SAN FERNANDO VALLEY STATE COLLEGE

NEWHALL WINDS OF THE SAN FERNANDO VALLEY

**A thesis submitted in partial satisfaction of the
requirements for the degree of Master of Arts in**

Geography

by

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SAN FERNANDO VALLEY STATE COLLEGE

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PREFACE

My fascination for the study and analysis of wind was acquired during my college career at San Fernando Valley State. I took courses in meteorology, climatology, topoclimatology, and hydroclimatology, and received my Bachelor of Arts degree in geography in January 1965. In a short term-paper on "Wind vs Baseball," I analyzed five years of wind records for the months of February, March and April, to discuss the extreme difficulty and discomfort of playing baseball at the college field during Newhall wind storms. Some changes were suggested in the orientation of the playing field and the dimensions of the fences, based on the wind data as well as my personal experience and knowledge of the baseball field and baseball in general. I had played baseball at the College for four years under the extreme conditions of numerous wind storms.

Fully aware of the seven years of wind data recorded at the College by the Los Angeles County Air Pollution Control District, I chose for my master's thesis a study of the "Newhall" winds, which had never been investigated before. I wanted to find out when these winds could be expected each year; when the most intense wind storms would normally occur; and how they affect the San Fernando Valley..

Because the Newhall winds are a significant feature of the Valley and will continue to be a main climatic feature in this area, these winds and their effects should receive more attention, especially as this area develops rapidly into part of one of the world's great metropolitan areas. This thesis could be the first of several investigations of the Newhall winds of the San Fernando Valley. Many surface wind data for the entire Valley are available,

particularly at the Los Angeles County Air Pollution Control District. Studies of the lean of large trees in the Valley and of the relations between Newhall winds and air temperature, suggested in the text, would increase further the knowledge and understanding of these winds.

I wish to express my deep appreciation and gratitude for the assistance and guidance, throughout the study, of Dr. Arnold Court, climatology professor at San Fernando Valley State College and my thesis chairman. As the professor of all my climatology courses, his ideas and climatological knowledge clearly influenced me on several important issues.

Abstract

The Newhall Winds of the

San Fernando Valley

by

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To study the seasonal cycle, frequency and duration of the violent Newhall wind storms of the San Fernando Valley, seven years of surface wind data recorded in the northwestern portion of the Valley were analyzed. A Newhall "period" is defined as 6 or more continuous hours of northerly winds with mean speeds of at least 9 mph. A period continues as long as prevailing winds during each "moving" 6-hours are northerly with mean speeds of 9 mph or more. A Newhall wind "storm" is defined as a sequence of successive "periods" with no more than 24 hours elapsing between any consecutive periods.

From October through April, the northwest San Fernando Valley can expect 20 to 30 storms, half of them in November, December and January. Half of the wind storms will last 12 to 55 hours and usually three-fifths, or about 8 of the longest storms, will occur during November, December and January.

Chapter I INTRODUCTION

In the San Fernando Valley, a 10 by 23 mile basin forming the northern portion of the City of Los Angeles, the normal wind regime is essentially a combination of land-sea and mountain-valley breezes (Edinger et al, 1961). Superimposed on these are the winds of occasional cyclonic storms and fronts during the winter half of the year, a few rare thunderstorms, and strong, gusty, dry northerly winds several times each fall and winter. These may persist for several days, uprooting trees, breaking power lines, unroofing houses, swirling dust into homes and offices, and fanning fires.

The purpose of this thesis is to investigate these damaging northerly winds, to develop a definition of these winds, and to determine their seasonal and monthly frequency and duration.

RESEARCH ON NEWHALL WINDS BEFORE 1966

These northerly winds are closely related to the Santa Ana winds, well known in the Santa Ana Valley some 60 miles east of the San Fernando Valley. The typical Santa Ana wind blows through Cajon Pass, north of San Bernardino, and along the valley of the Santa Ana River (Map I).

MAP I MAJOR MOUNTAIN PASSES OF SOUTHERN
CALIFORNIA THROUGH WHICH THE NOR-
THERLY WINDS DESCEND

"The Santa Ana is a local name given to a dry northeast foehn-type wind that blows from the Cajon Pass down through the Santa Ana Canyon of Southern California toward the Pacific Ocean. The wind velocity may reach as high as 60 or 70 miles per hour, and the relative humidity is quite low (20 percent or less). This foehn-type wind occurs most frequently during the fall and winter months; however, it occurs occasionally in the Spring and may occur in the early or late Summer, but such cases are rare. . .

"Generally speaking when the Santa Ana blows through the Santa Ana Canyon, a similar wind simultaneously affects the entire Southern California area. Thus when meteorological conditions are favorable, this dry northeast wind will blow through the many passes and canyons, over all the mountainous areas including the highest peaks, and quite often at exposed places along the entire coast from Santa Maria to San Diego." (Sergius and Huntoon, 1949)

The western counterpart to the Santa Ana generally blows through the Newhall Pass into the San Fernando Valley, and because of this close association may be called a Newhall wind. Cajon Pass at the eastern end of the San Gabriel Mountains is much wider than the Newhall Pass at the western end. Therefore, more violent northerly winds pass through the regions below Cajon Pass than in the San Fernando Valley, and the Santa Ana winds have received much more attention than the Newhall winds.

In one of the few statements about Newhall winds, Zierer (1934) said that the San Fernando Valley also suffers in the autumn and winter from severe northers because the mountain ranges to the north are low. The San Fernando Valley received little attention in "Surface Wind Patterns in the Los Angeles Basin During 'Santa Ana' Conditions" (Edinger et al, 1964).

NATURAL SETTING

San Fernando Valley ($34^{\circ} 8'$ to $34^{\circ} 20'$ N, $118^{\circ} 15'$ to $118^{\circ} 39'$ W) is virtually surrounded by mountains, which converge and interlock in the north to form several well-defined mountain passes (Map 2). On the east and north, the San Gabriel mountains contain peaks more than 6,000 feet above sea level. The Santa Susana mountains to the north rise to 3,700 feet. The crest of Newhall Pass, separating these mountain ranges, is only about 1,250 feet. Beyond it, leading from the Mojave Desert, is Soledad Canyon.

On the south, the Santa Monica mountains reach their highest point around the Valley at Saddle Peak, 2,800 feet, and gradually lower to 1,800 feet toward the east. To the west are the lower Simi Hills, averaging only about 2,000 feet. To the southeast, the Verdugo and Hollywood Hills, between the San Gabriel and Santa Monica ranges, have high points of 3,100 and 1,800 feet, respectively. Santa Susana Pass, Topanga Canyon, Sepulveda Pass, and Cahuenga Pass are located in the northwest, southwest, south and southeast.

The natural drainage of the Valley is from northwest to southeast. The Valley slopes gradually from about 1,000 feet in the north and 900 feet in the west to less than 500 feet at the southeast exit through a mile-wide Glendale gap between the Verdugo and Hollywood Hills. The normal sea breezes from the coast at Long Beach or Santa Monica normally enter the Valley through this gap; others may flow into the Valley from the Oxnard Plain to the west.

CAUSES OF NEWHALL WIND STORMS

Synoptic conditions which cause Santa Ana and Newhall wind storms have been discussed by Young (1931) and Lockhart (undated); Krick (1933) described the thermodynamics of the Santa Ana.

MAP II SAN FERNANDO VALLEY AND SURROUNDING TOPOGRAPHY

During fall, winter and early spring, after cold air has settled in the Great Basin, causing high pressure, conditions may become favorable for this air to flow over and through the mountains down to the Pacific Ocean. (Bailey (1966) suggests that this accumulation of air dissipates by flowing just above the surface into the surrounding areas. The air which has accumulated over high ground (the mean elevation of the Great Basin is around 5,000 feet) tends to flow to lower elevation. It also subsides, adding to the compressional effects upon temperature. These effects lead to increased temperature of the air as it travels toward Southern California (compressional warming occurs at the rate of $5\frac{1}{2}$ degrees F per 1,000 feet of descent).

Furthermore, the relative humidity of the air continually decreases during the downward flow. Because the air passes over some of the driest regions (Mojave Desert, etc.) of the world, it does not obtain any significant amount of moisture. Thus, winds, originating as cold, dry air sweep down from the Great Basin, warming as they come. Reaching ground near the desert rim, they sweep down mountain slopes and through canyons to the sea.

Small variations in the synoptic pattern can produce large changes in the mesoscale Santa Ana and Newhall characteristics. Generally, the synoptic conditions necessary for the development of a Santa Ana or Newhall wind storm are: 1) development of high-pressure air over the Great Basin and 2) a cold front or at least a low-pressure ^{trough} hovering over Southern California. This combination usually results in strong, gusty winds and very low humidities over most of Southern California.

The nature of the High or anticyclone in the vertical depends on the temperature distribution within it. If the temperature is

highest at the center, the High will increase in intensity with height (warm-core High). If the temperature is the lowest in the center, the High will decrease in intensity aloft (cold-core High). The Great Basin High is usually of the cold-core type in fall and winter (Sergius, 1952). Thus, there is subsidence in the cold air with divergence near the surface and inflowing warmer air aloft. During the early fall and late spring, however, the warm-core type is frequently observed.

TYPES OF STORMS

Over mountain ridges and passes Santa Ana and Newhall flow patterns are persistent in direction, whereas in areas where spreading takes place (such as at lowest elevations) the variability of wind direction is apparent (Sergius, 1963). Eddies, usually associated with areas of maximum winds, are common in the Southern California region during the wind storms. They often dominate the direction of ultimate movement of fires.

Sergius (1963) divides the Santa Anas or Newhalls into two major classes. One type occurs at the surface, warming temperatures and lowering humidities over the entire area in the lee of the mountains; it was originally cold, dry air (polar Continental) denser than the marine air it replaced. This type is associated with most of the large and disastrous fires in the Los Angeles area, and has been of most concern here. The second type occurs only at high and intermediate levels, and does not surface into the Los Angeles basin and/or reach the coast. Winds of this type do not possess the necessary temperature properties to burn out the marine air and reach the coast. Such cases are infrequent.

Mixtures of these two types of wind storms undoubtedly occur as well. These mixtures as well as weak Newhall wind storms, eddy effects and general turbulence can result in the "lifting" of the violent winds from the surface for a period of time.

TEMPERATURE ASSOCIATED WITH NEWHALL WINDS

Although the Santa Anas or Newhalls are often called "desert winds," their occasional high temperatures and low humidities were recognized long ago as due not so much to their having passed over the desert as to the descent and compression of the air as it flows into lower elevations. As far back as December 30, 1901, the Riverside Daily Press published the correct explanation:

'Local Forecast: More north winds. High pressure and fair, cold weather to continue to give drying winds in Southern California, where it is considerably warmer, owing to the adiabatic or mechanical heating of the air' (Sergius, 1962).

Unusually high temperatures will sometimes accompany the Newhall winds in early fall and spring in the San Fernando Valley. However, in the late fall and winter the temperatures associated with these winds are rarely very high, because the High over the Great Basin is more often cold than warm during these months. Hence the adiabatic warming of the descending air usually brings it to a temperature not much different from the coastal air it displaces. The normal maximum temperatures for the Newhall wind storms range from 60 to 70 degrees F.

SUMMARY

The strong, gusty, dry northerly winds of the San Fernando Valley, called Newhall winds because of their close association

with Newhall Pass, are the western counterpart to the Santa Ana winds. When certain meteorological conditions occur (high-pressure over the Great Basin and low-pressure over Southern California), these violent winds blow through the Newhall Pass into the Valley.

The purpose of this thesis is to define the Newhall winds and determine their seasonal and monthly frequency and duration.

CHAPTER II NEWHALL WINDS EFFECTS

Local winds are one of the physical processes controlling the temperature distribution of the San Fernando Valley. Basically in this area two sets of winds work together throughout the year; the mountain-valley breeze and the land-sea breeze. These winds are responsible for most of the surface air passage through the region each year, principally during the spring and summer months. But during fall and winter the Newhall winds become very important.

The Newhall winds bring clear, dry air which results in fair weather and prevent smog from entering most of the Valley. They also bring much havoc and damage to property and persons in the region. Of particular concern are the extreme fire danger, the great damage inflicted upon citrus orchards, and the damage to vegetation and structures.

EXTREME FIRE DANGER

A great population influx into the San Fernando Valley has created a fire-fighting problem possibly without equal anywhere else in the world. Residential sub-divisions have pushed into steep, chaparral-covered mountains with narrow and winding access roads. Compounding an already enormous fire hazard is the threat of the Newhall winds. Wind speeds (gusts) may often reach 100 mph (Countryman, 1964) at exposed areas, and relative humidity frequently drops below 10 percent. Under these conditions brush and other vegetation that have been soaked by rain a few days before quickly become tinder dry. Fires during violent Newhalls are almost impossible to fight, and cause extensive damage annually.

Local weather conditions have a very important influence on the inception and behavior of wild fires (Edinger et al, 1964). In particular, strong surface winds, low humidities and vertical instability, which normally accompany the Newhall winds, favor the rapid development of a minor blaze into a full-blown conflagration. Examples of such destructive fires are the Griffith Park fire of October 3, 1933, the Bel Air-Brentwood fire of November 4-7, 1961, and the Pacoima Canyon fire of November 1, 1966. (The following details of these fires are summarized from accounts in the Los Angeles Herald-Examiner and the Los Angeles Times for November 2, 1966.)

The most tragic fire was the 1933 Griffith Park blaze which burned to death 29 welfare workers, pressed into service to help fight the fast-moving fire whipped by New hall winds. On November 4, 1961, a spark ignited the slopes of the Santa Monica mountains in Bel Air, and largely because of the violent Newhall winds the fire raged out of control for several days. Damage amounted to well over 24 million dollars, including four schools, 490 homes, and 125 automobiles destroyed; fortunately, no lives were lost.

In the most recent and second most tragic fire in the Los Angeles area, November 1, 1966, ten fire fighters were killed when they were trapped on a rugged Pacoima Canyon hillside while battling one of three brush fires in the northern hills of the San Fernando Valley. The first fire apparently started before dawn when Newhall gusts of 45 to 50 mph snapped a power line and sent sparks into dry hillside brush.

Other major fires in recent years included the 1958 New Year's Eve blaze in Topanga Canyon, the 1959 Laurel Canyon fire;

the 1961 Griffith Park fire, and the 1964 Chevy Chase, Whiting Woods, and Weldon fires in the Verdugo Hills. Hundreds of smaller fires in and around the San Fernando Valley have been caused by Newhall winds in one way or another.

DAMAGE TO CITRUS ORCHARDS

In the early twentieth century, when the Valley was mainly agricultural, the frequency and severity of the Newhalls were important factors in determining whether citrus fruits could be grown successfully. The Newhall wind storms were extremely unwelcome because of their damaging effect upon the citrus orchards. According to Durrenberger (1955), such winds probably rank next to freezes in their destructive effects on citrus in Southern California. These dry gusty winds cause rapid transpiration with a consequent loss of foliage, sunburning and fruit-drop.

Even though windbreaks such as large eucalyptus trees were used to reduce the wind's strength, citrus groves as well as other agricultural crops in the Valley often were injured severely by these winds. Several early accounts of damage associated with the violent dry northerly winds are given by Durrenberger (1955). The wind storm of January 11-13, 1946 caused three million dollars damage to the citrus orchards of Southern California (Bailey, 1966).

The decline in citrus production in the San Fernando Valley has made the Newhall winds less important for this crop here; but the related wind blowing down the Santa Clara Valley, northwest of the San Fernando Valley, is a major hazard to the citrus groves there.

DAMAGE TO VEGETATION AND STRUCTURES

Although these strong northerly winds are only a minor annoyance to the sheltered Valley dweller, they are still generally disliked. The wind storms, especially the strongest ones, cause an enormous amount of damage to the landscapes of thousands of Valley homes each year. Small trees fall under the wind's force, branches of larger trees (particularly the Chinese Elm) break, and crush whatever they fall upon. Smaller bushes and plants are also disrupted and destroyed.

One of the most important aspects of the Newhall winds is that they remove a large amount of soil moisture which results in some instances in destruction of or damage to vegetation. This removal of the top soil water results in additional expense to the Valley people due to higher water bills.

The cost of the landscape destruction by the Newhall winds must be huge; most private residences suffer some expense and inconvenience each year. Orchards were planted with some knowledge and understanding of these winds, but home owners, particularly recent buyers in the northern and western sections of the Valley, are generally completely ignorant of them. Trees and bushes planted directly in the path of the intense Newhall winds are seldom provided stakes, placed properly for added strength.

Buildings throughout the Valley also are damaged by these violent winds. Sections of home roofs are torn apart, windows are broken, and wooden fences are blown down. The winds knock down power lines, signs and television antennas, and trash containers, causing additional inconvenience and expense for the Valley residents.

The Newhall wind storms are most dreaded by those who live in regions which bear the full force of these winds, where they

are sometimes strong enough to unroof houses. On March 12, 1956 "Santa Ana" gusts up to 90 mph demolished houses in the Sunland-Tujunga area and caused fires (Sergius, 1962). Usually the people most affected by these strong gusty winds are motorists, farmers, pilots of light airplanes, people who work outdoors, and fire fighters most of all.

These Newhall winds are also a health problem to many people living in the San Fernando Valley. These winds carry allergens such as dusts, mold spores, animal danders, and pollen from a variety of plants. Asthmatic persons quite often have severe attacks during and after these wind storms. Hundreds of other people suffer dryness of the skin and scalp during these storms as well. Furthermore, during the normal "cobl" Newhall storms, many people develop colds or influenza because of the continuous rapid movement of cold air.

SUMMARY

The Newhall winds bring clear, dry air into the San Fernando Valley and prevent air pollution from entering most of the Valley. They also cause much annoyance and damage to persons and property throughout the region. The greatest concerns are the extreme fire danger, the damage to structures and vegetation, including citrus orchards and other crops.

CHAPTER III DEFINITION OF NEWHALL WINDS

Long before the advent of daily weather maps, people living in the San Fernando Valley, notably farmers and ranchers, had known of the Santa Ana or Newhall wind storms, and a body of legend had grown up around the behavior of this feature of the local climate. Several early accounts of high winds occur in books and newspapers, but often they cannot be identified definitely with the now famous Santa Ana or Newhall wind storms.

NO PRIOR DEFINITION

Even today no precise definition exists for these winds. During its most intense stage, a storm can be identified readily. But when did the storm begin and when can it be considered to have ceased?

For many years these wind storms have been considered as strong, gusty northerly winds accompanied by high wind speeds, low relative humidities, and occasional high temperatures. However, no quantitative limits have ever been given to these winds, such as the mean wind speed for a minimum number of hours. No mention has been found as to what wind speed is required before a genuine Santa Ana or Newhall wind storm can be said to exist or have existed. How many successive hours must these winds maintain these mean speeds? Is one hour long enough? Two hours? Ten hours?

This lack of quantitative limits is not unique to the Santa Ana or Newhall definitions. No such limits have been given to most, if not all, local winds throughout the world, listed in the

Meteorological Glossary (Anonymous, 1951). For example, the Norte is defined as "a strong, cold, northerly wind which blows mainly in winter on the shores of the Gulf of Mexico. Here it is sometimes humid and accompanied by precipitation." The Khamsin is a "southerly wind blowing over Egypt in front of depressions passing eastward along the Mediterranean or north Africa, while the pressure is high to the east of the Nile. As this wind blows from the interior of the continent it is hot and dry, and it often carries a considerable quantity of dust. It is supposed to be most prevalent for about 50 days from April to June." The Buran is "a strong NE. wind which occurs in Russia and central Asia. It is most frequent in winter, when it is very cold and often raises a drift of snow, but strong NE. winds in summer are also termed buran."

Local winds and others usually are defined only in general terms with no precise quantitative limits; without such limits, how can it be known for certain that any particular local wind occurred or was occurring at any given time?

To study the "Frequency of Dry East Winds over Northwest Oregon and Southwest Washington" and concomitant large forest fires, Cramer (1957) developed a "classification" of surface east winds. A "major-east-wind day" is defined as a day during which easterly winds were stronger than 9 mph, accompanied by relative humidities of less than 36 percent on at least two regular hourly observations. An "extreme-east-wind day" is a major-east-wind day with wind speeds greater than 19 mph accompanied by relative humidities of less than 26 percent on at least two regular hourly observations. Thus, Cramer uses the direction, speed, and humidity of the wind for his "classification" or definition of the

dry east winds over that area.

Edinger et al (1964) used certain criteria to study Santa Ana days in the Los Angeles basin, such as northerly winds of 10 mph or greater in the San Fernando Valley. Acceptance of a day as a Santa Ana day was contingent upon the existence of a recognizable foehn flow in the basin.

NEED FOR DEFINITION

Within the last few decades weather elements such as temperature, precipitation, and wind have been recorded with a good deal of accuracy and abundance. With the available surface wind data, a precise definition can be given to both the Santa Ana and Newhall wind storms, and hence these questions concerning the beginning and ending of the wind storms as well as numerous others can be answered.

Because the Newhall winds are important to most San Fernando Valley people, a definition of them would have much practical value. Not only would it be useful and informative to the residents of the Valley, but it could be used as a guide or "building-block" for a more comprehensive investigation of these winds in and around the Valley.

Such a definition which employs quantitative limits can provide an easy method of recording these winds, and hence also make it easy to study them. Annual and monthly data such as mean duration, frequency, longest and most intense wind storms, and other pertinent information can be gathered and kept on record. Without a good and easily-used definition only a rough, or at best, a fair record of these violent wind storms could be obtained. But why settle for a fair record when a good one can be made?

A definition of any natural phenomenon, especially wind, must be readily understood and used easily. How the weather element is recorded plays a vital role in the determination of the definition. For instance, if the element is recorded only twice a day, then the definition must take into account this fact. Otherwise, the definition will have no real value.

WIND OBSERVATIONS

To describe the Newhall winds of the San Fernando Valley, a weather station located near the wind's exit from Newhall Pass would be desirable. The only official weather station in the Valley, Burbank Airport in the southeastern portion of the Valley, is too far away from the Pass to give a fair representation of these winds. Fortunately the Los Angeles County Air Pollution Control District operates about ten wind recording stations in the Valley. The primary interest is in stagnant air, or winds of low speeds, in relation to air pollution in the Los Angeles region.

At San Fernando Valley State College, five miles south-southwest of Newhall Pass, wind records were obtained by the Air Pollution Control District from 1957 to 1963. Only the periods of low wind speed had been summarized, so these wind records provided extensive data on strong winds that had not been heretofore analyzed.

At this Air Pollution Control District station, a wind vane and a cup anemometer were located on top of the stock room building in the College maintenance yard. The top of the wind vane stood about 18 feet above the ground.

At the time of installation in 1956, no trees or other obstructions were close to the instruments. Eucalyptus trees to

the northeast, north-northwest, and south, were all more than 500 feet away. Hence, each wind direction could be easily recorded.

By 1966, however, small pine trees planted around the maintenance yard had grown into very large trees. Within 50 feet directly south of the wind instruments were four large pines averaging about 30 feet in height. Five other pines of the same size were some 150 feet or more to the northeast. Furthermore, several other trees averaging around 15 feet run the length of the northern fence of the yard.

Even with these obstacles the wind instrument location for the 1957-1963 period was adequate as far as the Newhall winds are concerned. Northerly winds and hence all of the Newhall wind storms were easily recorded because there were no physical obstructions in close proximity to the wind instruments.

DATA COMPILATION

Each week an Air Pollution Control District technician serviced the wind instruments and gathered the chart rolls bearing a continuous record of direction and speed of the wind. At the District office, hourly values were extracted from the charts: speeds to the nearest mile per hour and directions to 16 points: N, NNE, NE, etc. These were "eyeball" values -- the analyst's best judgment of the hourly average for the 60-minute period centered on each hour. Personal judgment and biases undoubtedly played a small role in the final results, but this method provides data of sufficient accuracy for most purposes, including the present study. At least, such hourly averages data are vastly superior to observations made only once an hour, or less

frequently.

Normally, wind strength increases with height above the surface. The friction near the ground, from the many obstacles producing turbulence, may cause wind speeds to double in the first 50 feet above the ground. Thus, the wind data obtained less than 20 feet from the ground surface are undoubtedly much lower than speeds at higher elevations. When the wind speed recorded at the College was 15 mph, some 50 to 100 feet higher it may have been 30 or 35 mph.

DEVELOPING A DEFINITION

The definition of the Newhall wind storm was developed from a study of seven years of hourly surface wind data recorded at San Fernando Valley State College by the Los Angeles County Air Pollution Control District. The definition was developed systematically by: 1) establishing a quantitative threshold for mean wind speed; 2) determining a minimum number of hours for northerly winds exceeding this threshold to obtain the concept of the Newhall "period;" and 3) using the definition of the "period" to define a Newhall wind "storm."

Developing a definition of these violent winds required understanding of their main characteristics: 1) persistent northerly wind direction, 2) high wind speed, and 3) low relative humidity.

Due to the lack of relative humidity data for this study, this characteristic of the Newhall winds was not studied in any detail. Hence, humidity was virtually ignored while developing the definition of the Newhall wind storms.

Although low relative humidity is important, largely because of the drying effect in the Valley, the most important character-

istic of the Newhall winds is high speed. Newhall winds, subjectively identified, were stronger than other high winds which came during the passage of cyclonic storms and fronts: 93 percent of the winds of 10 mph or more blew from Newhall Pass (Table 2).

Since high wind speed characterizes the Newhalls, it seemed reasonable that speeds below 10 mph could be ignored temporarily. (According to the Beaufort scale, wind speed below 10 mph are considered only as light or gentle breezes.) The next step was to study and analyze every hourly wind speed of 10 mph or greater from any direction within the 112 1/2-degree sector from north-northwest to the east-northeast.

This "new" wind tabulation suggested that a mean wind speed of 9 mph (at a 20-foot height) was a suitable minimum mean speed for Newhall wind storms. Generally, a wind storm rapidly increases to well over 9 mph, but this mean value of 9 mph enables the first and the last few hours of a storm to be included in the description. Furthermore, an hour with an average wind speed of 9 mph usually has had wind gusts of 15 mph or more during Newhall winds. The normal northerly drainage wind flow during the night and early morning in the Valley rarely approaches 9 mph. Therefore, winds from northerly directions averaging 9 mph or more come almost without exception during a Newhall wind storm, especially when they persist for several hours.

PERSISTENCE

Another major characteristic of the Newhalls, revealed by analysis of the "new" tabulation, is the persistence of these

winds once they begin. Generally, a Newhall wind storm continued for several hours without being interrupted by any other local wind. This characteristic was embodied in the concept of a Newhall "period", which was needed in association with the 9 mph mean value.

A "period" means a length of time or minimum number of hours for the northerly winds to be called "storm" winds. To define this period a more detailed analysis of the wind records was needed. The data revealed that, almost without exception, when Newhall winds had blown for 6 consecutive hours with mean speeds of 9 mph or more they would continue for several more hours. Until the wind had persisted for 6 successive hours its continuation was uncertain. In many instances, northerly winds averaging 9 mph or more blew for a few hours, then either weakened or were displaced by some other local wind regime. The number of cases (1957-1963) in which there were 2, 3, 4, 5, 6, 7, and 8 continuous hours of northerly winds averaging 9 mph or more and then discontinued were:

hours:	2	3	4	5	6	7	8
cases:	30	24	24	22	10	6	6

Less than 6 continuous hours would not be a wise choice for the beginning of a "period."

DEFINITIONS ADOPTED

From the preceding considerations, two definitions were adopted:

A Newhall period is 6 or more continuous hours of northerly winds with mean speeds of at least 9 mph. The period continues as long as each

"moving" 6 hours has a northerly prevailing wind (NNW to ENE inclusive) with a mean speed of 9 mph or higher. During a prolonged Newhall period (24 hours or more) the moving 6-hour means may be less than 9 mph for short intervals, but the northerly winds must still prevail and with no more than one hourly speed less than 6 mph. Furthermore, the first and last hour of a Newhall period must have northerly wind directions with speeds over 5 mph.

This system of moving 6-hour means can be illustrated by the following example. During a Newhall period the wind direction and speed (miles per hour) were: N 16, N 8, N 10, NE 12, NE 10, N 9. If the next hourly recording was N 8, then the next 6-hour period would be: N 8, N 10, NE 12, NE 10, N 9, N 8. Both of these 6-hour periods have mean wind speeds greater than 9 mph and thus the former period had continued. This system of moving 6-hour mean speeds would continue until the mean fell below, or did not fulfill the other requirements developed above. When this occurs the Newhall periods is said to have ceased; another one may begin one hour later, or any time thereafter.

Upon further study of these Newhall periods it was found that many periods were followed within a few hours by other periods. During the 1957-1963 wind record one-third of the Newhall periods (Table 6) were closely succeeded by another period, and one-fifth of the periods were succeeded by two or more periods within a short time. Keeping these facts in mind a Newhall wind storm was defined.

A Newhall wind storm is any number of successive Newhall periods with no more than 24 hours elapsing between consecutive periods. The storm lasts from the beginning of the first period to the end of the last period.

For illustration, on January 9, 1962, a Newhall period was first recorded at 3 PM and continued for 5 more hours. Then 7 straight hours of local winds followed. Another period began at 9 AM on January 10 and continued for 33 more successive hours. Thus a storm began at 10 AM on January 9, continued until 6 PM on January 11; it was considered to have lasted 57 hours including the 7 hours of non-period winds.

The 24-hour limit between periods was specified after study of the Newhall periods in the seven-year wind record. These storms are very turbulent and quite often are recorded at the surface only partially while they continue to blow furiously above. The surface data could show 20 hours of Newhall winds, 10 hours of local winds, and then 20 more hours of Newhall winds, although aloft, and nearby, the wind storm persisted for the entire 50 hours. The synoptic conditions responsible for one Newhall period are essentially the same for a second Newhall period that occurs within 24 hours.

During a weak or mild Newhall storm the local wind regimes in the San Fernando Valley often regain control for a short time. But during strong or intense storms these local winds are much too weak and very rarely appear until the storm passes. A weak storm may lift up, permitting other winds to blow at the surface, while at higher elevations the storm continues to be dominant. Strong storms, however, rarely lift; they prevail over

all other winds with ease.

SUMMARY

A definition of the Newhall winds would have much practical value because they are important to most San Fernando Valley people. Not only would it be useful and informative to the residents, but it could be used as a guide or "building-block" for a more comprehensive investigation of these winds in and around the Valley.

The definition of the Newhall wind storm was developed from a study of seven years of surface wind data recorded at San Fernando Valley State College. The definition was developed systematically by: 1) establishing a quantitative threshold for mean wind speed; 2) determining a minimum number of hours for northerly winds exceeding this threshold to obtain the concept of the Newhall "period;" and 3) using the definition of the "period" to define a Newhall wind "storm. "

Generally, a Newhall period is 6 or more continuous hours of northerly winds with mean speeds of at least 9 mph. The period continues as long as each "moving" 6 hours has a northerly prevailing wind (NNW to ENE inclusive) with a mean speed of 9 mph or higher. (A Newhall wind storm is any number of successive Newhall periods with no more than 24 hours elapsing between consecutive periods.

CHAPTER IV GENERAL RESULTS: WIND DIRECTION, WIND SPEED, HUMIDITY, AND TEMPERATURE

For the most part, the major characteristics of the Newhall wind storms that distinguish them from other wind regimes in the San Fernando Valley are: 1) persistent northerly wind direction, 2) high wind speed, and 3) low relative humidity. These general characteristics, as well as air temperatures, were studied for the Newhall wind storms defined previously.

PERSISTENT NORTHERLY WIND DIRECTION

The direction of the Newhall winds is their most consistent characteristic. The winds usually originate over the Great Basin when high-pressure has developed there. When the high-pressure air begins to move toward low-pressure areas (Southern California), the winds are blocked by the towering Rocky Mountains on the east and by the Sierra Nevada Mountains to the west. Consequently, these winds head southwestward toward Southern California. They enter the San Fernando Valley mainly through Newhall Pass and hence are northerly winds as they pass through the Valley.

After studying most of the Newhall wind storms during the seven years of wind data, it was evident that the majority of the wind storms blow from north-northwest to north-northeast, inclusive particularly in the northern and northwestern portions. The mountain gaps and passes north of the Valley alter to some degree the usual large-scale northeast winds set up by the synoptic conditions discussed earlier: northeast winds are deflected to the west as they rip through the passes and enter the Valley.

The San Gabriel Mountains act as a windbreak or wind shadow (Edinger et al, 1964; Zierer, 1934), much of the time shutting out the violent winds from the Los Angeles basin, except where the air pours through the two mountain passes on either end of the range: Cajon Pass to the east and Newhall Pass to the west. Under these conditions the winds are usually confined to narrow belts below the passes. The winds pouring out of the Newhall Pass disrupt the northwestern, western and often the central portions of the San Fernando Valley, while the eastern and southeastern areas may be unaffected.

Often, the eastern part of the Valley is obscured by smog carried by the sea breeze from the southeast, while a Newhall wind blows unimpeded in other sections of the Valley. At times, however, the winds pour over the tops of the San Gabriels (Dec. 25, 1956 and Dec. 26, 1966) and cause destruction throughout the whole Valley. On March 16, 1964, wind damage estimated at two million dollars occurred in Burbank and Glendale (Countryman, 1964).

The direction of these violent winds within the San Fernando Valley can be estimated from the direction in which trees lean. Because the Newhalls are the only winds accompanied by high wind speeds over a period of several hours or days in the Valley, trees tend to lean in the direction that the wind is blowing. After rainfall has soaked the soil to considerable depth, a subsequent Newhall storm can push many trees downwind.

Probably the best type of tree for such a study is the eucalyptus, which grows to around 100 feet in height. Eucalypti were imported for planting a barrier against the wind. Their large vertical trunks make their leaning comparatively easy to notice.

of hours of winds greater than various speeds as:

<u>Wind Speeds over</u>	<u>9 mph</u>	<u>14 mph</u>	<u>19 mph</u>
NNW-ENE (Newhall Periods)	4,273	1,407	209
(Non-Newhall)	272	--	--
All other directions	358	17	2
Total	4,903	1,424	211

GUSTS

"Since foehn winds often are swift and the heating rapid, it follows that the most pronounced of them are quite likely to be accompanied by frequent but irregular convections, and therefore, strong gusts, swirls, and general turbulence" (Humphreys, 1916).

The Newhalls are accompanied by all of these and the gusts are actually responsible for the high reported speeds of these winds. Usually the strong speeds of Newhall or Santa Ana winds that are mentioned are gusts rather than hourly averages. The gustiness of the Newhalls causes most of the wind damage.

The gusts occasionally knock down power lines that sometimes set off sparks, igniting fires. Often gusts cause large tree limbs to crack and break, damaging automobiles, buildings, and even people. Over the years, large eucalyptus and other trees have been blown over by repeated high gusts of wind. Normally these occur after a prolonged rain storm which soaks the ground to great depths, so the soil surrounding the large trees and holding the root system of the trees is very loose.

To illustrate the gustiness of two wind storms, Graph I shows instantaneous wind observations at one minute intervals on

January 16 and March 17, 1966, for 30 and 100 minutes, respectively. These data were obtained from a fast-response, light-weight cup anemometer, installed in early 1965 on top of the College Sierra Hall Tower approximately 149 feet above the ground. During the January wind storm the gusts ranged from 18 mph to 52 mph; the mean was 36.3 mph, and most were between 30 and 40 mph. During the March storm the lowest gust for the first hour was 11 mph and the highest was 33 mph. As the storm intensified so did the gusts, with a low gust of 15 mph and a high of 49 mph recorded.

The speed of the Newhall winds is highly variable from one minute to the next, in fact, from second to second. The gusts are greater and occur over a far longer time than other local wind regimes in the Valley. The gusty nature of the Newhall wind storms is their most dangerous feature: the wind speed can increase from 15 mph to 50 or 60 mph in one minute or less.

HIGHER SPEEDS DURING DAYTIME

Generally, the Newhall wind storms increase during the day until mid-afternoon and then decrease (Edinger et al, 1964). Of the 1,407 hours of Newhall winds of 15 mph or greater (Table 4), 287, or more than one-fifth, were during the three hours around 1:00 PM (Graph II); almost half (623/1,407) came during the seven hours from 9 AM to 3 PM, inclusive. The 209 hours of Newhall winds of 20 mph or more (Table 5) similarly were more frequent in the forenoon and early afternoon (Graph II), with half (101/209) from 9:00 AM to 3:00 PM.

Another aspect of the diurnal variation of the wind speed is the average speed, by hours for the Newhall storms (Graph III).

GRAPH I WIND GUSTS (MPH) DURING TWO
NEWHALL WIND STORMS*

* Data recorded on top of Sierra Hall Tower, San Fernando Valley State College, 149 feet high.

GRAPH II NUMBER OF HOURS OF WINDS EXCEEDING 14 AND 19 MPH
BY TIME OF DAY, 1957-63

GRAPH III

MEAN HOURLY WIND SPEED (MPH) DURING 67 NEWHALL STORM DAYS,
1957-1963

Individual storms, however, often do not follow this average pattern; only about half of the wind storms used for Graph III resembled the graph. The strongest winds in a given storm can occur at any time of the day or night, but usually the strongest ones occur in the early afternoon.

LOW RELATIVE HUMIDITY

As air descends from the Great Basin toward Southern California, it compresses with a corresponding increase in temperature and decrease in relative humidity. By the time this air flows through the Valley it has a dew point corresponding to the original temperature in the middle troposphere over the Great Basin. Consequently, the relative humidity of the Newhall winds is usually very low.

Sergius (1952) and Edinger et al (1964), in describing the climatology of the surface winds, temperature, and humidity associated with Santa Ana (and hence the Newhall), found that humidities were less than 20 percent throughout Southern California during this wind storm; they noted a slight tendency for humidity to be as high as 30 percent on mountain tops.

Newhall winds sometimes bring relative humidities as low as 5 percent, or less, during some of the driest wind storms. On November 6, 1961, during the disastrous Bel-Air fire, a temperature of 90 F and a relative humidity of only 4 percent was recorded at noon one and a quarter miles southwest of the fire area (Connon, 1962).

As mentioned earlier, there were no humidity data available for the 1957-1963 wind record at the College. Consequently, little investigation of this characteristic of the Newhalls was possible. Only a few wind storms were studied in 1966 and 1967.

During two early 1966 Newhall wind storms, relative humidity was recorded each minute at San Fernando Valley State College, from 16:20 to 16:45 on January 16, 1966 and from 08:00 to 09:42 on March 17, 1966. During both of these periods the relative humidity was below 20 percent. On February 20, 1967 during a Newhall wind the relative humidity fell to almost 10 percent.

TEMPERATURE ASSOCIATED WITH NEWHALLS

The presence of a Newhall storm often changes the normal diurnal temperature regime in the Valley. Despite occasional hot temperatures (90 F or more), the usual maximum temperature associated with these winds is much cooler (mid-60's F).

Thermograms during twenty wind storms at San Fernando Valley State College during October, November, December and January of 1961 suggest: 1) a minimum temperature for the day higher than normal, 2) a maximum temperature not necessarily higher than normal, 3) hence a small temperature range for the day, and 4) sometimes a rapid temperature increase upon the onset of a Newhall wind storm. The following examples from a single season appear typical of Newhall wind storm behavior.

Newhall winds resulted in higher minimum temperatures during the day. On the three days preceding a Newhall storm in December 1961, the minimum temperatures were 39, 41 and 40 F; after the two-day wind storm began, shortly before midnight of

the 21st of December, the lowest temperatures were 61 and 64 F.

The maximum temperature during a Newhall storm is not necessarily higher than the normal maximum temperatures of the season. For example, during the October 28, 1961 storm the maximum temperature was just 65 F, much lower than the 83 F recorded only three days earlier. During the 5-day storm of January 2-6, 1961, the high temperatures were 62, 62, 61, 65 and 74 F, and the succeeding two days had highs of 74 F each.

Temperatures throughout the day during a Newhall storm were clustered closely together. During the 5-day storm in January 1961, temperature ranges were 16, 11, 17, 13 and 20 F, respectively. The following two days, without a Newhall storm, had temperature ranges of 41 and 40 F.

When a Newhall wind storm begins at night, the temperature generally increases rapidly. On January 18, 1961, after the temperature had dropped to 41 F at 5:30 AM, a wind storm blew into the Valley, and in one hour the temperature rose 23 degrees to 64 F. On December 22, 1961 the temperature increased 16 degrees in one and a half hours after the onset of a Newhall wind storm.

At the end and start of the Newhall season, Newhall storms can bring very high temperatures. On April 15, 1966, a Newhall wind brought heated desert air which caused the temperature in downtown Los Angeles to rise to a record-breaking 99 F, -- the hottest April 15 in the 80 years of Weather Bureau records. Other temperature readings were 97 in Burbank, 96 in San Fernando and Canoga Park, and in the mid-90's throughout the Valley. In mid-October of 1966 two other hot Newhalls occurred and on November 1

a third one sent the mercury to 101 at Los Angeles International Airport and 100 F at the Los Angeles Civic Center, -- the hottest day of the year there, erasing the 99 F recorded on April 15. The Valley blistered as well, with Burbank recording a high of 97 and Northridge 96. (These hot Newhall storms are described in the Los Angeles Times for April 16 and November 2, 1966).

Occasionally, cold weather will accompany the Newhall wind storms. The maximum temperature recorded at San Fernando Valley State College during a very intense wind storm was only 44 F during December 13 and 14, 1967. Burbank recorded maximum temperatures of 45 and 47 F, respectively, for both days. Cold Newhall wind storms are rare, however.

SUMMARY

The Newhall winds are characterized by: 1) persistent northerly wind direction, usually north, north-northeast and northeast, 2) high wind speed resulting from high wind gusts sometimes over 100 mph at higher elevations near passes and 50 mph at lower elevations into the Valley, and 3) low relative humidity, usually below 30 percent and sometimes less than 10 percent. Effects of northerly winds are shown by the direction of lean of large eucalyptus and other trees.

A Newhall storm often suppresses the usual diurnal temperature regime in the Valley. The Maximum temperature for the day during most wind storms is usually in the mid-60's F, and is only occasionally 90 F or more.

CHAPTER V SPECIFIC FINDINGS: FREQUENCY AND DURATION

The definition of the Newhall wind storms enabled easy study and analysis of the seven-year wind records concerning: 1) the number of storms per year and month; 2) the duration of the storms per year and month; and 3) the number of intense storms per year and month. Using the adopted Newhall wind storm definition, 169 wind storms were recorded in the San Fernando Valley during the 1957-1963 period. It was found that there was a seasonal cycle of the wind storms with a maximum occurrence in December and January (winter solstice). Because of this seasonal character of the Newhall winds, the discussion that follows will deal with the seasonal values from July through June.

FREQUENCY

One of the most important facts about the wind storms is their annual total and how they are distributed throughout the year (July through June). Table 6 and Graph IV show the number of Newhall wind storms for the 1957-1963 period. A high of 29 storms was reached during the 1960-61 season and a low of 20 storms occurred during the 1962-63 season. Besides these two extremes the seasons were fairly close to one another. The seasonal mean was 24.3 and the median 24.0.

The distribution of Newhall wind storms is similar from one season to the next. The first two wind storms of the season normally occur in October. Their frequency increases through January, then declines gradually during the next three months.

GRAPH IV ANNUAL NUMBER OF NEWHALL PERIODS,
STORMS, AND INTENSE STORMS, 1957-
1963

The last storm of the season usually occurs in April; sometimes May.

November (mean 3.7), December (mean 4.6), and January (mean 4.9) have the most wind storms each season (Graph V). January 1962 had 8 Newhall wind storms which blew for 37.6 percent of the hours of that month. During the 1961-62 season 18 storms occurred from November through January. The lowest number during these three months was 9 storms in the 1962-63 season.

DURATION

Persistence of Newhall wind storms is shown on Graph VI, giving the cumulative frequency of the duration (hours) of Newhall storms. Of the 169 storms, 75 percent lasted longer than 12 hours, 50 percent longer than 28 hours, 25 percent longer than 55 hours, and 10 percent longer than 83 hours. The mean was 36.5 hours and the median 28.0. Six of the storms lasted more than four days.

Table 8 shows the mean and median duration of Newhall storms for each month. November through February have means of over 40 hours and medians of 42, 39, 35 and 30 hours respectively. The months of November, December and January accounted for 63 percent of the hours of Newhall wind storms for the seven-year period. February, March and April accounted for another 29 percent.

Usually longer storms occur during November, December and January. Of the 92 storms that occurred during these months only 32 (35%) lasted 24 hours or less; of the 77 storms in the remaining months, 47 (61%) persisted for 24 hours or less. Of the 46 storms lasting more than two days, 30 (65%) came during November, December and January.

GRAPH V NUMBER OF NEWHALL STORMS BY MONTHS, 1957-1963

During the seven years of wind data, Newhall winds were most dominant during December, January and February of 1960-61 (Table 10). The storms accounted for 231, 298 and 328 hours respectively, or 39.3 percent of all hours in these three months. The second worst three-month period occurred in November, December and January of 1957-58 when 30.3 percent of the hours had Newhall wind storms. The mean number of hours of Newhall winds was 883.0 with November, December and January accounting for 555.7 hours (61.2%).

Probably more significant than the number of hours of Newhall storms is the number of hours of Newhall periods (Table 9 and Graph VIII) and the proportion of each month that Newhall periods existed (Graph V). These values are more important because they include only the violent Newhall winds and no other winds.

The mean number of hours of Newhall periods was 783.1, some 100 less than the Newhall storms which included non-period winds. A high of 1077 hours occurred during 1960-61 and a low of only 516 hours occurred in 1962-63. November, December and January had a combined mean of 502.9 hours (64.2%) of Newhall periods. Usually, Newhall periods account for well over 20 percent of the hours of these three months.

LONGEST NEWHALL WIND STORM

The longest Newhall wind storm during the seven years of surface wind records at San Fernando Valley State College occurred December 21-28, 1956, just after the installation of the wind instruments, and was not included in the tables or graphs of the 1957-1963 data. This storm began at 14:00 December 21 and continued

GRAPH VII PROPORTION OF MONTH THAT NEWHALL PERIODS EXISTED, 1957-1963

GRAPH VIII NUMBER OF HOURS DURING NEWHALL PERIODS BY MONTHS, 1957-1963

for 178 consecutive hours until midnight of December 28. The wind speeds were very high: 165 hourly wind speeds were greater than 9 mph; and one hourly speed surpassed 30 mph. The mean hourly speed for the seven-day storm was 15.7 mph.

That the Newhall winds did not affect the entire Valley for all seven days is shown by the wind directions and speeds at six A. P. C. D. weather stations in the Valley (Table 13). Winds were variable in the eastern third of the Valley, while most of the remainder of the Valley was continually under the complete dominance of the Newhalls. The eastern portions, sheltered by the San Gabriel mountains from the strong winds from the Great Basin, are less affected by the violent northerly winds and the local wind regimes can continue. Hence, winds which roar out of the Newhall Pass usually pass through only the western two-thirds of the Valley, while the eastern areas experience their normal local winds.

The persistence of the local winds in the eastern and southeastern (and occasionally the northeastern) parts, is clearly evident (Table 13). Following the initial onset of the wind storm, the regular local wind regimes regained control of the eastern portions. The farthest penetration of the sea breezes during this storm, in the daytime hours of December 23, was very close to Newhall Pass, where they stopped abruptly in the face of the oncoming Newhall winds. During the lull in the seven-day storm, the Newhall winds were the weakest of the entire storm and affected the smallest area of the Valley.

The Christmas wind storm intensified in the early afternoon of December 24, and by midnight scoured the entire Valley; even the eastern and southeastern areas recorded six-hourly

wind speeds of 20 mph or more on December 25, 1956. Although the winds continued to pour through the western two-thirds of the Valley during the next few days, they were non-existent in the eastern areas except for a few late afternoon hours on the 26th.

The storm ended at midnight December 28 in the areas adjacent to Newhall Pass; the western and central areas had experienced their last Newhall winds some five hours earlier. The eastern Valley sections below the San Gabriel Mountains, as usual, did not have northerly winds at all that day.

This Newhall wind storm indicates that the violent winds do not affect the various sections of the Valley in the same manner. The eastern sections receive less amounts of Newhall winds than the central sections and far less than the northwestern and western sections.

INTENSE NEWHALL STORMS

Undoubtedly an important question for many people, especially those engaged in construction, is the number of intense Newhall wind storms in the San Fernando Valley each season, and when they are to be expected. An intense storm was generally defined as any one which persisted for 24 hours or more with many hours of wind speeds of 12 mph or more. Storms which lasted less than 24 hours but had at least six consecutive hours of wind speeds over 14 mph were considered intense as well.

Because the wind readings taken during each wind storm was only 20 feet above the ground, the wind speeds were much lower than would be obtained at a higher elevation or at a more exposed location in the northwestern portion of the Valley. Hence, although the College reading would be 12 mph the winds over most

of the northwestern area would be higher, perhaps 18 to 20 mph.

The mean and median numbers of intense storms per season were 12.5 and 11.5, respectively (Table 7). Almost two-thirds of the intense storms normally occur in November, December and January. An intense Newhall wind storm is rare from April through October; only 11 of the 85 intense storms during 1957-1963 occurred within these months.

MOST INTENSE STORM

The most intense Newhall wind storm was recorded at the College A. P. C. D. station November 29-30, 1957. It continued for 48 hours with 47 hourly wind speeds greater than 9 mph. The highest hourly speed was 24 mph and the mean speed for this two-day wind storm at the College was 17.8 mph -- extremely high for the Valley, even for the Newhall winds.

Table 14 shows the wind direction and speed for eight A. P. C. D. weather stations in the Valley during the storm. Although this particular storm was very powerful, it was otherwise typical of most Newhall wind storms. The onset was rapid, first in the northern and northwestern areas, and shortly afterward affecting the entire western two-thirds of the Valley. Mean wind speeds for the duration of the storm, were 16.9 mph at San Fernando in the northern part of the Valley, 15.2 mph at Van Nuys in the Central part, and 17.1 mph at Canoga Park in the Western part. Typically, the eastern sections did not experience these violent winds at the beginning, but had Newhall winds in the afternoons of both days. The northerly winds were pronounced in the northeast areas only during daylight generally, and the southern areas had fairly high wind speeds during day-time as well.

SUMMARY

Using the adopted Newhall wind storm definition, it was determined that the San Fernando Valley (largely the western and northwestern portions) can expect 20 to 30 Newhall wind storms each season with most occurring in November, December and January. The seasonal mean and median number of wind storms was 24.3 and 24.0, respectively. Most of the wind storms will persist for more than 24 hours, but one-quarter will last only 12 hours or less. The mean and median duration was 36.5 and 28.0 hours, respectively.

There is a seasonal cycle of wind storms with a maximum occurrence in December and January (winter solstice). The first two wind storms of the season normally occur in October. Their frequency increases through January, then declines gradually during the next three months. The last storm of the season usually occurs in April.

CONCLUSION

The Newhall wind storm definition was developed by:

- 1) establishing a quantitative threshold for mean wind speed;
- 2) determining a minimum number of hours for northerly winds exceeding this threshold to obtain the concept of the Newhall "period;" and
- 3) using the definition of the "period" to define a Newhall wind "storm."

For the most part, a Newhall period is defined as 6 or more continuous hours of northerly winds with mean speed of at least 9 mph, as measured 20 feet above the surface at San Fernando Valley State College. This period continues as long as each "moving" 6-hours has northerly prevailing winds with mean speeds of 9 mph or more. One or more such periods form a Newhall storm with no more than 24 hours elapsing between consecutive periods.

FREQUENCY AND DURATION

The western two-thirds of the San Fernando Valley can expect 20 to 30 Newhall wind storms, so defined, every season; November, December and January receive about half the total. Furthermore, a little over one-half of the wind storms will be intense (lasting 24 hours or more with many hours of wind speeds of 12 mph or more or storms which last less than 24 hours but had many consecutive hours of wind speeds of 14 mph or more); three-fifths of these occur in November, December and January.

Annual distribution of Newhall wind storms is similar from one season to the next. The first two wind storms normally occur

in October. Their frequency increases through January, then declines gradually. The last storm of the season usually occurs in April; sometimes in May.

The mean duration of a Newhall wind storm is nearly 40 hours but one-quarter persist for only 12 hours or less, while another quarter last longer than 55 hours. Three-fifths of the longest storms per season occur during November, December and January.

OTHER FINDINGS

A well defined boundary often separates the Newhall winds from the weak winds in the lee of the San Gabriel mountains. While the western and often the central Valley are scoured out by the Newhalls day and night, the eastern portion may feel only the diurnal ebb and flow of much weaker winds. Only during very intensive storms, or strong stages of storms, do the eastern areas experience the violent winds. Consequently, the frequency of Newhall storms and hours in the eastern one-third of the Valley is far less than that of the other sections of the Valley, particularly the north, northwestern and western sections.

SHORTCOMINGS

The definition of the Newhall winds is based on detailed study of seven years of surface wind data from a single weather station four miles from Newhall Pass; the wind recordings were made only 20 feet above the surface. Because the Newhall winds affect the various sections of the San Fernando Valley differently, the definition presented must be modified for use in other areas of the Valley. In the southern section the mean wind speed might

have to be lowered to 7 or 8 mph, or the 6-hour period might be shortened to 4 or 5 consecutive hours. Likewise, the wind direction criterion would have to be altered so as to be centered on Newhall Pass.

A major deficiency in the proposed definition of Newhall winds is the absence of relative humidity; low relative humidity is a major characteristic of the Newhall winds. Some short wind storms hence classified as Newhall winds may have been other fairly strong winds originating from Tujunga Canyon, or some other large canyon, or even a portion of a cyclonic storm. However, such mis-classified winds represent a very small proportion of the data, and could be avoided by a quantitative limit for the relative humidity.

RECOMMENDATIONS

Newhall winds will continue to be a main feature of the San Fernando Valley climate. The rapid population influx into the Valley and the concurrent development of this region into part of the world's great metropolitan areas require these violent winds and their effects to receive much more attention. It is hoped that this initial investigation will be a "building block" for several such studies.

The Newhall wind storm definition, while imperfect, is the first to be proposed for such phenomena. Its major value is that it can be used easily for study of such wind storms. Future investigations which use more thorough and extensive wind data, including relative humidity measurements, can improve the definition and understanding of these destructive winds.

APPENDIX

**Table 1 Locations of Wind Recording Stations
in the San Fernando Valley**

1. Canoga Park (CP, West Valley), 7507 Canoga Avenue;
elevation 800 feet.
2. Northridge (NR, Northwest Valley), 18111 Nordhoff Street,
San Fernando Valley State College; elevation 875 feet
3. San Fernando (SF, North Valley), 14808 Lassen Street,
KGIL Radio Station; elevation 880 feet.
4. Sun Valley (SV, Northeast Valley), 11805 Sheldon Street,
San Fernando Steam Plant; elevation 910 feet.
5. Burbank (B, East Valley), Burbank Lockheed Air Terminal;
elevation 699 feet.
6. North Hollywood (NH, Southeast Valley), 12755 Burbank
Blvd., KMPC Radio Station; elevation 670 feet.
7. Encino (E, South Valley), 5001 Balboa Avenue;
elevation 770 feet.
8. Van Nuys (VN, Central Valley), 8030 Balboa Avenue,
Air National Quad Base; elevation 793 feet.

TABLE 2 NUMBER OF HOURS WITH WIND SPEEDS
EXCEEDING 9 MPH, 1957 - 1963

	<u>FROM NEWHALL PASS (NNW-ENE)</u>		ALL OTHER	
	During Periods	Other Times	DIRECTIONS	TOTAL
JULY	6	0	29	35
AUG.	5	0	10	15
SEPT.	35	9	15	59
OCT.	176	27	7	210
NOV.	719	29	8	756
DEC.	1044	31	3	1078
JAN.	1041	46	17	1104
FEB.	504	39	37	580
MAR.	452	31	41	524
APRIL	245	46	89	380
MAY	34	10	36	80
JUNE	12	4	66	82
TOTAL	4273	272	358	4903

TABLE 3 NUMBER OF HOURS WITH WIND SPEEDS EXCEEDING
9 MPH DURING NEWHALL PERIODS, 1957-1963

	1957	57- 58	58- 59	59- 60	60- 61	61- 62	62- 63	1963	Total	Mean
JULY	-	6	0	0	0	0	0	0	6	0.9
AUG.	-	0	0	0	0	0	5	0	5	0.7
SEPT.	-	0	27	0	0	8	0	0	35	5.0
OCT.	-	47	13	28	32	36	4	16	176	25.1
NOV.	-	139	88	177	99	120	56	40	719	102.7
DEC.	-	98	174	173	191	123	95	190	1044	149.1
JAN.	129	200	90	76	245	226	75	-	1041	148.7
FEB.	16	32	45	77	214	21	99	-	504	72.0
MAR.	92	43	83	73	67	38	56	-	452	64.6
APR.	6	75	6	89	10	44	15	-	245	35.0
MAY	0	0	2	12	16	0	4	-	34	4.9
JUNE	12	0	0	0	0	0	0	-	12	1.7
TOTAL	255	640	528	705	874	616	409	246	4273	610.4

TABLE 4 NUMBER OF HOURS WITH WIND SPEEDS EXCEEDING
14 MPH DURING NEWHALL PERIODS, 1957-1963

	1957	57- 58	58- 59	59- 60	60- 61	61- 62	62- 63	1963	Total	Mean
JULY	-	6	0	0	0	0	0	0	6	0.9
AUG.	-	0	0	0	0	0	1	0	1	0.1
SEPT.	-	0	5	0	0	0	0	0	5	0.7
OCT.	-	11	2	10	9	15	0	0	47	6.7
NOV.	-	73	39	63	18	45	6	6	250	35.7
DEC.	-	46	43	83	97	33	18	35	355	50.7
JAN.	39	61	31	14	64	60	43	-	312	44.6
FEB.	9	5	9	22	56	3	57	-	161	23.0
MAR.	41	5	30	40	18	5	25	-	164	23.4
APR.	0	11	0	47	2	19	1	-	80	11.4
MAY	0	0	1	8	13	0	2	-	24	3.4
JUNE	2	0	0	0	0	0	0	-	2	0.3
TOTAL	91	218	160	287	277	180	153	41	1407	201.0

TABLE 5 NUMBER OF HOURS WITH WIND SPEEDS EXCEEDING
19 MPH DURING NEWHALL PERIODS, 1957-1963

	1957	57- 58	58- 59	59- 60	60- 61	61- 62	62- 63	1963	Total	Mean
JULY	-	0	0	0	0	0	0	0	0	0
AUG.	-	0	0	0	0	0	0	0	0	0
SEPT.	-	0	0	0	0	0	0	0	0	0
OCT.	-	0	0	1	0	2	0	0	3	0.4
NOV.	7	29	12	5	2	20	0	0	68	9.7
DEC.	-	5	0	9	15	2	1	0	32	4.6
JAN.	8	2	0	0	2	3	23	-	38	5.4
FEB.	2	0	0	2	9	0	13	-	26	3.7
MAR.	9	0	2	3	3	0	0	-	17	2.4
APR.	0	2	0	14	0	3	0	-	19	2.7
MAY	0	0	0	6	0	0	0	-	6	0.9
JUNE	0	0	0	0	0	0	0	-	0	0
TOTAL	19	38	14	40	31	30	37	0	209	30.0

TABLE 6 NUMBER OF NEWHALL PERIODS/STORMS, 1957-1963

	1957	57- 58	58- 59	59- 60	60- 61	61- 62	62- 63	1963	Total	Mean	Median
JULY	-	1/1	0/0	0/0	0/0	0/0	0/0	0/0	1/1	0.1/0.1	0/0
AUG.	-	0/0	0/0	0/0	0/0	0/0	1/1	0/0	1/1	0.1/0.1	0/0
SEPT.	-	0/0	3/1	0/0	0/0	1/1	0/0	0/0	4/2	0.6/0.3	0/0
OCT.	-	2/1	3/2	4/3	5/2	4/2	1/1	3/2	22/13	3.1/1.9	3/2
NOV.	-	9/5	4/4	10/5	2/2	6/4	6/2	5/4	42/26	6.0/3.7	6/4
DEC.	-	5/3	8/4	6/3	7/7	7/6	3/3	9/6	45/32	6.4/4.6	7/4
JAN.	4/3	9/5	6/4	5/5	7/5	11/8	4/4	-	46/34	6.6/4.9	6/5
FEB.	1/1	5/2	3/2	6/3	11/4	1/1	5/4	-	32/17	4.6/2.4	5/2
MAR.	5/5	3/2	5/4	6/1	7/6	4/2	5/2	-	35/22	5.0/3.1	5/2
APR.	1/1	6/4	1/1	4/4	1/1	3/2	2/2	-	18/15	2.6/2.1	2/2
MAY	0/0	0/0	1/1	1/1	2/2	0/0	1/1	-	5/5	0.7/0.7	1/1
JUNE	1/1	0/0	0/0	0/0	0/0	0/0	0/0	-	1/1	0.1/0.1	0/0
TOTAL	12/11	40/23	34/23	42/25	42/29	37/26	28/20	17/12	242/169	36.0/24.1	36/24

TABLE 7 NUMBER OF INTENSE NEWHALL STORMS, 1957-1963

	1957	57- 58	58- 59	59- 60	60- 61	61- 62	62- 63	1963	To- tal	Me- an	Med- ian
JULY-	-	0	0	0	0	0	0	0	0	0	0
AUG.	-	0	0	0	0	0	0	0	0	0	0
SEPT.	-	0	0	0	0	0	0	0	0	0	0
OCT.	-	1	0	1	1	1	0	0	4	0.6	1
NOV.	-	2	1	3	2	3	2	0	13	1.9	2
DEC.	-	3	3	4	4	3	2	3	22	3.1	3
JAN.	2	3	1	2	4	4	2	-	18	2.6	2
FEB.	1	0	1	1	3	0	2	-	8	1.1	1
MAR.	4	0	3	2	2	1	1	-	13	1.9	2
APR.	0	1	0	3	0	1	0	-	5	0.7	0
MAY	0	0	0	1	1	0	0	-	2	0.3	0
JUNE	0	0	0	0	0	0	0	-	0	0	0
TOTAL	7	10	9	17	17	13	9	3	85	12.2	13

TABLE 8 MEAN AND MEDIAN DURATION (HOUR)
OF NEWHALL STORMS AND PERIODS
1957-1963

	<u>S t o r m s</u>		<u>P e r i o d s</u>	
	<u>mean</u>	<u>median</u>	<u>mean</u>	<u>median</u>
JULY	6.0	6.0	6.0	6.0
AUG.	6.0	6.0	6.0	6.0
SEPT.	32.5	32.5	12.0	10.0
OCT.	28.9	13.0	12.3	20.0
NOV.	42.3	42.0	22.2	14.0
DEC.	43.1	39.0	28.8	20.0
JAN.	41.5	35.0	28.1	21.0
FEB.	48.8	30.0	20.7	15.5
MAR.	29.2	18.0	16.9	18.5
APR.	22.5	14.0	17.4	14.0
MAY	9.4	6.0	9.4	6.0
JUNE	16.0	16.0	16.0	16.0
TOTAL	36.5	28.0	21.8	15.0

TABLE 9 NUMBER OF HOURS DURING NEWHALL PERIODS,
1957-1963

	1957	57- 58	58- 59	59- 60	60- 61	61- 62	62- 63	1963	Total	Mean
JULY	-	7	0	0	0	0	0	0	7	1.0
AUG.	-	0	0	0	0	0	6	0	6	0.9
SEPT.	-	0	38	0	0	10	0	0	48	6.9
OCT.	-	59	26	54	47	55	7	22	270	38.6
NOV.	-	178	110	227	114	149	84	71	933	133.3
DEC.	-	122	223	203	231	150	116	249	1294	184.9
JAN.	148	269	121	94	290	280	91	-	1293	184.7
FEB.	18	60	70	108	263	24	120	-	663	94.7
MAR.	113	57	96	100	99	53	73	-	591	84.4
APR.	8	107	8	107	14	51	19	-	314	44.9
MAY	0	0	6	16	19	0	6	-	47	6.7
JUNE	16	0	0	0	0	0	0	-	16	2.3
TOTAL	303	859	698	909	1077	772	522	342	5482	783.1

TABLE 10 NUMBER OF HOURS DURING NEWHALL STORMS,
1957-1963

	1957	57- 58	58- 59	59- 60	60- 61	61- 62	62- 63	1963	Total	Mean
JULY	-	7	0	0	0	0	0	0	7	1.0
AUG.	-	0	0	0	0	0	6	0	6	0.9
SEPT.	-	0	55	0	0	10	0	0	65	9.3
OCT.	-	83	40	59	86	72	7	29	376	53.7
NOV.	-	223	110	273	114	154	118	84	1076	153.7
DEC.	-	135	249	229	231	170	116	273	1403	200.4
JAN.	156	310	153	94	298	309	91	-	1411	201.6
FEB.	18	+83	90	142	328	24	126	-	811	115.9
MAR.	113	59	104	109	105	63	90	-	643	91.9
APR.	8	124	8	107	14	57	19	-	337	48.1
MAY	0	0	6	16	19	0	6	-	47	6.7
JUNE	16	0	0	0	0	0	0	-	16	2.3
TOTAL	311	1024	815	1029	1195	859	579	386	6198	883.0

TABLE 11 NUMBER OF HOURS OF NEWHALL PERIODS,
 1957-1963

	MAX.	MIN.	2ND HIGHEST	NEXT TO LOWEST	MEAN	MEDIAN
JULY	7	0	0	0	1.0	0
AUG.	6	0	0	0	0.9	0
SEPT.	38	0	10	0	6.9	0
OCT.	59	7	55	22	38.6	47
NOV.	227	71	178	84	133.3	114
DEC.	249	116	223	122	182.7	203
JAN.	290	91	280	94	184.7	148
FEB.	263	18	120	24	94.7	70
MAR.	113	53	100	57	84.4	96
APR.	107	8	107	8	44.9	19
MAY	19	0	16	0	6.7	6
JUNE	16	0	0	0	2.3	0

TABLE 12 TOTAL NUMBER OF NEWHALL WIND STORMS,
1957-1963

	MAX.	MIN.	2ND HIGHEST	NEXT TO LOWEST	MEAN	MEDIAN
JULY	1	0	0	0	0.1	0
AUG.	1	0	0	0	0.1	0
SEPT.	1	0	1	0	0.3	0
OCT.	3	1	2	1	1.9	2
NOV.	5	2	4	2	3.7	4
DEC.	7	3	6	3	4.6	4
JAN.	8	3	5	4	4.9	5
FEB.	4	1	3	1	2.4	2
MAR.	6	1	5	2	3.1	2
APR.	4	1	2	1	2.1	2
MAY	2	0	1	0	0.7	1
JUNE	1	0	0	0	0.1	0

TABLE 13 DECEMBER 21-28, 1956 NEWHALL STORM: HOURLY WIND DIRECTION AND SPEED

STATION	H O U R S											
	00 12	01 13	02 14	03 15	04 16	05 17	06 18	07 19	08 20	09 21	10 22	11 23
December 21, 1956												
NR (NW)	- 2 ESE 5	- 2 ESE 4	- 1 N 16	- 1 N 22	- 1 N 32	- 2 E 20	- 2 ESE 10	NW 1 - 12	SE 1 - 16	E 3 - 15	E 4 - 10	SE 3 - 10
SF (N)	N 10 SE 6	NE 3 SE 6	N 3 NNW 12	N 3 NNW 19	N 3 NNW 17	NNE 3 NW 10	NNE 3 NW 10	NNE 3 NW 17	ESE 1 NW 16	SE 3 NW 17	ESE 4 WNW 13	SE 5 NW 8
SV (NE)	NNE 9 SSE 7	NNE 5 SSE 7	NNE 3 SSE 10	NNE 4 NW 20	NNE 6 NNW 19	NE 3 NW 9	NNE 3 NW 15	NNE 3 NW 13	NNE 2 NW 13	SSE 3 NW 12	SSE 5 WNW 10	SE 6 NNW 11
CP (W)	- 3	- 5	-- NNE 5	No Data NNE 7	No Data NNE 9	-- NNE 9	-- NNE 9	N 7	N 5	S 5	NE 5	NE 8
NH (SE)	WNW 4 SSE 6	W 1 S 6	W 2 NNW 4	W 2 NNW 18	WNW 2 NNW 16	WNW 2 NNW 25	W 4 NNW 14	W 2 NW 20	N 2 NW 15	N 1 NW 15	SE 6 NW 12	SE 5 NW 14

TABLE 13 (Continued)

STATION	H O U R S											
	00 12	01 13	02 14	03 15	04 16	05 17	06 18	07 19	08 20	09 21	10 22	11 23
B (E)	ENE 7	NE 7	NNE 6	ENE 15	NW 23	E 23	E 10	E 15	NW 17	S 13	SW 16	ESE 18
December 22, 1956												
NR (NW)	20 N 22	20 N 18	16 N 20	20 N 20	18 N 20	18 NNW 15	20 - 16	22 - 18	24 - 14	28 - 10	24 - 10	20 - 10
SF (N)	NW 6 SE 12	NW 16 S 6	NW 16 W 6	NW 16 NNW 16	NW 15 NNW 12	NNW 10 NNW 12	NW 16 NNW 17	N 16 NNW 18	N 10 NNW 15	NNW 8 NNW 16	NNW 16 NNW 14	N 18 NNW 12
SV (NE)	NNW 11 SE 9	WNW 10 SE 7	WNW 10 SSE 6	NNE 5 SSE 5	NE 3 SSW 3	NE 3 SE 3	NE 4 W 4	NE 4 NNW 5	NNW 2 NNE 5	SE 3 N 7	SSE 4 N 7	SE 9 N 6
CP (W)	NE 7 NNE 13	N 8 NNE 19	NW 10 NNE 16	NE 7 NNE 14	- 7 NNE 14	N 14 NNE 14	N 9 N 7	NNE 10 NNE 8	NNE 6 NNE 4	NNE 14 NE 0	NNE 14 NW 0	N 14 SW 1
NH (SE)	NNW 14 ESE 7	NNW 12 SE 7	N 6 SSE 6	NW 5 S 4	NW 3 SSE 2	W 2 N 1	NW 4 NNW 5	W 3 N 6	SW 2 NNW 3	W 1 NNW 9	SW 1 NW 3	ESE 5 W 1

TABLE 13 (Continued)

STATION	H O U R S											
	00 12	01 13	02 14	03 15	04 16	05 17	06 18	07 19	08 20	09 21	10 22	11 23
B (E)	N 10 E	NNW 11 SSE	SW 3 S	SSW 3 S	W 2 S	W 3 NE	NNE 3 NS	NNW 3 NNW	SSE 1 NNE	S 2 NNW	SW 1 NNE	SED 7 SW
December 23, 1956												
NR (NW)	14	15	10	---	No Data	---						
				10	8	6	3	1	16	-	-	17
	19	15	17	---	No Data	---						
				17	15	20	15	15	17	16	15	16
SF (N)	NNW 11 E 4	NNW 8 SE 6	NNW 10 SE 6	N 9 S 5	NNE 5 S 1	NNW 5 W 3	NNE 6 N 5	NE 4 NNE 1,	NNW 4 NNW 6	NW 6 NNW 14	SE 5 NNW 10	E 4 NNW 13
SV (NE)	N 7 SSE 4	N 5 SE 4	N 7 SSE 7	N 4 SSE 6	N 4 SSE 3	N 7 SE 4	NNE 10 NNW 4	NNE 8 NNW 6	N 6 NNW 7	NW 3 N 7	WSW 3 NNE 7	SE 3 NNE 7
CP (W)				---	No Data	---						
				---	No Data	---						
				---	No Data	---						
	4	10	11	10	6	4	7	-	-	-	-	-
NH (SE)	W 4 SE 3	NNW 3 SSE 5	WNW 2 S 8	NNE 1 S 6	N 1 SSW 1	WNW 1 N 1	WNW 3 NW 1	WNW 1 W 1	W 3 NW 4	W 1 W 3	N 2 NW 2	SW 2 W 5

TABLE 13 (Continued)

B (E)	E 1 S 2	NNE 2 E 5	SW 1 S 9	ENE 3 SSW 7	E 1 SSW 2	NNW 8 SSE 5	NNW 2 NNW 1	SE 1 NW 1	NW 1 NW 1	W 1 SW 1	WSW 2 NNW 3	NW 1 NW 2
December 24, 1956												
NR (NW)	16	17	19	18	16	14	17	16	16	20	18	20
	16	16	16	14	15	15	16	10	12	16	23	24
SF (N)	NNW 14 NNE 20	NNW 16 NNE 18	NNW 18 NNE 17	NNW 16 N 15	NNW 18 N 13	NNW 17 N 13	NNW 14 N 10	NNW 17 NW 12	NNW 18 NNE 10	NNW 15 NNE 10	NNE 18 NNE 12	NNE 18 NNE 15
SV (NE)	NNE 7 NNE 20	SSE 5 NNE 18	NNE 4 NNE 18	NNE 5 NNE 17	NNE 3 N 12	N 4 - 11	NNE 6 - 10	N 5 - 11	N 4 - 9	ESE 3 - 9	NNE 12 - 10	NNE 20 - 12
CP (W)	7	10	9	8	4	0	1	1	1	14	19	23
	19	24	14	14	14	14	14	14	14	11	10	10
NH (SE)	W 4 NE 10	NE 2 NNE 12	W 1 NNE 12	N 2 NNE 10	NE 2 NNW 6	W 1 NW 7	NW 1 N 4	WNW 1 NW 5	WNW 3 SW 4	WNW 2 W 2	NNE 10 WSW 2	NE 10 N 2
B (E)	NW 3 ENE 15	SSE 2 NNE 10	ENE 1 - -	NW 2 NE 18	E 1 NE 10	SE 1 W 2	NE 1 SW 6	NE 1 WNW 2	SSW 1 N 3	NNE 1 E 8	S 1 S 1	SSE 2 E 2

TABLE 13 (Continued)

STATION	H O U R S											
	00 12	01 13	02 14	03 15	04 16	05 17	06 18	07 19	08 20	09 21	10 22	11 23
December 25, 1956												
NR (NW)		--	No Data	--								
	20	16	16	12	10	20	19	23	24	20	18	17
	15	15	16	15	14	13	12	14	15	17	18	18
SF (n)	NNE	N	N	N	NNW	NNW	NNW	NNW	NNW	NNE	NNE	NNE
	16	18	12	13	13	20	17	17	16	20	20	17
	NNE	NNE	NNE	NNE	N	N	NNW	NNW	NNW	NNW	NNW	NNW
	18	16	20	20	16	15	12	20	22	20	20	17
SV (NE)		--	No Data	--								
	13	16	15	7	10	7	7	-	-	-	-	-
	-	-	NE	NE	NE	N	N	NNE	NNE	NNW	N	N
	-	-	15	15	10	9	6	5	6	12	14	14
CP (W)		--	No Data	--								
	12	14	13	13	8	9	9	10	10	14	14	13
	16	20	14	14	14	14	9	0	12	14	14	13
NH (SE)	N	NNE	NE	NNE	N	NNW	NNW	NNE	NNE	NNE	NNE	NE
	2	6	10	20	10	10	14	22	20	17	13	16
	NE	NE	NNE	NNE	NE	NNW	NNW	NNW	NNW	NNW	NNW	NNE
	18	20	20	20	16	18	2	7	10	14	14	10
B (E)	ENE	ENE	E	NNE	NNE	NNE	NNE	NNE	NNE	N	SSE	NE
	2	17	7	16	21	23	20	22	16	9	9	17
	NE	NNE	NE	NNE	NNE	S	SSE	WNW	NE	NNW	NE	NE
	16	25	21	11	17	5	1	6	6	8	7	8

TABLE 13 (Continued)

STATION	H O U R S											
	00	01	02	03	04	05	06	07	08	09	10	11
	12	13	14	15	16	17	18	19	20	21	22	23
December 26, 1956												
NR	-	-	-	-	-	-	-	-	-	-	NNE	NNE
(NW)	18	18	16	17	15	16	15	14	16	16	18	20
	NNE	NNE	NNE	N	N	N	N	N	N	N	N	N
	20	19	18	20	20	18	17	20	13	13	13	16
SF	NNW	NNW	NNW	NNW	NNW	NNE	NNE	NNE	N	N	N	N
(N)	15	16	16	14	12	13	14	14	20	20	17	20
	N	N	NNW	NNW	NNW	N	N	NNW	NNW	NNW	NNW	NNW
	20	18	17	18	17	17	16	20	16	12	10	14
SV	NNE	-	-	-	-	-	-	-	-	-	-	-
(NE)	10	7	11	10	9	5	9	9	6	11	13	16
	-	-	N	N	N	N	N	N	N	N	NNW	NNW
	13	16	5	4	10	12	18	19	16	14	13	14
CP			--	No Data	--							
(W)	14	13	16	16	14	14	14	14	14	16	18	18
	-	-	-	NNE	NNE	NNE	NNE	NNE	NNE	N	N	NNE
	9	9	9	20	20	20	20	16	18	16	16	20
NH	N	W	W	W	SW	NW	WNW	N	W	SE	ENE	NE
(SE)	3	1	1	2	1	2	2	1	2	1	2	5
	ESE	ENE	SE	NNW	N	N	WNW	WNW	WNW	W	WNW	NW
	6	4	4	8	14	13	9	5	5	5	5	1
B	NE	E	E	ESE	E	NW	WSW	WSW	E	W	E	SSE
(E)	3	3	3	1	1	1	1	2	1	1	6	3
	E	E	E	S	NNW	NNW	N	E	ENE	NW	WNW	ESE
	6	8	9	2	1	6	9	2	5	7	3	3

TABLE 13 (Continued)

STATION	H O U R S											
	00 12	01 13	02 14	03 15	04 16	05 17	06 18	07 19	08 20	09 21	10 22	11 23
December 27, 1956												
NR (NW)	N	N	N	N	NNE	NNE	NNE	NNE	NNE	NNE	NNE	NNE
	15	16	16	15	14	10	10	10	10	-	-	16
	NNE	NNE	NNE	NNE	N	N	N	NNE	N	N	N	N
SF (N)	17	17	17	16	14	13	12	16	16	17	17	14
	NNW	NNW	NNW	NNW	NNW	NNW	NW	NNW	N	NNE	N	N
	10	12	17	16	14	12	10	6	10	16	16	18
SV (NE)	N	N	N	NNE	N	N	N	N	N	NW	NNW	NW
	18	17	17	16	17	14	13	12	14	8	11	13
	NNW	NW	NNW	NNW	NNW	NNE	NNE	NNE	NNE	NNE	SSE	SE
CP (W)	13	14	12	9	7	9	6	5	7	13	7	4
	N	N	SE	SE	NNW	NNW	N	N	NNW	N	NNW	NNW
	13	17	10	4	13	14	14	15	12	8	6	9
NH (SE)	NNE	NNE	NNE	NNE	NNE	NNE	N	N	NNE	NNE	NNE	NNE
	12	14	14	12	10	9	8	6	10	7	12	14
	NNE	NNE	NNE	N	NNW	N	N	NNE	NNE	NNE	NNE	NNE
B (E)	14	14	12	10	6	8	9	8	12	12	11	12
	W	WNW	WNW	W	W	NW	NNW	NW	N	NE	E	SE
	2	4	3	6	4	3	1	7	14	7	4	1
B (E)	N	E	ESE	SE	NNE	S	W	WNW	NW	NNW	W	SW
	5	8	5	1	1	2	4	5	2	1	4	4
	WNW	E	E	N	N	E	ESE	NW	E	ESE	E	E
B (E)	3	5	2	1	2	6	1	7	7	6	8	2
	SW	SE	ESE	ESE	S	ESE	W	NE	NW	E	SW	WNW
	1	7	5	5	1	5	2	8	8	5	2	1

TABLE 13 (Concluded)

STATION	H O U R S											
	00	01	02	03	04	05	06	07	08	09	10	11
	12	13	14	15	16	17	18	19	20	21	22	23
December 28, 1956												
NR (NW)	N	N	N	N	N	N	N	N	N	N	N	NNE
	14	10	15	15	16	16	17	17	16	16	16	15
	N	N	NNE	NNE	N	NNE	NNE	NNE	NNE	N	N	N
SF (N)	15	15	8	12	10	10	10	9	8	6	9	12
	WNW	NW	NW	NW	NW	NW	NW	NW	NW	NW	E	ESE
	11	12	11	10	14	11	12	12	12	11	4	3
SV (NE)	SE	SE	ESE	SSE	NW	N	NNE	NNW	NW	NW	NNW	NNW
	4	5	4	4	2	3	5	6	6	10	7	8
	NW	NW	NE	SE	NNE	NNE	NE	ESE	SE	SSE	SSE	SSE
CP (W)	7	3	3	3	4	4	2	3	3	4	5	3
	SSE	S E	SSE	-	SSW	NE	NNE	NNE	NNE	NNN	N	N
	3	6	7	5	3	2	5	5	7	7	9	7
NH (SE)	NNE	NNE	NNE	NNE	NNE	NNE	NNE	NNE	NNE)	NNE	NNE	NNE
	11	11	13	12	10	12	9	10	13	13	14	14
	NNE	NNE	NNE	NNE	NNE	NNE	NNE	SE	SW	SSW	SSW	SSW
B (E)	14	14	12	11	10	9	8	1	0	0	0	0
	WSW	NNW	N	N	N	NW	W	WNW	N	NE	E	ESE
	5	1	1	1	1	1	1	1	1	1	2	1
B (E)	SE	SSE	SSE	S	ESE	NW	WNW	W	WNW	WNW	WNW	NW
	2	7	5	2	1	1	1	2	1	1	1	2
	SW	ENE	S	S	SE	ESE	NE	SE	SE	ENE	SSE	ESE
B (E)	6	2	1	1	1	1	1	1	1	1	1	6
	S	SE	S	S	SSE	ENE	NW	W	NNE	N	NNE	NE
	6	5	9	6	6	1	1	2	1	1	2	1

TABLE 14 HOURLY WIND DIRECTION AND SPEED AT EIGHT STATIONS DURING NEWHALL PERIOD
NOVEMBER 29-30, 1957

STATION	H O U R											
	00 12	01 13	02 14	03 15	04 16	05 17	06 18	07 19	08 20	09 21	10 22	11 23
November 29, 1957												
NR (NW)	N 9 N 20	N 12 NNE 18	N 13 NNE 19	NNE 14 NNE 21	NNE 15 NNE 21	N 16 NNE 19	N 18 NNE 19	N 18 N 17	N 20 NNE 20	NNE 22 NNE 21	NNE 24 NNE 19	N 21 NNE 20
SF (N)	NNE 7 NNE 22	ENE 8 NNE 23	NE 8 NNE 23	NNW 17 NNE 23	NNW 16 N 21	NW 16 N 24	N 17 N 24	N 18 N 17	N 18 N 18	N 22 N 18	N 22 N 14	N 20 NNW 12
SV (NE)	NNE 3 NE 10	NNE 4 NNE 14	NNE 5 NNE 18	N 5 N 21	N 7 N 23	NE 9 N 20	NNE 10 NNE 13	N 10 NNE 8	N 9 N 8	N 12 NE 3	N 16 NW 3	NE 16 N 7
CP (W)	W 2 NNE 22	SSW 2 NNE 23	S 2 NNE 22	NNE 14 NNE 21	NNE 15 NNE 22	NNE 14 NNE 20	NNE 18 NNE 20	NNE 18 NNE 20	NNE 20 NNE 20	NNE 23 NNE 20	NNE 25 NNE 20	NNE 24 NNE 21
VN (C)	4 18	-- 3 20	No Data 4 21	-- 15 19	15 18	14 18	16 17	15 16	15 16	17 16	18 15	15 13
E (S)	3 18	-- 3 18	No Data 3 19	-- 5 19	6 17	6 15	6 13	10 10	14 14	14 13	15 10	15 5

TABLE 14 (Continued)

STATION	H O U R S											
	00 12	01 13	02 14	03 15	04 16	05 17	06 18	07 19	08 20	09 21	10 22	11 23
NH (SE)	W 1 NNE 12	W 1 NNE 10	NNW 1 NE 8	W 2 N 14	N 2 N 15	NE 2 NNW 9	WSW 2 N 4	NNW 2 W 4	NW 3 SW 3	E 2 NNE 2	E 2 NNW 2	NNE 4 SW 2
B (E)	WNW 1 NNE 20	N 1 ENE 16	NW 1 E 12	WNW 1 N 10	NNE 3 NNW 13	E 2 N 5	S 1 SSE 1	WNW 1 SW 1	SE 3 S 1	SSE 6 SE 1	E 6 NNW 5	SSW 1 NNW 7
November 30, 1957												
NR (NW)	NNE 21 N 22	N 19 N 22	N 20 N 22	N 20 NNE 21	N 21 NNE 20	N 21 N 19	N 21 NNE 13	N 22 NNE 15	N 21 NNE 16	N 21 NNE 15	N 21 N 11	N 20 NNW 10
SF (N)	NNW 12 NW 17	NNW 12 NNW 16	NNW 14 NNW 17	NNW 16 NNW 16	NNW 15 NNW 15	NNW 13 NNW 17	NNW 15 NNW 18	NNW 16 NNW 15	NNW 18 NNW 17	NW 18 NNW 18	NW 17 NNW 18	NW 16 NNW 18
SV (NE)	NNE 10 N 5	SE 4 NNE 9	NNE 5 N 12	NNW 7 N 15	NW 12 N 11	NW 5 NW 5	E 1 NNW 6	NNE 3 N 5	NNW 3 NW 5	NNW 3 NW 3	NE 2 NW 5	NNE 5 NW 7

TABLE 14 (Concluded)

STATION	H O U R S											
	00 12	01 13	02 14	03 15	04 16	05 17	06 18	07 19	08 20	09 21	10 22	11 23
CP (W)	NNE 19 NNE 13	NNE 15 NNE 12	NNE 13 NNE 8	NNE 15 NNE 10	NNE 15 NNE 6	NNE 16 NNE 2	NNE 15 NNE 2	NNE 15 NNE 2	NNE 12 NNE 2	NNE 15 NNE 2	NNE 15 NNE 2	NNE 15 NNE 2
VN (C)	13	12	-- 14	No Data 15	-- 14	14	14	14	14	14	14	14
	14	14	-- 15	No Data 15	-- 14	15	15	14	14	14	13	14
E (S)	4	5	-- 6	No Data 5	-- 5	5	5	4	5	10	11	11
	14	13	-- 14	No Data 13	-- 10	5	6	6	5	4	3	3
NH (SE)	N 2 NW 8	NNW 1 NW 10	W 6 NW 11	W 6 NNW 10	W 4 NNW 11	N 2 WNW 5	NW 2 W 4	WSW 3 W 5	W 4 W 4	NW 6 W 2	NW 6 W 2	NW 6 W 2
B (E)	ENE 1 WNW 5	SSE 1 WNW 5	NW 1 WNW 7	WNW 1 NNW 12	W 6 NNW 12	ESE 3 NW 12	N 3 NNE 1	N 2 NE 3	NW 2 NW 2	ESE 3 ENE 1	S 2 N 1	SSW 1 SE 1

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