97	98	94	89	75		
	Min.	-10	-9	-8	2	11	16	26	28	29	23	8	4		
Yosemite Park	Mean	36.4	36.5	41.7	45.0	50.5	57.4	64.7	71.7	71.1	66.1	56.4	44.3	104	-1
	Mean Max.	46.4	47.0	54.7	59.2	65.6	73.2	81.6	89.9	90.0	85.4	74.2	58.0		
	Mean Min.	26.3	25.9	28.7	30.8	35.4	41.6	47.8	53.4	52.1	46.8	38.6	30.6		
	Max.	65	69	79	89	89	91	102	104	104	102	98	86		
	Min.	-1	7	10	10	20	26	30	38	32	28	21	16		
Cherry Valley Dam	Mean	38.7	38.6	39.8	41.0	44.8	54.6	62.8	70.9	69.9	65.1	55.5	45.5	105	-3
	Mean Max.	49.7	50.2	52.3	54.0	58.4	69.0	77.8	87.2	86.2	81.0	69.9	57.3		
	Mean Min.	27.7	26.9	27.2	27.9	31.2	40.2	47.8	54.5	53.5	49.1	41.1	33.6		
	Max.	70	73	72	80	83	90	102	105	102	98	92	82		
	Min.	-3	4	-2	6	15	22	29	43	40	32	17	13		

3.4.1 Mean Temperature Distribution

The data presented in the figures and tables in this section provide generalized information for BLM lands located within each of the study regions. However, temperature is a variable which is subject to microclimatological effects and the actual temperature at a given location will depend upon several variables as previously indicated. The data show that variability among stations within a particular region is fairly modest and that the average values provided in the summary figures can be used with a good degree of confidence. Caution when using these values is warranted when the location of interest varies significantly from the elevation of the key stations or if a particular location experiences important micro-scale effects (e.g., anomalous ground cover conditions).

Annual Average

Figure 3.4-2 provides the mean annual temperature distribution for the Folsom District and also appears as Overlay D. The figure shows a 20°F range in mean annual temperature across the region, from a low of 43°F at Tahoe City to a maximum of 63°F at Five Points. The data indicate that temperatures are fairly uniform along the Pacific Coast where the annual mean is in the mid-50's °F. Temperatures gradually increase with eastward progression into the Central Valley where the mean annual temperature reaches the low 60's °F. There is a fairly steep temperature gradient with continued eastward movement into the higher terrain of the Sierra Nevada, where temperatures drop rapidly from the low 60's °F on the valley floor to the low 40's °F at the highest locations.

Mean maximum and mean minimum temperature data are summarized in Figures 3.4-3 through 3.4-5 for the three major climatic zones (for ease of discussion and due to regional similarities, the Coastal and Coastal Mountain CZ's are discussed as one) in the Folsom District on a monthly basis. The influence of the Pacific Ocean on coastal temperature characteristics can be noted from the figures which provide a comparison with other regions. Coastal regions experience a modest 15°F temperature increase from winter to summer, while the Central Valley and mountain locations experience a 35°F change.

Mean Maximum

During the months of December and January, maximum temperatures range from the mid-40's °F in the mountains to around 60°F at coastal locations (See Figure 3.4-4.) Winter maxima in the Central Valley are generally in the mid-50's °F. During the summer, temperatures reach the mid-90's °F at valley locations while at seaside stations, temperatures are generally in the mid-70's °F. Mountainous areas experience summertime maxima in the low to mid 80's °F. Maximum temperatures generally

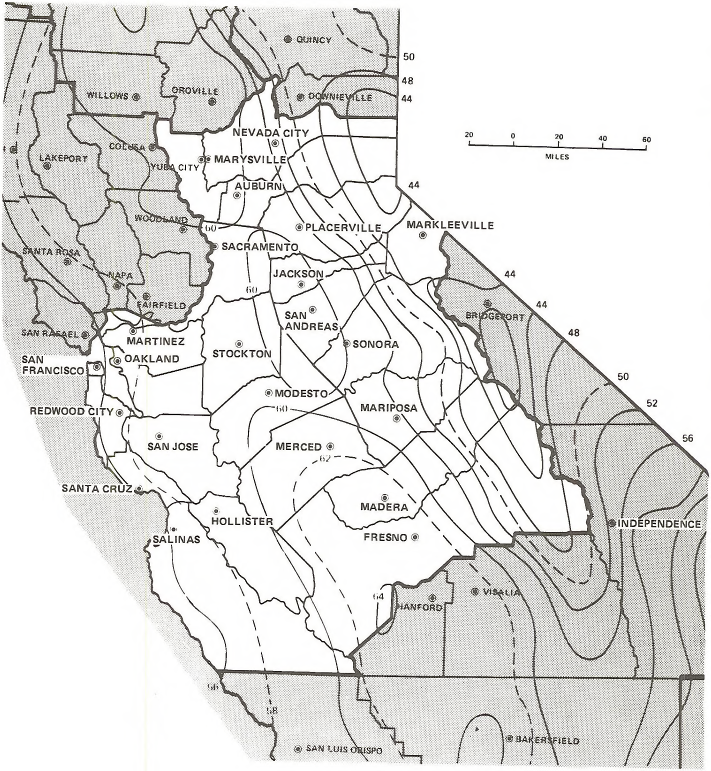


Figure 3.4-2
Mean Annual Temperature Contours (^{o}F)
in the Folsom District

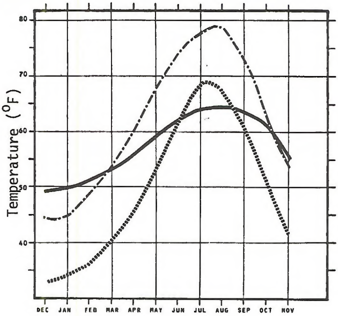


Figure 3.4-3
Folsom District
Mean Temperature

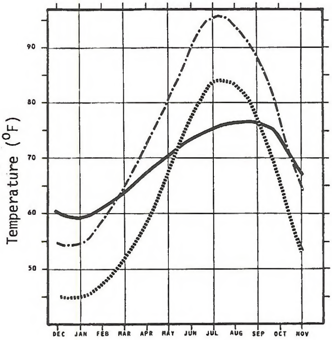


Figure 3.4-4
Folsom District
Mean Maximum Temperature

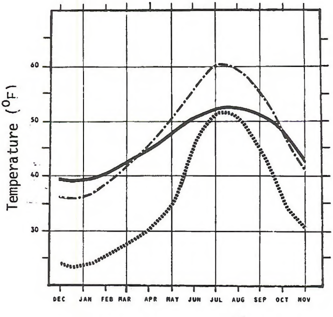


Figure 3.4-5
Folsom District
Mean Minimum Temperature

▬ Coastal
–·– Central Plain
▪▪▪▪ Interior Mountain

reach a peak in August and September at coastal locations and during July and August in the Central Valley and in the mountainous areas.

Mean Minimum

Figure 3.4-5 indicates that during the winter months, minima in the mountainous areas tend to be in the mid-20's °F. At the valley stations and along the coastline, temperatures generally range from the mid-30's °F to around 40 °F. By summertime, overnight lows in the mountains and along the coastline are generally in the low 50's °F, while in the Central Valley, nighttime temperatures drop to only 60 °F during July.

3.4.2 Temperature Extremes

Temperature extremes for key stations in each of the four climatic zones identified for the Folsom District are provided in Tables 3.4-2 through 3.4-5. Temperature extremes are strongly influenced by microclimatological effects and considerable caution must be used when identifying extreme temperatures for use at locations within the Folsom District, for some locations may not be adequately described by the key stations provided in the tables.

The data indicate that in the Coastal CZ, record maximum temperatures range from 101°F at Monterey to 110°F at Redwood City. Temperatures of this magnitude at coastal locations occur in conjunction with "Santa Ana" conditions which occur most frequently during late summer and fall, but which can occur during any time of the year. During a Santa Ana, air is compressed and heated as it rapidly descends over the Sierra Nevada resulting in hot, dry conditions at coastal California locations.

Record low temperatures along the Coastal CZ range from a minimum of 20°F at Salinas to 24°F at San Francisco. Record low temperatures are generally associated with particularly large outbreaks of Artic air which occasionally spill over the Sierra Nevada during the winter.

In the nearby Coastal Mountain CZ, record maximum temperatures range from 111°F at King City to 115°F at Livermore. Once again, these temperatures are associated with "Santa Ana" conditions during late summer and fall. The higher values experienced in this zone as opposed to the Coastal CZ reflect the increase in distance from the moderating influence of the Pacific Ocean. The record minimum temperature in the zone was recorded at both Hollister and King City at 15°F. This is substantially colder than the record minima observed at coastal stations, once again reflecting the more continental nature of the area.

Record temperatures are available for several key cities in the Central Plain CZ as indicated in Table 3.2-4. Record maxima range from 109°F at Newman to a regional maximum of 116°F at Madera. Temperatures of this magnitude can occur either with "Santa Ana" conditions or during late summer when surface heating reaches a maximum at low-lying inland locations. Record low temperatures in the Central Plain CZ exhibit considerable variability ranging from a regional mimimum of 4°F at Madera to 22°F at Modesto. Minimum temperatures reflect local terrain and micrometeorological effects as well as such factors as the degree of urban development and the length of record available for the data base. However, the table would indicate that temperatures lower than the upper teens (°F) are quite rare in the zone and probably only occur at a few stations particularly conducive to such anomolies.

Finally, record temperatures for the Interior Mountain CZ are contained in Table 3.4-5. In this zone, record values are particularly influenced by the elevation and exposure of the particular stations. Therefore, considerable caution is urged relative to the use of extreme temperature data as provided. The data indicate a range of record values from 90°F at Tahoe City to 105°F at Cherry Valley Dam. Record lows range from -1°F at Yosemite Park to -16°F at Tahoe City. Record maximum temperatures at these locations generally occur during mid-summer and are not associated with "Santa Ana" conditions. Record minima occur during mid-winter during periods of Artic outbreaks which spread into California on occasion from the Great Basin states.

3.4.3 Frost-Free Period

The growing season varies considerably as a function of specific crop types. Some types of vegetation continue to grow when air temperatures are near freezing (32°F), whereas other forms of plant life die at temperatures above freezing. In general, it is convenient to define the growing season for a particular region by noting the mean number of days between the first and last occurrence of freezing temperatures, i.e., the frost-free period.

The mean length of the growing season is depicted by isolines of 50 day intervals for the entire Folsom District in Figure 3.4-6. As indicated in the figure, the growing season length differs considerably at coastal locations as compared to regions located further inland. The coastal areas are largely influenced by nearby Pacific waters. The marine environment tends to warm ambient air masses in winter and reduce air temperatures during the summer months. Coastal areas in the Folsom District experience growing seasons on the order of 350 days. This maritime influence is limited, however, to a narrow strip of land along the coast that extends only 25-40 miles inland. Therefore, other coastal areas, particularly those with elevated terrain, such as the Diablo Range, experience a severely reduced mean growing season of approximately 200-250 days. In mountain areas just west of Coalinga, California, the growing season drops even further, to 150 days or less.

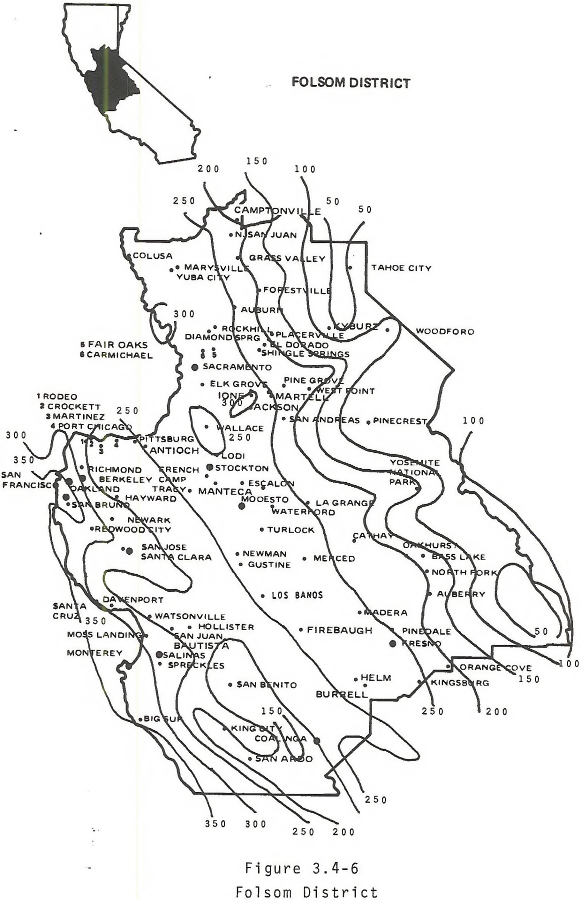


Figure 3.4-6
Folsom District
Frost-Free Period or Length of Growing
Season by 50-Day Intervals

The mean frost-free period for most of the Central Valley ranges between 250-300 days, offering a rather lengthy growing season for the rich and fertile soil of the San Joaquin Valley. This area constitutes one of the most important agricultural zones in the United States.

A rapid change in the length of the growing season is experienced as one moves eastward toward the Sierra Nevada. As depicted in Figure 3.4-6, the mean growing season drops to less than 50 days at the highest elevations, if one exists at all. Most of the elevated mountain terrain of the Sierra region experiences frost-free periods generally less than 150 days. Extreme caution should be exercised in interpolating frost-free periods from the contours outlined in Figure 3.4-6, especially in the mountain areas.

Table 3.4-6 presents 16 years of historical freeze data for selected stations. For each year since 1960, the occurrence of the last spring freeze and first fall occurrence of 32°F are provided. The number of Julian days between the freezing events are also listed to provide the growing season length.

In summary, little difference in frost-free period lengths is experienced between northern and southern coastal stations. Stations slightly inland (e.g., Redwood City) observe a considerable change in the length of the frost-free period. Central Valley locations demonstrate a more homogeneous distribution of frost-free periods from station to station. In this region, the frost-free period averages 276 days. The mountain regions reveal a wide range of growing season lengths. A comparison of data from Cathay, Cherry Valley Dam, Tahoe City and Yosemite Park Headquarters further emphasizes these large differences.

Table 3.4-6

Folsom District

Frost-Free Periods at Selected Stations

	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	Average
SAN FRANCISCO																		
Last Spring 32°F	Jan 2	Jan 4	Jan 24	Jan 20	None	Jan 1	Mar 3	None	Jan 6	None	None	Jan 5	Jan 5	Jan 7	Jan 8	Jan 30	Jan 2	Jan 10
First Fall 32°F	None	None	Dec 25	None	None	Dec 17	Dec 28	Dec 15	Dec 21	None	None	None	Dec 5	None	Dec 25	None	None	Dec 28
Julian Days	364	361	335	345	366	351	300	349	350	365	365	360	335	358	351	335	364	350
MONTEREY																		
Last Spring 32°F	Jan 4	None	Feb 27	None	None	None	None	None	None	None	None	None	Jan 4	Jan 7	None	Jan 30	Jan 29	Jan 8
First Fall 32°F	None	None	Dec 25	None	None	None	None	Dec 14	None	None	None	None	Dec 5	None	Dec 24	None	None	Dec 28
Julian Days	362	365	301	365	366	365	365	348	366	365	365	365	336	358	358	335	337	354
REDWOOD CITY																		
Last Spring 32°F	Jan 17	Jan 21	Feb 28	Jan 22	Mar 25	Feb 12	Mar 17	Mar 5	Jan 28	Feb 3	Jan 6	Mar 6	Feb 2	Feb 1	Feb 7	Feb 23	Mar 9	Feb 13
First Fall 32°F	Dec 7	Nov 17	Dec 25	Dec 11	Nov 17	Dec 15	Nov 25	Dec 2	Dec 3	Nov 29	Dec 20	Dec 15	Dec 5	None	Dec 23	Nov 19	Nov 28	Dec 7
Julian Days	325	300	300	323	237	307	253	272	310	299	348	284	307	332	319	269	264	297
STOCKTON																		
Last Spring 32°F	Mar 2	Mar 7	Feb 28	Mar 18	Apr 24	Feb 12	Mar 17	Mar 5	Jan 28	Mar 14	Feb 19	Mar 6	Feb 3	Jan 27	Feb 9	Feb 23	Apr 17	Mar 2
First Fall 32°F	Dec 6	Nov 17	Nov 30	Dec 10	Nov 16	Nov 28	Dec 27	Dec 9	Nov 29	Nov 18	Dec 24	Nov 17	Dec 5	None	Nov 28	Nov 19	Nov 28	Dec 3
Julian Days	279	255	275	267	206	290	285	279	306	249	308	256	306	338	292	269	225	276
CATHAY																		
Last Spring 32°F	Mar 22	Apr 24	Apr 29	Apr 17	May 3	May 6	Mar 17	Apr 29	Apr 22	Apr 7	Apr 29	Apr 22	Apr 14	Apr 2	Apr 10	May 5	Apr 17	Apr 22
First Fall 32°F	Nov 15	Oct 29	Nov 18	Nov 21	Nov 24	Nov 26	Nov 23	Nov 29	Nov 27	Nov 17	Dec 3	Oct 18	Oct 30	Nov 4	Nov 24	Oct 23	Nov 27	Nov 15
Julian Days	177	188	203	218	195	204	251	214	219	224	218	179	199	216	228	171	224	207
CHERRY VALLEY DAM																		
Last Spring 32°F	May 24	Jun 1	Jun 4	May 12	Jun 10	May 24	Apr 21	Jun 2	May 24	May 3	May 12	Jun 2	Jun 11	May 6	May 20	May 21	Apr 25	May 2
First Fall 32°F	Oct 10	Sep 18	Oct 15	Nov 6	Nov 2	Sep 19	Oct 13	Nov 22	Oct 15	Oct 5	Oct 7	Sep 27	Oct 18	Oct 8	Oct 29	Oct 7	Nov 13	Oct 16
Julian Days	139	109	133	178	145	118	175	173	144	155	148	117	129	155	162	139	199	148
TAHOE CITY																		
Last Spring 32°F	May 27	May 31	Jun 7	Jun 30	Jun 19	Jun 15	Jun 4	Jun 13	Jun 13	Jun 28	Jun 11	Jun 5	Jun 11	Jun 18	Jun 26	Jun 28	Jun 12	Jun 14
First Fall 32°F	Aug 23	Sep 17	Oct 5	Oct 12	Sep 1	Sep 17	Sep 14	Oct 3	Aug 22	Aug 6	Sep 5	Sep 18	Sep 11	Aug 24	Jul 11	Jul 1	Aug 7	Sep 1
Julian Days	88	109	120	104	74	94	102	112	70	39	86	105	92	67	15	3	56	79
YOSEMITE PARK																		
Last Spring 32°F	May 23	May 7	May 21	May 11	May 8	May 8	Jun 3	May 12	May 23	Apr 26	May 12	Jun 2	Apr 26	May 5	May 21	May 21	Apr 30	May 14
First Fall 32°F	Oct 10	Oct 10	Nov 12	Nov 1	Nov 13	Sep 29	Oct 13	Oct 6	Aug 22	Oct 3	None	Sep 26	Oct 25	Oct 3	Oct 29	Oct 7	Oct 17	Oct 17
Julian Days	140	156	175	174	179	144	132	147	91	160	233	116	182	151	161	139	170	156

3.5 PRECIPITATION

Precipitation plays a very important role in the effective management of large land areas for agriculture, forest management, energy development or other pertinent interests. Precipitation is one of the most basic of climatological parameters and is best described in terms of seasonal and annual means and extremes coupled with a discussion of the type of precipitation experienced in a given area. A region can be prone to either general prolonged rainfall or precipitation occurrences in short, violent bursts, such as heavy showers or thunderstorms. The nature of the precipitation is almost equal in importance to the amount of precipitation in terms of the effectiveness of the moisture for interests such as agriculture. In addition, the type of precipitation (i.e., liquid vs. frozen) and the amount of each also plays an important role.

Precipitation results from the expansion and cooling of ascending air. Therefore, it is important to investigate and understand the atmospheric conditions that cause large masses of air to spontaneously rise. Three characteristic causes that can result in precipitation are:

- Convective lifting due to unstable atmospheric conditions

- Orographic or terrain-induced lifting of air masses

- Large scale atmospheric disturbances

The three are not mutually exclusive, and precipitation is generally not the result of just one type, but more often the joint action of several types of atmospheric lifting processes.

The following sections provide a detailed breakdown of precipitation amounts, types and frequencies. Seasonal and annual means and extremes are provided as well as rainfall intensity, and a detailed discussion on snowfall. More unusual types of precipitation such as hail are discussed in the section provided on severe weather.

3.5.1 Annual Distribution

Figure 3.5-1 presents a base map which includes the selected stations for which precipitation data are available. A climatic zone overlay (Overlay C) for the Folsom District is suitable for use with the precipitation maps.

Precipitation in California and within the Folsom District is primarily the result of the influence of maritime Pacific air and orographic influences imposed by the substantial terrain within the region. The neighboring Pacific Ocean serves as the major moisture source for precipitation in the district.

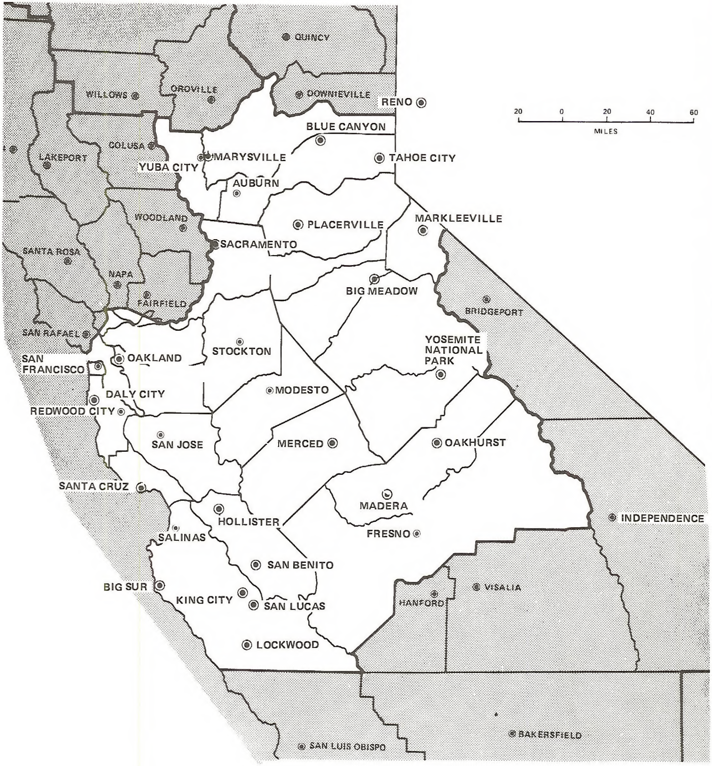


Figure 3.5-1
Selected Precipitation Stations for the Folsom District

Therefore, locations closest to the source and westward facing slopes of higher terrain experience the heaviest precipitation totals in the district.

The mean annual precipitation for the Folsom District is depicted on Figure 3.5-2 in the form of contours (isohyets). An identical map is provided with this district report as a color coded overlay (Overlay E) to facilitate inter-parameter comparisons and correlations by the reader. The figure indicates that large gradients (amount of change as a function of distance) of mean annual precipitation exist along the coastal regions, eastern slopes of the Diablo Mountain Range, and the eastern slopes of the Sierra Nevada. These rapid changes in precipitation levels are directly associated with the influence of local terrain on moisture-laden, maritime air masses. The forced or orographic lifting of saturated air by the Diablo and Sierra Nevada Mountain Ranges causes large local variations in precipitation levels in and near these areas. The Central Valley, on the other hand, is situated in the lee of the Diablo Range with no mechanism to institute forced lifting of ambient air masses. Hence, precipitation levels are considerably less at valley locations than on the windward slopes of the coastal ranges and Sierra Nevada. This is particularly true at stations along the western portion of the Central Valley where a "rain-shadow" effect is experienced due to the downward moving air passing over the Diablo Range.

Annual totals range from a low of less than 6 inches at some locations just east of the Diablo Range to over 80 inches in the Sierra Nevada northeast of Sacramento. Annual totals along the immediate coastline range from around 15 inches near Monterey to over 40 inches in the rugged mountainous area in the southwest portion of the District. Certain well exposed westward facing slopes of higher terrain in the coastal area experience precipitation amounts over 40 inches reaching to over 60 inches in the southwest portion. Inland valley locations in the Salinas and Santa Clara valleys experience precipitation totals between 10 and 20 inches and precipitation amounts in the Diablo Range are in excess of 20 inches at well exposed locations.

In the Central Valley, precipitation ranges from 6 to nearly 20 inches, with the highest values being recorded in the northern portion of the district. In the high Sierra, precipitation amounts increase rapidly with altitude reaching over 80 inches at one location but generally in excess of 60 inches. The Sierra force air masses to rise to great altitudes resulting in generous precipitation amounts. Rainfall and snow accumulation in the Sierra are the major water source for agricultural and domestic development in the Central Valley and much of California. On the leeward side of the range, precipitation amounts drop dramatically due to the "rain shadow" effect and portions of the Folsom District along the Nevada border experience rainfall of less than 20 inches.

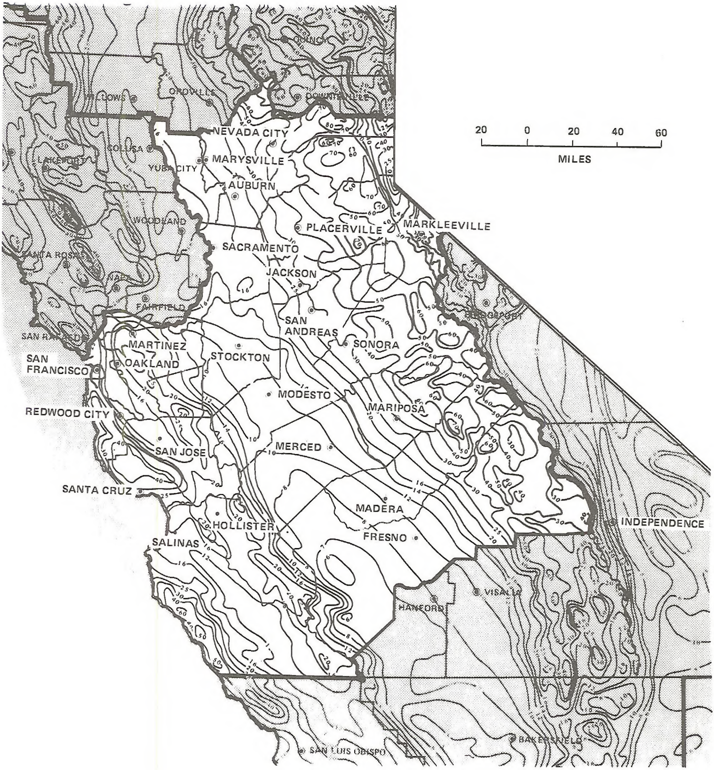


Figure 3.5-2
Mean Annual Precipitation (Inches) in the Folsom District

3.5.2 Seasonal Precipitation

A major portion of the precipitation that occurs in California is associated with cyclonic storms, both surface and upper air. Cyclonic storms originating in the western Pacific are intensified as they move through the Gulf of Alaska. These storms are a winter season phenomenon which result in a distinct rainy season in California and they move as far south as southern California during the fall and winter months. The amount of precipitation associated with these storm systems depends upon the "storm track" or path with the greatest amounts of precipitation occurring near the storm center.

Rainy season storms from the west can result in rain for prolonged periods when the storm-track becomes established across central California. Rains may last for a week or more with only partial clearing between episodes. The actual amount of precipitation at a given station in the District, therefore, will be dependent upon such factors as (1) storm path, (2) station elevation and (3) nearby terrain features.

Storms from the southwest are the least common type of rainy season system but they occasionally bring heavily saturated air masses which can result in considerable flooding during the winter season. Southern California is most often effected by this type of storm but the Folsom District will only occasionally experiences this phenomenon.

Table 3.5-1 provides monthly precipitation means and extremes for selected station locations throughout the Folsom District. A review of these statistics indicates that in each of the climatic zones, a definite rainy season exists between late fall and early spring. Coastal areas and the windward slopes of the Sierra experience the greatest precipitation totals. Precipitation amounts will increase with northward progression in the Central Valley due to the closer proximity of the northern portion of the region to the mean rainy season storm track.

Rainy season, cyclonic storm and frontal activity throughout the district and summer season convective shower activity in the mountains constitute the primary forms of precipitation observed in the Folsom District. On rare occasions, moisture laden extratropical cyclones, the remants of hurricanes which develop in the warm Pacific waters west of Central America, bring substantial rainfall to the area in late summer and fall.

3.5.3 Snowfall

Snowfall has been observed at most locations within the Folsom District. However, snow infrequently accumulates west of the Sierra Nevada except in elevated areas in the coastal mountain ranges. Table 3.5-2 provides the historical record of maximum 24-hour snowfalls and monthly snowfall amounts for various stations throughout the Folsom District. Average amounts

Table 3.5-1
Folsom Precipitation (Inches)
Monthly Means and Extremes

Station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Oec	Annual	
San Francisco	Mean	4.51	2.97	2.77	1.63	0.54	0.17	0.01	0.05	0.17	1.06	2.60	4.18	20.66	Coastal
	Max	10.7	8.49	8.22	5.47	3.19	1.42	0.62	0.49	2.06	5.51	7.80	11.5	11.5	
	Min	1.00	0.04	0.12	T	T.	0.00	0.00	0.00	0.00	T	T	0.18	0.00	
San Francisco Airport	Mean	4.37	3.04	2.54	1.59	0.41	0.13	0.01	0.03	0.16	0.98	2.29	3.98	19.53	
	Max	10.40	9.52	9.01	6.39	3.81	0.86	0.23	0.29	2.30	7.30	7.94	12.30	12.30	
	Min	0.31	T	T	T	T	0.00	0.00	T	T	T	0.00	0.21	0.00	
Oakland	Mean	4.03	2.83	2.32	1.58	0.55	0.14	0.01	0.03	0.18	1.08	2.37	3.57	18.69	
	Max	8.90	8.85	5.69	4.60	3.42	1.21	0.80	0.34	3.27	8.56	7.42	11.30	11.30	
	Min	0.65	0.02	0.04	T	T	0.00	0.00	0.00	0.00	T	0.00	0.28	0.00	
Monterey	Mean	2.90	2.00	2.10	2.00	0.20	0.10	0.10	T	0.10	0.40	2.10	2.20	14.20	
	Max	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Min	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Moffett Field	Mean	2.90	1.90	1.90	1.10	0.40	0.10	T	T	0.20	0.60	1.70	2.50	13.30	Coastal Mountain
	Max	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Min	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Hollister	Mean	2.62	2.16	1.83	1.26	0.32	0.06	0.02	0.03	0.17	0.53	1.67	2.58	13.27	
	Max	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Min	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
King City	Mean	2.19	1.94	1.56	1.00	0.21	0.02	0.00	0.01	0.09	0.32	1.15	1.90	10.39	
	Max	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Min	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
8eale AF8	Mean	3.70	4.00	2.80	2.20	0.70	0.10	T	T	0.40	2.20	3.10	2.30	21.50	Central Plain
	Max	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Min	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Sacramento	Mean	3.73	2.68	2.17	1.54	0.51	0.10	0.01	0.05	0.19	0.99	2.13	3.12	17.22	
	Max	8.50	8.77	5.62	4.76	3.13	0.63	0.79	0.65	1.61	7.51	7.41	12.6	12.60	
	Min	0.38	0.15	0.14	0.00	T	0.00	0.00	0.00	0.00	0.00	0.02	0.17	0.00	

Table 3.5-1 (cont.)
Folsom Precipitation (Inches)
Monthly Means and Extremes

Station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	
Stockton	Mean	2.91	2.11	1.96	1.37	0.42	0.07	0.01	0.03	0.17	0.72	1.72	2.68	14.17	Central Plain
	Max	7.06	6.00	5.60	3.55	1.91	0.66	0.61	0.81	3.00	2.97	6.22	8.05	8.05	
	Min	0.18	0.05	T	0.00	T	0.00	0.00	0.00	0.00	T	T	0.04	0.00	
Merced	Mean	2.00	1.70	1.50	1.30	0.50	0.10	T	T	0.10	0.50	1.30	1.80	10.80	
	Max	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Min	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Fresno	Mean	1.84	1.72	1.62	1.24	0.32	0.06	0.00	0.02	0.07	0.42	1.22	1.71	10.24	
	Max	8.56	5.97	5.79	4.41	1.56	0.60	0.04	0.25	0.92	1.54	3.50	6.73	8.56	
	Min	0.37	T	0.00	0.02	T	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	
Livermore	Mean	1.4	1.4	0.8	0.7	0.2	0.1	T	T	0.1	0.4	1.1	1.0	7.2	
	Max	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Min	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Blue Canyon	Mean	13.7	9.42	8.55	5.47	3.14	0.99	0.10	0.27	0.52	4.14	9.04	12.3	67.6	Interior Mountain
	Max	33.9	23.2	18.7	16.6	10.9	3.06	5.86	3.10	3.78	22.3	28.4	45.1	45.1	
	Min	2.55	0.82	1.86	0.35	0.12	0.00	0.00	0.00	0.00	0.00	T	1.11	0.00	
Reno	Mean	1.21	0.86	0.70	0.47	0.66	0.40	0.26	0.22	0.23	0.46	0.68	1.09	7.20	
	Max	4.13	3.69	2.02	2.04	2.89	1.31	1.06	1.65	1.02	2.14	2.04	5.25	5.25	
	Min	T	T	0.03	T	T	0.00	0.00	0.00	0.00	T	0.00	0.01	0.00	
Yosemite Park Hqtr	Mean	6.51	5.53	5.10	3.50	1.55	0.56	0.27	0.16	0.50	1.60	4.91	6.95	37.14	
	Max	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Min	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Boca	Mean	4.52	2.71	2.42	1.56	1.27	0.76	0.44	0.51	0.43	1.17	2.35	4.13	22.27	
	Max	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Min	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

Table 3.5-2
Folsom District
Maximum Monthly Snowfall

Station	Month												ANNUAL
	J	F	M	A	M	J	J	A	S	O	N	D	
San Francisco	T	T	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	T
Date	1962	1951	1951									1972	Dec 1972
Max. in 24 hr.	T	T	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	T
Date	1962	1951	1951									1972	Jan 1962
San Francisco A.P.	1.5	T	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.5
Date	1962	1976	1976									1972	Jan 1962
Max. in 24 hr.	1.5	T	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.5
Date	1962	1976	1976									1972	Jan 1962
Oakland	T	1.0	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.0
Date	1971	1976	1976									1932	Feb 1976
Max. in 24 hr.	T	1.0	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.0
Date	1971	1976	1976									1932	Feb 1976
Sacramento	T	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	2.0
Date	1972	1976										1976	Feb 1976
Max. in 24 hr.	T	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	
Date	1974	1976										1972	
Stockton	0.0	0.3	T	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.3
Date		1976	1976	1976								1972	Feb 1976
Max. in 24 hr.	0.0	0.3	T	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	0.3
Date		1976	1976	1970									Feb 1976
Fresno	2.2	T	T	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	1.2	2.2
Date	1962	1976	1973							1974		1978	Jan 1962
Max. in 24 hr.	1.5	T	T	0.0	0.0	0.0	0.0	0.0	0.0	T		1.2	1.5
Date	1962	1976	1973							1974		1968	Jan 1962
Bishop	23.2	31.9	14.5	8.8	2.3	0.0	0.0	0.0	T	0.2	3.9	13.2	31.9
Date	1969	1969	1952	1956	1964				1955	1957	1964	1967	Feb 1969
Max. in 24 hr.	18.0	14.2	7.5	8.8	2.3	0.0	0.0	0.0	T	0.2	3.9	6.7	18.0
Date	1969	1976	1952	1956	1964				1955	1957	1964	1967	Jan 1969

T = Trace (Less than 0.1")

are not provided as snow is extremely rare at sea level and low-lying stations. Snow is not an important climatic parameter at such locations and is more of a novelty topic.

Precipitation in the form of snow is common during winter in most parts of the Sierra Nevada. At elevations above 2000 ft., snowfall amounts and intensities begin to rapidly increase with elevation, peaking at approximately the 8000 ft. level. Numerous physical factors such as increased wind speeds, reduced available moisture content, and the steep incline of the terrain cause snowpack depths to decrease, on the average, with higher elevations. Strong winds at levels above 8000 ft. often cause blowing snow conditions and tend to increase the rate of evaporation of fallen snow. In addition, accumulated snowfall tends to slide or migrate to lower elevations where terrain surfaces provide a more stable base producing substantial snowpacks. Figure 3.5-3 illustrates the change in mean snowpack (in water content) as a function of elevation. The wide graphical region depicted on this figure details the area for which most of the snow data are found. The solid line depicts the average of all the station observations for the Folsom District. The data used to compile this plot were obtained from all snow course observations, as available from the California State Department of Water Resources, Flood Management Division, Sacramento, California.

Table 3.5-3 provides the mean monthly and mean annual maximum snowpack depth and associated water content for numerous stations within the Sierra Nevada in the Folsom District. Figure 3.5-4 illustrates the various snow basin regions located in the Folsom District as organized by the California Department of Water Resources, Division of Flood Management. Snow basins are determined according to particular river systems in which snow melt can contribute a significant water supply. The particular river-snow basins included in the Folsom District are listed on Table 3.5-4. This table provides the basin reference number as indicated by the California Department of Water Resources.

Table 3.5-4
River-Snow Basins for the Folsom District

River-Snow Basin Name	Basin #
Yuba (southwestern portion)	6
American	7
Mokelumne	8 (north)
Stanislaus	8 (south)
Tuolumne	9 (north)
Merced	9 (south)
San Joaquin	10
Kings	11
Truckee	13 (north)
Tahoe	13 (south)

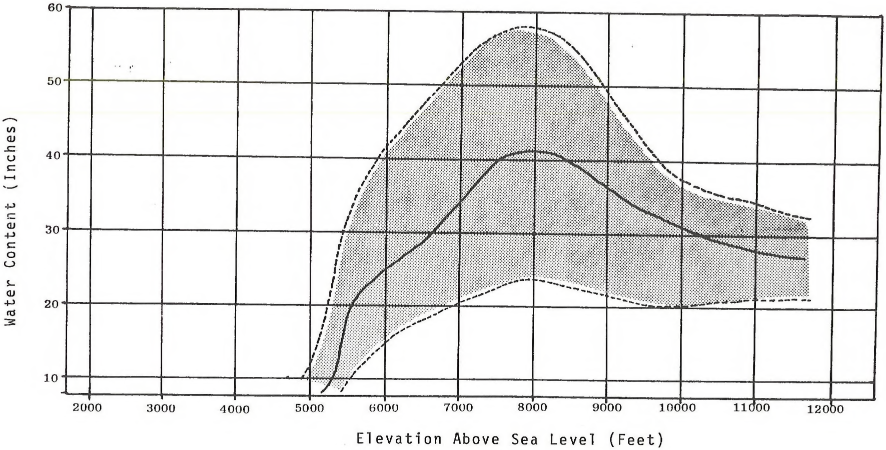


Figure 3.5-3
Folsom District Snow Analysis
Mean April 1 Water Content Versus Elevation

Table 3.5-3

Mean Snow Depth and Water Content (WC) in Inches at Selected River-Snow Basin Stations in the Folsom District

Basin	Course #	Lat.		Long.		Max. Mean	Max. Annual	Jan.		Feb.		Mar.		Apr.		May		# Years		Elevation in Feet
		Del	Min	Del	Min	Depth	WC	Depth	WC	Depth	WC	Depth	WC	Depth	WC	Depth	WC	Depth	WC	
Yuba (6)*	65	39	21.2	120	21.2	127.0	53.2	45.9	14.7	87.5	30.9	104.3	41.4	118.3	51.5	92.8	45.5	32	32	7400
Yuba (6)	66	39	25.0	120	30.5	122.8	53.7	49.0	15.8	76.3	26.3	114.6	41.3	120.4	52.8	108.3	50.1	54	55	7200
Yuba (6)	83	39	37.5	120	36.0	52.1	21.7	22.0	8.0	31.0	11.0	45.5	18.5	49.6	20.6	64.0	29.5	49	49	5650
Yuba (6)	85	39	19.0	120	38.5	60.6	25.8	33.8	9.9	47.2	15.8	52.0	21.0	54.8	23.9	34.6	15.5	48	48	5200
American (7)	115	39	16.9	120	31.6	113.8	48.3	57.3	20.3	79.1	28.8	101.4	39.5	104.4	45.9	78.3	38.3	41	41	6600
American (7)	371	39	6.7	120	17.0	71.9	28.7	NA	NA	52.2	17.5	61.7	22.7	61.7	26.4	40.7	18.5	10	10	6050
American (7)	124	38	47.6	120	8.7	38.4	13.8	21.3	5.5	28.9	9.7	28.9	10.9	19.9	8.0	6.1	2.4	34	34	5700
American (7)	127	38	48.7	120	22.5	43.0	15.1	8.5	2.5	29.6	8.8	32.6	11.5	23.9	9.4	8.3	3.5	42	42	5300
Mokelumne (8)	364	38	37.5	120	38.0	103.4	43.5	NA	NA	81.1	29.2	92.5	37.0	95.8	41.8	53.3	24.3	13	13	8150
Mokelumne (8)	339	38	31.6	120	13.7	80.3	29.3	59.0	18.5	51.9	17.3	66.8	23.4	69.1	26.8	46.3	20.0	46	46	6600
Stanislaus (8)	384	38	30.0	119	56.2	103.4	41.0	71.5	18.0	69.1	23.3	94.1	32.0	91.0	38.4	81.3	37.6	7	7	7750
Stanislaus (8)	143	38	16.8	119	43.8	52.3	19.6	47.0	13.5	35.8	9.8	45.9	15.1	48.6	19.0	21.1	9.3	48	48	7250
Stanislaus (8)	145	38	19.6	119	54.7	57.4	21.2	32.5	9.0	41.8	12.6	49.2	16.8	49.9	19.9	22.3	9.2	47	47	6500
Tuolumne (9)	161	37	52.4	119	21.0	59.3	21.9	18.0	5.0	46.2	13.6	46.9	15.9	54.8	20.8	47.7	21.6	48	48	8600
Tuolumne (9)	163	38	5.0	119	38.0	109.3	41.7	NA	NA	72.1	23.3	97.2	34.7	103.4	40.6	120.3	53.8	32	32	8000
Tuolumne (9)	165	38	5.1	119	50.2	95.3	37.1	13.0	4.0	62.7	20.9	87.2	32.8	88.6	36.2	120.3	55.0	30	30	7900
Tuolumne (9)	348	38	10.6	119	57.6	61.9	22.8	NA	NA	47.7	15.4	55.6	20.5	45.9	18.8	31.8	14.1	14	14	7000
Merced (9)	177	37	38.2	119	33.0	88.1	34.5	NA	NA	61.7	20.0	72.6	25.8	80.8	32.3	59.7	27.1	40	40	8200
Merced (9)	178	37	50.3	119	26.9	79.2	32.4	26.0	7.0	58.3	16.9	69.2	25.2	73.5	30.9	57.7	29.8	48	48	8150
Merced (9)	179	37	45.9	119	46.7	87.5	34.9	87.0	28.0	57.9	19.6	73.0	27.7	76.2	32.0	51.1	23.3	48	48	7000
San Joaquin (10)	185	37	16.3	118	52.6	73.3	26.3	49.0	18.0	56.2	16.9	55.7	17.5	71.0	29.5	81.2	32.8	35	35	10100
San Joaquin (10)	188	37	10.7	118	43.2	58.9	20.8	46.0	14.0	46.4	12.8	49.8	16.2	57.1	20.6	66.3	27.3	34	34	9700
San Joaquin (10)	189	37	43.6	119	8.5	80.6	30.5	NA	NA	61.9	19.5	72.7	24.6	75.0	29.7	61.0	27.8	47	47	9450
San Joaquin (10)	324	37	22.9	119	1.2	50.8	16.4	NA	NA	40.1	11.1	41.4	13.0	32.8	12.5	11.7	5.1	19	19	7800
San Joaquin (10)	200	37	31.7	119	16.5	55.6	21.4	NA	NA	49.8	14.8	19.3	6.0	51.3	20.7	32.1	14.5	38	38	7000
Kings (11)	299	36	46.2	118	24.9	80.1	30.0	NA	NA	60.3	19.0	50.5	16.0	76.8	28.6	74.1	31.1	23	23	10700
Kings (11)	397	36	41.1	118	35.8	54.2	19.2	NA	NA	35.6	9.8	NA	NA	54.0	19.6	NA	NA	5	5	9650
Kings (11)	396	36	58.8	118	43.2	80.0	30.2	33.3	8.0	47.7	14.3	50.3	12.0	78.0	29.4	50.8	22.3	5	5	9900
Kings (11)	234	37	7.3	118	53.7	66.6	25.3	27.0	4.5	43.2	12.5	40.3	12.5	63.4	24.7	52.7	27.7	48	48	8200
Truckee (13)	86	39	25.5	120	19.0	109.7	43.3	28.3	5.3	60.3	20.3	86.1	31.2	103.5	41.3	101.1	43.8	41	41	8450
Truckee (13)	91	39	29.5	120	16.9	41.0	14.3	3.0	0.3	28.9	8.8	35.2	11.7	34.0	13.0	17.6	7.0	41	41	6500
Truckee (13)	93	39	20.0	120	11.5	38.7	12.7	37.0	10.0	34.5	10.5	34.6	11.8	26.1	9.8	12.0	6.0	13	13	6400
Tahoe (13)	333	39	5.0	119	54.5	39.9	12.8	17.1	3.8	29.5	7.8	34.6	10.3	36.8	12.2	16.0	7.0	36	36	6900
Tahoe (13)	376	39	8.0	120	14.0	103.2	41.2	40.3	12.8	74.5	24.3	87.2	32.5	93.6	38.8	82.7	37.5	13	13	6750
Tahoe (13)	104	38	52.4	119	59.0	29.3	10.2	17.4	3.9	24.9	7.4	27.1	9.2	18.7	7.3	6.5	2.5	45	45	6400

*River Basin Number

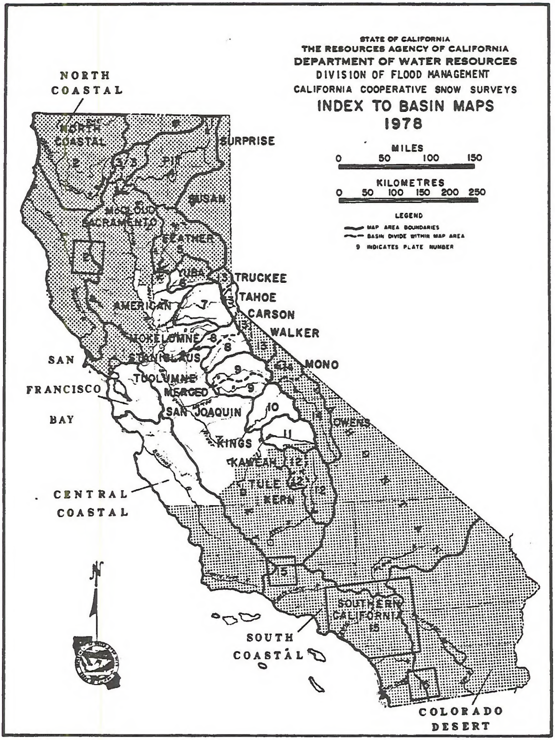


Figure 3.5-4
Snow Basin Map

The greatest snowfall on record for the entire snow season in California fell in 1906 and 1907 at Pomerac in Alpine County where 884 inches of snow was recorded at 8000 feet MSL. The average seasonal snowfall at that station is 450 inches. The greatest 24-hour snowfall occurred at Giant Forest in Sequoia National Park at 6360 feet MSL on January 19, 1933 when 60 inches fell. It should be noted that there are relatively few snow observation stations in the Sierra, therefore, snowfall amounts in excess of these record amounts may have occurred.

Monitoring of snowfall amounts is extremely important. Snow accumulation in the Sierra provides substantial water supplies for the farming industries in the Central Valley regions. Considerable damage can result from either heavy or light snowfall seasons. A rapid melt of heavy snowfall accumulation in the mountains can result in extremely damaging flood conditions during the spring months along the Sierra foothills and the Central Valley. During such years, crop damage and soil erosion results in tens of millions of dollars of damage affecting produce supply and prices. Conversely, a light snowfall year with minimal snowpack accumulations can create serious shortages in available water supply for northern California.

3.5.4 Precipitation Frequency

An analysis of rainfall intensity for selected areas offers added insight into regional precipitation characteristics. Rainfall frequency and intensity studies, sometimes referred to as pluvial indices, provide an understanding of the nature of precipitation and rainfall in a given region. Isopluvial maps facilitate an evaluation of rainfall intensity for particular areas over selected short-term time periods or intervals. Isohyet analyses coupled with isopluvial studies provide an indication of the nature of the precipitation means for the area, i.e., frequent light rains versus sporadic heavy rainstorms.

Appendix A provides isopluvial analyses for the Folsom District as well as for the entire state of California. These figures provide information for the following return periods and rainfall duration times:

- 2 year-6 hour precipitation
- 5 year-6 hour precipitation
- 10 year-6 hour precipitation
- 25 year-6 hour precipitation
- 50 year-6 hour precipitation
- 100 year-6 hour precipitation
- 2 year-24 hour precipitation
- 5 year-24 hour precipitation
- 10 year-24 hour precipitation
- 25 year-24 hour precipitation
- 50 year-24 hour precipitation
- 100 year-24 hour precipitation

These maps present precipitation amounts received within designated time periods based on recurrence intervals of 2, 5, 10, 25, 50 or 100 years. For example, Figure A-1 provides isopluvials of precipitation amounts for a 6 hour period, experienced at least once in a 2 year time frame. The isoline intervals provided on these maps were designed to provide a reasonably complete description of isopluvial patterns in various regions of the state. Dashed intermediate lines are placed between the normal isopluvial intervals where a linear interpolation would lead to erroneous results.

Rainfall frequency values for selected key stations within the Folsom District were obtained from the Appendix and summarized in Table 3.5-5. This table provides easy reference to pluvial indices for the climatic zones throughout the district. The tables and figures indicate that coastal areas such as Big Sur and Davenport could expect the most intense rainfall amounts over a 6 or 24 hour period. In these areas, rainfall could total as high as 8 to 10 inches in a single 24 hour period. This value exceeds some of the Interior Mountain CZ stations where maximum values of 7 to 8 inches of rain could occur in a 24 hour period. Pluvial indices for locations in the Central Plain CZ increase gradually as one moves northward. The isopluvial maps, as previously mentioned, strongly reflect the influence of topography on the nature of precipitation as evidenced by the values indicated in Table 3.5-5 for the District's mountainous areas.

Table 3.5-5
Pluvial Indices (in tenths of inches) at Selected Stations in the Folsom District

Time Frame	6 Hour				24 Hour			
Return Period	2 YR	10 YR	25 YR	50 YR	2 YR	10 YR	25 YR	50 YR
Station	Coastal							
San Francisco	14	18	20	22.5	23	32	37	41
Oakland	14	21	25	25	26	40	45	51
Daly City	14	19	21	24	25	34	40	45
Davenport	22	32	38	42	40	70	75	80
Santa Cruz	19.5	30	36	38	35	60	60	63
Monterey	10	14	16	18	16	25	27	34
Big Sur	26	38	50	55	53	80	90	100
	Coastal Mountain							
Livermore	11.5	18	20	22.5	20	35	35	40
Hollister	11	18	18	20	18	27.5	32.5	35
San Benito	12	16	17	21	19	30	35	39
Coalinga	9	13	16	17	12	20	25	27
San Lucas	9.5	14	16	18	16	25	30	35
Lockwood	14	18	22	25	25	35	37.5	40
	Central Plain							
Sacramento	12	17.5	20	22.5	20	29	33	38
Marysville	12	17	19	21.5	22.5	34	39	44
Stockton	11	14.5	17	19	16.5	22.5	26.5	29
Modesto	9	13	15	17	14	19	23	25
Merced	10	13	15	17	15.5	21	24.5	27
Los Banos	8	12	13	14.5	13	19	24	25
Madera	9	12	14	16	13.5	18	22.5	24
Fresno	9.5	14	16	18	14	20	24	25
	Interior Mountain							
Tahoe City	17	22	27	32	35	50	60	65
Placerville	16	22	26	27.5	36	50	60	69
Big Meadow	18	26	30	35	40	60	70	80
Yosemite Park	16	22	26	27.5	35	55	65	70
Oakhurst	16	24	28	30	35	57	68	80

3.6 PREVAILING WINDS

Wind is considered a primary climatic parameter since air flow characteristics directly affect ambient air moisture content and regional temperature levels. Seasonal and diurnal air flow patterns can promote periods of wet or dry weather as well as determine hot or cold climates. The prevailing winds are responsible for much of the climatic characteristics of an area and are deeply interrelated with other climatic parameters. The distribution of wind direction and wind speed are used to categorize this parameter.

Observations of wind direction are usually classified into the 16 cardinal compass directions using either a directional abbreviation or the heading in degrees. The degrees associated with each compass heading are listed in Table 3.6-1. Meteorological convention requires that the compass heading associated with a given wind observation is the direction from which the air is flowing. In other words, north or northerly winds mean that air is moving from north to south.

The following sections will describe wind on both an annual and seasonal basis. A primary tool used to graphically describe the prevailing wind conditions at a given station is known as a wind rose. As described in detail in Section 4.2.1, a wind rose is a plot of the frequency of winds from each of the sixteen cardinal directions. The diagram resembles a compass face with the length of the line drawn for each direction indicating the frequency of occurrence of flow from that direction for the indicated period of record.

3.6.1 Annual Wind Distribution

California lies within the zone of prevailing westerly winds and is situated on the east side of the Eastern Pacific semi-permanent high pressure center. Since general air flow patterns in the Northern Hemisphere are clockwise (anticyclonic) about high pressure centers, basic air flow over California is from the west and northwest. Figure 3.6-1 illustrates a typical pressure situation off the California coast and depicts the associated wind flow patterns. As the seasons progress, there exists considerable variation in this generalized scheme due to mesoscale (several hundred miles) and synoptic (thousands of miles) scale pressure distribution changes. Most importantly, several mountain chains within the state are responsible for deflecting the large scale flow. Except along the immediate coast, wind direction and speed is likely to be largely a function of local terrain and orographic effects rather than the prevailing circulation patterns observed in a hemispheric sense.

Figure 3.6-2 depicts various selected station locations in the Folsom District for which reduced historical wind speed and direction data have been summarized. Annual wind roses are superimposed on this study map for selected key stations within

Table 3.6-1
Wind Direction Classification

Direction (Abbreviation)	Direction (Degrees)	Direction (Winds From)
N	348.75 - 11.25	North
NNE	11.25 - 33.75	North - Northeast
NE	33.75 - 56.25	Northeast
ENE	56.25 - 78.75	East - Northeast
E	78.75 - 101.25	East
ESE	101.25 - 123.75	East - Southeast
SE	123.75 - 146.25	Southeast
SSE	146.25 - 168.75	South - Southeast
S	168.75 - 191.25	South
SSW	191.25 - 213.75	South - Southwest
SW	213.75 - 236.25	Southwest
WSW	236.25 - 258.75	West - Southwest
W	258.75 - 281.25	West
WNW	281.25 - 303.75	West - Northwest
NW	303.75 - 326.25	Northwest
NNW	326.25 - 348.75	North - Northwest

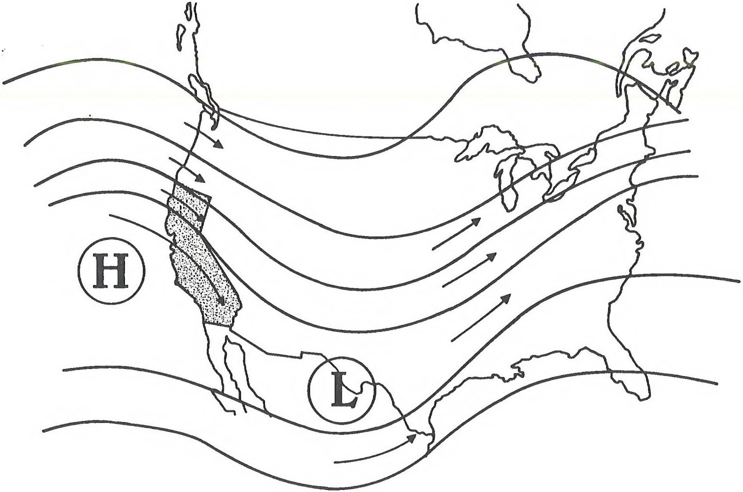


Figure 3.6-1
Prevailing Synoptic Scale Wind Flow Patterns Over California

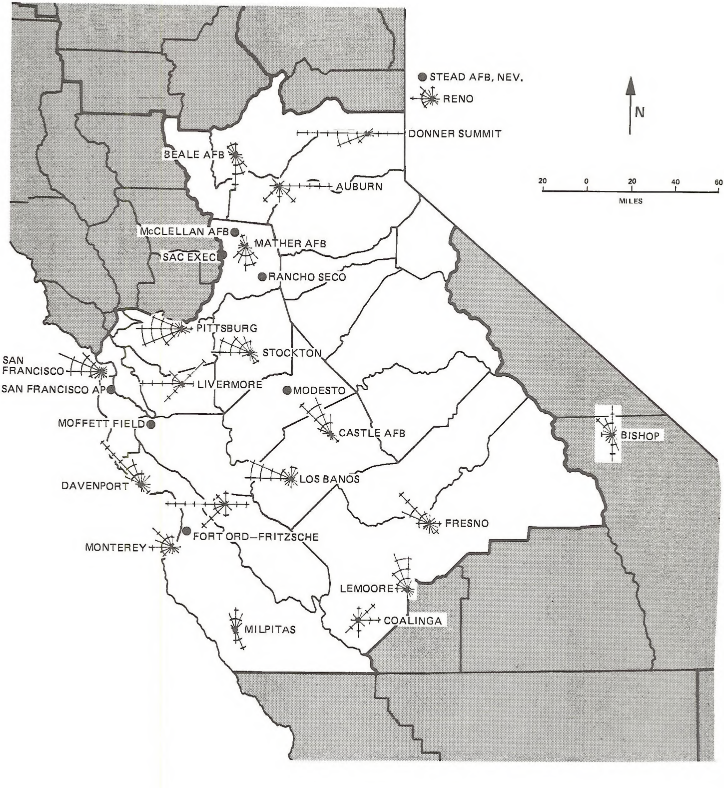


Figure 3.6-2
Annual Wind Roses at Selected Key Stations
in the Folsom District

each climatic zone in the district. The climatic zone overlay (Overlay C) map may be used to isolate these particular areas. A detailed analysis and breakdown of wind speed versus wind direction characteristics is provided in the dispersion meteorology section.

The annual wind roses provided in Figure 3.6-2 indicate that the flow along the coast is from the west to northwest. As air flow penetrates the San Francisco Bay region and moves into the Central Valley, important alterations to the mean wind pattern develop. The divergence pattern illustrated in Figure 3.6-3 is a result of surface air flow entering the Central Valley from the west and being obstructed by the Sierra Nevada Mountain Range thus forcing flow to be channeled up and down the valley.

The wind rose diagrams for Central Valley locations as seen in Figure 3.6-2 clearly indicate that the dominant air flow is directed along the longitudinal axis of the Central Valley. Regions south of Stockton experience prevailing flow from the northwest to north. Concurrently, areas near Sacramento and northward experience winds primarily from the southwest sector.

In the mountain regions, the dominant wind flow is from the west as air is forced up the western slopes of the Sierra and channeled through the mountain passes and deep valleys. In these areas, local topography has a maximum influence on annual wind direction frequency distributions. The wind rose for Donner Summit, which lies on the crestline of the Sierra Nevada, indicates that westerly wind flow is experienced 35 percent of the time while easterly flow occurs nearly 20 percent of the time. Reno, Nevada on the other hand, is situated on the eastern slopes of the Sierra Nevada, and also experiences prevailing westerly flow. This site also has a secondary maximum for flow from the north. Bishop, California, the only first order weather station in California east of the mountain regions near the Folsom District, exhibits three obvious preferential directions from historical wind data, these being north, south, and northwesterly. The north-south air movement is the result of winds being channelled along the Owens Valley, while the dominant northwesterly flow is a result of the prevailing regional flow crossing the Sierra.

Local valley flow is also noted along the floor of the Salinas Valley near Monterey, California. In this case, air flow emanating from the west-northwest at Monterey Bay and Moss Landing is channelled along the foothills of the coastal ranges. The prevailing flow at Salinas provides an indication of this channeling effect.

3.6.2 Seasonal Wind Distribution

Table 3.6-2 summarizes monthly winds at key stations in the Folsom District. During the winter season, storm trajectories move further toward the south allowing migratory low pressure

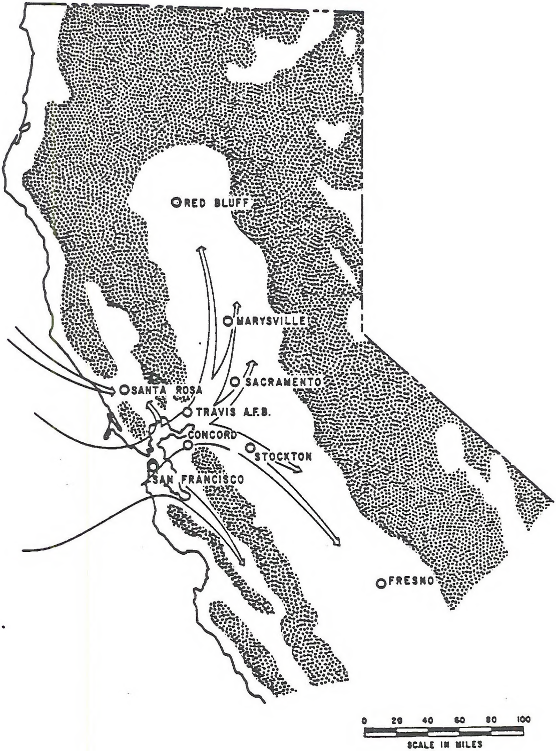


Figure 3.6-3
Surface Flow Pattern
Into the Central Valley Areas

Source: "Climate of the Sacramento Valley Air Basin", State of California Air Resources Board

Table 3.6-2
Monthly Prevailing Wind Speed (MPH) and Direction in the Folsom District

		J	F	M	A	M	J	J	A	S	O	N	D
San Francisco Fed. Office	WD	N	W	W	W	W	W	W	W	W	W	N	W
	WS	6.7	7.5	8.5	9.5	10.4	10.9	11.2	10.5	9.1	7.6	6.3	6.5
Oakland	WD	SE	W	W	W	W	W	WNW	WNW	WNW	NNW	WNW	E
	WS	6.7	7.3	9.0	9.5	10.0	10.0	9.3	9.0	7.8	6.8	6.3	6.5
Monterey	WD	E	W	W	W	W	W	W	W	W	W	E	E
	WS	6.0	6.0	6.0	7.0	8.0	8.0	8.0	6.0	6.0	5.0	5.0	7.0
San Francisco Intl. Airport	WD	WNW	WNW	WNW	WNW	W	W	NW	NW	NW	WNW	WNW	WNW
	WS	7.1	8.5	10.3	12.1	13.1	13.9	13.6	12.8	11.0	9.2	7.2	6.8
Moffett Field	WD	SE	SE	NWW	NNW	NNW	NNW	NWW	NNW	NNW	NNW	NNW	SE
	WS	6.0	6.0	7.0	7.0	7.0	8.0	7.0	7.0	6.0	6.0	5.0	6.0
Beale AFB	WD	S	S	SSE	S	S	S	S	S	S	S	S	S
	WS	6.0	7.0	7.0	7.0	7.0	7.0	6.0	6.0	6.0	6.0	5.0	6.0
Stockton	WD	SE	SE	W	W	W	WNW	WNW	W	W	W	SE	W
	WS	6.7	7.0	7.6	8.1	9.1	8.1	7.6	7.0	6.3	5.7	6.2	7.4
Merced	WD	SE	SE	WNW	WNW	NW	NW	NW	NW	NW	NW	SE	NW
	WS	6.0	6.0	7.0	8.0	8.0	9.0	9.0	8.0	7.0	6.0	5.0	7.0
Fresno	WD	SE	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	SE
	WS	5.4	5.7	6.7	7.2	7.9	8.0	7.1	6.5	5.9	5.3	4.8	5.0
Sacramento	WD	SE	SSE	SW	SW	SW	SW	SSW	SW	SW	SW	NNW	SSE
	WS	8.0	8.0	9.0	9.1	9.4	10.0	9.2	8.7	7.9	6.9	6.5	7.2
Lemoore	WD	NNW	NNW	NNW	NNW	NNW	NNW	NNW	NNW	NNW	NNW	NNW	SSE
	WS	3.0	5.0	6.0	6.0	7.0	7.0	7.0	6.0	6.0	5.0	3.0	3.0
Reno	WD	S	S	WNW	WNW	WNW	WNW	WNW	WNW	WNW	WNW	S	SW
	WS	6.0	6.1	7.6	8.0	7.6	7.2	6.6	6.2	5.4	5.3	5.3	5.1
Blue Canyon	WD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	WS	10.7	10.2	9.9	8.1	8.2	8.0	7.1	7.3	8.0	9.1	9.1	8.7

centers to pass over California more frequently than during other seasons. Numerous wind changes are associated with these conditions; for example, southerly and southeasterly flow develops prior to the passage of a weather front. This can be seen during the winter months at several stations in Table 3.6-2. The pressure gradients associated with frontal system passage over California are weakened considerably as they move south. This often results in lighter wind speeds than are experienced in the Pacific Northwest.

During winter, a high pressure center is often situated over the Great Basin area. When this system is intense, winds will tend to flow out of the Great Basin into the Central Valley, the Southeastern Desert Basin and the South Coast. In Southern California, this situation is known as a "Santa Ana" condition. This flow pattern can promote gusts of extremely dry winds that sometimes exceed 100 miles per hour particularly below mountain canyons. In the San Joaquin Valley, this regime is referred to as "northers". Compressional heating of this air flow out of the Great Basin and down the slopes of the Sierra Nevada can result in intense heat waves during the summer months and rather warm temperatures during the winter season. In both instances, winds are persistent and dry.

During the summer season, westerly and northwesterly wind flow dominates the basic wind pattern over most areas in California as indicated in Table 3.6-2. These winds are a result of the dynamics of a low pressure system induced by surface heating over the Central Valley and Inland Desert areas in conjunction with the semi-permanent high pressure system located just west of the California coastline. This regime is most commonly known as the "sea breeze" condition. Figure 4.2-11, which appears in Section 4.2-5, provides a simplistic depiction of the sea breeze regime. In the San Francisco region, during such conditions, onshore winds can persist 24 hours a day with diurnal variations mainly in wind speed rather than in wind direction. This condition can cause serious pollution problems for the Central Valley areas while cleansing the California coastline.

Along coastal regions, during days of strong inland surface heating and good nocturnal radiational cooling, the well known sea-land circulation dominates the diurnal wind patterns. During daylight hours, strong surface heating inland promotes thermal bouyancy and rapidly rising air. As a result, offshore air masses are forced to flow inland. During the nighttime hours, the reverse takes place. Ground surfaces in inland areas cool rapidly, promoting rapid stabilization of adjacent air. Concurrently, surface ocean temperatures are fairly static during nocturnal hours, allowing less stabilization of the overlying air. Therefore, air movement from the land towards the sea develops as the air flows outward from this inland region of relative high pressure.

At all stations, wind speeds show most variance during the winter months. Seasonally, strongest wind speeds are found (1) along the coast in summer when the sea breeze regime dominates and (2) during the winter at mountain stations.

3.7 EVAPORATION AND RELATED PARAMETERS

Evaporation is the physical process by which water is transformed from the liquid to the gaseous state. The rate of evaporation in a particular region is dependent upon many climatic parameters, but is primarily influenced by wind, temperature, relative humidity, sky conditions, precipitation and solar radiation.

Evapotranspiration is the process whereby water vapor is returned to the atmosphere both by living plants (transpiration) and from the earth's surface (evaporation). An assessment of regional evapotranspiration is important to the water and agricultural industries as it provides a complete picture of natural water demand for a given geographical area.

Solar radiation is the earth's principle source of energy. This energy is naturally dispersed in numerous forms such that much of the received solar energy is used to generate winds, heat air masses, as well as supply latent heat energy to the atmosphere by contributing to the rate of evaporation of large quantities of water into the atmosphere. Consequently, mean monthly and annual solar radiation levels for particular locations are often expressed in terms of equivalent evaporation units. The standard conversion of solar radiation units, as expressed in Langleys, to inches of evaporation, requires that 1 inch of evaporation be equivalent to 1486 Langleys.

3.7.1 Evaporation and Evapotranspiration

The California State Department of Water Resources has determined regional evaporative demand areas on the basis of similar monthly levels of evaporation and evapotranspiration rates. These areas are provided in Figure 3.7-1 for the entire state of California.

The Folsom District includes four of the eleven statewide zones of similar evaporative demand. A contour map depicting areas of equal annual evaporative demand levels for the Folsom District is provided as Figure 3.7-2. Note that considerable gradients of evaporative demand exist along the narrow coastal strip extending 10-25 miles inland. These rapid changes in regional evaporation rate are a result of the considerable effect of the nearby Pacific Ocean. Air masses along the coast experience modest temperature variations coupled with high relative humidity. These factors significantly limit the potential rate of evaporation since the ambient air has a diminished ability to hold additional water vapor.

A rapid change in regional evaporative demand occurs in the eastern portions of the Sierra Nevada. In this region, air masses are forced to ascend vertically by upward flow along the

ZONES OF SIMILAR EVAPORATIVE DEMAND IN CALIFORNIA

1. North Coast, Coastal Valleys and Plains
2. North Coast Interior Valleys
3. Northeastern Mountain Valleys
4. Sacramento Valley Floor
5. San Joaquin Valley Floor
6. Central Coast Interior Valleys
7. Sierra
8. Central Coast, Coastal Valleys and Plains
9. South Coast, Coastal Valleys and Plains
10. South Coast Interior Valleys
11. Southern California Desert*

Figure 3.7-1

*Reliable Data on evaporative demand is generally unavailable in the Southern California Desert. Studies by other agencies are in progress in Imperial Valley and Palo Verde Valley (Zone 11)

Source: "Vegetative Water Use in California, 1974", State of California Department of Water Resources

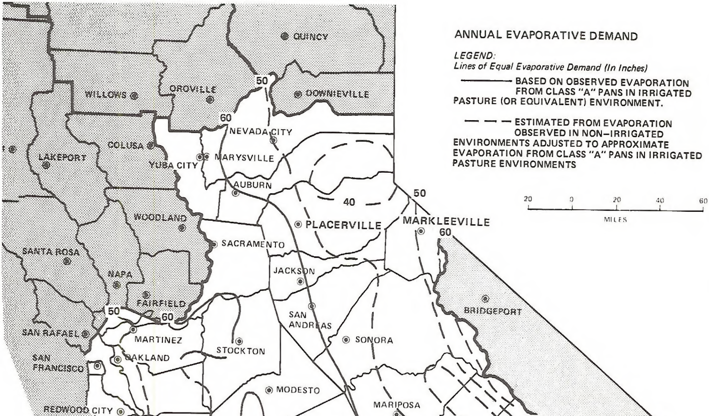


Figure 3.7-2
Annual Evaporation Demand

steep mountain slopes. This causes ambient air parcels to cool and approach saturation levels. This action tends to decrease the potential of air parcels to be able to obtain additional water vapor through evaporation. A very low evaporative demand occurs at mountain peak locations since relative humidities are high, temperatures are cold, and ambient air masses are often near saturation. As these air masses pass over the mountain crestline and descend down the eastern slopes of the Sierra, evaporation rates can increase dramatically since leeward air flow is generally associated with low relative humdities and much of the available mositure has been depleted from the air mass.

A comparison of annually averaged evaporative demand and evapotranspiration rates for different geographical areas can lead to ambiguous results. Annual evaporative totals for two areas may be similar, but monthly patterns of evaporation and evapotransiration may differ significantly. Monthly tabulations of average pan evaporation rates and estimated potential evapotranspiration rates for the various California climatic regions are presented in Table 3.7-1.

Maximum evaporation rates occur during July. During this month in all climatic regions, the incidence of solar radiation and the mean wind speed are at a maximum. The Central Valley locations experience about 10 inches of evaporation during July, while the coastal areas experience about 8 inches. Conversely, during January, evaporative demand is less in Central Valley areas in comparison to the coastal zone. The Central Valley areas experience considerable cloud cover during the winter months which sheilds the surface from incident solar radiation.

The ratio of evapotranspiration to evaporation (ET/Ep) is obtained empirically by simply observing and comparing simultaneous pan evaporation and net water loss from vegetation soil tanks (the tank is designed such that all water added to the apparatus and all water left after a testing period can be measured). This ratio thus allows a more definitive evaluation of water demand in a particular region.

Since evapotranspiration values are so dependent upon crop and vegetation type, it is useful to observe ET/Ep ratios on a monthly basis for the entire growing season of particular crops. In general, potential evapotranspiration values as presented in Table 3.7-1 are determined by using grass as the standard vegetation type. Table 3.7-2 provides a summary of observed monthly ET/Ep ratios for the principle irragated crops in California as provided by the California State Water Resources Control Board in Sacramento.

3.7.2 Sky Conditions

Sky cover is a measure of the degree of cloudiness characteristic of a given area for a certain time period. Sky cover conditions experienced in a particular region are inter-

Table 3.7-1

Average Monthly Pan Evaporation Rate(1) and Estimated Potential Evapotranspiration(3) For the Folsom District

Evaporation Region		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	March through October	Annual Total
Sacramento Valley (4)	EP	1.5	2.4	3.9	5.7	7.5	9.3	10.1	8.6	6.8	4.6	2.2	1.4	56.5	64.0
	ET	1.1	1.8	3.0	4.4	5.8	7.3	7.9	6.7	5.2	3.4	1.6	1.0	43.7	49.2
San Joaquin Valley (5)	EP	1.3	2.3	4.2	5.9	8.3	9.6	10.0	8.5	6.3	4.4	2.1	1.0	57.2	63.9
	ET	0.9	1.7	3.2	4.5	6.5	7.5	7.8	6.6	4.8	3.3	1.5	0.7	44.3	49.0
Central Coast-Interior Valleys (6)	EP	2.3	2.9	4.3	5.6	7.3	7.9	8.6	7.7	6.2	5.0	3.1	2.1	52.6	63.0
	ET	1.6	2.1	3.3	4.3	5.7	6.2	6.7	6.0	4.8	3.8	2.3	1.5	40.8	48.3
Central Coast-Coastal Valleys (8)	EP	2.5	3.3	4.1	4.9	5.8	6.6	7.0	7.0	5.8	4.6	3.6	3.1	45.8	58.3
	ET	1.8	2.1	3.1	3.9	4.7	4.9	5.3	4.8	3.8	3.2	2.2	1.5	33.7	41.3

(1) Evaporation from USWB - Class "A" Pans located in irrigated pasture environment
(2) March through October is the principal growing season
(3) Potential ET = ET of grass

Table 3.7-2
Summary of Observed Monthly ET/Ep Ratios for Principal Irrigated Crops 1/

Crop	Location	Observer	Year	Active Growing Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Growing Season Average
Alfalfa (Hay)	Arvin 2.5NW	DWR	1959	Mar-Oct	-	-	-	0.64	0.52	0.64	0.63	0.70	0.90	0.71	1.04	1.12	-
			1960	"	-	-	-	-	-	0.77	0.64	0.81	0.67	0.63	-	-	-
			1963	"	1.00	0.88	0.72	0,73	0.78	0.73	0.86	0.90	0.85	0.91	0.70	1.00	0.81
			Average		1.00	0.88	0.72	0.69	0.64	0.71	0.71	0.80	0.81	0.75	0.88	1.17	0.73
	McArthur 4ESE	DWR	1960	Apr-Sep	-	-	-	-	-	0.64	0.81	0.97	0.86	0.95	-	-	-
			1961	"	-	-	0.28	0.83	0.87	0.77	-	0.86	0.85	0.51	0.33	0.14	-
			1962	"	-	-	-	0.74	0.92	0.72	0.61	0.61	1.06	-	-	-	0.75
			1963	"	-	-	-	-	0.98	0.88	0.90	0.79	0.77	0.79	1.63	-	-
			1964	"	-	-	-	0.67	1.27	0.52	0.68	0.85	0.71	1.18	-	-	0.78
			1965	"	-	0.70	0.69	0.41	0.85	0.90	0.80	0.96	1.19	-	-	-	0.87
			Average		-	0.70	0.52	0.69	0.98	0.74	0.76	0.83	0.91	0.87	0.83	0.14	0.82
Barley	Davis 2W (Grain Crop)	U.C.	1969-70	Nov-May	0.70	0.95	0.72	0.64	0.25	-	-	-	-	-	0.27	0.50	0.52
	Wasco 2W (Grain Crop)	DWR	1972	Feb-May	-	0.48	1.22	0.83	0.18	-	-	-	-	-	-	-	0.62
	Arvin 2.8NW (Winter Cover)	DWR	1966-67	Oct-Dec	-	-	-	-	-	-	-	-	-	0.12	0.90	0.95	0.46
Beans (Dry)	Davis 2W	U.C.	1968	Jul-Sep	-	-	-	-	-	-	0.42	0.85	0.43	-	-	-	0.56
Cantaloupes	Arvin 2.5S	DWR	1970	Mar 25-Jul 10	-	-	-	0.15	0.32	0.86	0.38	-	-	-	-	-	0.48
Castor Beans	Arvin 2.9NW	DWR	1970	May-Oct	0.49	0.28	0.32	0.06	0.14	0.67	1.01	0.95	0.78	0.69	0.39	0.44	0.71
Corn (Field)	Davis 2W	U.C.	Average 1970-71	Jun-Sep	-	-	-	-	0.12	0.48	0.89	0.84	0.50	-	-	-	0.62

1/ Ratios of observed evapotranspiration to evaporation from Class "A" pans in irrigated pasture, or comparable environments data collected by Department of Water Resources and/or cooperative agencies.

2/ Growing season ratios calculated from seasonal totals of ET and evaporation.

Source: "Vegetative Water Use in California, 1974", State of California Department of Water Resources

Table 3.7-2 (Continued)
Summary of Observed Monthly ET/Ep Ratios for Principal Irrigated Crops 1/

Crop	Location	Observer	Year	Active Growing Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Growing Season Average
Cotton	Arvin 2.5NW (Solid Plant)	DWR	1959	May-Oct	-	-	-	-	0.19	0.81	1.09	0.91	0.86	0.68	0.08	-	0.77
			1960	"	-	-	0.26	0.14	0.03	0.53	1.07	1.10	0.82	0.24	0.53	0.36	0.66
			1961	"	0.44	0.54	0.28	0.06	0.14	0.55	0.90	1.05	0.92	0.54	0.29	0.33	0.69
			Average		0.44	0.54	0.27	0.10	0.13	0.63	1.02	1.01	0.87	0.49	0.26	0.33	0.70
	Arvin 2.5NW (Skip 2 x 2)	DWR	1962	May-Oct	0.38	0.32	0.23	0.14	0.08	0.37	0.88	0.92	0.83	0.41	0.14	-	0.59
	Arvin 2.5NW (Skip 2 x 1)	DWR	1963	May-Oct	0.06	0.33	0.22	0.28	0.20	0.49	0.91	1.06	0.87	0.76	0.20	0.25	0.70
	Buttonwillow 2.5SE (Skip 2 x 2) (Fine textured soil)	DWR	1965	May-Oct	-	-	-	-	0.07	0.15	0.68	0.88	0.62	0.26	0.14	0.26	0.46
Deciduous Orchard	Arvin 3NNW (Plums)	DWR	1959	Apr-Oct	-	-	-	0.51	0.70	0.69	0.83	0.76	0.42	0.23	0.04	-	0.59
			1960	"	-	-	-	-	-	0.82	0.92	0.79	0.77	0.34	0.21	-	-
			1962	"	0.38	0.68	0.26	0.36	0.59	0.62	0.66	0.48	0.68	0.87	0.91	0.33	0.61
			1963	"	0.39	0.71	0.56	0.92	0.67	0.61	0.69	0.90	0.94	0.82	0.84	0.38	0.79
			1964	"	0.53	0.33	-	-	-	0.57	0.83	0.86	0.95	0.88	0.32	0.60	-
			Average		0.44	0.56	0.42	0.56	0.65	0.66	0.78	0.76	0.74	0.62	0.43	0.43	0.69
Grain Sorghum (Milo)	Bakersfield 9W	DWR	1971	Jul-Oct	-	-	-	-	-	-	0.26	0.91	0.82	0.40	-	-	0.58
Pasture (Improved) & Grass	Arvin 2.5NW (Grass)	DWR	1959-65 Average	Mar-Oct	0.50	0.72	0.82	0.75	0.81	0.74	0.82	0.88	0.88	0.90	0.81	0.69	0.82
	Davis 2W (Grass)	U.C.	1959-71 Average	"	0.79	0.75	0.70	0.73	0.77	0.78	0.79	0.79	0.74	0.68	0.64	0.73	0.76
	Davis 2W (Grass)	DWR	1959-60 Average	"	0.50	0.51	0.67	0.74	0.76	0.50	0.78	0.76	0.73	0.64	0.53	0.40	0.69
	Glenburn 0.3SE (Improved Pasture)	DWR	1964-66 Average	Apr-Sep	-	-	-	0.70	0.70	0.79	0.74	0.96	0.86	0.76	0.45	-	0.79
	Guadalupe 2NW (Improved Pasture)	SLOFC & DWR	1963-67 Average	Mar-Oct	0.77	0.81	0.78	0.82	0.78	0.69	0.77	0.85	0.84	0.87	0.87	0.79	0.79
	Lompoc 1N (Grass)	ARS	1968-70	"	0.44	0.75	0.80	0.69	0.73	0.64	0.75	0.69	0.55	0.67	0.69	0.50	0.69
	San Luis Obispo 1NW (Improved Pasture)	CSPC & DWR	1969-72 Average	"	0.92	0.84	0.74	0.59	0.76	0.62	0.72	0.59	0.71	0.63	0.82	0.82	0.67
	Soledad 3.5NW (Improved Pasture)	CDC & DWR	1963-70	"	0.75	0.79	0.77	0.77	0.71	0.68	0.75	0.82	0.75	0.78	0.82	0.64	0.75
	Thornton 2S (Improved Pasture)	DWR	1963-68	"	0.78	0.64	0.73	0.89	0.85	0.85	0.81	0.78	0.75	0.70	0.62	0.62	0.81

Table 3.7-2 (Continued)
Summary of Observed Monthly ET/Ep Ratios for Principal Irrigated Crops 1/

Crop	Location	Observer	Year	Active Growing Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Growing Season Average
Pasture (Native) (High Water Table Meadow)	Alturas 2SE	DWR	1959	Apr-Sep	-	-	-	0.94	0.98	1.14	1.06	1.05	0.96	0.78	-	-	1.03
			1960	"	-	-	-	0.67	0.81	0.82	1.09	1.12	1.02	0.97	-	1.33	0.95
			1961	"	0.17	0.47	0.74	0.78	1.00	1.00	1.19	0.96	1.12	1.00	-	-	1.02
			1962	"	-	-	0.35	0.72	0.76	0.86	0.96	0.98	0.95	0.77	0.69	0.60	0.88
			1963	"	0.42	0.36	0.48	0.59	0.61	0.98	0.81	0.89	0.89	0.83	-	-	0.82
			1964	"	-	-	-	0.56	0.66	0.86	0.93	0.99	0.89	0.86	-	-	0.85
			Average	"	0.44	0.40	0.56	0.75	0.80	0.94	1.00	1.00	0.96	0.85	0.69	0.88	0.93
Pasture (Native) **(Continued)**	Lookout 3S	DWR	1961	Apr-Sep	0.20	0.30	0.42	0.68	0.82	1.00	0.84	0.97	0.94	0.77	-	-	0.88
			1962	"	-	-	-	0.69	0.95	0.84	0.87	0.82	0.85	0.70	0.62	0.56	0.84
			1963	"	-	-	0.61	-	-	0.94	1.06	0.99	1.00	1.15	-	-	-
			Average	"	0.20	0.30	0.50	0.68	0.88	0.92	0.92	0.92	0.92	0.86	-	-	0.88
Potatoes	Arvin 2.8NW	DWR	1966	Apr-Jun	-	-	-	0.91	1.01	0.49	-	-	-	-	-	-	0.87
			1967	"	-	-	0.50	0.66	0.90	0.51	0.38	-	-	-	-	-	0.66
			Average	"	-	-	0.50	0.83	0.94	0.49	0.38	-	-	-	-	-	0.76
Sugar Beets	Arvin 2.5S	DWR	1966	Apr-Jul	-	-	-	0.68	1.01	1.02	0.68	-	-	-	-	-	0.86
	Davis 2W	U.C.	1965	Jul-Oct	-	-	-	-	-	-	0.41	0.92	0.88	0.88	0.57	-	0.66
			1966	Apr-Sep	-	-	-	0.17	0.36	0.86	0.93	0.83	0.91	-	-	-	0.64
Tomatoes	Arvin 2.5NW	DWR	1968	Apr-Jul	-	-	-	0.14	0.72	0.70	0.50	-	-	-	-	-	0.53
			1969	"	-	-	-	0.35	0.86	0.98	0.82	-	-	-	-	-	0.78
			Average	"	-	-	-	0.25	0.80	0.84	0.76	-	-	-	-	-	0.64
	Davis 2W	U.C.	1969		-	-	-	-	0.22	0.39	0.87	0.90	0.62	-	-	-	0.59
Vineyard	Arvin 1NW (Thompson Table Grapes)	DWR	1966	May-Oct	-	-	-	-	0.41	0.57	0.79	0.45	0.30	-	-	-	-
			1967	"	-	-	-	-	-	0.51	0.66	0.79	0.64	0.32	0.04	0.50	-
			1968	"	0.50	0.31	0.16	0.13	0.62	0.68	0.58	0.51	0.65	0.24	0.11	0.42	0.58
			1969	"	0.87	0.20	0.11	0.11	0.35	0.68	0.72	0.65	0.64	0.38	0.12	0.15	0.60
			Average	"	0.62	0.27	0.15	0.12	0.46	0.61	0.67	0.62	0.55	0.32	0.08	0.35	0.56

related with the mean incoming solar radiation, mean temperature, and precipitation levels, as well as having numerous secondary effects on many other climatic parameters, all of which effect the local evaporative demand. In addition, as discussed in Section 4.2-2, sky cover has an application to dispersion meteorology through its impact on insolation, and thus is an important parameter in the determination of atmospheric stability.

Clouds substantially insulate the surface from receiving large quantities of solar energy. Reflection and scattering of light energy from cloud tops and cloud interiors contribute significantly to the overall reduction of light received at ground level. Generally, cloud cover is classified according to various categories. These categories include clear or cloudless sky conditions, mostly clear skies, partly cloudy conditions, mostly cloudy and cloudy conditions, or completely overcast skies. In order to make sky cover observations more definitive, these observations are defined in terms of categories using fractional units expressed in tenths of the sky covered by clouds (See Table 3.7-3).

Table 3.7-3
Sky Cover Categories

Generalized Category	Sky Cover in Tenths
clear	0
mostly clear	0-3
partly cloudy	4-7
mostly cloudy	8-10
cloudy or complete overcast	10

Mean monthly and annual sky conditions at several coastal, Central Valley and mountain regions are provided in Figures 3.7-3 through 3.7-5. In all regions of the district, the winter season brings the most cloudy skies. The winter months experience a breakdown in the semi-permanent high pressure system residing in the eastern Pacific which normally shields California from low pressure areas and frontal systems. When this occurs, storms and frontal systems frequently pass through the area causing cloudy and overcast conditions. In the Central Valley, the increased persistence of radiational fog during the winter season adds substantially to the reported mean cloud cover percentages. Sky cover conditions are generally clearer at leeward mountain stations as represented by Bishop data.

During the summer months, sky cover conditions tend to reverse in the Central Valley locations with moderate changes along the coast and in the mountain regions. During July, the sky conditions over the Central Valley are extremely clear such that the mean monthly sky cover is only about 1/10th. During the summer months, coastal locations typically report 3/10ths to 3.5/10ths of sky cover.

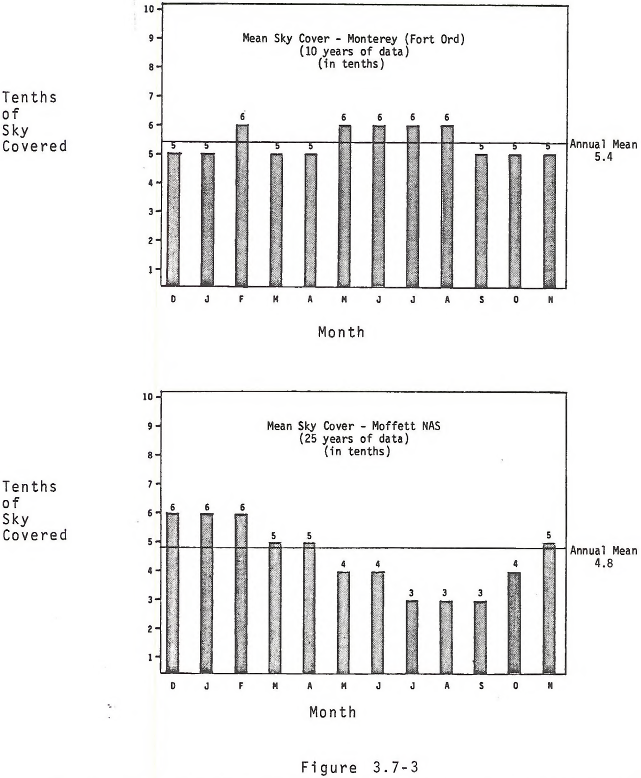


Figure 3.7-3
Coastal Climatic Zone Monthly and Annual Sky Cover Distribution

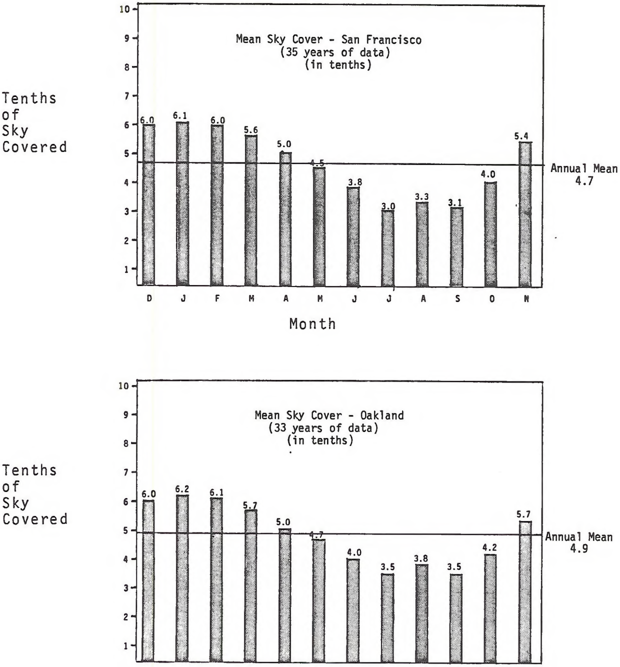


Figure 3.7-3 (Continued)
Coastal Climatic Zone Monthly and Annual Sky Cover Distribution

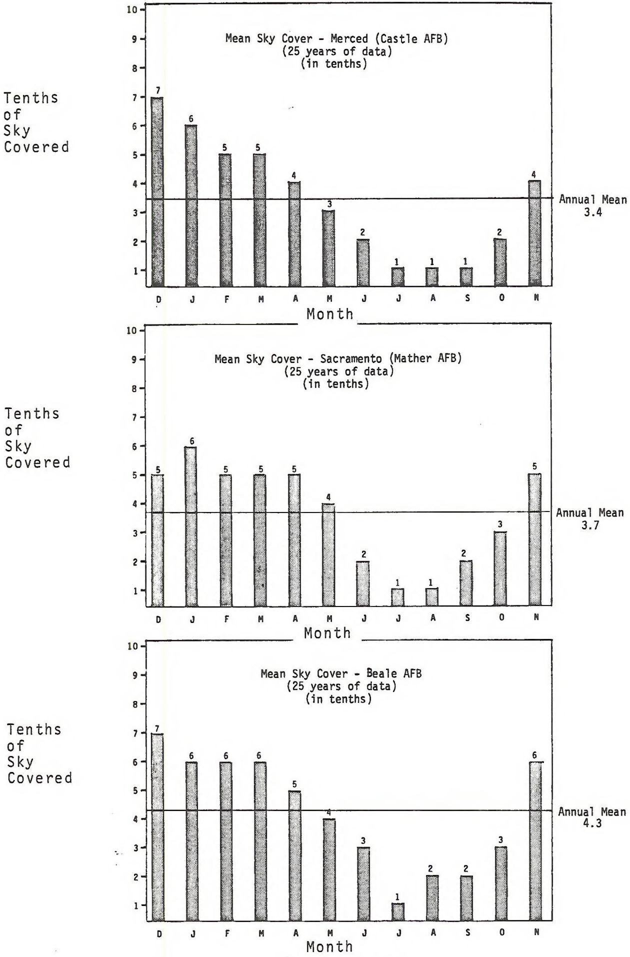
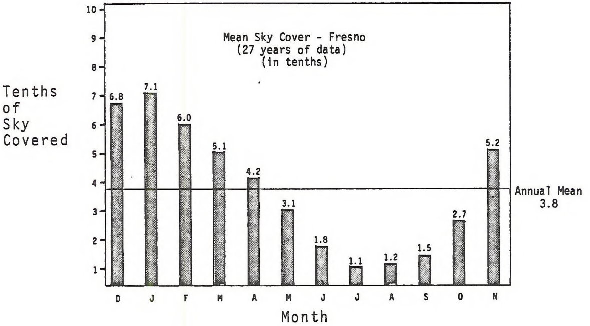


Figure 3.7-4
Central Plain Climatic Zone Monthly and Annual Sky Cover Distribution



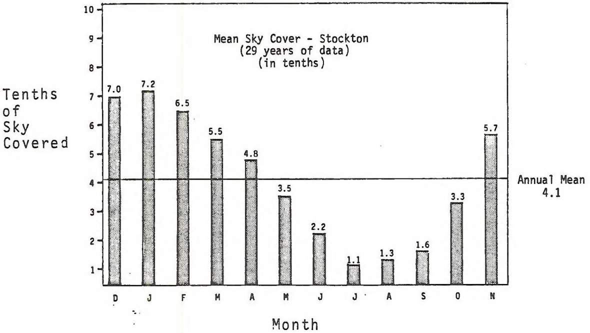


Figure 3.7-4 (Continued)
Central Plain Climatic Zone Monthly and Annual Sky Cover Distribution

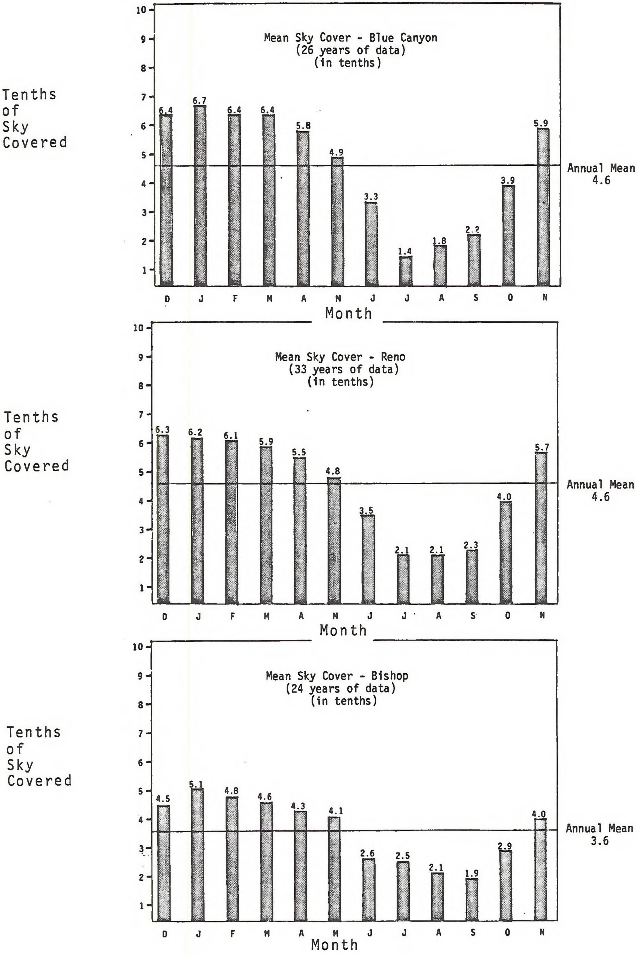


Figure 3.7-5
Interior Mountain Climatic Zone Monthly and Annual Sky Cover Distribution

Tables 3.7-4 through 3.7-6 provide the seasonal-diurnal variations of sky cover distribution for the coastal areas, north Central Valley and the south Central Valley of the Folsom District. Percentages of probabilities of occurrence are presented for sky condition categories including mostly cloudy, partly cloudy and mostly clear. As depicted in Table 3.7-4, mostly clear conditions are generally more likely to occur during the evening hours than during the daylight hours. During the day, low lying, moist air becomes buoyant and tends to rise to levels where the contained water vapor is forced to condense, forming clouds. During the nighttime hours, atmospheric conditions tend to stabilize, causing cool moist air parcels to settle towards the surface. Nocturnal cooling processes often promote foggy conditions or low lying clouds. Partly cloudy conditions are considerably less probable throughout the northern Central Valley and southern Central Valley regions as well as the coastal areas. Observations for the Folsom District indicate that sky cover is generally clear or mostly cloudy rather than an intermediate amount.

The importance of sky cover as a parameter affecting atmospheric stability will be discussed further in section 4.2.3 and is especially detailed in Table 4.2-4

3.7.3 Solar Radiation

Monthly-annual averages of total incoming solar radiation for the various evaporative demand zones in California (equivalent in inches of evaporation of water) are presented in Table 3.7-7. The Folsom District includes areas in the Central Coast, Coastal Valleys, San Joaquin and Sacramento Valley, and Sierra Mountain regions (little data are available for the Sierra Mountain regions).

The Folsom District, on an annual basis, receives an abundant amount of sunshine, particularly in the Central Valley regions. Most parts of the Folsom District receive approximately 70% of the total possible sunshine on an annual basis. A further distiction can be made between the various climatic zones in the Folsom District when comparing solar radiation data on a monthly basis. Table 3.7-8 provides a monthly-annual breakdown of mean daily solar radiation in Langleys as observed at selected stations within the Folsom District. As implied by this table, the Central Plain CZ experiences considerable cloud cover during winter, but receives abundant amounts of sunshine during the summer months. The Coastal CZ experiences less solar insolation during the summer than selected locations in the Central Plain CZ and other portions of the District, due to occasional coastal fog and low cloudiness.

Table 3.7-4

Seasonal/Diurnal Frequencies (%) of Mostly Clear (0-0.3 Sky Cover) Conditions in the Folsom District

	COAST				NORTH CENTRAL VALLEY				SOUTH CENTRAL VALLEY			
TIME	WINTER	SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL
01	48	54	54	62	41	68	89	77	44	68	92	80
02	45	51	51	59	41	67	88	77	42	68	93	81
03	44	52	50	56	40	65	89	76	42	69	92	80
04	43	48	45	53	38	63	88	75	41	68	89	78
05	41	44	41	52	36	59	85	74	40	60	86	76
06	38	39	37	46	34	53	83	69	37	56	86	69
07	31	38	38	42	30	51	83	66	30	55	85	68
08	29	38	44	43	29	52	83	64	31	56	86	68
09	30	41	57	46	30	50	83	65	31	55	87	69
10	32	44	63	52	30	49	83	67	32	54	85	70
11	33	45	71	58	30	48	82	68	31	51	85	70
12	35	45	74	60	29	47	83	65	30	50	85	70
13	35	47	76	64	28	47	83	65	30	49	85	70
14	35	49	77	64	29	48	84	65	30	49	85	72
15	34	49	77	67	31	48	83	66	33	49	84	70
16	36	48	75	67	33	48	83	66	36	50	85	70
17	37	50	74	64	34	51	84	68	37	51	84	70
18	41	49	72	66	38	54	84	70	39	53	85	75
19	45	52	70	68	40	56	84	73	43	58	86	77
20	45	54	69	67	41	60	86	75	44	62	90	78
21	45	56	67	68	41	63	89	77	44	64	91	78
22	46	56	67	68	42	67	91	77	46	66	92	79
23	47	56	65	67	43	68	90	78	45	68	94	81
24	48	55	59	67	43	69	89	78	45	69	94	80
AVERAGE	40%	48%	62%	59%	35%	56%	85%	71%	38%	58%	88%	74%

Table 3.7-5
Seasonal/Diurnal Frequencies (%) of Partly Cloudy (0.4-0.7 Sky Cover) Conditions in the Folsom District

	COAST				NORTH CENTRAL VALLEY				SOUTH CENTRAL VALLEY			
TIME	WINTER	SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL
01	09	08	10	06	07	06	04	06	08	07	05	06
02	09	10	08	06	08	08	05	06	07	06	04	05
03	08	09	07	07	06	06	04	05	08	06	05	07
04	08	08	08	07	06	09	04	05	08	06	05	06
05	10	10	09	06	07	10	06	06	07	12	07	06
06	11	11	10	09	08	11	06	08	08	11	06	09
07	10	11	13	11	09	11	06	10	10	11	07	07
08	09	12	15	11	08	10	07	09	08	11	06	09
09	08	12	13	13	06	12	08	09	08	12	05	09
10	09	14	11	12	07	11	06	07	08	12	08	09
11	12	14	11	11	08	12	08	06	10	14	07	08
12	13	15	09	11	11	11	08	09	10	15	06	08
13	13	14	10	10	11	13	08	09	12	15	07	10
14	13	13	09	10	12	14	07	10	14	14	07	10
15	12	14	09	09	10	14	07	09	13	14	08	10
16	11	14	11	10	10	14	08	08	10	13	08	09
17	12	14	11	12	12	13	06	09	11	13	08	10
18	12	15	12	12	10	12	08	08	12	13	06	07
19	12	14	12	11	09	12	08	09	10	13	07	08
20	11	14	10	10	08	11	07	07	11	11	05	07
21	11	12	10	11	09	10	06	06	10	11	06	07
22	12	12	10	10	09	09	04	04	09	09	05	08
23	12	10	10	08	08	07	05	05	09	09	03	05
24	10	10	10	07	07	07	05	05	08	07	04	06
AVERAGE	11%	10%	11%	10%	09%	11%	06%	08%	10%	11%	06%	08%

Table 3.7-6
Seasonal/Diurnal Frequencies (%) of Mostly Cloudy (0.8-1.0 Sky Cover) Conditions in the Folsom District

TIME	COAST				NORTH CENTRAL VALLEY				SOUTH CENTRAL VALLEY			
	WINTER	SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL
01	44	37	36	32	52	25	08	16	48	25	03	14
02	46	39	40	35	51	26	07	16	50	26	04	14
03	47	40	43	37	54	27	08	18	50	25	04	13
04	49	43	40	40	55	29	08	18	51	26	06	16
05	49	45	49	42	56	31	09	20	53	27	07	17
06	52	50	52	45	58	36	10	21	55	33	08	22
07	59	51	49	47	61	38	11	22	59	35	08	25
08	61	49	42	46	64	38	10	27	61	34	08	24
09	61	47	31	41	64	38	10	25	61	33	07	22
10	59	43	22	36	63	40	10	20	60	34	07	22
11	55	41	18	31	62	40	09	20	60	35	08	22
12	53	40	17	29	61	41	09	19	59	35	09	21
13	53	39	14	26	61	40	09	19	58	36	08	19
15	53	37	14	24	59	38	10	20	55	37	07	20
16	53	38	14	24	58	37	09	19	55	36	07	21
17	52	37	15	23	54	36	09	19	53	36	08	19
18	47	36	17	21	52	35	08	18	49	34	08	17
19	43	34	18	22	50	32	08	17	46	28	07	15
20	43	32	20	23	51	29	06	17	45	27	05	15
21	44	32	23	22	50	27	05	17	45	24	03	15
22	42	32	24	22	50	24	06	15	45	24	03	15
23	42	34	25	24	49	25	05	15	46	23	02	14
24	42	36	31	27	50	25	06	17	47	24	03	14
AVERAGE	47%	39%	28%	31%	56%	33%	08%	19%	53%	30%	06%	18%

Table 3.7-7

Monthly Solar Radiation Summary for the Folsom District (In Equivalent Inches of Evaporation(1))

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	March through October	Annual Average
Sacramento Valley (4)	3.8	5.4	8.6	10.9	13.7	14.0	14.8	13.0	10.2	7.7	4.4	3.4	92.9	109.9
San Joaquin Valley (5)	4.0	5.5	8.8	10.8	13.0	13.4	13.8	12.4	10.0	7.7	4.7	3.2	89.9	107.3
Central Coast-Interior Valleys (6)	3.9	5.6	8.3	10.1	11.6	12.1	12.5	11.0	8.9	6.8	4.4	3.8	81.3	99.0
Central Coast-Coastal Valleys (8)	5.5	6.6	9.8	11.7	12.9	12.7	13.3	12.2	9.7	8.0	5.7	5.0	90.3	113.1

(1) Solar Radiation expressed as equivalent inches of evaporation (1486 Langleys = 1 inch Ep)

Table 3.7-8

Monthly Averages of Daily Solar Radiation For the Folsom District (Langleys)

Station Name	Climate Zone	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual	Period of Record
San Francisco	Coastal	186	247	354	482	545	579	533	449	411	297	208	151	370	1970-1977
Burlingame		211	279	373	496	629	639	636	554	446	334	249	181	419	1971-1977
San Jose		180	266	353	485	574	599	610	537	459	312	205	274	396	1964-1976
Livermoore	Coastal Mt.	231	168	431	573	611	672	670	618	519	366	251	195	450	1970-1974
Salinas		227	267	339	418	528	519	519	456	413	323	248	182	370	1974-1977
Redwood City		192	277	374	523	610	646	637	566	459	320	219	161	415	1970-1976
Los Banos	Central Plain	197	315	433	602	670	686	603	565	479	362	251	185	446	1959-1963
Stockton		128	316	433	601	667	733	719	611	555	391	225	173	463	1960-1962
Folsom Dam		145	214	314	456	568	680	687	594	479	337	228	156	405	1974-1978
Fresno		183	289	431	556	656	704	694	622	514	376	245	162	453	1928-1978
Soda Springs Snow Lab	Interior Mt.	195	286	406	555	626	662	752	659	511	340	225	167	449	1946-1974
Reno		192	257	377	483	564	570	596	528	443	316	207	164	391	1966-1977

1 Langley = 6.45 cal/in^2

3.8 OTHER CLIMATIC PARAMETERS

This section presents analyses of various secondary climatic parameters. These parameters have considerable potential for short-term influence on BLM land use alternatives, but when considered on a long-term climatological basis, they are less significant in characterizing the climate than the parameters previously discussed. The particular climatic parameters reviewed in this section include:

- Dew Point and Relative Humidity
- Severe Weather
- Barometric Pressure
- Fog and Visibility
- Ocean Surface Temperatures

Variations of these particular climatic parameters are briefly discussed and variations within specific climatic zones of the Folsom District are presented in the form of figures and tables. A complete bibliography is provided in the back as for previous sections.

3.8.1 Relative Humidity and Dew Point

Relative humidity and dew point temperature are discussed together in this section as they both represent measures of the available moisture in the atmosphere as a function of ambient air temperatures. Relative humidity describes the saturation moisture percentage of the atmosphere. More accurately, this parameter is defined by the ratio of the actual vapor pressure of air to the saturation vapor pressure of ambient air parcels. Dew point temperature represents the temperature to which a given parcel of air must be cooled, at constant pressure and water vapor content, in order for saturation to occur. For example, the dew point temperature is the temperature at which moisture condenses on grass and other exposed surfaces during the cool early morning hours. When this temperature is below freezing, it becomes the frost point temperature, i.e., the point at which frost will develop on exposed surfaces.

Dew point and relative humidity both provide a measure of the amount of moisture available in the atmosphere for condensation. However, care must be used in interpreting these parameters. For example, the higher the relative humidity, the higher the amount of moisture available for condensation. However, a low dew point does not necessarily mean low availability of moisture. The key criterion in interpreting dew point data is the difference between the dew point temperature and the ambient air temperature which is commonly known as the dew point depression. When this temperature difference is small, the amount of available moisture is high. When there is no difference, the atmosphere is saturated. Finally, when the dew point depression is large, the amount of available moisture in the atmosphere is quite small. In a great majority of normal atmospheric conditions, supersaturation does not occur; therefore, the dew point temperature should never be higher than the ambient air temperature.

Atmospheric moisture content also plays an important role in air quality. High moisture levels not only reduce visibility but can also enhance the formation of secondary air pollutants such as sulfates and nitrates, which can further reduce visibility.

Summary tables and figures have been provided for the Folsom District which present relative humidity and dew point temperature data on a diurnal, monthly, seasonal and annual basis. Relative humidity and dew point temperature data are generally available only for major first order stations; however, the data base for the Folsom District is sufficient to provide regional long-term averages. Once again, data from major reporting stations have been used to summarize conditions in each of three major climatic areas including the Coastal, the Central Plain and the Interior Mountain climatic zones.

Figure 3.8-1 summarizes seasonal mean dew point temperature and relative humidity for the state of California. The data indicate that atmospheric moisture content is highest along the coastline, particularly in the extreme northwestern portion of the state. There is a tendency for moisture to flow in through the Bay Area and during the late fall, winter and early spring seasons, this moisture reaches the Central Valley. During other seasons of the year, most of the valley is significantly dryer than coastal locations as indicated by the figure.

Dew point temperature and relative humidity tend to be lowest on the east side of the Sierra. There is a general decrease in available moisture with a west to east progression through the district as depicted in Figure 3.8-1. However, the terrain of the region does play a role in the indicated moisture distribution patterns. In the Folsom District, relative humidities tend to be highest in winter and lowest in summer. Detailed information on relative humidity is presented in Figures 3.8-2 through 3.8-4. Figure 3.8-5 provides a review of annual dew point temperatures on a monthly basis at selected key first order stations including Monterey, Stockton, Fresno and Bishop. Finally, diurnal distributions of relative humidity and dew point at key stations are provided on a seasonal basis in Tables 3.8-1 and 3.8-2.

To summarize the data in the tables and figures, relative humidities remain fairly high at the coastal locations throughout the year and are consistently very low at Bishop. Considerable variability exists at Central Valley stations where relative humidities are quite high during winter and considerably lower during summer afternoons with the lowest values occurring in the lower San Joaquin Valley.

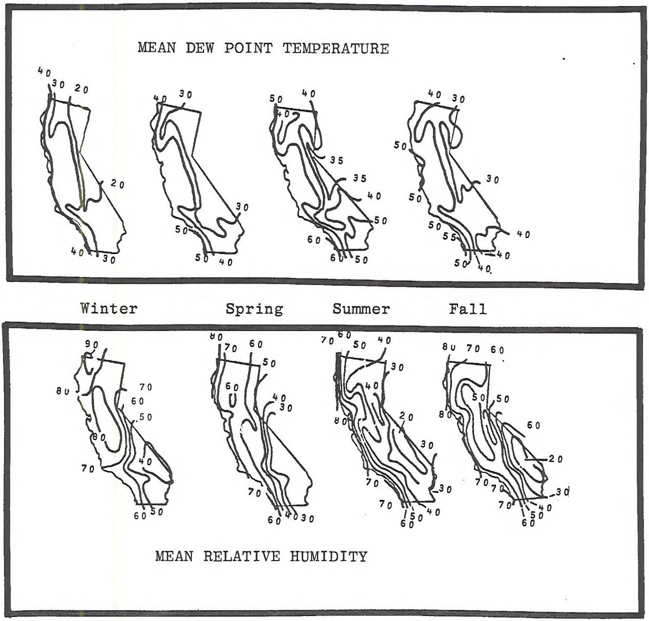


Figure 3.8-1
Mean Seasonal Dew Point (^{o}F)
and Relative Humidity (%) in California

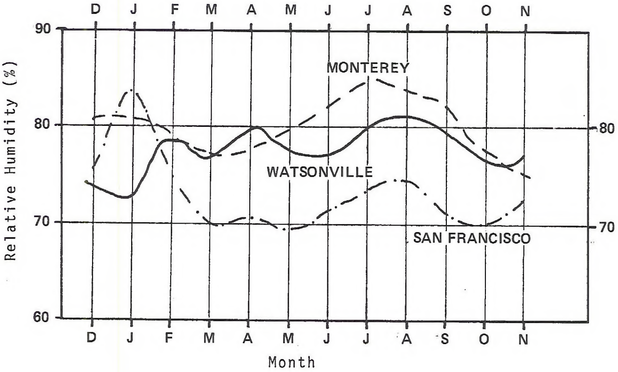


Figure 3.8-2
Coastal Climatic Zone
Monthly-Annual Humidity Distribution
in the Folsom District

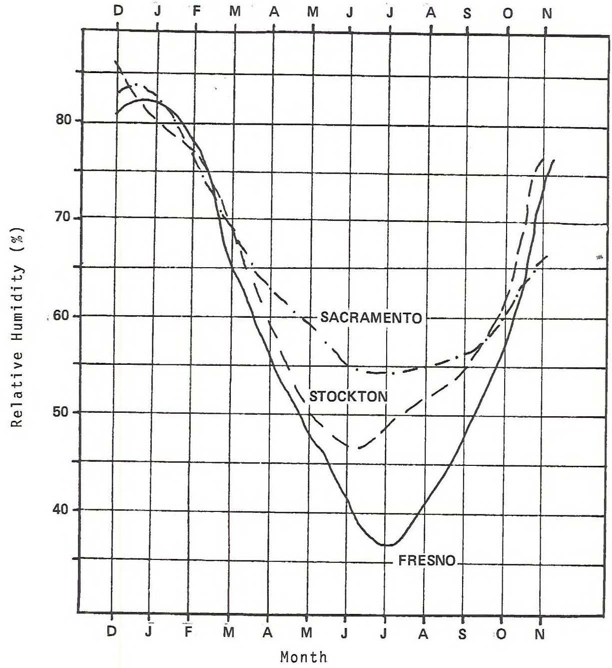


Figure 3.8-3
Central Plain Climatic Zone
Monthly-Annual Humidity Distribution
in the Folsom District

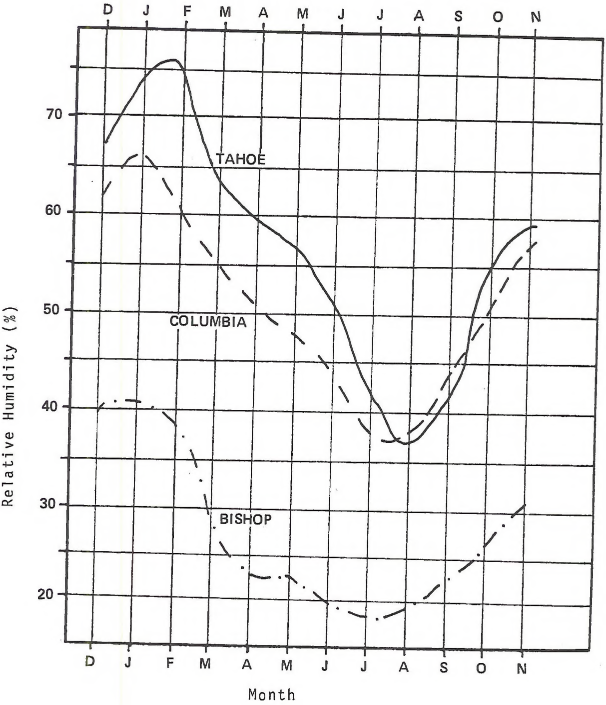


Figure 3.8-4
Interior Mountain Climatic Zone
Monthly-Annual Humidity Distribution
in the Folsom District

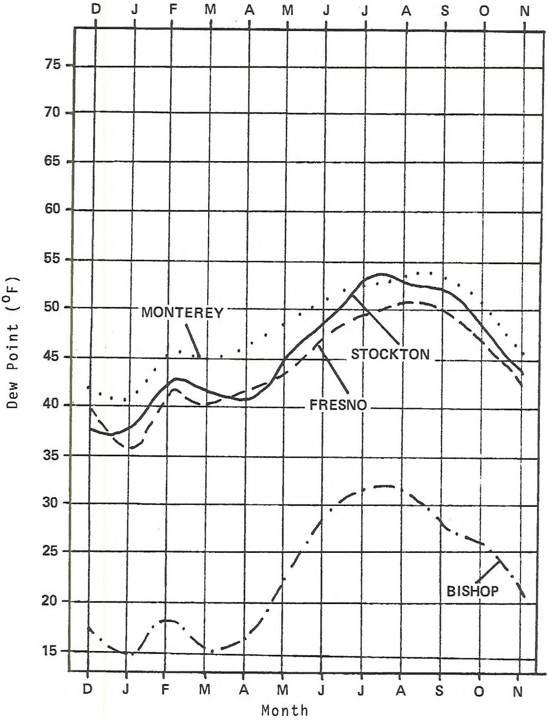


Figure 3.8-5
Folsom District
Monthly - Annual Dew Point Temperature

Table 3.8-1

Seasonal - Diurnal Distribution of Relative Humidity (%) in the Folsom District

Winter

	HOUR OF THE DAY																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Monterey	82	81	82	81	81	81	81	81	79	74	69	65	63	62	62	64	66	72	77	79	80	81	81	81
Stockton	87	*	*	89	*	*	90	*	*	83	*	*	69	*	*	64	*	*	77	*	*	83	*	*
Fresno	89	90	90	91	91	91	91	92	90	87	81	76	71	67	64	62	63	69	75	80	83	86	87	89
Bishop	*	*	*	*	*	*	65	66	62	53	40	33	28	26	24	24	26	33	40	45	*	*	*	*

Spring

	HOUR OF THE DAY																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Monterey	85	86	87	87	87	87	87	84	79	75	71	69	68	68	66	67	67	69	73	78	81	83	84	85
Stockton	72	*	*	77	*	*	75	*	*	53	*	*	41	*	*	38	*	*	52	*	*	66	*	*
Fresno	69	73	76	78	80	82	81	76	67	58	52	46	42	38	35	34	33	35	39	46	52	58	62	66
Bishop	*	*	*	*	*	*	51	44	34	28	22	19	17	15	15	14	15	17	20	25	*	*	*	*

Summer

	HOUR OF THE DAY																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Monterey	91	92	92	93	93	93	92	90	86	83	80	77	74	72	70	70	70	73	76	81	86	87	89	90
Stockton	63	*	*	69	*	*	63	*	*	44	*	*	32	*	*	28	*	*	39	*	*	55	*	*
Fresno	47	51	55	58	61	64	62	55	48	42	37	33	29	26	23	21	19	19	22	26	31	35	39	44
Bishop	*	*	*	*	*	*	43	34	26	22	18	16	14	12	12	12	12	14	15	18	*	*	*	*

Fall

	HOUR OF THE DAY																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Monterey	85	86	86	86	86	86	86	85	81	76	72	69	67	66	66	67	69	74	78	81	82	83	84	84
Stockton	75	*	*	79	*	*	81	*	*	62	*	*	47	*	*	44	*	*	58	*	*	70	*	*
Fresno	70	73	75	77	78	79	80	78	72	63	56	50	45	41	39	37	37	42	48	54	58	62	65	68
Bishop	*	*	*	*	*	*	58	54	44	36	28	24	21	19	18	18	19	24	29	33	*	*	*	*

* No Data

Table 3.8-2

Seasonal - Diurnal Distribution of Dew Point Temperature (^{O}F) in the Folsom District

Diurnal Dew Point Temperature
Winter

Hr.	Bishop	Monterey	Stockton	Fresno
1	****	42.3	37.8	38.6
2	****	41.6	****	38.2
3	****	41.4	****	37.9
4	****	40.9	36.8	37.6
5	****	40.5	****	37.4
6	****	40.2	****	37.0
7	16.2	40.0	36.1	36.6
8	15.8	39.7	****	36.5
9	16.7	39.8	****	36.9
10	18.6	41.3	39.7	38.5
11	18.1	42.5	****	39.4
12	17.0	43.2	****	40.0
13	15.9	43.6	41.3	40.2
14	15.6	43.9	****	40.0
15	15.2	44.7	****	39.9
16	15.3	45.2	41.1	39.7
17	15.7	45.6	****	39.8
18	17.3	45.8	****	40.4
19	17.7	45.3	40.7	40.7
20	17.9	44.5	****	40.6
21	****	44.0	****	40.3
22	****	43.5	39.3	40.0
23	****	43.0	****	39.5
24	****	42.7	****	39.0

Diurnal Dew Point Temperature
Spring

Hr.	Bishop	Monterey	Stockton	Fresno
1	****	46.3	41.8	43.1
2	****	46.0	****	43.1
3	****	45.9	****	43.0
4	****	45.6	42.2	42.8
5	****	45.3	****	42.5
6	****	45.1	****	42.2
7	21.8	45.0	42.1	42.3
8	22.2	45.5	****	42.7
9	21.9	46.1	****	43.3
10	20.9	46.5	43.5	43.2
11	18.8	46.6	****	43.1
12	17.6	47.0	****	42.6
13	16.2	47.3	42.6	41.6
14	15.4	47.6	****	40.6
15	14.8	47.6	****	39.8
16	14.8	47.7	41.7	39.3
17	15.6	47.8	****	38.8
18	16.3	47.7	****	38.9
19	18.1	47.5	43.0	40.0
20	19.8	47.3	****	41.5
21	****	47.0	****	42.4
22	****	47.0	42.9	43.0
23	****	46.8	****	43.1
24	****	46.6	****	43.2

Table 3.8-2 (Continued)
Seasonal - Diurnal Distribution of Dew Point Temperature (^{O}F)
in the Folsom District

Diurnal Dew Point Temperature
Summer

Hr.	Bishop	Monterey	Stockton	Fresno
1	****	52.2	50.6	50.2
2	****	52.0	****	50.2
3	****	51.9	****	50.2
4	****	51.8	50.7	50.2
5	****	51.6	****	50.3
6	****	51.5	****	50.2
7	35.6	51.4	52.3	50.6
8	35.8	52.0	****	50.9
9	34.9	52.4	****	51.6
10	33.7	52.7	52.7	51.9
11	32.7	52.9	****	51.6
12	31.1	53.2	****	51.3
13	29.0	53.6	52.7	50.0
14	27.6	53.7	****	48.8
15	27.0	53.8	****	47.4
16	27.1	53.9	51.1	46.0
17	27.5	53.6	****	45.2
18	28.8	53.5	****	44.8
19	30.4	53.2	51.6	45.7
20	31.9	52.9	****	47.4
21	****	52.7	****	48.6
22	****	52.5	51.0	49.3
23	****	52.4	****	49.7
24	****	52.3	****	50.1

Diurnal Dew Point Temperature
Fall

Hr.	Bishop	Monterey	Stockton	Fresno
1	****	49.1	47.0	46.6
2	****	48.8	****	46.2
3	****	48.4	****	46.0
4	****	48.0	46.4	45.8
5	****	47.7	****	45.6
6	****	47.4	****	45.2
7	25.6	47.2	46.3	45.0
8	25.6	47.2	****	45.3
9	26.5	48.2	****	46.4
10	26.6	49.4	49.1	47.2
11	25.9	50.0	****	47.5
12	25.1	50.3	****	47.4
13	23.9	50.6	48.9	47.0
14	23.3	50.9	****	46.3
15	22.6	51.3	****	45.5
16	22.3	51.6	48,0	44.9
17	23.1	51.7	****	44.6
18	25.0	52.0	****	45.5
19	26.2	51.5	48.6	46.6
20	26.4	51.0	****	47.2
21	****	50.5	****	47.2
22	****	50.1	48.3	47.2
23	****	49.8	****	47.0
24	****	49.4	****	46.7

3.8.2 Severe Weather

This section presents a basic summary of severe weather in the Folsom District. The regional formation and statistical incidence of thunderstorms, tornadoes, hail and ice are discussed in this section. The damaging effects of these abnormal weather features are also reviewed. In comparison with other areas of the country, thunderstorms, tornadoes, hail and ice occur relatively infrequently in most portions of the state.

Thunderstorms

Thunderstorms are rare along the coast and over the Central Valley and have no well defined season. On the other hand, thunderstorms developing over the interior mountains are severe on occasion and occur primarily during summer. Most of the thunderstorms that occur in the Folsom District cause little, if any, damage. The storms usually are accompanied by brief gusts of wind, heavy rain and lightning as well as some small hail. Large hail, strong winds and a funnel cloud or tornado are quite rare.

Winter thunderstorms generally occur in conjunction with rapidly moving cold fronts that pass over the district. Advancing frontal systems can promote considerable instability aloft which contributes to thunderstorm development. Summer thunderstorms develop over mountainous areas as strong surface heating effects couple with moist maritime air and forced orographic lifting. Table 3.8-3 provides the mean number of days that thunderstorms occur seasonally and annually at several reporting stations in the Folsom District.

Table 3.8-3

Mean Number of Thunderstorm Days

Station	Winter	Spring	Summer	Fall	Annual
Fresno	0.4	2.0	0.5	1.4	4.3
Hayward	0.6	0.8	0.5	0.2	2.1
Los Banos	0.7	1.9	0.3	1.4	4.3
Marysville	0.8	2.6	1.4	1.7	6.5
Merced	0.7	1.9	0.3	1.4	4.3
Sacramento	0.9	2.9	0.6	1.0	5.4
San Francisco	0.5	0.6	0.6	0.1	1.8
Stockton	0.4	0.9	0.6	0.9	2.8

Isolated thunderstorm activity, as observed on radar over mountain areas, averages as high as 50 to 60 days per year at some locations. Lightning strikes resulting from these thunderstorms can cause dry brush to ignite and promote forest fires.

Isolines of the annual mean number of thunderstorm days are depicted on a national scale in Figure 3.8-6. Generally, the Folsom District experiences 5-10 thunderstorm days per year. Considerable data resolution is lacking on Figure 3.8-6 and the distribution does not reflect the higher incidence of thunderstorm days that can be experienced in the Sierra Nevada Mountains.

Tornadoes

Tornadoes and funnel clouds are associated with severe thunderstorms. They develop when just the right conditions of moisture, atmospheric stability, and winds are present. Tornadoes frequently form within thunderstorms that have organized into lines. Frequently, but not always, these "squall lines" are associated with vigorous and rapidly advancing cold fronts that promote rapid lifting of ambient air to heights in excess of 60,000 feet.

The environmental setting in California limits the potential for the development of tornadic conditions. The near proximity of the cool waters of the Pacific Ocean and the Eastern Pacific semi-permanent high pressure center tends to inhibit the necessary rapid lifting of surface air. The downward air motion associated with this high pressure area tends to warm and stabilize the atmosphere, thus creating conditions adverse to tornado or severe thunderstorm activity. On rare occasions, surges of cold air at upper levels move into California and can combine with warm moist onshore surface winds to produce the unstable atmospheric conditions necessary for tornado formation.

Tornadoes have been reported in California, but with an average frequency of only 1 or 2 per year. They are generally not severe, in many cases causing little more than damage to trees or light buildings. Pilots occasionally report sightings of funnel clouds aloft, particularly off the southern California coast. The map on Figure 3.8-7 depicts areas of tornado activity in California for the period from 1930-1974. Table 3.8-4 provides a complete listing of historical funnel cloud observations for the Folsom District and nearby regions.

Fujita has presented a classification scheme for tornadoes, presented in Table 3.8-5, which has been used to categorize California tornadoes as shown in Table 3.8-6. A scale is presented below as devised by Fujita and as outlined in a report submitted to the University of California by Meteorology Research, Inc (MRI). Specifications of damage are presented as visual guidelines, and not as absolute criteria.

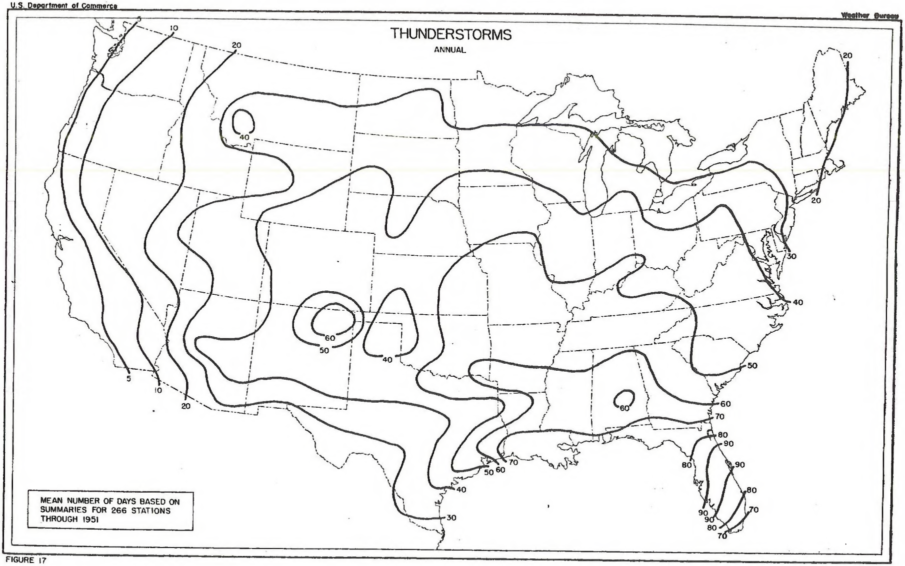


Figure 3.8-6

Mean Number of Thunderstorm Days in the United States

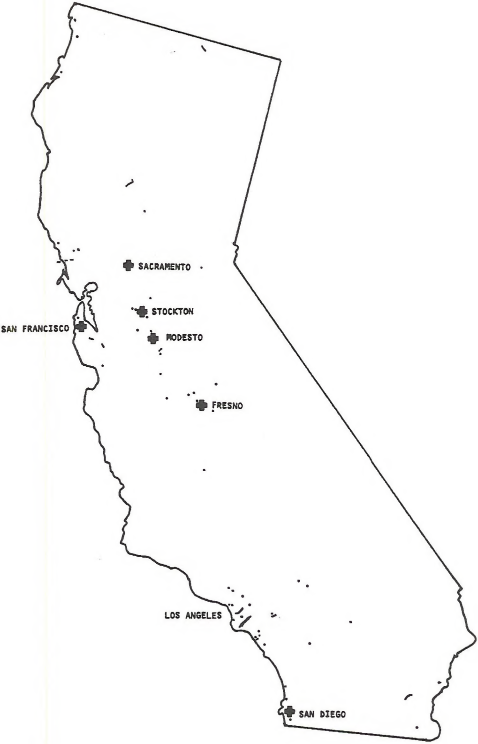


Figure 3.8-7
Tornado Activity in California
During the Period 1930-1974

Table 3.8-4

Review of Tornado Sightings in the Folsom District

Date	Time	Location	Type	Remarks
Oct. 26, 1921	1430	Sacramento	T *	Children hurt, extensive damage
Jan. 11, 1951	0830	Mountain View	T	Considerable Damage
1967				
March 11, 1967	1515	Sacramento	FC **	
March 13, 1967	1742	Alameda	FC	
April 7, 1967	1020	Chowchilla	FC(3)	
April 19, 1967	1108	Fairfield	FC	
April 21, 1967	1722	Madera	T, FC	Touched ground (story in Weatherservice)
April 22, 1967	1802	Tracy	FC	
April 22, 1967	1815	Merced	T	Home Destroyed
April 22, 1967	1855	Fresno	T	
April 23, 1967	1800	Fresno	FC	
April 23, 1967		Madera	FC	FC photographed, observed to touch ground
1968				
March 14, 1968	1057	Fairfield	FC(2)	
March 16, 1968	1225	Marysville	FC	
April 1, 1968	0910	Pt. Merger	FC	
April 1, 1968	1829	Sacramento	FC	
1969				
January 4, 1969	1233	Fresno	FC	
January 4, 1969	1602	Fresno	FC	

* Tornado
** Funnel Cloud (number in parenthesis)
† Dust Devil
†† Windstorm

Table 3.8-4 (Continued)

Review of Tornado Sightings in the Folsom District

Date	Time	Location	Type	Remarks
February 2, 1969		Citrus Heights	FC	FC sighted, wind damage
February 6, 1969		Redwood City		Structural Damage
February 28, 1969	1517	Stockton	FC	SE of Stockton Airport
March 12, 1969	1000	Hamilton AFB	FC	
October 16, 1969	1525	Modesto-Stockton	T & FC	20 miles west of Modesto
1970				
February 17, 1970	1545	Stockton	FC	East of airport
April 27, 1970	1630	Stockton	T	Touched down 3 points, trees uprooted
July 3, 1970	1545	Concord	FC(2)	2 funnels aloft
November 6, 1970	1310	Sacramento	FC	Reached to within 500 feet of ground
1971				
April 24, 1971	1535	Stockton	T	Minor crop damage
1972				
April 18, 1972	1515	Chico	DD†	Uprooted trees
October 3, 1971		Sacramento	T	Building damage
October 14, 1972		Monterey	FC	
October 15, 1972		Sacramento (NE)	T	
October 15, 1972	1327	Sacramento (SSW)	FC	
October 15, 1972	1324	Merced 46 NE	T	
October 15, 1972	2330	Monterey 8E	FC	
October 17, 1972	1630	San Francisco	FC	
October 17, 1972	1640	Oakland	FC	
November 7, 1972	1450	Modesto	FC	Small

* Tornado

** Funnel Cloud (number in parenthesis)

† Dust Devil

†† Windstorm

Table 3.8-4 (Continued)

Review of Tornado Sightings in the Folsom District

Date	Time	Location	Type	Remarks
1973				
February 14, 1973	1431	36.3N, 119.4W	FC	
February 14, 1973	1646	37.3N,120.5W	FC	
March 6, 1973	1734	Sacramento, A.P.	FC, T	
November 12, 1973	1240	San Jose	FC	
December 1, 1973	1248	Fresno	FC	
1974				
February 12, 1974	1900	San Jose	FC	
March 30, 1974	1535	Merced	FC	
March 30, 1974	1716	Sacramento	FC	
April 18, 1974	0918	Stockton	FC	
July 9, 1974	1725	Lodi	FC	
1975				
March 13, 1975	1517	Fowler	T	
April 5, 1975	1100	Los Banos	T	Uprooted trees, damaged houses
April 5, 1975	1735	Fresno	T	Minor Damage

* Tornado

** Funnel Cloud (number in parenthesis)

† Dust Devil

†† Windstorm

Table 3.8-5
Fujita Tornado Classification Scheme

(F0) GALE TORNADO, Light Damage
40-72 mph
Some damage to chimneys and TV antennae; breaks twigs off trees; pushes trees over.

(F1) WEAK TORNADO, Moderate Damage
73-112 mph
Peels surface off roofs; windows broken; light trailer houses overturned; some trees uprooted or snapped; automobiles pushed off the road.

(F2) STRONG TORNADO, Considerable Damage
113-157 mph
Roofs torn off frame houses leaving only strong walls upright; trailer houses destroyed; large trees snapped or uprooted; railroad box cars derailed; light object missiles generated; cars blown off highway.

(F3) SEVERE TORNADO, Severe Damage
158-206 mph
Roofs and some walls torn off frame houses; trains derailed or overturned; steel framed hangar-warehouse type structures torn; cars lifted off the ground.

(F4) DEVASTATING TORNADO, Devastating Damage
207-260 mph
Whole frame houses leveled, leaving piles of debris; steel structures badly damaged; small flying objects debark trees; cars and trains thrown or rolled considerable distances, large missiles generated.

(F5) INCREDIBLE TORNADO, Incredible Damage
261-318 mph
whole frame houses tossed off foundations; automobile-sized missiles generated; incredible phenomena can occur.

(F6) 319-379 mph

(F7) 380-445 mph

(F8) 446-513 mph

(F9) 514-585 mph

(F10) 586-659 mph

(F11) 660-737 mph

(F12) 738-818 mph

Photographs and eyewitness accounts of the larger tornadoes have been used to compile the various classifications. Table 3.8-6 presents a summary of the historical intensities of California tornadoes.

Table 3.8-6
Historical Intensity Of California Tornadoes
Based Upon the Fujita Classification Scheme

Class	No. of Storms	Percentage (%) of Observations
F0	8	16.7
F1	32	66.7
F2	8	16.7
F3 or worse	0	0.0

Hail

Hail results from the formation of spheres of irregular chips of ice which are produced by convective activity in storm clouds, such as in cumulonimbus types. Thunderstorms which are characterized by strong updrafts, high water content, large cloud drop sizes, and great vertical height extent offer great potential for hail and ice formation. Hail sizes can range from that of a few millimeters in diameter to sizes on the order of several centimeters. Table 3.8-7 presents the incidence of hail and sleet seasonally and annually at several selected stations in the Folsom District.

Table 3.8-7
Mean Number of Days With Hail/Sleet or Ice*

Station	Winter	Spring	Summer	Fall	Annual
Bishop	1.0	0.0	0.0	0.0	2.0
Fresno	1.0	3.0	0.0	0.0	4.0
Monterey	4.0	0.0	0.0	0.0	4.0
Stockton	0.0	0.0	0.0	0.0	0.0
Sacramento	0.0	0.0	0.0	0.0	0.0
San Francisco	0.0	0.0	0.0	0.0	0.0

*Based on 5 years of hourly observations

3.8.3 Atmospheric Pressure

Atmospheric pressure, as a climatic parameter, has little direct effect on the ambient environment but acts as a climatic control parameter, such that slight variations in atmospheric pressure can induce remarkable variations in general weather conditions. Pressure gradients regulate wind, and wind is a major determinant of regional air temperature and moisture conditions. This also provides a connection between pressure and dispersion meteorology and ambient air quality. In addition, pressure systems are often positively correlated with pollutant levels. For example, the semi-permanent eastern Pacific High Pressure system permits the buildup of high pollutant levels in Southern California during summer.

Atmospheric pressure is defined as the force exerted by the atmosphere upon a unit surface area as a consequence of gravitational attraction on all air molecules. Hence, atmospheric pressure is a measure of the total weight of air situated above an area in question.

Pressure is defined in dimensions of force per unit area, such as dynes per square centimeter (dynes/cm^2), pounds per square inch (lbs/in^2), or newtons per square meter (N/m^2). Meteorologists often refer to the dynes/cm^2 ratio as millibars (mb), such that, 1 mb equals 1,000 dynes/cm^2.

Pressure measurements are at times expressed in terms of standards. The average global mean sea level pressure has been determined to be 1,013.25 mb (14.7 lbs/in^2). This value of pressure is often referred to as 1 Standard Atmosphere (Atm). Similarly, the pressure level of approximately 506 mb (7.35 lbs/in^2)is referred to as 0.5 Atm.

Atmospheric pressure values are often expressed in terms of equivalents. Since the atmosphere exerts a force or weight per unit area, it therefore counter-balances an equivalent weight. A column of air one square inch in cross-sectional area extending from sea level to the top of the atmosphere weighs approximately 14.7 pounds. This weight can be balanced by a column of mercury having the same cross-sectional area extending vertically 29.92 inches or 760 millimeters. Therefore, pressure values can be referred to in units of inches (in) or millimeters of mercury (mmHg) with the understanding that these values represent the atmospheric mass that supports a vertical column of mercury so many inches or millimeters long. As atmospheric pressure changes in an area, the air mass above that region changes, and likewise, its ability to counter-balance the weight of the previously described column of mercury.

Table 3.8-8 provides the conversion factors necessary to transform pressure values into various conventional pressure units and equivalents. An example demonstrating how to use these factors is provided below the table.

Figures 3.8-8 through 3.8-11 provide a representative cross-section of the mean seasonal pressure contours on a national scale. General atmospheric flow can be estimated by assuming that winds move nearly parallel to isobars (lines of equal pressure values). In the northern hemisphere, winds blow clockwise (anticyclonic) around the high pressure centers and counterclockwise (cyclonic) about low pressure centers.

Table 3.8-8

Pressure Conversion Factors

	UNITS (B)					
UNITS (A)	POUNDS/IN^2	DYNES/CM^2	MILLIBARS	ATMOSPHERES	INCHES OF MERCURY	MILLIMETERS OF MERCURY
POUNDS/IN^2	1.000	$6.902x10^4$	$6.902x10^1$	$6.812x10^2$	2.038	$5.177x10^1$
DYNES/CM^2	$1.449x10^{-5}$	1.000	$1.000x10^{-3}$	$9.870x10^{-7}$	$2.953x10^{-5}$	$7.501x10^{-4}$
MILLIBARS	$1.449x10^{-2}$	$1.000x10^3$	1.000	$9.870x10^{-4}$	$2.953.10^{-2}$	$7.501x10^{-4}$
ATMOSPHERES	$1.468x10^1$	$1.013x10^6$	$1.013x10^3$	1.000	$2.992x10^1$	$7.600x10^2$
INCHES OF MERCURY	$4.906x10^{-1}$	$3.386x10^4$	$3.386x10^1$	$3.342x10^{-2}$	1.000	$2.540x10^1$
MILLIMETERS OF MERCURY	$1.932.10^{-2}$	$1.333x10^3$	1.333	$1.316x10^{-3}$	$3.937x10^{-2}$	1.000

* Multipy pressure in (A) units by appropriate factor to transform into (B) units (i.e. 14.68 LBS/IN^2 x 6.902x10 = 1013.2 mb).

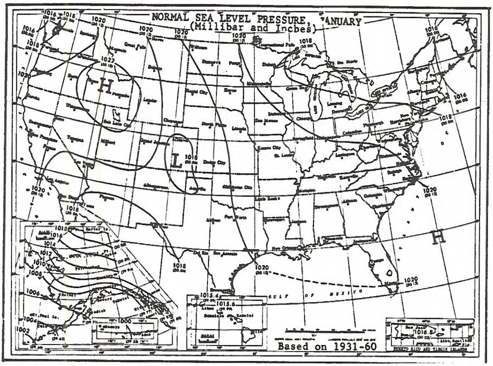


Figure 3.8-8
Mean Winter (January) Pressure Distribution
in the United States

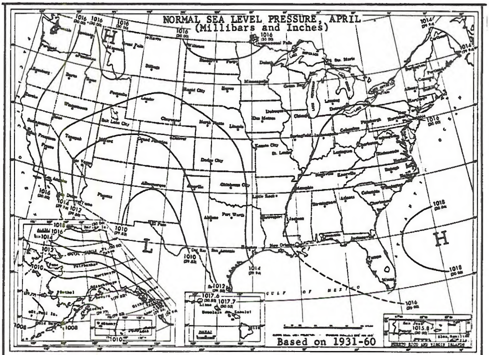


Figure 3.8-9
Mean Spring (April) Pressure Distribution
in the United States

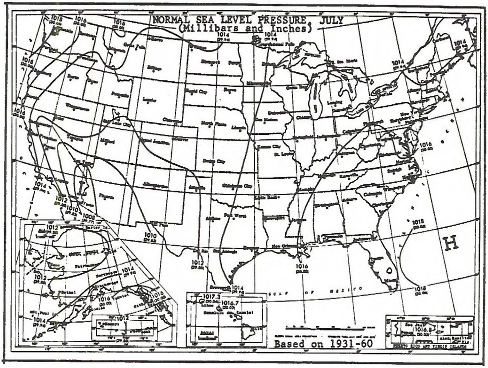


Figure 3.8-10

Mean Summer (July) Pressure Distribution
in the United States

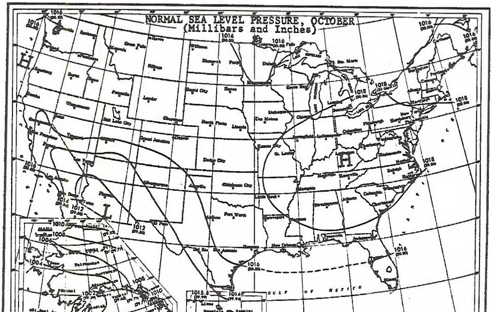


Figure 3.8-11

Mean Fall (October) Pressure Distribution
in the United States

During the winter months, a high pressure center is generally situated to the northeast of California and the semi-permanent Eastern Pacific high pressure system is depressed well to the south. This permits moist air to be channeled into the state from the northwest, west and southwest. The strong potential for moisture advection during the winter months in California promotes the "rainy" season. Air quality also tends to be better during this season.

In the hot summer months, a low pressure center dominates the southwestern portion of the nation. Winds generally flow inland as the sea breeze regime becomes established. The Eastern Pacific High Pressure area becomes well entrenched over California and inhibits the flow of moist, maritime air into the area, thus permitting the development of high pollutant levels.

Definite pressure cycles occur on numerous time scales. Mean pressure values experienced in particular regions vary seasonally and diurnally. Latitude, elevation, topography and surface albedo collectively influence the mean pressure tendencies registered at a particular location. Variations in atmospheric pressure, typical in each climatic zone in the Folsom District, are depicted on a monthly-annual basis in Figure 3.8-12 and on a diurnal-seasonal basis in Figure 3.8-13. In all zones, the mean barometric pressure is at a maximum during the winter months and at a minimum during the summmer months. Coastal zones, greatly influenced by the neighboring Pacific Ocean, exhibit smaller magnitudes in seasonal variation of atmospheric pressure than inland areas. Mountainous zones reflect the greatest seasonal variation in ambient air pressure.

3.8.4 Visibility and Fog

Visibility provides an indication of atmospheric clarity. Visibility measurements or estimates are generally expressed in miles or kilometers denoting the maximum distance at which one can distinguish objects such as buildings, mountains and other large landmarks. Visibility reduction is the result of numerous physical factors that include both general air quality as well as thermodynamic and optical properties. Some of the more common factors that play an important role in atmospheric visibility and contrast reduction are air moisture content, relative humidity, falling rain, snow, hail, blowing dust, sea spray, high concentrations of suspended particulate matter, sulfates, oxides of nitrogen, and smoke.

Tables 3.8-9 through 3.8-12 present monthly, seasonal and annual percentage frequency distributions of visibility for various stations in or near the Folsom District. The selected first order stations include Monterey, Fresno, Stockton and Bishop. The data represent observations of visual range by trained NWS observers at major airport locations.

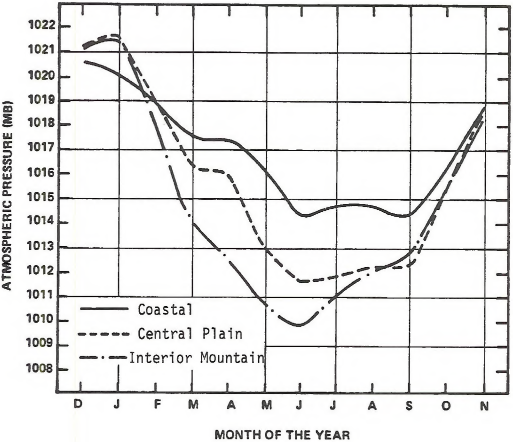
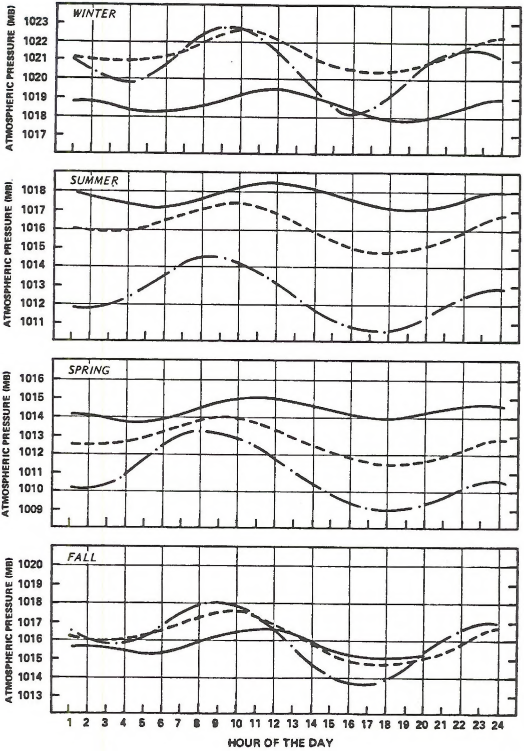


Figure 3.8-12

Monthly - Annual Distribution of Atmospheric Pressure in the Folsom District



—— Coastal
---- Central Plain
—·— Interior Mountain

Figure 3.8-13
Diurnal - Seasonal Pressure Variations
in the Folsom District

Table 3.8-9

Frequency (%) of Selected Visibility Categories at Monterey, California for the Period 1959 to 1963

PERIOD	VISIBILITY (MILES)						
	<¼	¼-1	1-3	3-5	5-10	10-25	>25
DEC	3.0	0.6	1.4	4.7	40.0	45.3	4.9
JAN	0.6	0.9	1.9	4.7	34.9	51.7	5.2
FEB	2.0	1.0	1.2	4.7	32.6	52.6	4.9
WINTER	1.9	0.8	1.8	4.7	36.0	49.8	5.0
MAR	1.3	0.7	1.3	2.1	23.7	68.0	2.9
APR	1.3	0.5	1.0	2.3	31.8	61.9	1.3
MAY	0.6	0.6	1.0	2.8	27.8	63.0	4.1
SPRING	1.1	0.6	1.1	2.4	27.8	64.3	2.8
JUN	2.9	1.2	2.4	3.1	45.1	44.8	0.5
JUL	4.5	3.3	4.6	5.6	49.0	31.9	1.2
AUG	4.9	2.7	4.6	7.5	48.7	31.0	0.6
SUMMER	4.1	2.4	3.9	5.4	47.6	35.8	0.8
SEP	6.9	2.3	4.1	6.0	48.2	31.9	0.8
OCT	6.0	1.5	2.5	4.4	36.4	46.0	3.2
NOV	3.5	1.6	3.4	4.6	34.7	48.4	3.8
FALL	5.5	1.8	3.3	5.0	39.7	42.1	2.6

Table 3.8-10

Frequency (%) of Selected Visibility Categories at Fresno, California for the Period 1960 to 1964

PERIOD	VISIBILITY (MILES)						
	<¼	¼-1	1-3	3-5	5-10	10-25	>25
DEC	22.8	14.4	20.8	15.3	14.6	10.5	1.7
JAN	19.4	8.9	14.4	17.4	16.0	20.9	2.8
FEB	6.8	2.6	7.4	12.8	29.1	36.9	4.3
WINTER	16.7	8.8	14.4	15.2	19.6	22.3	2.9
MAR	0.8	0.2	1.8	4.0	19.2	64.1	9.9
APR	0.0	0.1	0.5	2.0	15.8	71.0	10.6
MAY	0.1	0.0	0.1	0.5	9.7	75.8	13.9
SPRING	0.3	0.1	0.8	2.1	14.9	70.3	11.5
JUN	0.0	0.0	0.1	0.1	12.2	81.1	6.5
JUL	0.0	0.0	0.0	0.3	14.8	76.8	8.1
AUG	0.0	0.0	0.0	0.8	17.4	78.0	3.8
SUMMER	0.0	0.0	0.0	0.4	14.8	78.6	6.1
SEP	0.2	0.0	0.3	3.7	30.8	63.5	1.5
OCT	1.5	1.3	5.1	13.9	35.1	40.8	2.3
NOV	7.8	4.7	11.5	17.8	29.5	25.9	2.8
FALL	3.2	2.0	5.6	11.8	31.9	43.4	2.2

Table 3.8-11

Frequency (%) of Selected Visibility Categories at Stockton, California for the Period 1972 to 1976

PERIOD	VISIBILITY (MILES)						
	<¼	¼-1	1-3	3-5	5-10	10-25	>25
DEC	16.2	10.2	24.0	14.4	17.7	12.3	5.2
JAN	20.5	7.4	14.0	15.6	19.4	17.8	5.3
FEB	7.1	1.8	6.6	11.3	33.9	29.2	10.1
WINTER	14.9	6.6	15.1	13.8	23.4	19.5	6.8
MAR	0.7	1.0	2.9	5.7	22.7	51.0	15.8
APR	0.2	0.1	0.4	0.8	12.4	64.4	21.7
MAY	0.0	0.0	0.0	0.9	9.1	75.0	15.0
SPRING	0.3	0.4	1.1	2.5	14.8	63.5	17.4
JUN	0.0	0.0	0.1	0.3	11.4	71.3	16.8
JUL	0.0	0.0	0.2	0.6	11.5	70.8	16.9
AUG	0.0	0.0	0.3	0.8	15.5	69.7	13.7
SUMMER	0.0	0.0	0.2	0.6	12.8	70.6	15.8
SEP	0.0	0.0	0.5	2.4	33.0	57.5	6.6
OCT	1.2	1.1	4.7	10.2	43.6	32.7	6.5
NOV	6.7	6.7	13.6	16.6	27.7	22.6	6.3
FALL	2.6	2.6	6.2	9.8	34.9	37.5	6.4

Table 3.8-12

Frequency (%) of Selected Visibility Categories at Bishop, California for the Period 1960 to 1964

PERIOD	VISIBILITY (MILES)						
	<¼	¼-1	1-3	3-5	5-10	10-25	>25
DEC	0.0	0.1	0.3	0.3	0.4	20.1	78.6
JAN	0.0	0.3	0.8	0.5	1.6	18.3	78.5
FEB	0.4	0.2	0.4	1.0	1.9	12.9	83.2
WINTER	0.1	0.2	0.5	0.6	1.3	17.2	80.0
MAR	0.2	0.1	0.3	0.5	0.8	4.8	93.3
APR	0.0	0.1	0.3	0.1	0.3	2.0	97.1
MAY	0.1	0.0	0.3	0.0	1.1	1.7	96.8
SPRING	0.1	0.1	0.3	0.2	0.7	2.9	95.7
JUN	0.0	0.0	0.0	0.1	0.4	0.5	98.9
JUL	0.0	0.0	0.0	0.1	0.1	0.3	99.4
AUG	0.0	0.0	0.1	0.2	0.2	1.0	98.6
SUMMER	0.0	0.0	0.0	0.1	0.2	0.6	99.0
SEP	0.0	0.1	0.1	0.2	0.5	5.0	94.2
OCT	0.0	0.0	0.1	0.3	0.7	9.4	89.4
NOV	0.1	0.2	0.8	0.5	1.6	16.4	80.4
FALL	0.0	0.1	0.3	0.3	0.9	10.3	88.0

In the mountains, visibility is extremely variable. Data is very scarce and the BLM is participating in programs geared to determine visibility on federally-administered lands. The data presented in Tables 3.8-9 through 3.8-12 is not felt to be indicative of conditions in rural, mountainous locations. In the Sierra Nevada, visibility is often impaired or reduced due to increased humidity caused by rapid uplifting of air from the Central Valley floor as well as by wind-blown dust.

Air quality can be determined from visibility observations at particular locations within the district. By eliminating moisture influences on atmospheric clarity, the remaining reduction in visibility is largely due to suspended to air contaminants. Table 3.8-13 presents the number of hours during a representative five year period that substantial visibility reduction occurred due to non-moisture effects. The criteria denoting a visibility violation in California was used to develop this table. A violation occurs when visibility is less than 10 miles and the relative humidity is less than 70 percent. Once again, data are not available for much of the mountainous areas in the district.

Table 3.8-13 indicates that at Monterey, violations of the California visibility standard occur primarily during the fall and winter months when stagnation episodes are most likely to occur. At Fresno, fall clearly dominates the ditribution of violations of the standard. The frequency of violations at this station represents the maximum for the data presented in Table 3.8-13 and corresponds well to the agricultural burn season. The southern end of the Central Valley portion of the Folsom District probably experiences the poorest dispersion meteorological conditions in the district. Stockton, located to the north of Fresno, also shows a fall maximum of violations of the visibility standard; however, the frequency is much lower than that at Fresno. This results in large part from Stockton's closer proximity to maritime Pacific air flowing eastward through the Carquinez Straits. Finally, at Bishop, east of the Sierra Nevada, air quality is generally quite good and violations of the standard are rare. In addition, many of these violations can be attributed to naturally occurring incidents of blowing dust. A more detailed discussion of dispersion meteorology and air quality is provided in other sections of this report.

Fog

Considerable visibility reduction is directly related to ambient moisture levels. Table 3.8-14 presents the mean number of days that visibility is less than one-quarter mile due to the presence of heavy fog.

The coastal regions of the Folsom District, as depicted by the San Francisco airport and Oakland data, experience heavy fog and visibility reduction during all months of the year, but primarily during winter. The Central Valley, as described by

Table 3.8-13

Total Hours Violating the California Visibility Standard *

in the Folsom District

MONTEREY

YEAR	DEC	JAN	FEB	WNTER	MAR	APR	MAY	SPRNG	JUN	JUL	AUG	SMMER	SEP	OCT	NOV	FALL	POS OBS
1959	127	36	35	198	34	50	48	132	26	45	29	100	12	50	110	172	8758
1960	24	30	14	68	6	14	6	26	30	26	47	103	43	55	30	128	8746
1961	19	77	18	114	14	43	3	60	23	23	11	57	66	23	13	102	8760
1962	64	5	16	85	13	16	1	30	4	5	21	30	6	34	41	81	8760
1963	90	134	21	245	22	28	21	71	25	33	62	120	85	59	52	196	8760

FRESNO

YEAR	DEC	JAN	FEB	WNTER	MAR	APR	MAY	SPRNG	JUN	JUL	AUG	SMMER	SEP	OCT	NOV	FALL	POS OBS
1960	87	89	61	237	122	30	9	161	95	72	119	286	156	332	138	626	8754
1961	50	63	95	208	29	78	26	133	90	130	80	300	183	346	326	855	8756
1962	171	104	13	288	69	120	34	233	85	170	134	389	217	180	257	654	8760
1963	13	276	102	391	95	59	146	300	87	77	166	330	173	196	68	437	8758
1964	37	81	250	368	128	85	42	255	56	106	143	305	291	323	82	696	8760

STOCKTON

YEAR	DEC	JAN	FEB	WNTER	MAR	APR	MAY	SPRNG	JUN	JUL	AUG	SMMER	SEP	OCT	NOV	FALL	POS OBS
1972	4	11	23	38	21	9	16	46	20	31	12	63	58	74	20	152	2920
1973	4	17	14	35	19	31	24	74	4	15	9	28	39	85	22	146	2920
1974	17	12	39	68	23	12	30	65	35	23	31	89	96	124	41	261	2929
1975	36	8	22	68	10	12	19	41	50	33	69	152	70	30	34	134	2920
1976	112	75	40	227	23	7	9	39	7	16	12	35	37	127	82	246	2920

BISHOP

YEAR	DEC	JAN	FEB	WNTER	MAR	APR	MAY	SPRNG	JUN	JUL	AUG	SMMER	SEP	OCT	NOV	FALL	POS OBS
1960	6	1	1	8	0	0	2	2	0	0	7	7	2	2	13	17	5084
1961	0	0	0	0	2	0	2	4	1	5	0	6	9	6	0	15	5098
1962	0	12	1	13	4	0	2	6	0	0	0	0	0	2	0	2	5108
1963	0	0	0	0	10	5	0	15	3	0	0	3	0	0	4	4	5107
1964	5	4	1	10	6	1	3	10	0	0	2	2	0	0	5	5	5109

* Visibility <10 miles; Relative Humitidy <70%

Table 3.8-14

Mean Number of Days With Visibility Less Than ¼ Mile Due to Heavy Fog in the Folsom District

	J	F	M	A	M	J	J	A	S	O	N	D	Annual	# of Years
San Francisco Airport	4	3	*	*	*	*	*	*	1	2	3	4	17	39
Oakland	4	2	1	*	*	0	0	0	*	2	3	4	16	46
Sacramento	10	6	2	*	*	0	0	*	*	2	6	9	35	28
Stockton	12	7	2	*	*	*	0	*	*	2	8	11	43	34
Fresno	12	7	2	*	*	0	0	*	*	1	6	11	40	27
Bishop	*	0	0	*	0	0	0	0	0	0	*	*	*	17

* Less than 1/2 day

data from Sacramento, Stockton and Fresno, experiences substantial visibility reduction due to heavy fog during the winter months. Visibility is reduced to less than one-quarter mile due to fog in the Central Valley portion of the Folsom District on nearly 40 days per year. Bishop, located on the leeward side of the Sierra, experiences very little visibility reduction due to fog.

Fog, is associated with moist, cool, surface air masses at the point of saturation. Fog can be classified into numerous types according to the physical processes responsible for its development. Fog types that are common in the Folsom District include:

- Radiational
- Advection
- Frontal

A very common type of land fog often experienced in the Central Valley regions, known as radiational or surface inversion fog, is produced by the radiational cooling of relatively shallow layers of calm, humid air, overlying a chilled land surface. This type of fog development requires certain nighttime conditions which include:

- Stable surface air
- Light or calm winds
- Clear skies

Stable surface conditions inhibit vertical diffusion of fog formed at the surface. Light winds promote radiational fog development by limiting mixing. Cloudless skies promote fog since they allow rapid heat loss from the surface thus permitting the ground to cool rapidly, even below surface air temperatures.

Radiational fog occurs in low-lying areas as cool, dense air drains into valleys and low-lying regions. Often, hilly areas will remain clear while adjacent lowlands are foggy. Radiational or ground fog deepens from the ground upward at night and is dissipated during the day by the warming sunlight from the top downward.

A particular fog type that often occurs in the Central Valley during the winter months is called Tule Fog. This type of fog develops not in conjunction with a surface inversion but when the inversion layer is commonly located at 400 to 2000 ft. above the surface. During this situation, warm dry air overlies cool air at the surface, thereby suppressing vertical movement. Continued cooling of surface air for a succession of nights results in fog at the surface. Turbulence and somewhat warmer temperatures usually lift the fog layer several hundred feet above the surface during the day. Hence, the fog appears as a low stratus cloud deck, residing at the base of the elevated inversion. High inversion type fogs are most prevalent during the winter season when influxes of polar maritime air often stagnate over the Central Valley providing ideal temperature and moisture conditions for such fog development.

Advection fog, unlike radiational fog, requires considerable air movement to promote formation. It simply requires that warm moist air masses be moved over cold surfaces and this most commonly occurs over ocean and coastal locations during summer. During this period, pressure gradients between oceanic and inland air masses are at a maximum, thus promoting inland movement (sea breeze). At coastal locations, warm moist air is channelled over and mixed with cold, moist, surface maritime air. Condensation of water vapor in the ambient air is promoted, thus forming fog. This type of coastal sea fog is most commonly observed during the summer months.

The frequency of occurrence of fog by month in the Folsom District is depicted in Figure 3.8-14. The figure depicts fog frequency in each of the three major climatic zones of the Folsom District.

3.8.5 Ocean Temperatures

Seasonal variations of ocean temperatures have a definite effect on the climatology of coastal areas. During the winter months, ocean temperatures are near and often above ambient air temperatures. In the summer, however, ocean temperatures are generally below ambient air temperatures. The physical effect of ocean temperatures on mean seasonal air temperatures at coastal locations in comparison to inland areas is outlined in the temperature section of this report. Mean monthly ocean temperature contours are presented in Appendix B. The mean monthly temperature change from the maximum to the minimum is only approximately 2.4^{o}C or 4.3^{o}F. Table 3.8-15 presents the mean monthly ocean temperatures for San Francisco and Monterey. Generally, ocean temperatures are warmer at Monterey than at San Francisco.

Mean annual temperatures for much of the California coastline are presented in Figure 3.8-15. Generally, the coastal waters along the southern portion of the Folsom District average about 54.5^{o}F. The northern coastal locations in the district record mean annual temperatures on the order of 53.2-53.6^{o}F.

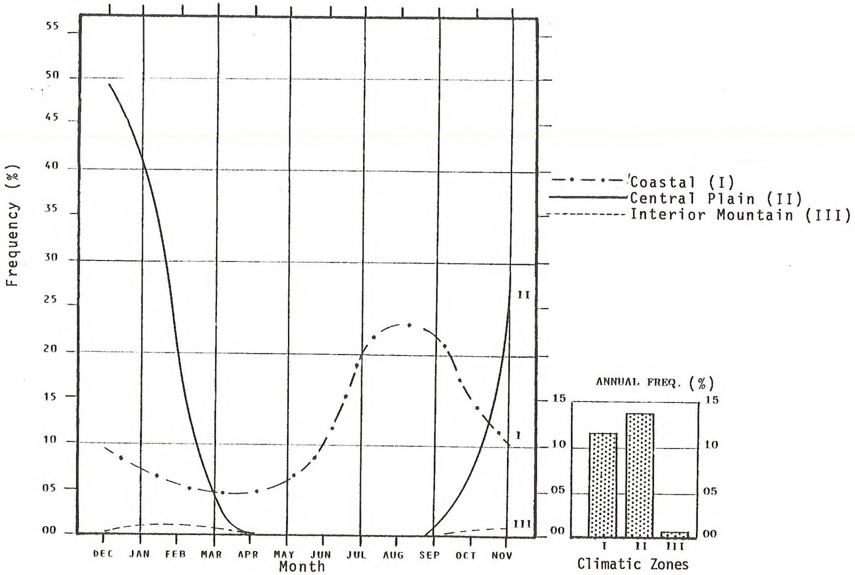
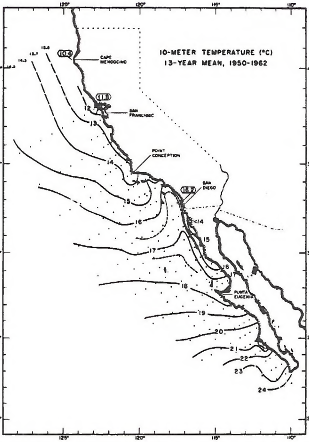


Figure 3.8-14

Frequency of Fog Development in the Folsom District

Table 3.8-15
Mean Monthly Sea Temperatures Along the Folsom District Coastline

	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
San Francisco												
°C	11.6	11.4	11.1	10.8	10.8	11.1	11.8	12.7	13.2	13.1	12.6	12.0
°F	52.9	52.5	51.9	51.4	51.4	51.9	53.2	54.7	55.8	55.6	54.7	53.6
Monterey												
°C	12.9	12.1	11.5	11.4	11.5	11.6	11.7	11.9	12.5	13.3	13.8	13.6
°F	55.2	53.8	52.7	52.5	52.7	52.9	53.1	53.4	54.5	55.9	56.8	56.5



Ten-meter temperature (°C);* 13-year mean, 1950–62. Interval: 1° C. In this and other figures thin, short-dashed lines show half intervals and thick, long dashes show continuation of standard-interval isopleths into regions of infrequent sampling. Boxed values refer to shore stations.

Figure 3.8-15

$*{}^{o}C = \frac{5}{9}\ ({}^{o}F-32)$

3.9 URBAN EFFECT UPON METEOROLOGIC PARAMETERS

There is hardly a meteorologic element that can be named that is not influenced to some extent by cities. It is, however, difficult to separate urban effects from microclimatologic effects since very few measurements have been made with the specific aim of comparing urban and non-urban measurements. There are several causes for the differences between urban and open country climates. One of these is the alteration of the surface, e.g., the change from meadow, forest or swamp to buildings and streets of concrete, brick, steel, and asphalt. Not only does this cause changes in reception and reflection of solar radiation and evaporation, but also in the roughness of the surface over which the wind moves. Another change involves the production of a sizable quantity of heat due to combustion processes carried out in the city and the addition of material to the atmosphere in the form of dusts, gases, and vapors which change the atmosphere's composition in the vicinity of cities.

Temperature

The comparison of temperatures within cities with those outside reveal that city temperatures, especially at time of minimum, are higher (Mitchell, 1961). Also during the period right after sunset, the city temperature does not cool as rapidly as does the country air due to heat content of buildings and radiation between buildings, rather than toward the sky. Between sunrise and noon, urban and non-urban temperatures are nearly the same (Landsberg, 1956). The influence of the city extends in the vertical on the order of three times the height of the buildings (Duckworth and Sandberg, 1954). The average heat island effect over New York City extends to 300 meters (100 feet) and has been observed as high as 500 meters (1650 feet) (Bernstein, 1968). Also, the change of temeprature with height is quite different over the city, especially at night. In the open country, radiation inversions form frequently, whereas in the city, isothermal or neutral conditions frequently exist through the night with a radiation inversion layer above the city (DeMarrais, 1961).

Since temperatures in the city are warmer than those of the surrounding countryside, the city's heating requirements are less by as much as 10%. Variations between city and country temperatures are extremely noticeable at northern latitudes when the countryside is covered with snow which has melted in the city.

Humidity

Lower relative humidities exist in cities partly due to higher temperatures, but also because of lower absolute humidity. Although little is available in the way of measurements, it is felt that lower absolute humidities are a consequence of the rapid runoff of precipitation in the cities. Also, the existance of little vegetation in the urban environment reduces moisture received from evapotranspiration processes (Landsberg, 1956).

Precipitation

Precipitation is one of the most variable meteorological elements and, because of this, it is difficult to establish significant differences between urban and non-urban areas. However, numerous studies have been made which show either greater precipitation amounts and/or greater frequency of precipitation within cities. Schmauss in 1927 showed 11 percent increase of days with small amounts of precipitation occurring in Munich compared to stations outside the city. Bolgolepow in 1928 reported an increase in precipitation of 10 percent in Moscow compared to a country station for 17 years of record. Ashworth in 1929 noted the increase of average annual precipitation over 3 decades amounting to 13 percent. He also noted less increase for Sundays than for weekdays. Wiegel in 1938 using a 35 year record, noted a 5 percent increase in precipitation, as well as a 12 to 18 percent increase in the number of days with precipitation for the Ruhr area of Germany. These references are all reported in Landsberg (1956). Landsberg also reports a study for Tulsa where topographical effects are at a minimum and the urban area is confined to a rather definite area. In addition to a precipitation increase within the city over a 70 year period, there was an increase of 7 percent in the city compared to surroundings for a 14 year period.

Two more recent studies by Changnon (1961a, 1961b) indicate there may be some urban effect upon precipitaiton over Chicago and the moderate-sized communities of Champaign, and Urbana, Illinois.

The principal suspected causes of the increase of precipitation over cities is the increase of condensation nuclei over cities due to air pollutants and the increased turbulence caused by increased surface roughness. Although water vapor is added to the air from combustion sources, this is not expected to add significantly to the amount of precipitable water or to evoke a major effect.

Snow

Precipitation in the form of snow indicates to some extent the influence of temperature in the urban area. Kossner in 1917 and Maurain in 1947 indicated greater frequencies of snowfall outside as compared to within Berlin and Paris, respectively. On the other hand, Kratzer in 1937 in Munich reported occurrances of snow within the city when none occured in the surroundings, and Keinle in Mannheim, a heavy industry location, reported that snow fell from a fog and stratus layer on two successive days in January 1949 while none fell outside the urban area. It is probable that this was due to air pollutants furnishing condensation nuclei for supercooled water vapor. These references appear in Landsberg (1956) who also estimates a 5% average decrease in snowfall for urban areas (Landsberg, 1968).

Cloudiness

From climatological records there seems to have been a slight increase in cloudiness over the years but this has been so slight (less than 1/10 of mean sky cover) that for so subjective a measure as sky cover this may not be significant. Any increase may be primarily due to city fogs, as increases in early morning cloud cover seems to be greatest. Nearly all large cities show a decrease in the number of clear days over that obseved in adjacent rural areas. The primary effects may be expected to be due to addition of condensation nuclei by air pollution and the release of additional water vapor. Kratzer in 1937 in Munich indicated an 8 percent increase in summer cloudiness compared to a 3 percent increase in winter cloudiness over the city (Landsberg, 1956). This may indicate that surface roughness and therefore, increasing turbulence, may play a part in the formation of cumulus type summer clouds.

Wind

Because of the general increase of the size of the roughness elements in the city over that in the rural areas, wind speeds are decreased within the city. Also the frequency of calms is increased on the order of 5 to 20 percent (Landsberg, 1956). Recently, Pooler (1961) has shown that under conditions of light stable flow, an inflow of air toward the center of the city of Louisville occurs (heat island effect). In addition to the decrease of wind speed in cities, there is of course channeling of the wind in the canyons formed by alternating streets and groups of buildings.

Radiation

The decrease of solar radiation within cities as compared to rural areas is on the order of 15 to 20 percent. This is due to the absorption, reflection, and scattering of particles in the atmosphere, and the absorption of gases. These particles and gases are primarily the result of air pollution. The radiation most affected is the ultraviolet with the infrared being least affected. This is important because of the bactericidal effect of ultraviolet radiation.

Recently, McCormick (1960) has begun measuring of the attenuation of the solar beam at 0.5 micron wave length in order to have an objective measure of the entire pollution layer. In terms of duration of sunshine, Landsberg (1968), shows a decrease in the range of 5-15% in urban areas. Randerson (1970) has showed an average of 23% loss in intensity of light attributed to pollution in Houston, Texas.

Visual Range

The decrease of visibility in urban areas is probably the most noticeable of meteorological differences between urban and rural areas. Comparisons between hourly observations of visibility at city locations and at rural locations (Landsberg, 1956) have shown higher frequencies of fog, smoke, and low visibilities than in neighboring rural areas.

Holzworth and Maga (1960) analyzed visibility measurements from California locations to determine if trends which might be caused by increases in air pollution were noticeable. Results indicated that several cities showed trends toward lowering visibilities. Other showed lowering visibilities until efforts at controlling certain pollutants were made, after which no trend was discernible.

3.10 GENERAL ASSISTANCE IN CLIMATIC PROBLEMS

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American Meteorological Society (See above)

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Professional Meteorological Consultants

Professional meteorologists advertise their services in the Professional Directory section of the Bulletin of the American Meteorological Society. In the May 1979 Bulletin, 83 such firms and individuals were listed. The American Meteorological Society has in the last several years instituted a program of certifying consulting meteorologists. Of the 83 professional services listings in the Bulletin, 40 list Certified Consulting Meteorologists.

Local U.S. National Weather Service Office

A wealth of meteorological informaiton and experience is available at the local city or airport Weather Service Office pertaining to local climatology, pecularities in local micrometeorological conditions including topographic effects, and exposure and operating characteristics of meteorological instruments.

Contract Work

Many universities do contract work for private organizations and for government agencies on meteorological problems.

3.11 GLOSSARY OF TERMS

Abscissa	The Horizontal coordinate or axis of any graph; usually denoted by X.
Absorption	The process in which incident radiant energy is retained by a substance.
Advection	The process of transport of an atmospheric property solely by the mass motion (i.e., wind) of the atmosphere.
Air Pollution Meteorology	That aspect of meteorology concerned with atmospheric dispersion characteristics
Aitken Nuclei	The microscopic particles in the atmosphere which serve as condensation nuclei for droplet growth. These nuclei are both liquid and solid with diameters of tens of microns or smaller.
Albedo	A measure of the part of the incoming solar radiation which is reflected from the earth and the atmosphere.
Annual Moisture Deficit	The moisture deficit of a month is the potential evapotranspiration less the rainfall and stored soil water. The sum of the appropriate months is the annual moisture deficit.
Anticyclone	Movements of air traveling in a clockwise direction (in the northern Hemisphere). Since anticyclone circulation and relative high atmospheric pressure usually coexist, the terms anticyclone and high pressure are often used interchangeably.
Attentuation	The process by which energy decreases with increasing distance from the energy source
Ceiling	The height of the lowest layer of clouds or other obscuring phenomena (e.g., dust). During clear weather, the ceiling in unlimited. With fog, the ceiling is obscured.
Centripetal Acceleration	Acceleration on a particle moving in a curved path, directed toward the center of curvature of the path.

Climate	The average condition of the weather at a place over a period of years as exhibited by temperature, wind velocity, and precipitation.
Compressional Heating	The disturbance of a fluid (e.g., air) such that the pressure and density and, therefore temperature, increase in the direction of motion.
Condensation	The physical process by which a vapor becomes a liquid or a solid.
Condensation Nuclei	A particle, either liquid or solid, upon which condensation of water vapor begins in the atmosphere.
Continental Climate	The climate that is characteristic of the interior of a land mass. It is marked by large annual, daily and day to day ranges of temperature, humidity and precipitation.
Convection	In general, mass motions within a fluid (e.g., air) resulting in transport and mixing of the properties of that fluid.
Cooling Degree Days	A form of degree day used to estimate the energy requirements for air conditioning or refrigeration. One cooling degree-day is given for each degree that the daily mean temperature deports above a base of 75°F.
Coriolis Force	A deflective force resulting from the earth's rotation; it acts to the right of wind direction in the Northern Hemisphere and to the left in the Southern Hemisphere.
Crystallization Nuclei	A particle which serves as a nucleus in the formation of ice crystals in the atmosphere.
Cumulonimbus	A principal cloud type, exceptionally dense and vertically developed, occurring either as isolated clouds or as a line or wall of clouds with separated upper portions.
Cumulus	A principal cloud type in the form of individual, detached elements which are generally dense and possess sharp non-fibrous outlines.

Cyclones	Movements of air traveling in a counterclockwise direction (in the northern Hemisphere). Since cyclonic circulation and relative low atmospheric pressure usually coexist, the terms clclone and low pressure system often are used interchangeably.
Cyclonic Storms	Large storm systems (50 to 900 miles in diameter or more) characterized by air rotating around a center of low pressure. More common in winter than summer. Rainfall and snowfall associated with such storms may be light, but may persist for two to three days or longer.
Dew Point	The temperature to which air must be cooled in order for saturation to occur.
Dew Point Depression	The difference between the air temperature an the dew point.
Divergence	The expansion or spreading out of a vector field (e.g., velocity field).
Dry Bulb Temperature	The ambient temperature of the air as measured by a dry-bulb thermometer.
Eddy Viscosity	The turbulent transfer of momentum by eddies (a glob of fluid with a fluid mass that has a life history of its own) giving rise to fluid friction.
Electromagnetic Waves	The ordered array of all known electromagnetic radiations, extending from the shortest cosmic rays, through gamma rays, x-rays, ultraviolet light, visible/light, infrared radiation, and including microwave and all other lengths of radio energy.
Electromagnetic Waves	Energy propagated through space or through material media in the form of an advancing disturbance in electric and magnetic fields existing in space.
Evaporation	The physical process that returns water from the earth to the atmosphere.
Evapotranspiration	The combined processes by which water is transferred from the surface of the earth to the atmosphere; <u>evaporation</u> of liquid or solid water plus <u>transpiration</u> from plants.

Exposure	The general surroundings of a site, with special reference to its openness to winds and sunshine.
Fall Velocity	That limited velocity attained by a body freely falling in air when the resisting force is equal to the gravitational force.
First Order Stations	A meteorological station at which automatic records and hourly readings of weather elements are made.
Free Atmosphere	That portion of the earth's atmosphere, above the planetary boundary layer, in which the effects of the earths surface friction on the air motion are negligible.
Friction Layer	The term is interchangeable with planetary boundary layer and surface boundary layer and refers to the layer between the surface and the free atmosphere.
Frictional Drag	The frictional impedence offered by air to the motion of bodies passing through it.
Front	In meteorology, generally, the interface or transition zone between two air masses of different density.
Frost-Free Period	The frost-free period refers to the length of the growing season as determined by the number of days between the last frost (i.e., 32°F) in spring and the first frost in fall.
Fujita Scale	A scale baed upon maximum wind speed to define the intensity of a tornado.
Gradient	The rate of change of a parameter as a function of distance.
Greenhouse Effect	The heating effect exerted by the atmosphere upon the earth by virtue of the fact that the atmosphere absorbs and reemits infrared radiation.
Growing Season	Generally, the period of the year during which the temperature of cultivated vegetation remains sufficiently high to allow plant growth (Usually synonymous with Frost-Free Period).

Heat Island	The accumulation of heat by large, man-made structures such as cities, resulting in considerable differences in temperature in comparison with surrounding areas, particularly at night.
Heating Degree Days	A form of degree-day used as an indication of fuel consumption; in the United States, one heating degree day is given for each degree that the daily mean temperature departs below a base of 65°F.
Hygroscopic Nuclei	Nuclei with a marked ability to accelerate thecombustion of water vapor.
Infrared (Radiation)	Electromagnetic radiation lying in the wavelength interval between visible radiation (light) and microwave radiation.
Inversion	An increase in temperature with height--a reversal of the normal decrease with height in the troposhpere; may also be applied to other meteorological properties.
Ions	In atmospheric electricity, any of several types of electrically charged submicroscopic particles normally found in the atmosphere.
Isobars	A line of equal or constant pressure.
Isohyet	A line drawn through geographical points recording equal amounts of precipitation during a given time period or for a particular storm.
Isothermal	Of equal or constant temperature, with respect to either space or time; more commonly, temperature with height; a zero lapse rate.
Jet Stream (Upper Level)	A quasi-horizontal stream of winds 50 miles per hour or more concentrated within a narrow band embedded in the westerlies in the high troposphere.
Julian Days	A calendar system based upon the sequantial numbering of each day of the year up to 365 with no monthly delineation.
Killing Frost	The frost sufficiently severe to damage the vegetation of an area. For the purpose of this report, when temperatures are 28°F or less.

Kinetic Energy	The energy which a body possesses as a consequence of its motion.
Lake Evaporation	Evaporation from a lake large enough and deep enough so that evaporation from most of its surface is unaffected by the temperature of the surrounding and underlying land.
Langley	Unit of energy per unit area commonly employed in radiation. One Langley is equal to one gram - calorie per square centimeter. The unit was named in honor of the American scientist, Samuel P. Langley (1834-1906) who made many contributions to the knowledge of solar radiation.
Lapse Rate	The decrease of an atmospheric variable (commonly, temperature) with height.
Latent Heat	The amount of heat absorbed (converted to Kinetic Energy) during the processes of change of liquid water to water vapor, ice to water vapor, or ice to liquid water; or the amount released during the reverse processes. Four such processes are condensation, fusion, sublimation and vaporization.
Leeward	The downwind side of an obstacle.
Marine (also Maritime)	A regional climate which is under the predominant influence of the sea. A marine climate is characterized by small diurnal and annual ranges in temperature.
Mechanical Turbulence	The induced eddy structure of the atmosphere due to the roughness of the surface over which the air is passing.
Mediterranean Climate	A type of climate characterized by hot, dry, sunny summers and a winter rainy season.
Meridional	Longitudinal; northerly or southerly; opposed to zonal.
Meso Scale	Between 5 and 50 miles.

Micrometeorology (also, Micro-climatology	That portion of the science that deals with the observation and exploration of the smallest scale physical and dynamic occurrences within the atmosphere.
Moisture Deficit	The moisture deficit of a month is the potential evapotranspiration less the rainfall and stored soil water.
Molecular Friction	Whenever the surface of one molecule slides over that of another, each molecule exerts a frictional force on the other, parallel to the surfaces.
Norther	A strong, very dry, dusty, northerly wind which blows in late spring, summer and early fall in the Valley of California or in the West Coast when pressure is high over the mountains to the north.
Orographic Lifting	The lifting of an air current caused by its passage up and over mountains.
Palmen's Model	A model describing the general meridional circulation of the earth's atmosphere.
Pan Evaporation	Evaporation of water from small pans exposed to the atmospehre. The standard Calss A land pan is four feet in diameter and ten inches deep, raised six inches from the ground so that air can circulate around it.
Parameter	In general, any quantity that is not an independent variable. The term is often used in meteorology to describe almost any meteorological or climatological quantity or element.
Perturbation	Any departure introduced into an assumed steady state of a system.
Planck's Law	An expression for the variation of monochromatic emittance as a function of wavelength of black-body radiation at a given temperature. It is the most fundamental of the radiation laws.
Pluvial Indices	The amount of precipitation falling in one day, or other specified period, that is likely to be equalled or exceeded at a given place only once in a given return period (often, 100 years).

Polar Front	The semi-permanent, semi-continuous front separating air masses of tropical and polar origins.
Potential Energy	The energy which a body possesses as a consequence of its position in the field of gravity.
Potential Evapotranspiration	Combined evaporation from the soil surface and transpiration from plants when the water supply in the ground is unlimited.
Pressure Gradient Force	The force due to differences in pressure within a fluid mass (e.g., air).
Radiational Fog	A major type of fog, produced over a land area where radiational cooling reduces the air temperature to or below its dew-point.
Radiosonde	A balloon-borne instrument for the simultaneous measurement and transmission of meteorological data.
Rainfall Frequency	The number of times during a specific period of years that precipitation of a certain magnitude or greater, occurs or will occur at stations.
Rain Shadow	The region, on the lee side of a mountain or mountain range, where the precipitation is noticeably less than on the windward side.
Rainfall Duration	The length of a rain event.
Rainfall Intensity	The rate of rainfall, usually expressed in inches per hour.
Reflection	The process whereby a surface of descontinuity turns back a portion of the incident radiation into the medium through which the radiation approached.
Roughness	A measure of the irregularity of a surface over which a fluid (e.g., air) is flowing.
Santa Ana	A hot, dry wind generally from the northeast or east, especially below mountain passes in Southern California.

Saturation	The condition in which the partial pressure of a fluid, e.g., air, is equal to its maximum possible partial pressure under existing environmental conditions such that any increase in the amount will initiate a change to a more condensed state.
Saturation Vapor Pressure	The vapor pressure, at a given temperature, wherein the vapor of a substance is in equilibrium with a plane surface of that substance's pure liquid or solid phase.
Scattering	The process by which small particles suspended in the atmosphere diffuse a portion of the incoming solar radiation in all directions.
Sea Breeze	A coastal local wind that blows from sea to land, caused by the temperature difference when the sea surface is colder than the adjacent land.
Sensible Heat	Same as enthalp, which is the measure of heat imparted to a system during a thermodynamic process.
Snow Basin	A term applied to a watershed for the measurement of snow characteristics such as depth, water content, etc.
Snow Course	An established line, usually from several hundred feet to as much as a mile long, transversing representative terrain in a mountainous region of appreciable snow accumulation.
Snow Pack	The amount of annual accumulation of snow at higher elevations in the Western United States, usually expressed in terms of average water equivalent.
Solar Insolation	The total radiant energy from the sun incident on a unit area of a horizontal plane located at the surface of the earth.
Solar Radiation	The total electromagnetic radiation emitted by the sun.
Squall Line	Any non-frontal line or narrow band of active thunderstorms.

Stagnation Episodes	Periods of poor atmospheric ventilation resulting in the potential for substantial pollutant levels.
Standard Atmosphere	A hypothetical vertical distribution of atmospheric temeprature, pressure and density, which by international agreement is taken to be representative of the global atmosphere.
Storm Track	The path followed by a center of low atmospheric pressure.
Stratosphere	The atmospheric layer above the tropopause, average altitude of base and top, 7 and 22 miles respectively; a very stable layer characterized by low moisture content and absence of clouds.
Stratus	A principal cloud type in the form of a gray layer with a rather uniform base.
Supercooled	The reduction of temperature of any liquid below the melting point of that substance's solid phase; that is, cooling beyond its nominal freezing point.
Supersaturation	In meteorology, the condition existing in a given portion of the atmosphere, when the relative humidity is greater than 100 percent.
Synoptic	In general, pertaining to or affording an overall view. In meteorology, it refers to the use of meterological data obtained simultaneously over a wide area for the purpose of presenting a comprehensive and nearly instantaneous picture of the state of the atmosphere.
Synoptic Scale	Weather patterns associated with high and low pressure systems in the lower troposphere, i.e., large scale.
Terrestrial Radiation	(also called earth radiation, eradiation) The total infrared radiation emitted from the earth's surface.
Thermal Buoyancy	Buoyancy attributable to a local increase in temperature.
Transpiration	The process by which water in plants is transferred as water vapor to the atmosphere.

Tropopause	The transition zone between the troposphere and stratosphere, usually characterized by an abrupt change of lapse rate.
Troposphere	That portion of the atmosphere from the earth's surface to the tropopause; that is, the lowest 6 to 12 miles of the atmosphere. The troposphere is characterized by decreasing temperature with height and by appreciable water vapor.
Tule Fog	A persistent, dense fog common in the Central Valley of California.
Turbulence	A state of fluid flow in which the instantaneous velocities exhibit irregular and apparently random fluctuations so that in practice only statistical properties can be recognized and subjected to analysis.
Ultraviolet (radiation)	Electromagnetic radiation of shorter wavelength than visible light but longer than x-rays.
Water Equivalent	The liquid water present within a sample of snow.
Wavelength	In general, the mean distance between maxima of a roughly periodic pattern (e.g., light).
Weather	The state of the atmosphere mainly with respect to its effects upon life and human activities. As distinguished from climate, weather consists of the short term (minutes to months) variations of the atmosphere. Popularly, weather is thought of in terms of temperature, humidity, precipitation, cloudiness, brightness, visibility and wind.
Wet Bulb Temperature	The temperature measured by a wet, muslim-covered bulb thermometer. The temperature an air parcel would have if cooled adiabatically to saturation at constant pressure by evaporation of water into it.
Wind Roses	Diagrams designed to show the distribution of wind speed and direction experienced at a given location over a considerable period. The most common form consists of a circle from which 8 or 16 lines emanate, one for each

	compass point. The length of the line is proportional to the frequency of wind from that direction; the frequency of calms is entered in the center.
Zonal	Latitudinal; easterly or westerly; opposed to meridional.

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