CHAPTER 17. SEVERE WEATHER

17.1 GENERAL BACKGROUND

Severe weather conditions vary greatly from the western portion of Placer County to the eastern portion, primarily due to variation in topography and elevation across the county. Heavy rainfall and snowfall result when humid air masses blow in from the ocean and move up the mountain ranges. Moist air, traveling inland on prevailing westerly winds, pushes up against the Sierra Nevada mountains, which wrings moisture out of the air as it rises, cools and condenses.

Roseville's location in the western, low-lying portion of the county helps explain why, at well below the 4,000 foot snowfall region, the city avoids the harshest of winter conditions that occur in eastern Placer County. Figure 17-1 shows Roseville's elevation at approximately 165 feet above sea level. Although the climate of Roseville is relatively nice, with an average of 257 sunny days each year, the City is near the foothills of the Sierra Nevada mountain range and can experience severe weather conditions resulting from rapid changes in topography.

Map 17-1 shows regional average precipitation from 1971 through 2000. Digital climate maps created using the Parameter-elevation Regression on Independent Slopes Model, available through the Spatial Climate Analysis Service, indicate that annual precipitation for the Roseville area averages between 16 and 20 inches.

Most of the federal and state disaster declarations declared in the Roseville area and Placer County are related to severe weather conditions. Federal disaster declarations may be issued by the U.S. Department of Agriculture and the Small Business Administration, as well as through FEMA. The quantity and character of the damage are the determining factors for which agency will authorize the disaster declaration.

DEFINITIONS

Severe Local Storm—Small atmospheric systems, including tornadoes, thunderstorms, windstorms, ice storms and snowstorms. Typically, major impacts from a severe storm are on transportation infrastructure and utilities. These storms may cause a great deal of destruction and even death, but their impact is generally confined to a small area.

Thunderstorm—Typically 15 miles in diameter and lasting about 30 minutes, thunderstorms are underrated hazards. Lightning, which occurs with all thunderstorms, is a serious threat to human life. Heavy rains over a small area in a short time can lead to flash flooding. Strong winds, hail and tornadoes are also dangers associated with thunderstorms.

Tornado—Tornadoes are funnel clouds of varying sizes that generate winds more than 300 miles per hour. A tornado is formed by the turbulent mixing of layers of air with contrasting temperature, moisture, density and wind flow. The mixing layers of air account for most of the tornadoes occurring in April, May and June, when cold, dry air meets warm, moister air moving up from the south. They can affect an area up to a mile wide, with a path of varying length. Tornadoes can come from lines of cumulonimbus clouds or from a single storm cloud. They are measured using the Fujita Scale ranging from F0 to F6.

Windstorm—A storm featuring violent winds. Southwesterly winds are associated with strong storms moving onto the coast from the Pacific Ocean. Southern winds parallel to the coastal mountains are the strongest and most destructive winds. Windstorms tend to damage ridgelines that face into the winds.

Winter storm—The National Weather Service defines a winter storm as having significant snowfall, ice, and/or freezing rain; the quantity of precipitation varies by elevation. Heavy snowfall is 4 inches or more in a 12-hour period, or 6 inches or more in a 24-hour period in non-mountainous areas; and 12 inches or more in a 12-hour period or 18 inches or more in a 24-hour period in mountainous areas.

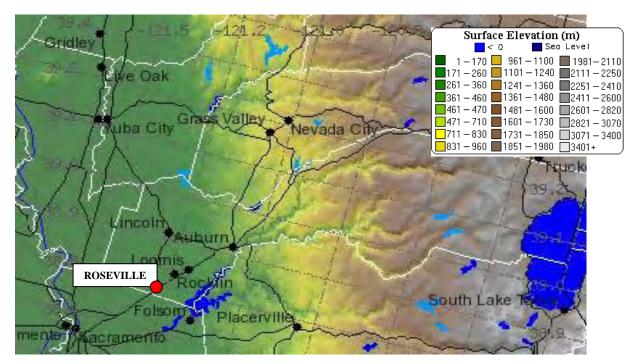


Figure 17-1. Roseville Regional Surface Elevation

17.1.1 Tornadoes

A tornado is a violently rotating column of air extending between, and in contact with, a cloud and the surface of the earth. Tornadoes are often (but not always) visible as a funnel cloud. On a local-scale, tornadoes are the most intense of all atmospheric circulations and wind can reach destructive speeds of more than 300 mph. A tornado's vortex is typically a few hundred meters in diameter, and damage paths can be up to 1 mile wide and 50 miles long. Figure 17-2, as adopted from FEMA, illustrates the potential impacts and damage from tornadoes of different magnitude. Tornadoes can occur throughout the year at any time of day but are most frequent in the spring during the late afternoon. As shown in Figure 17-3, California has a relatively low risk compared to states in the Midwestern and Southern U.S.

17.1.2 Windstorms

Windstorms are generally short-duration events involving straight-line winds or gusts of over 50 mph. These gusts can have sufficient strength to cause property damage. Windstorms are especially dangerous in areas with significant tree stands and areas with exposed property, poorly constructed buildings, mobile homes (manufactured housing units), major infrastructure, and above-ground utility lines. A windstorm can topple trees and power lines, cause damage to residential, commercial and critical facilities, and leave tons of debris in its wake.

Windstorms in Placer County are more probable during the fall through early spring. Because of the shape and orientation of the Sacramento Valley, prevailing winds are southerly. When atmospheric conditions are favorable, usually in conjunction with a significant storm tracking along the coast, these winds may combine and become strong enough to cause property damage and personal injury. The most significant windstorms in Northern California were the Columbus Day storm of 1962. Significant damage occurred along the coast and in the far northern part of the Sacramento Valley. Because Roseville lies far enough south in the Valley, windstorms such as those during the Columbus Day Storm of 1962, typically do not intensify to damaging levels. It is very infrequent for southwesterly winds flowing parallel to the Sierra Nevada Mountains to reach sustained gusts above 60 mph in the valley floor.

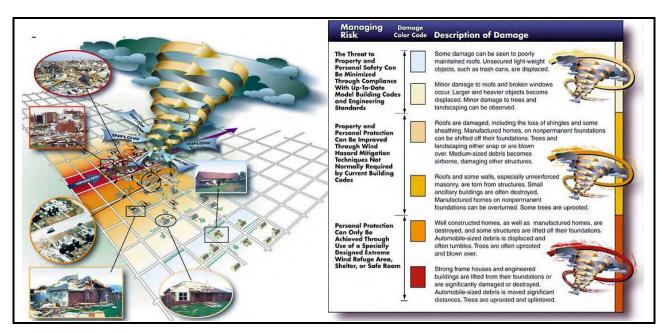


Figure 17-2. Potential Impact and Damage from a Tornado

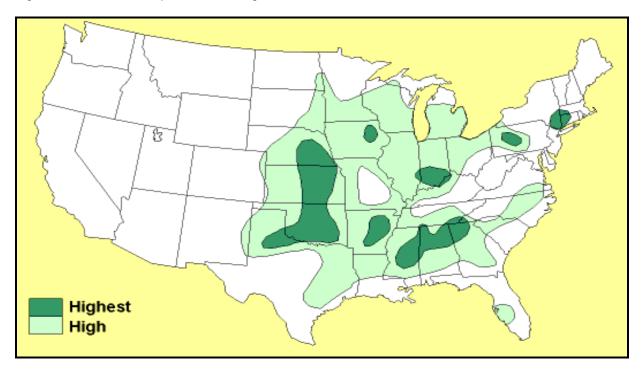


Figure 17-3. Tornado Risk Areas in the Coterminous United States

Site-specific data on windstorms in Roseville are inconclusive and incomplete. Regionally there have been a few historic windstorm events that resulted in significant damage. The impacts of these events were felt to the north and east of Roseville. There have been a couple of instances of unusual wind bursts that resulted in some property damage. December 1993 saw a downburst of wind that did significant damage to a sound wall that was under construction. Another event occurred on January 1, 1995 when a wind gust burst through northwest Roseville snapping several power poles. Table 17-1 shows monthly wind records for Sacramento.

TABLE 17-1. MONTHLY WIND RECORDS FOR SACRAMENTO, CALIFORNIA					
Month	Year of Record	Fastest Wind Speed (miles per hour)	Month	Year of Record	Fastest Wind Speed (miles per hour)
January	1954	60	July	1956	36
February	1938	58	August	1954	38
March	1952	66	September	1965	42
April	1955	45	October	1950	68
May	1912	40	November	1953	70
June	1950	47	December	1952	70

17.1.3 Fog

Fog is a cloud near the ground. Fog forms when air close to the ground can no longer hold all the moisture it contains. This occurs either when air is cooled to its dew point or the amount of moisture in the air increases. Heavy fog is particularly hazardous because it can restrict surface visibility. Severe fog incidents can close roads, cause vehicle accidents, cause airport delays, and impair the effectiveness of emergency response. Financial losses associated with transportation delays caused by fog have not been calculated in the United States, but it is known to be substantial. Fog can occur almost anywhere during any season and is classified based on how it forms, which is related to where it forms. Certain seasons are more likely to have foggy days or nights based on a number of factors, including topography.

In Placer County, heavy fog occurs mostly during the midwinter. A low-lying, early morning "tule fog" can occur anytime during the wet, cold season. Tule fog or radiation (ground) fog is common on clear nights with little or no wind and is caused by the rapid cooling of the Earth and corresponding drop in air temperature to the dew point. This type of fog is known as "valley fog" when it persists throughout the day and is thick. Table 17-2 summarizes dense fog events in the southern Sacramento valley.

TABLE 17-2. MONTHLY DENSE FOG OCCURRENCE					
Month	Year of Record	Mean Number of Days	Maximum Number of Days		
January	1961	9.9	23		
February	1963*	5.3	13		
March	1986	1.7	6		
October	1962	1.4	11		
November	1982	5.3	11		
December	1989*	9.5	22		
Annual	1962	33.8	64		
* Also occurred in previous years. Source: Masters-Bevan 2001.					

Given the nature of fog in the Roseville area and evidence of at least three fog events causing injury or property losses in the past few years, future severe or dense fog events are expected to happen on an annual basis, but are not expected to occur frequently.

17.1.4 Heavy Rains, Thunderstorms and Lightning

Severe weather in the City of Roseville generally includes heavy rains and is periodically accompanied by strong winds, lightning, or hail. Heavy rains coupled with low temperatures or other severe weather conditions can result in increases in traffic accidents, disruptions in transportation, commerce, government, and education. Severe weather incidents can also cause utility outages due to falling trees or other debris as well as injuries.

Roseville experiences what climatologists classify as a Mediterranean type of climate. This climate regime is typified by nearly 90 percent of the annual precipitation occurring a relatively narrow window of about 16 weeks. The most severe storms occur during the late fall to early spring. The climate pattern, coupled with the onshore flow of warm, moist Pacific air during the winter, can generate severe and prolonged periods of heavy rain.

Roseville experiences periods of heavy rains on an annual recurring basis. Some of these severe winter storms may also contain embedded thunderstorms. Thunderstorms are typically few in number and are more likely to appear in the spring or late fall. Table 17-3 shows the average and record occurrence of thunderstorms in Sacramento between 1948 and 2008.

Month	Year of Record	Average Number of Days with Thunderstorms	Greatest Number of Days with Thunderstorms
January	1970	0.4	3
February	1970	0.5	4
March	1992	0.8	4
April	1983	0.7	3
May	1967	0.3	3
June	1956	0.2	2
July	1989	0.2	2
August	1991*	0.2	2
September	1989*	0.5	2
October	1989*	0.3	2
November	1979*	0.3	3
December	1970	0.2	2
Annual	1970	4.7	10

^{*} Also occurred in previous years between January 1948 and December 2000. *Source*: Masters-Bevan 2008.

NOAA classifies a thunderstorm as a storm with lightning and thunder produced by cumulonimbus clouds, usually producing gusty winds, heavy rain, and sometimes hail. Thunderstorms are usually short in duration (seldom more than two hours). Heavy rains associated with thunderstorms can lead to flash flooding during the wet or dry season. According to the American Meteorological Society *Glossary of Meteorology*, thunderstorms are reported as light, medium, or heavy according to the following characteristics:

- Nature of the lightning and thunder
- Type and intensity of the precipitation, if any
- Speed and gustiness of the wind
- Appearance of the clouds
- Effect on surface temperature.

Lightning is an electrical discharge that results from the buildup of positive and negative charges within a thunderstorm. When the buildup becomes strong enough, lightning appears as a "bolt." This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning reaches temperatures approaching 50,000°F instantaneously. The rapid heating and cooling of air near the lightning causes thunder. Lightning is a major threat during a thunderstorm. In the United States, between 75 and 100 Americans are struck and killed by lightning each year.

Ice and freezing rain storms are not part of the climate pattern in southern Sacramento valley. Periods have occurred where the daily minimum temperature has been at or below 32°F for several days. Yet the low temperatures reflect diurnal variations with clear skies, not part of a synoptic feature generating any precipitation. The bitterest cold snap on record, occurring December 9 to 15, 1935, was ended by the onset of a Pacific storm bringing warmer air. Although ice storms and freezing rains are a significant natural hazard, the extremely remote possibility of their occurrence in Roseville precludes any further discussion in this analysis.

17.2 HAZARD PROFILE

17.2.1 Past Events

Table 17-4 summarizes past severe weather events in Roseville and Placer County as recorded by the National Oceanic and Atmospheric Administration since 1958.

17.2.2 Location

Severe weather events have the potential to happen anywhere in Placer County. Communities in low-lying areas next to streams or lakes are more susceptible to flooding. Mountainous regions experience heavier snowfall and a greater risk of road closures. Wind events are most damaging to areas that are heavily wooded. Maps 17-1, 17-2, 17-3, and 17-4 illustrate severe weather conditions for the Roseville planning area.

17.2.3 Frequency

Severe weather disaster declarations for Placer County, as shown in Table 17-4, are often related to heavy rains, thunderstorms, and freezing temperatures. The planning area can expect to experience exposure to some type of severe weather event at least annually.

TABLE 17-4.
SEVERE WEATHER EVENTS IN PLACER COUNTY SINCE 1958 (NOAA 2010)

Location	Date	Туре	Magnitude	Deaths or Injuries	Property Damage	
Placer County	01/13/1957	Tornado	F0	0	0	
Placer County	04/22/1967	Hail	0.00 Inches	0	0	
Placer County	10/15/1972	Tornado	F0	0	0	
Placer County	03/03/1983	Tornado	F0	0	0	
Placer County	03/22/1983	Tornado	F1	0	\$250,000	
Placer County	04/23/1990	Tornado	F0	0	\$2,500	
Placer County	12/30/1992	 Hail	0.50 inches	0	0	
•		erstorms produced golf bo	all-sized hail. Da	mage included signi	ficant destruction	
Roseville	12/22/1996	Thunder Storm/Wind	0	0	0	
Description: Down	iburst winds sna	pped five power poles that	t stood 75 feet hi	gh into several piece	?s	
Roseville	01/22/1997	Flash Flood	0	0	0	
Description: Heav	y rains on sature	ited soil caused flooding o	on Dry Creek and	d Linda Creek, dama	iging 21 homes.	
Roseville	01/26/1997	Flash Flood	0	0	0	
Description: Heav		ooding on Dry Creek and I		naging 21 buildings.		
Placer County	01/12/1998	Heavy Rain	N/A	0	0	
		rong Pacific storm caused and nearby foothills.	l widespread but 	minor flooding acro	oss the Sacramento 	
Placer County	01/18/1998	Heavy Rain	N/A	2	0	
Description: 0.75 inches of rain in 6 hours in downtown Sacramento was among the rainfall totals as a Pacific storm brought brief but heavy rain to the Sacramento and Northern San Joaquin Valleys and surrounding foothills. 27,000 customers across the area lost power at sometime during the storm. Numerous traffic accidents also occurred, including one near Loomis, CA in which two teens were drowned as their car flipped into a flooded ditch.						
Roseville	01/22/200	Heavy Rain	N/A	0	0	
Description: Rainf	all totaling 5.43	inches fell in just over 48	hours.			
Roseville	02/11/2000	Heavy Rain	N/A	0	\$10,000	
Description: Heavy rain that persisted for nearly 72 hours was responsible for the closure of Granite Bay High School. The school lost power and phone service. Local businesses were affected by the flooding and closed as well.						
Placer County	12/17/2005	Heavy Rain	N/A	0	0	
Description: A series of powerful and warm winter storms brought heavy rainfall to Northern California over five days. Five-day rainfall for Roseville was 2.99 inches.						
Placer County 01/01/2006 Severe Storm/Flood N/A 0 \$2,000,000 Description: A series of warm winter storms brought heavy rain, mudslides, flooding, and high winds to Northern California. Levee overtopping, breaching, and river flooding occurred along numerous rivers, creeks, and streams. Several urban areas had significant street flooding. The Sacramento weir was opened for the first time since 1997. Airports were closed due to high winds and major road closures resulted from flooding and mudslides. Interstate 80 between Sacramento and Reno, NV, was closed for more than a day due to a mudslide, as were both directions of U.S. Highway 50 between Sacramento and South Lake Tahoe. Place County was among the counties declared in need of federal disaster assistance.						

17.2.4 Severity

The most common problems associated with severe storms are immobility and loss of utilities. Fatalities are uncommon, but can occur. Roads may become impassable due to flooding, downed trees, ice or snow, or a landslide. Power lines may be downed due to high winds or ice accumulation, and services such as water or phone may not be able to operate without power. Lightning can cause severe damage and injury.

Windstorms can be a frequent problem in Placer County and Roseville and have been known to cause damages to utilities. The predicted wind speed given in wind warnings issued by the National Weather Service is for a one-minute average; gusts may be 25 to 30 percent higher.

Tornadoes are potentially the most dangerous of local storms, but they are not common in the Roseville vicinity. If a major tornado were to strike a populated area such as Roseville, damage could be widespread. Businesses could be forced to close for an extended period or permanently, fatalities could be high, many people could be homeless for an extended period, and routine services such as telephone or power could be disrupted. Buildings may be damaged or destroyed. Compared with other states, California ranks 32nd for frequency of tornadoes, none for number of deaths, 36th for injuries, and 31st for cost of damages. California ranks 44th for the frequency of tornados per square mile.

17.2.5 Warning Time

A meteorologist can often predict the likelihood of a severe storm. This can give several days of warning time. However, meteorologists cannot predict the exact time of onset or the severity of the storm. Some storms may come on more quickly and have only a few hours of warning time.

17.3 SECONDARY HAZARDS

The most significant secondary hazards associated with severe local storms are floods, falling and downed trees, landslides and downed power lines. Rapidly melting snow combined with heavy rain can overwhelm natural and man-made drainage systems, causing overflow and property destruction. Landslides occur when the soil on slopes becomes oversaturated and fails.

17.4 CLIMATE CHANGE IMPACTS

Climate change presents a significant risk management challenge, and dealing with weather and climate extremes is one of its more demanding aspects. The frequency of extreme weather events has increased steadily over the last century. The number of weather-related disasters during the 1990s was four times that of the 1950s, and cost 14 times as much in economic losses. Historical data shows that the probability for severe weather events increases in a warmer climate (see Figure 17-4). Understanding vulnerabilities from weather and climate extremes is a key first step in managing the risks of climate change.

The impacts on Placer County and the Roseville planning area could be significant. Rising seas and warmer climates could have significant impacts on the jet stream, which would impact the planning area's susceptibility to severe wind events and coastal storms. The changing hydrograph caused by climate change could have a significant impact on the intensity, duration and frequency of storm events.

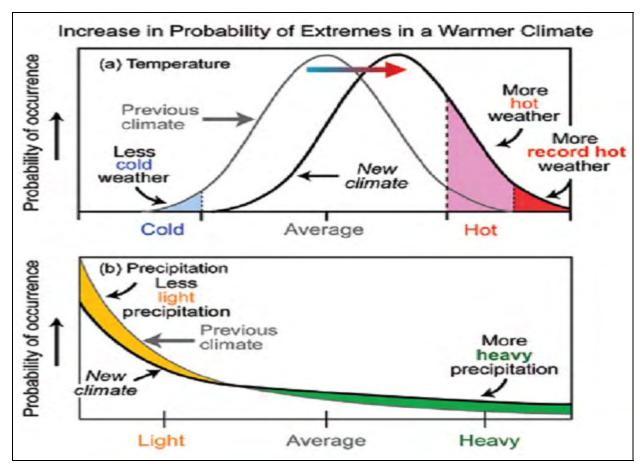


Figure 17-4. Severe Weather Probabilities in Warmer Climates

17.5 EXPOSURE

17.5.1 Population

A lack of data separating severe weather damage from flooding and landslide damage prevented a detailed analysis for exposure and vulnerability. However, it can be assumed that the entire Roseville planning area is exposed to severe weather events. Certain areas are more exposed due to geographic location and localized weather patterns. Populations living at higher elevations with large stands of trees or power lines may be more susceptible to wind damage and black out, while populations living in low lying areas are at risk for flooding.

17.5.2 Property

According to Roseville's most recent Quarterly Development Report, there are 37,451 residential buildings and 1,678 non-residential building units within the City. The total assessed value of this building stock is \$21,967 billion. This represents the approximate direct economic exposure to severe weather events within the City. All are considered to be exposed to this hazard, but structures in poor condition or built without the influence of building codes risk the most damage. The frequency and degree of damage will depend on specific locations.

17.5.3 Critical Facilities and Infrastructure

All critical facilities exposed to flooding (see Chapter 13) are also likely exposed to severe weather. Additional facilities on higher ground may also be exposed to wind damage or damage from falling trees. The most common problems associated with severe weather are loss of utilities. Downed power lines can cause blackouts, leaving large areas isolated. Phone, water and sewer systems may not function. Roads may become impassable due to ice or snow or from a secondary hazard such as landslides.

17.5.4 Environment

Severe storm events can drastically affect the physical environment, changing natural landscapes. Natural habitats such as streams and trees are exposed to the elements during a severe storm and risk major damage and destruction. Prolonged rains can saturate soils and lead to slope failure. Flooding caused by severe weather can cause stream channel migration. Additionally, snowmelt after snowstorms can cause riverine flooding, which has the potential to damage riparian habitat.

17.6 VULNERABILITY

There are currently no loss estimation tools with uniform damage functions for severe weather events. This can be attributed to the variety of impacts that severe weather events generate. Also, the severity of severe weather events varies by location. Since secondary effects of severe weather events include flooding, landslides or even wildfires in drier climates, the vulnerability assessments under those hazards can provide emergency managers a gage of the economic impact of severe weather events. For this section, the vulnerability to severe weather events is discussed anecdotally. Where possible, damage estimates are made using reasonable assumptions and best available data.

17.6.1 Population

Particularly vulnerable populations are the elderly, low income or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads. Power outages can be life threatening to those dependent on electricity for life support. Isolation of these populations is a significant concern. These populations face isolation and exposure during severe weather events and could suffer more secondary effects of the hazard.

17.6.2 Property

All property is vulnerable during severe weather events, but structures in poor condition or constructed to low building code standards risk the most damage. Those in higher elevations and on ridges may be more prone to wind damage. Those that are located under or near overhead lines or near large trees may be vulnerable to falling ice or may be damaged in the event of a collapse.

Loss estimations for the severe weather hazard are not based on modeling utilizing damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the assessed value of exposed structures. This allows emergency managers to select a range of potential economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 17-5 lists the loss estimates to the general building stock.

TABLE 17-5. ROSEVILLE BUILDINGS VULNERABLE TO SEVERE WEATHER HAZARD					
	Building Count	Assessed Value	10% Damage	30% Damage	50% Damage
Residential	37451	\$16,651,608,919	\$1,665,160,892	\$4,995,482,676	\$8,325,804,459
Commercial	1452	\$4,217,017,632	\$421,701,763	\$1,265,105,290	\$2,108,508,816
Industrial	127	\$924,770,716	\$92,477,072	\$277,431,215	\$462,385,358
Religion	39	\$99,045,483	\$9,904,548	\$29,713,645	\$49,522,742
Government	10	\$31,961,690	\$3,196,169	\$9,588,507	\$15,980,845
Education	50	\$43,422,420	\$4,342,222	\$13,026,666	\$21,711,110
Total	39,129	\$21,967,826,860	\$2,196,782,666	\$6,590,347,999	\$10,983,913,330

17.6.3 Critical Facilities and Infrastructure

Incapacity and loss of roads are the primary transportation failures, most of which are associated with secondary hazards. Landslides that block roads are caused by heavy prolonged rains. High winds can cause significant damage to trees and power lines, with obstructing debris blocking roads, incapacitating transportation, isolating population, and disrupting ingress and egress. Snowstorms at higher elevations can impact the transportation system and the availability of public safety services. Of particular concern are roads providing access to isolated areas and to the elderly.

Prolonged obstruction of major routes due to landslides, snow, debris, or floodwaters can disrupt the shipment of goods and other commerce. Large and prolonged storms can have negative economic impacts for an entire region.

Severe windstorms, downed trees, and ice can create serious impacts on power and above-ground communication lines. Freezing of power and communication lines can cause them to break, disrupting both electricity and communication for households. Loss of electricity and phone connection would result in isolation because some residents would be unable to call for assistance.

17.6.4 Environment

The environment vulnerable to the severe weather hazard is the same as the environment exposed to the hazard.

17.7 FUTURE TRENDS IN DEVELOPMENT

Many of the impacts associated with severe weather hazards can be addressed through proactive planning and utilization of best available information in making land use decisions. Roseville has and will achieve this goal through the implementation of its General Plan. The General Plan serves as a long-term policy guide for the physical, economic, and environmental growth of the City and includes a statement of the community's vision of its ultimate physical growth. Implementation of its General Plan along with other programs such as Building Code enforcement, public information and early warning will help Roseville to manage the probable impacts of severe weather hazards as the City grows in the future.

17.8 REVIEW OF EXISTING ORDINANCES, PROGRAMS, AND POLICIES

Roseville implements numerous programs and policies that can impact severe whether hazards. Like most programs and policies sited in this plan, these are tied to the city's General Plan. These programs and policies are addressed in Chapter 20, Review of Mitigation Alternatives. These existing programs are listed as an "ongoing" initiative under this review.

17.9 SCENARIO

A worst-case event would involve prolonged high winds during an extreme rainstorm or snowstorm accompanied by freezing temperatures, followed by warmer weather and continued rain. Such an event would have both short-term and long-term effects. Initially, schools and roads would be closed due to flooding, downed tree obstructions, and downed power lines. Power outages would be common throughout the city. Some subdivisions in the city could experience limitations on ingress and egress. Later, as the weather warms and rains continue while snow melts, the sudden runoff could produce flooding, overtopped culverts with ponded water on roads, and landslides on steep slopes. Flooding and landslides could further obstruct roads and bridges, further isolating residents.

17.10 ISSUES

In general, every household and resident in the City is likely to be exposed to severe weather, but some are more likely than others to experience isolation as a result. Those residing in higher elevations with limited transportation routes may have the greatest vulnerability to isolation from storms. Another group at risk is the portion of the population that is over the age of 65.

