



Hazard Identification, Risk Assessment and Consequence Analysis

JANUARY 2015



CITY OF SAN ANTONIO & BEXAR COUNTY

**City of San Antonio and Bexar County Office of Emergency Management
Hazard Identification, Risk Assessment (HIRA) and Consequence Analysis**

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Section 1 - Introduction

Hazard Identification, Risk Assessment (HIRA) and Consequence Analysis Overview

In order to prepare and plan for emergencies that may impact the City of San Antonio and Bexar County, it is necessary to understand potential hazards, what their history of activity is, and how vulnerable the community is to those hazards. The City of San Antonio and Bexar County, Hazard Identification, Risk Assessment (HIRA) and Consequence Analysis, is the first step in evaluating natural and technological hazards that exist. The hazards identified in this document have the potential of becoming emergencies or disasters that can adversely and irreversibly affect the people, economy, environment, and property of the City of San Antonio and Bexar County.

The HIRA serves as a basis for the development of plans, public education programs, responder training and exercises. It also lays the foundation to begin mitigation efforts to minimize these identified potential threats.

This HIRA contains information gathered from public information, in addition to federal, state, and local government sources. It is a living document, and will be updated at regular intervals in the future, to document changes in hazards, risks, and vulnerabilities.

Background of Assessment

In 2005, the City of San Antonio and Bexar County participated in the development of the Alamo Area Council of Government's (AACOG) Regional Multi-Hazard Mitigation Plan. This plan looked at a range of hazards, and provided some basic risk and vulnerability information for those identified. Hazards included in the 2005 hazard mitigation plan were: flood; hurricane and coastal storm; severe thunderstorm and tornado; wildfire; drought/extreme heat; winter storm and freeze; hail; erosion; dam/levee failure; earthquake, sinkhole, and landslide; terrorism; hazardous materials incident; and energy pipeline failure.

In 2010, when the plan was ready to be updated, the City and County again participated in the effort. As part of the update process, the list of hazards to be profiled was revisited, and some changes were made to the final list. The hazards included in the updated mitigation plan were: flood; dam/levee failure; tornado; tropical storm and hurricane; thunderstorm; drought; hail; wildfire; winter storm; geologic hazards (earthquake and sinkhole); energy pipeline failure; hazardous materials incident; pandemic; and terrorism.

Though these regional hazard mitigation planning efforts provided some information regarding hazards, risks, and vulnerabilities, the San Antonio Office of Emergency Management (SAOEM) and the Bexar County Office of Emergency Management (BCOEM) determined that a more comprehensive assessment - one that was able to focus specifically on San Antonio and Bexar County - was in order.

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Hazard Identification

A hazard assessment meeting was held with the SAOEM and BCOEM staff on September 3, 2013. As part of that meeting, a lengthy and detailed discussion was held as to the hazards that would be included in the assessment. After evaluating Federal Emergency Management Agency’s (FEMA) planning guidance and performing extensive research, the group identified thirteen hazards to be addressed. Using a listing of each hazard included in both the AACOG Regional Multi-Hazard Mitigation Plan Update 2010-2013, the State of Texas Hazard Mitigation Plan Update and past disaster declarations; SAOEM, BCOEM and emergency management partners formed a HIRA working group to discuss each possible hazard, the data available, the areas of concern for the area, and finally determined whether or not the assessment would address that particular hazard.

Table 1.1 Texas Federally Declared Major Disasters and Emergencies for San Antonio/Bexar County

Year	Number	Description	Hazard
Major Disaster Declarations			
2011	DR-1999-TX	Wildfires	Wildfire
2008	DR-1780-TX	Hurricane Dolly	Hurricane
2007	DR-1730-TX	Tropical Storm Erin	Tropical Storm
2005	DR-1606-TX	Hurricane Rita	Hurricane
2002	DR-1425-TX	Severe Storms and Flooding	Thunderstorm, Flood
1998	DR-1257-TX	Severe Storms, Flooding, and Tornadoes	Thunderstorm, Flood, Tornado
1997	DR-1179-TX	Severe Storms, Flooding	Thunderstorm, Flood
1988	DR-816-TX	Hurricane Gilbert	Hurricane, Tornado
Emergency Declarations			
2010	EM-3313	Tropical Storm Alex	Tropical Storm
2008	EM-3290	Hurricane Gustav	Hurricane
2008	EM-3284	Wildfires	Wildfire
2007	EM-3277	Hurricane Dean	Hurricane
2005	EM-3261	Hurricane Rita	Hurricane
2005	EM-3216	Hurricane Katrina	Hurricane
1999	EM-3142	Extreme Fire Hazards	Wildfire
1998	EM-3127	Severe Wildfire Potential	Wildfire

(Source: Federal Emergency Management Agency)

Table 1.2 provides the outcome for the full range of natural, technological, and security hazards considered. The table documents the evaluation process used for determining the significance of each hazard. Only hazards identified as significant were included. Hazards not identified for inclusion at this time may be addressed during future evaluations and updates.

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Table 1.2 Hazard Identification Process

Hazard	Significant	Justification
Natural		
Drought	YES	Included in the State Plan and AACOG Plan. San Antonio and Bexar County have been under drought conditions between 10% and 14.9% of the time for the 100-year period beginning in 1895 and ending in 1995.
Earthquake	NO	According to the State Plan, an earthquake occurrence for the South Central Region, where San Antonio and Bexar County are located, is considered rare. Although a small event is possible, it would pose little to no risk for the area.
Expansive Soils	NO	While expansive soils are listed as a threat in the State Plan for coastal counties, the impact of this hazard is limited and the frequency is occasional.
Extreme Heat	YES	Included in the State Plan; high frequency of occurrence.
Extreme Wind	YES	Included in the State Plan; the area has a potential risk for extreme winds.
Flood	YES	Included in the State Plan and AACOG Plan; high frequency of occurrence.
Hail	YES	Included in the State Plan and AACOG Plan; high frequency of occurrence.
Hurricane	NO	While hurricane is listed as a threat in the State Plan for coastal counties, this hazard does not directly affect the area.
Infectious Disease	YES	Communicable diseases can occur at any geographic location. In addition, San Antonio and Bexar County have been affected by the 2009 outbreak of H1N1 ("Swine flu").
Subsidence	NO	San Antonio has experienced a recent land shift event that was determined to be caused by a partial collapse of a retaining wall system. The frequency of occurrence is unlikely according to the State Plan.
Thunderstorm	NO	This was not included due to the fact that thunderstorms consist of flood, hail, extreme wind and tornadoes, which are covered in other sections.
Tornado	YES	Included in the State Plan and AACOG Plan; high frequency of occurrence.
Wildfire	YES	Included in the State Plan and AACOG Plan; high

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Hazard	Significant	Justification
		frequency of occurrence.
Winter Storm and Extreme Cold	YES	Included in the State Plan and AACOG Plan which signify a substantial threat.
Technological		
Dam Failure	YES	Included in the State Plan and AACOG Plan. There are 63 dams throughout San Antonio and Bexar County, some of which are located in highly populated areas posing potential risk.
Energy/Fuel Shortage	NO	Is not Included in the State Plan and AACOG Plan; it is unlikely that the energy/fuel shortage will occur in the area.
Hazardous Materials Incident	YES	Included in the AACOG Plan; such events can cause multiple fatalities, shut down facilities, and cause more than 50% of affected properties to be destroyed or suffer major damage.
Major Structural Fire	NO	While major structural fires occasionally occur in the area, this threat is not considered to be critical to the area.
Nuclear Facility Incident	NO	Is not Included in the State Plan and AACOG Plan; there are no nuclear facilities in the area.
Pipeline Failure	YES	There are over 500 miles of liquid and gas pipelines located throughout the City and County, and frequent incidents of pipeline failure occur according to the Texas Railroad Commission.
Water System Failure	NO	Is not Included in the State Plan and AACOG Plan; it is unlikely that the water system failure will occur in the area.
Security		
Civil Disorder	NO	Is not Included in the State Plan and AACOG Plan; it is unlikely that the civil disorder will occur in the area.
Enemy Military Attack	NO	Is not Included in the State Plan and AACOG Plan; it is unlikely that the enemy military attack will occur in the area.
Terrorism	YES	Although there has been no past occurrence, the potential impact of a terrorism event could be significant.

(Source: San Antonio Office of Emergency Management)

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *Federal Emergency Management Agency*
Disaster and Emergency Declarations
<http://www.fema.gov/disasters/grid/state-tribal-government/24> , and
Understanding Your Risks, Identifying Hazards and Estimating Losses, FEMA 386-2
<http://www.fema.gov/media-library-data/20130726-1521-20490-4917/howto2.pdf>

Regional/State Resources and Documents:

- *Alamo Area Council of Governments*
Regional Multi-Hazard Mitigation Plan Update Draft, 2012
<https://www.aacog.com/index.aspx?NID=405>
- *Legislative Reference Library of Texas*
Governor's Proclamations and Executive Orders
<http://www.lrl.state.tx.us/legeLeaders/governors/search.cfm>
- *State of Texas*
State of Texas Hazard Mitigation Plan Update, 2010-2013
<https://www.txdps.state.tx.us/dem/documents/txHazMitPlan.pdf>

Local Resources and Documents:

- *San Antonio Office of Emergency Management*

Section 2 - Community Profile

History

San Antonio and Bexar County's fusion of cultures began 300 years ago when Spain staked its claim in the New World and sent missionaries to colonize the native people. What is now San Antonio was originally a Coahuiltecan Indian village. In 1718, the Franciscans constructed a mission, San Antonio de Valero, to convert, educate, and serve as the economic core for the settlement. In 1731, Spain sent settlers from the Canary Islands to further establish their colonial presence and over the next few years, built four more missions along the river.

A lack of military support and raids by neighboring Comanche and Apache weakened Spain's control of the original mission, and in 1794, Mission San Antonio de Valero was secularized and became a Spanish military installation — the Alamo. Eventually, Mexico waged a war for independence from Spain, and after ten years, won sovereignty over land that included Texas.

In the early 1800s, land in the United States (US) was becoming expensive for pioneers. Stephen Austin, who inherited a Spanish land grant from his father, brought 300 families to Texas in 1821. Mexico also encouraged Americans to purchase land in Texas at a considerably lower rate than they could get in the US.

After 14 years, Americans considerably outnumbered Mexicans. Threatened, Mexican dictator Antonio Lopez de Santa Anna rescinded the country's favorable policies towards settlers. In 1835, Texas declared its independence from Mexico, and revolutionaries battled Mexico for control of San Antonio. One of the most pivotal battles occurred at the Alamo, where 189 Texas fighters held Santa Anna's 4,000 troops at bay for 12 days, fighting to their deaths. A mere 46 days after the fall of the Alamo, Sam Houston's forces won the Battle of San Jacinto — achieving Texas independence.

In 1845, Texas joined the union as the 28th State. German immigrants flooded the city, building up the King William area of town and making their homes in La Villita. They brought European architecture and cuisine to this now multicultural city. After the civil war, the region's wealth came from the cattle industry, and San Antonio was the starting point for the Chisholm Trail, which provided a cattle route from Texas to Kansas. Fort Sam Houston, now a significant army base, was also used as a training ground for Buffalo Soldiers. The twentieth century brought more military bases to the area, with a strong Air Force presence. (Source: *San Antonio Convention and Visitors Bureau*)

Figure 2.1 Downtown San Antonio



Geography and Location

Bexar County is situated in south central Texas between the Edwards Plateau to the northwest and the Gulf Coastal Plains to the southeast. Northwest of the area, the terrain slopes upward to the Edwards Plateau, and to the southeast it slopes downward to the Gulf Coastal Plains. Soils are blackland clay and silt loam on the Plains and thin limestone soils on the Edwards Plateau. (Source: *Southern Region Headquarters of the National Weather Service*)

The area's gently rolling terrain is dotted with oak trees, mesquite, and cacti, which flourish under the clear or partly cloudy skies that prevail more than 60 percent of the time. San Antonio has characteristics of other western urban centers in that it has sparsely populated areas and a low-density rate outside of the city. (Source: *City-Data.com*)

Bexar County is only 140 miles from the Gulf of Mexico and is approximately 701 feet above sea level. Its unique geographical position connects the east and west coasts, Canada, Mexico, Central and South America. Interstate highways connect San Antonio and Bexar County to the major Texas population centers and to primary border crossing points into Mexico including Laredo, Del Rio, Eagle Pass and the ports at Corpus Christi and Houston. Because of this combination of ideal location and quality infrastructure, more than 50 percent of the total goods, flowing between the US and Mexico, travel through Bexar County before reaching their final destination. (Source: *San Antonio Economic Development Foundation*)

Climate

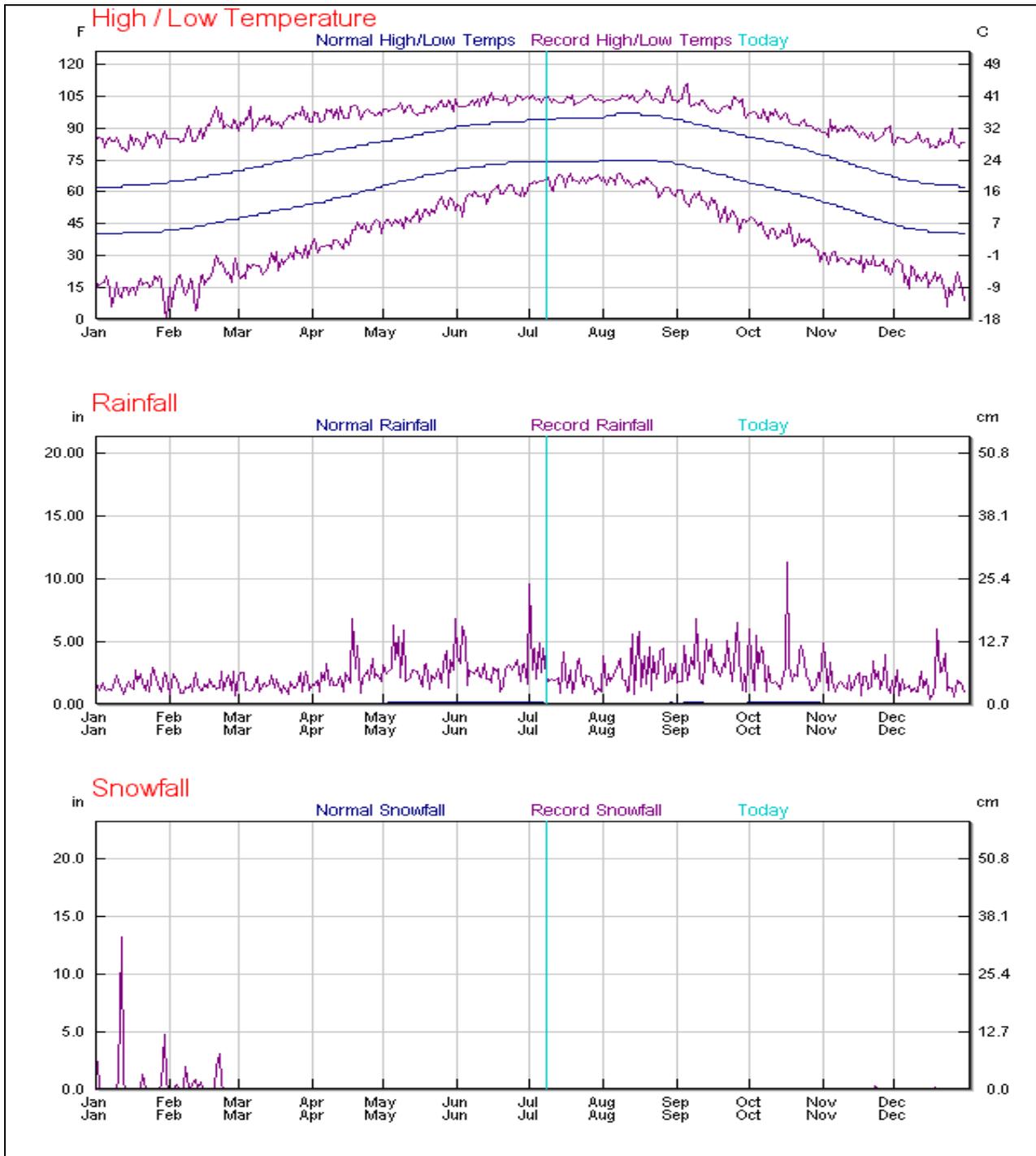
Although San Antonio lies 140 miles from the Gulf of Mexico, the seat of Bexar County is still close enough to experience the warm, muggy air of a semitropical climate. During the winter, temperatures drop below the freezing mark an average of only 20 days; precipitation is mostly in the form of light rain or drizzle. Annual rainfall is nearly 28 inches, enough for production of most crops. May and September see the most rainfall, often building to thunderstorms with winds from the southeast. The proximity to the Gulf of Mexico, however, can bring San Antonio and Bexar County some severe tropical storms. Summers are hot; in fact, federal studies of weather patterns rank San Antonio as the fourth hottest city in the nation because of the average 111 days each year that temperatures reach 90 degrees Fahrenheit (°F) or higher. (Source: *City-Data.com*)

Based on data provided by the National Oceanic and Atmospheric Administration (NOAA), the average annual temperature for San Antonio from 1981-2010 was 69.5 °F with January having the coldest average temperature of 51.8 °F, and August the hottest at 85.3 °F. According to a climate summary provided by NOAA, Bexar County experiences a modified subtropical climate with average monthly temperatures ranging from the 50's °F in the winter to the 80's °F in the summer. The record high temperature was recorded on September 5, 2000 at 111 °F, and the record low temperature was recorded on January 31, 1949 at 0 °F. (Source: *Southern Region Headquarters of the National Weather Service*)

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The following image illustrates the average temperatures and rainfall amounts in the San Antonio area.

Figure 2.2 Average Temperature, Rainfall, and Snowfall Ranges, as of July 2012



(Source: Weather Underground Inc.)

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Demographics

The following demographic information of San Antonio/Bexar County was obtained from the US Census Bureau, and is current as of the 2010 Census.

Table 2.1 Demographics of San Antonio/Bexar County

People QuickFacts	Bexar County	San Antonio
Population, 2012 estimate	1,785,704	1,382,951
Population, 2010 (April 1) estimates base	1,714,777	1,327,605
Population, percent change, April 1, 2010 to July 1, 2012	4.10%	4.20%
Population, 2010	1,714,773	1,327,407
Persons under 5 years, percent, 2012	7.40%	7.60%
Persons under 18 years, percent, 2012	26.50%	26.80%
Persons 65 years and over, percent, 2012	10.70%	10.40%
Female persons, percent, 2012	50.80%	51.20%
White alone, percent, 2012 (a)	85.60%	72.60%
Black or African American alone, percent, 2012 (a)	8.10%	6.90%
American Indian and Alaska Native alone, percent, 2012 (a)	1.20%	0.90%
Asian alone, percent, 2012 (a)	2.70%	2.40%
Native Hawaiian and Other Pacific Islander alone, percent, 2012 (a)	0.20%	0.10%
Two or More Races, percent, 2012	2.10%	3.40%
Hispanic or Latino, percent, 2012 (b)	59.10%	63.20%
White alone, not Hispanic or Latino, percent, 2012	29.80%	26.60%
Living in same house 1 year & over, percent, 2008-2012	80.90%	80.80%
Foreign born persons, percent, 2008-2012	13.00%	13.90%
Language other than English spoken at home, pct age 5+, 2008-2012	42.40%	45.60%
High school graduate or higher, percent of persons age 25+, 2008-2012	81.90%	80.00%
Bachelor's degree or higher, percent of persons age 25+, 2008-2012	25.90%	24.20%
Housing units, 2012	670,662	524,246
Homeownership rate, 2008-2012	60.90%	57.00%
Housing units in multi-unit structures, percent, 2008-2012	26.90%	31.10%
Median value of owner-occupied housing units, 2008-2012	\$122,600	\$113,100
Households, 2008-2012	596,862	471,742
Persons per household, 2008-2012	2.82	2.78
Median household income, 2008-2012	\$49,141	\$44,937

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Business QuickFacts	Bexar County	San Antonio
Private nonfarm establishments, 2011	32,612	109,195
Private nonfarm employment, 2011	640,651	
Private nonfarm employment, percent change, 2010-2011	1.90%	
Nonemployer establishments, 2011	116,928	
Total number of firms, 2007	132,839	109,195
Black-owned firms, percent, 2007	3.80%	3.50%
American Indian- and Alaska Native-owned firms, percent, 2007	S	S
Asian-owned firms, percent, 2007	3.50%	3.60%
Native Hawaiian and Other Pacific Islander-owned firms, percent, 2007	S	S
Hispanic-owned firms, percent, 2007	37.30%	39.50%
Women-owned firms, percent, 2007	28.40%	28.00%
Manufacturers shipments, 2007 (\$1000)	12,305,089	11,971,361
Merchant wholesaler sales, 2007 (\$1000)	12,232,098	11,116,910
Retail sales, 2007 (\$1000)	22,815,281	20,252,070
Retail sales per capita, 2007	\$14,359	\$15,300
Accommodation and food services sales, 2007 (\$1000)	3,829,048	3,545,872
Building permits, 2012	5,695	
Geography QuickFacts	Bexar County	San Antonio
Land area in square miles, 2010	1,239.82	460.93
Persons per square mile, 2010	1,383.10	2,879.80
FIPS Code	29	65000

(Source: *United States Census Bureau, State & County QuickFacts*)

San Antonio is the seventh largest city in the US and the second largest in the State of Texas. The total population of San Antonio increased by 16% between the years 2000 and 2010. Two particular age groups were examined in more detail due to their increased risks associated with multiple hazards. The population group of children 5 years and younger grew to just over 100,000, representing 7.6% of the total population. Persons over 65 years reached nearly 140,000, representing 10.4% of the total population. Both of these percentages are reflective of the statewide percentages for the State of Texas. (Source: *United States Census Bureau, American Fact Finder*)

The demographic make-up of Bexar County is comprised of two main ethnic groups, the Hispanic or Latino population comprises 63.2% of the population (an increase from 61.2% in 2000), while the Caucasian population equates to 26.6% of the total population (a decrease from 28.9% in 2000). Other minority populations comprise the remainder of the total population, and appear to have been stable in their makeup from 2000 to 2010. (Source: *United States Census Bureau, State & County QuickFacts*)

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Economics

San Antonio and Bexar County's dynamic and diverse economy is a healthy mix of business services, with a rapidly growing biomedical and biotechnology sector, an emerging new energy economy and a diversified manufacturing sector, producing everything from aircraft and semiconductors to Toyota trucks. San Antonio and Bexar County are also strategically located in south central Texas, and have historically been the economic hub of the region. San Antonio's employment in May 2011 was 925,407, compared to 922,051 in May 2010. The city's unemployment rate was 7.3% compared to 7.9% in Texas and 8.7% in the US.

The following is a listing of corporate headquarters that are located in San Antonio/Bexar County:

- United Services Automobile Association (USAA) (financial services and insurance, fortune 500 company);
- HEB Grocery Company, LP (supermarket chain);
- Bill Miller B-B-Q Enterprises (fast food chain);
- Cullen/Frost Bankers, Inc. (financial services);
- Valero Energy Corporation (oil refinery and gasoline marketing);
- NuStar Energy LP (Energy);
- Tesoro Corporation (oil refiner and petroleum products);
- Calumet Specialty Products Partners (oil refinery)
- Southwest Research Institute (applied research and development);
- Clear Channel Communications (television & radio stations, outdoor advertisement);
- Rackspace Inc. (information technology managed hosting solutions);
- Kinetic Concepts Inc. (medical supplies – advanced wound care solutions and wound care therapy);
- Toyota Motor Manufacturing, Texas Inc. (vehicle assembly plant).

The following is a list of major employers in the area, and the number of people they employ:

- Lackland Air Force Base (military) – 37,097 employees;
- Fort Sam Houston – US Army (military) – 32,000 employees;
- USAA (financial services and insurance) – 14,832 employees;
- HEB (super market chain) – 14,588 employees;
- Northside ISD (school district) – 13,300 employees;
- Randolph Air Force Base (military) – 11,068 employees;
- North East ISD (school district) – 10,522 employees;
- City of San Antonio (local government) – 9,145 employees;
- San Antonio ISD (school district) – 7,581 employees;

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- Methodist Healthcare System (health care services) – 7,500 employees. (Source: *San Antonio Economic Development Foundation*)

Much like the greater area that it serves, the City of San Antonio and Bexar County are also economically healthy. The City's Office of Management and Budget publishes a five year financial forecast, in which an assessment of the City's financial situation – both current and projects – is discussed and analyzed. The County's Budget Office also prepares an annual operating budget document. Both serve to provide City/County Leadership and staff, as well as the general public, with a financial assessment and notice of any impending issues that will impact the budget.

In 2006, the City maintained financial reserves of just under 4%. In 2012, this percentage has increased to 9%. This represents a financial reserve of \$85.3 million, which is intended for use for the following events:

- Unforeseen operational or capital requirements which arise during the course of the fiscal year;
- An unforeseen or extraordinary occurrence, such as a natural disaster, catastrophic change in the City's financial position, or the occurrence of a similar event; or
- To assist the City in managing fluctuations in available General Fund resources from year to year, in stabilizing the budget.

This financial reserve, which is available for use in the event of a disaster or hazard event, means that the City of San Antonio is favorably positioned to begin immediate response and recovery efforts in the aftermath of a disaster.

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *National Oceanic and Atmospheric Administration*
<http://www.noaa.gov/>
- *United States Census Bureau*
American Fact Finder
<http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>, and
State & County QuickFacts
<http://quickfacts.census.gov/qfd/index.html>

Regional/State Resources and Documents:

- *Southern Region Headquarters of the National Weather Service*
San Antonio Climate Summary
<http://www.srh.noaa.gov/images/ewx/sat/satclisum.pdf>

Local Resources and Documents:

- *City-Data.com*
San Antonio: Geography and Climate
<http://www.city-data.com/us-cities/The-South/San-Antonio-Geography-and-Climate.html>
- *San Antonio Convention and Visitors Bureau*
- *San Antonio Economic Development Foundation*
Location
<http://www.sanantonioedf.com/business-profile/location>, and
Major Employers
<http://www.sanantonioedf.com/business-profile/major-employers>
- *San Antonio Office of Emergency Management*
- *Weather Underground Inc.*
Season Weather Averages, San Antonio International (KSAT)
<http://www.wunderground.com/NORMS/DisplayNORMS.asp?AirportCode=KSAT&SafeCityName=San Antonio&StateCode=TX&Units=none&IATA=SAT>

Section 3.1 - Dam Failure

Description

Dams are built for many purposes. Examples of common uses include water storage for potable water supply, livestock water supply, irrigation, fire suppression, flood control, and hydroelectric power. Dams may also provide various recreational opportunities like fishing or boating. Dams are commonly multifunctional, serving two or more of these purposes.

Large modern dams typically have control mechanisms such as gated spillways or outlet pipes for releasing water in a controlled fashion. During high water flow periods, water is stored behind a dam, while in low water flow periods, water is released to increase flows. The specific patterns of water storage and release vary from dam to dam, depending on the primary purpose(s) of the dam and on a wide variety of economic, regulatory and environmental considerations.

Modern dams, whether embankment dams or concrete dams, are typically constructed on a foundation, which may be concrete, natural rock or soils, or compacted soils. Dams are usually constructed along a constricted part of a river valley to minimize cost. Dams are also connected to the surrounding natural valley walls, which become the abutments of the dam structure itself.

Embankment dams, also referred to as earthfill or rockfill dams, are broad flat structures, typically at least twice as wide at the base as their height. Embankment dams are subject to erosion by running water. Thus, modern embankment dams always have erosion-resistant materials used in the water release and control mechanisms of the dam. There are many forms of controlled release mechanisms including concrete spillways with concrete or steel gates and outlet pipe systems with concrete or steel pipes.

Modern concrete dams fall into two major classes: gravity dams and arch dams. Concrete gravity dams are designed on principles similar to embankment dams. Concrete gravity dams are broad structures, generally triangular in shape with a flat base, a narrow top, a flat upstream side and a broad sloping downstream side. Typically, gravity dams are keyed into bedrock foundations and abutments to increase the stability of the dam. Concrete arch dams rely primarily on the strength of concrete to impound water. Concrete arch dams are much thinner in cross section than concrete gravity dams. An arch dam is typically constructed in a location with Canyon walls and takes advantage of the arch action in the dam to transfer the forces in the dam to the rock canyon walls as well as the base. The design and shape of the dam is determined by the site conditions and the steepness and width of the canyon walls. The use of the arch action reduces the amount of concrete required to carry the load.

Figure 3.1.1 Olmos Dam Spillway 2013 Memorial Day Flood



General Characteristics

Dam failures can occur at any time in a dam's life; however, failures are most common when water storage for the dam is at or near design capacity. At high water levels, the water force on the dam is higher and several of the most common failure modes are more likely to occur.

Correspondingly, for any dam, the probability of failure is much lower when water levels are substantially below the design capacity for the reservoir.

For embankment dams, the most common failure mode is erosion of the dam during prolonged periods of rainfall and flooding. When dams are full and water inflow rates exceed the capacity of the controlled release mechanisms (spillways and outlet pipes), overtopping may occur. Overtopping implies that the water level has exceeded the height of the dam and thus spills over the top. When overtopping occurs, scour and erosion of either the dam itself and/or the abutments may lead to partial or complete failure of the dam. Especially for embankment dams, internal erosion, piping or seepage through the dam, foundation, or abutments can also lead to failure. For smaller dams, erosion and weakening of dam structures by growth of vegetation and burrowing animals is a common cause of failure.

For embankment dams, earthquake ground motions may cause dams to settle or spread laterally. Such settlement does not generally lead, by itself, to immediate failure. However, if the dam is full, relatively minor amounts of settling may cause overtopping to occur, with resulting scour and erosion that may progress to failure. For any dam, improper design or construction or inadequate preparation of foundations and abutments can also cause failures. Improper operation of a dam, such as failure to open gates or valves during high flow periods can also trigger dam failure. For any dam, unusual hydrodynamic (water) forces can also initiate failure. Landslides into the reservoir, which may occur on their own or be triggered by earthquakes, may lead to surge waves which overtop dams or hydrodynamic forces which cause dams to fail under the unexpected load. Earthquakes can also cause seiches (waves) in reservoirs that may overtop or overload dam structures. In rare cases, high winds may also cause waves that overtop or overload dam structures.

Concrete dams are also subject to failure due to seepage of water through foundations or abutments. Dams of any construction type are also subject to deliberate damage via sabotage or terrorism. For waterways with a series of dams, downstream dams are also subject to failure induced by the failure of an upstream dam. If an upstream dam fails, then downstream dams also fail due to overtopping or due to hydrodynamic forces.

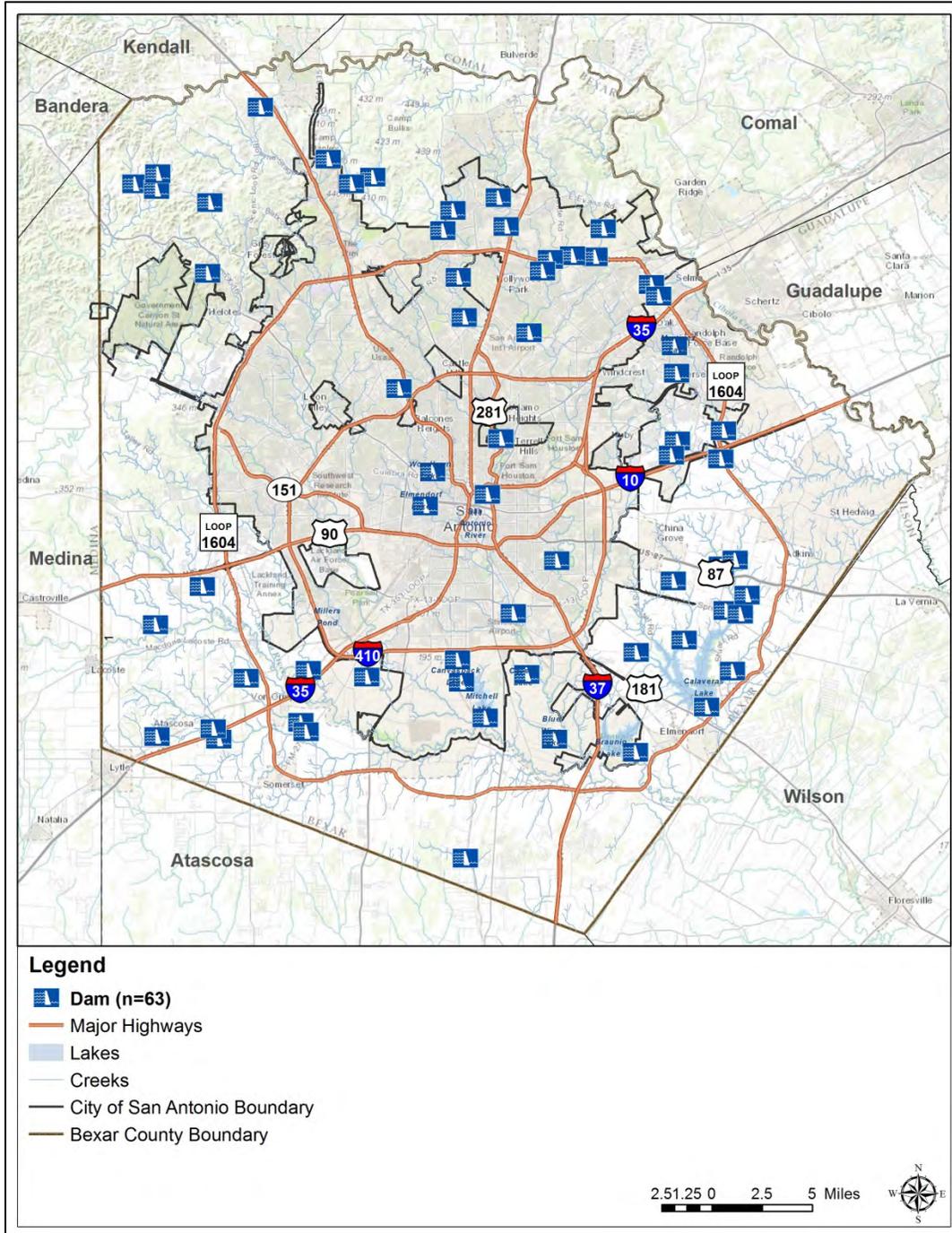
Overtopping of a dam is often a precursor of dam failure. National statistics show that overtopping due to inadequate spillway design, debris blockage of spillways, or settlement of the dam crest account for approximately 34% of all United States (US) dam failures.

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Location

According to the Texas Commission on Environmental Quality's (TCEQ) Dam Safety Program division there are currently 63 dams located in Bexar County, of those, 36 are considered high hazard, 1 significant hazard and 26 low hazard.

Figure 3.1.2 Dam Locations, San Antonio/Bexar County



(Source: Texas Commission on Environmental Quality)

Extent

Dam failure is at times difficult to mitigate due to the fact that any initial steps require determination of ownership. In Texas, there are a total of 7,183 dams. Of these 1,083 are high hazard dams, with another 483 as significant hazard dams. Almost 90% are over 25 years old. Responsibility for dams lies with the owners and managers of each dam.

In January 2009, revisions to the Texas Administrative Code (TAC) regulating dams and reservoirs went into effect. One of the major changes to the code included a revision to the definition of dams included under the regulatory authority of the state. Included are dams which:

- Have a height greater than or equal to 25 feet and a maximum storage capacity greater than or equal to 15 acre-feet;
- Have a height greater than 6 feet and a maximum storage capacity greater than or equal to 50 acre-feet;
- Are a high- or significant-hazard dam, regardless of height or maximum storage capacity; or
- Are used as a pumped storage or terminal storage facility.

In addition, revisions were made to sections relating to the hazard classification of dams. In summary, a dam is classified as having a low-hazard potential, significant-hazard potential, or high-hazard potential if the following criteria are met:

- Low: no loss of human life is expected (no permanent habitable structures in the breach inundation area downstream of the dam); and minimal economic loss (located primarily in rural areas where failure may damage occasional farm buildings, limited agricultural improvements, and minor highways);
- Significant: loss of human life possible (one to six lives or one or two habitable structures in the breach inundation area downstream of the dam); or appreciable economic loss (located primarily in rural areas where failure may cause damage to isolated homes, damage to secondary highways, damage to minor railroads; or interruption of service or use of public utilities);
- High: loss of life expected (seven or more lives or three or more habitable structures in the breach inundation area downstream of the dam); or excessive economic loss (located primarily in or near urban areas where failure would be expected to cause extensive damage to public, agricultural, industrial, or commercial facilities, public utilities, main highways, or railroads used as a major transportation system).

The San Antonio/Bexar County area could expect to experience the entire range of severity of the flood (dam and levee failure) hazard. The impact of the hazard could be catastrophic, depending on the severity of the failure of the dam or levee. If the dam or levee suffered total, unexpected failure, everything downstream of it would be flooded by fast-moving water. This would lead to extensive property damage, and great potential for injury and loss of life. If the dam or levee suffered a slower, detected failure, the damage may be capable of being contained, and people would have time to

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evacuate out of harm's way. Areas with lower elevation could reasonably expect to experience greater depths of flooding, as water will naturally accumulate at the lowest point.

Therefore, the severity of the levee and dam failure hazard is primarily a function of the inspection and maintenance processes in place by the dam/levee's owner/operator and/or carried out by State and Federal entities on behalf of, and in coordination with the county and its jurisdictions.

Previous Occurrences

There are 7,183 dams in the state of Texas, of those, 1,083 are considered high-hazard potential dams and 483 identified as significant-hazard potential dams. According to the TCEQ, since 1900, there have been 167 failures or incidents. Two dam failures in Texas resulted in 24 lives lost, 23 deaths related to the failure of Lake Austin Dam in 1900 and one reported death related to a failure of a dam in Northeast Texas in 1988.

There has been one reported dam failure in Bexar County which occurred in 2002. The J.C. Webb dam located in northern Bexar County overtopped during a flood event.

Estimated Recurrence Rate

The estimated recurrence rate of dam failure, based on historic occurrences in the City of San Antonio and Bexar County, is considered low.

Vulnerability

Population

People living immediately downstream from a dam are most vulnerable to a dam failure.

The extent of flooding or inundation due to a dam failure that the downstream population could experience would depend upon a variety of factors, many of which are continuously in flux, including:

- Volume of water contained by the dam/levee;
- Specific elevation of the facility in relation to ground level; and
- Type of failure suffered by the dam or levee (e.g., sudden, slow).

Inundation maps have been collected to assist in estimating the impact on the population for the 37 high or significant hazard dams in Bexar County.

Property

Property and structures downstream from a dam are highly vulnerable. Depending on the quantity of water, the force caused by its onrush can take out buildings, utilities, and destroy roadways. A large dam with a high head of water could effectively scour the terrain below it for miles, taking out all buildings, and other infrastructure.

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Environment

While the environment can generally withstand and recover from impacts of a dam failure, a major vulnerability of the environment is the amount and type of debris that the dam failure generates. Construction materials, household chemicals, vegetative and landscaping materials and chemicals – all of these items are frequently found in debris piles following such event, and all of these things can cause contamination of the environment.

City/County Operations

Critical facilities are those facilities or services that a community relies on for effective and efficient operation, particularly during and after a hazard event, or that would be of critical importance to a community in the event and aftermath of a hazard event. Typically, critical facilities include:

- Fire stations;
- Hospitals/clinics/medical centers;
- Chemical/heavy industrial/hazardous materials facilities or storage locations; and
- Communications facilities, such as radio and television broadcast locations.

A dam failure would generally impact a pre-identified area, it is inevitable, while studying various breach analyses, that facilities critical to the community will be located downstream will be impacted.

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *Association of State Dam Safety Officials*
Dam Failures and Incidents
<http://www.damsafety.org/news/?p=412f29c8-3fd8-4529-b5c9-8d47364c1f3e>
- *Carnegie Mellon University*
Dam Safety
<http://www.cmu.edu/homepage/environment/2013/spring/dam-safety.shtml>
- *Environmental Systems Research Institute*
Community Analyst
<http://www.esri.com/software/arcgis/community-analyst>
- *Federal Emergency Management Agency*
Dam Safety: An Owner's Guidance Manual, 1987
http://www.damsafety.org/media/Documents/FEMA/145_GuidanceManual_87.pdf
- *United States Army Corps of Engineers, Institute For Water Resources*
Management Measures Digital Library
[http://www.iwr.usace.army.mil/Missions/PlanningandManagement/ManagementMeasuresDigitalLibrary\(MMDL\).aspx](http://www.iwr.usace.army.mil/Missions/PlanningandManagement/ManagementMeasuresDigitalLibrary(MMDL).aspx)
- *United States Census Bureau*
- *United States Society on Dams*
Strength of Materials for Embankment Dams, 2007
<http://www.ussdams.org/07materials.PDF>

Regional/State Resources and Documents:

- *Texas Commission on Environmental Quality*
Central Registry Query
<http://www12.tceq.texas.gov/crpub/index.cfm>, and
Guidance on Implementing Dam Safety Legislation, September 1, 2013
http://www.tceq.texas.gov/assets/public/compliance/field_ops/damsafety/DamSafetyGuidance090113.pdf

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Summary of Dams in San Antonio/Bexar County

	Name	Longitude	Latitude	Height, ft	Length, ft	Max Storage, acre ft	Normal Storage, acre ft
1	VICTOR BRAUNIG DAM	-98.364467	29.246092	76	9638	32324	26500
2	ALAMO ANGUS RANCH LAKE DAM	-98.760065	29.339811	14	400	140	48
3	KIRBY LAKE DAM	-98.759002	29.258716	19	600	190	78
4	KILROY LAKE DAM	-98.585785	29.301452	13	550	520	168
5	CANVASBACK LAKE DAM	-98.507557	29.29718	19	1200	730	275
6	BALLASETAL LAKE DAM	-98.510961	29.313431	14	1300	450	112
7	LUCKEY LAKE DAM	-98.721155	29.367248	13	380	180	54
8	TX NO NAME NO 6 DAM	-98.708003	29.256632	17	950	190	67
9	SCOTT LAKE DAM	-98.685415	29.300811	15	500	300	54
10	BAKER LAKE DAM	-98.640157	29.268567	14	1625	312	112
11	OR MITCHELL LAKE 1 DAM	-98.633835	29.306443	32	2537	520	192
12	WOODLAWN LAKE DAM	-98.530665	29.449518	20	1250	460	77
13	ELMENDORF LAKE DAM	-98.537052	29.42503	10	2000	105	105
14	CALAVERAS CREEK WS SCS SITE 5 DAM	-98.289082	29.34842	28	1280	2085	121
15	CALAVERAS CREEK DAM	-98.305356	29.278505	79	5920	97441	60484
16	CALAVERAS CREEK WS SCS SITE 8 DAM	-98.271561	29.359437	27	1366	1413	198
17	CALAVERAS CREEK WS SCS SITE 3 DAM	-98.332326	29.370008	41	2580	3298	122
18	CALAVERAS CREEK WS SCS SITE 9 DAM	-98.277291	29.3455	28	1176	907	107
19	CALAVERAS CREEK WS SCS SITE 10 DAM	-98.283957	29.30434	41	1818	2825	116
20	MITCHELL LAKE DAM	-98.488257	29.271523	10	3500	5000	2640
21	CASSIN LAKE DAM	-98.453712	29.302812	24	1180	580	400
22	NEW ESPADA LAKE DAM	-98.464723	29.346963	12	420	120	120
23	BLUE WING LAKE DAM	-98.431172	29.255712	10	3700	1600	1000
24	LIONS PARK LAKE DAM	-98.428387	29.384903	0	674	145	67
25	CALAVERAS CREEK	-98.292591	29.38056	44	2463	3768	200

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	Name	Longitude	Latitude	Height, ft	Length, ft	Max Storage, acre ft	Normal Storage, acre ft
	WS SCS SITE 6 DAM						
26	CALAVERAS CREEK WS SCS SITE 7 DAM	-98.281115	29.384856	35	1955	1403	62
27	MARTINEZ CREEK WS SCS SITE 1 DAM	-98.328226	29.471268	0	1773	3509	200
28	MARTINEZ CREEK WS SCS SITE 2 DAM	-98.333222	29.46099	0	1640	1085	158
29	MARTINEZ CREEK WS SCS SITE 3 DAM	-98.292638	29.458188	0	1933	1622	197
30	MARTINEZ CREEK WS SCS SITE 6A DAM	-98.290302	29.478447	0	1552	1922	200
31	MARTINEZ CREEK WS SCS SITE 5 DAM	-98.330247	29.540103	0	2813	1922	230
32	MARTINEZ CREEK WS SCS SITE 4 DAM	-98.328581	29.520193	35	2132	1632	200
33	SALADO CREEK WS SCS SITE 8 DAM	-98.475502	29.648046	0	1675	7100	196
34	SALADO CREEK WS SCS SITE 4 DAM	-98.521555	29.624478	0	1451	3957	85
35	SALADO CREEK WS SCS SITE 2 DAM	-98.579236	29.663435	55	1910	4317	199
36	HEIMSATH CEMETERY LAKE DAM	-98.77649	29.659047	21	580	220	109
37	WHITE LAKE DAM	-98.758256	29.654725	0	725	420	124
38	SALADO CREEK WS SCS SITE 12 DAM	-98.388587	29.625278	0	2600	7837	169
39	OLMOS DAM	-98.474142	29.473497	58	1941	21970	15551
40	SALADO CREEK WS SCS SITE 13A DAM	-98.395607	29.604888	42	1690	3053	128
41	WATER TURKEY LAKE DAM	-98.32359	29.327121	17	1284	238	28
42	RILEY LAKE DAM	-98.363448	29.318263	18	957	94	43
43	JC WEBB DAM	-98.672252	29.714267	19	744	53	46
44	WHITE COMPANY LAKE DAM	-98.71427	29.645382	33	633	198	146
45	WILDLAKE DAM	-98.716422	29.594025	40	700	462	152
46	SALADO CREEK WS SCS SITE 1 DAM	-98.597042	29.658563	0	2320	8675	199
47	SALADO CREEK WS SCS SITE 5 DAM	-98.513025	29.638968	0	2673	5807	198
48	SALADO CREEK WS SCS SITE 13B DAM	-98.414276	29.605797	46	2802	1898	72
49	SALADO CREEK WS	-98.43267	29.603072	64	1775	6318	84

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	Name	Longitude	Latitude	Height, ft	Length, ft	Max Storage, acre ft	Normal Storage, acre ft
	SCS SITE 11 DAM						
50	SALADO CREEK WS SCS SITE 9 DAM	-98.469057	29.627175	0	2140	2612	94
51	SALADO CREEK WS SCS SITE 6 DAM	-98.50905	29.59041	0	2500	2830	100
52	WHITE RANCH LAKE DAM	-98.757395	29.666317	16	600	130	64
53	CREA BROTHERS LAKE DAM	-98.349121	29.584533	18	610	80	40
54	HARMAK LAKE DAM	-98.343248	29.576222	18	550	80	39
55	GROTHAUS LAKE DAM	-98.712572	29.264295	14	997	56	28
56	TX NO NAME NO 19 DAM	-98.636016	29.262012	10	890	140	68
57	PAX LAKE DAM	-98.504952	29.169883	14	780	114	57
58	SALADO CREEK WS SCS SITE 7 DAM	-98.50396	29.561392	0	2264	6864	94
59	SALADO CREEK WS SCS SITE 10 DAM	-98.439222	29.594862	0	1270	4063	97
60	SALADO CREEK WS NRCS SITE 15R DAM	-98.450661	29.550251	49	6615	8741	0
61	BROOKLYN STREET LOCK AND DAM	-98.485635	29.433256	0	33	28	28
62	HIDDEN SPRINGS DAM	-98.616047	29.676395	25	0	46	25
63	DENMAN PARK DAM	-98.55841	29.510263	20	490	19	12

(Source: Texas Commission on Environmental Quality, Central Registry Query)

3.2 - Drought

Description

Drought is a normal occurrence in virtually all climatic regions, including areas of either high or low average rainfall. A drought occurs the region receives the amount of precipitation that is lower than expected over an extended period of time, usually a season or more in length. Severity depends on duration, intensity (degree of precipitation shortfall and/or the severity of impacts associated with the shortfall), geographic extent, and the demands on regional water supplies. High temperatures, prolonged high winds, and low relative humidity can intensify the severity of a drought.

Drought differs from other natural hazards in three ways:

- A drought's onset and end are difficult to determine because the effects accumulate slowly and may linger after the apparent end of the event;
- There is no precise and universally accepted definition. This causes confusion about whether a drought exists and, if it does, its severity; and
- The impacts of drought are less obvious than those of other hazards and are spread over large geographical areas.

These differences have hindered the development of accurate, reliable and timely estimates of drought severity and effects, thus making hazard analysis and risk assessment more difficult. Also, the nature of drought as a slowly evolving hazard with far-reaching consequences makes it difficult to fully grasp the long-term ramifications of this hazard.

During the past decade, research efforts, such as those at the University of Nebraska-Lincoln Drought Center, have attempted to predict droughts and recommend policy on preparedness, mitigation, and warnings. However, this research is in its early stages, and accurate, consistent drought warning and prediction methodology is not readily available.

General Characteristics

A drought is a period of unusually persistent dry weather that continues long enough to cause serious problems such as crop damage or water supply shortages. The severity of the drought depends on its intensity, the duration, and the size of the affected area.

Figure 3.2.1 Local Drought Impacts



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The following classifications have been assigned to the different types of drought:

Meteorological drought is defined by a period of substantially diminished precipitation. The commonly used definition of meteorological drought is an interval of time, generally on the order of months or years, during which the actual rainfall at a given area consistently falls below the historical average.

Agricultural drought occurs when there is inadequate soil moisture to meet agriculture and livestock needs. Agricultural drought usually occurs after or during meteorological drought but before hydrological drought.

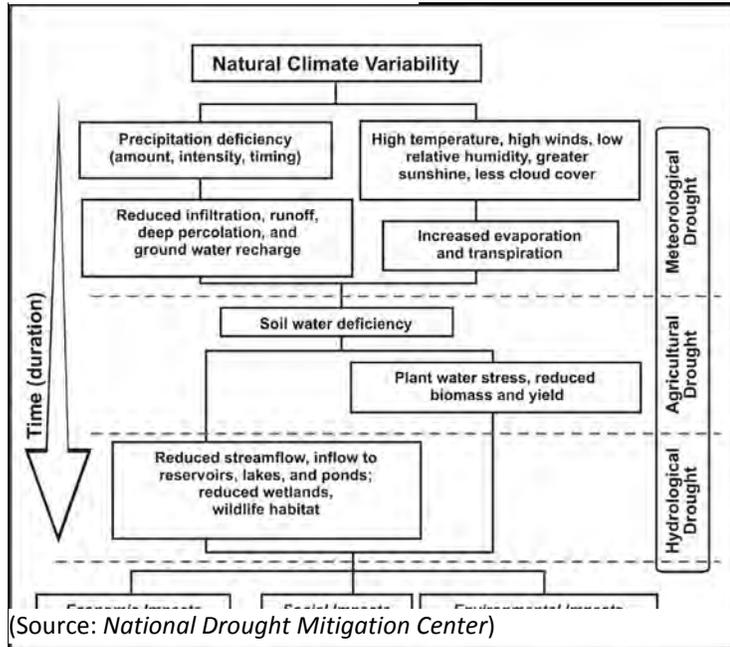
Hydrological drought refers to a shortage in surface and subsurface water supplies. It is measured as stream flow, snow pack, and as lake, reservoir, and groundwater levels. There is usually a delay between lack of rain or snow and less measurable water in streams, lakes, and reservoirs. Therefore, hydrological measurements tend to lag behind other drought indicators.

Socio-economic drought occurs when physical water shortages start to affect the health, well-being, and quality of life of the people, or when the drought starts to affect the supply and demand of an economic product.

Location

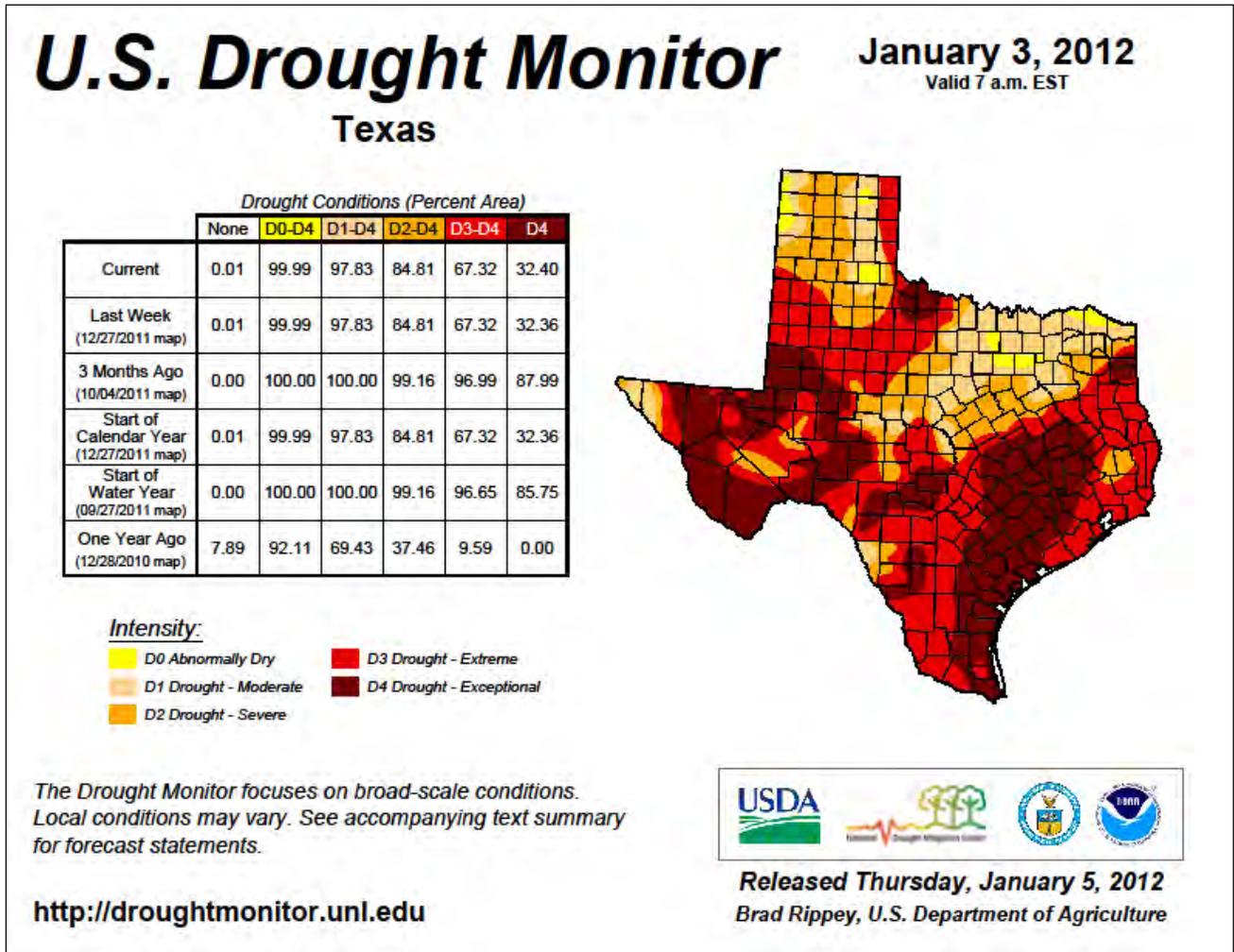
Drought is a large scale event hazard, and should be considered in terms of large geographic areas. Drought conditions are typically monitored and reported in terms of states or regions rather than in terms of counties or smaller geographic areas. Therefore, this assessment will include the State of Texas, encompassing the San Antonio/Bexar County area, rather than focusing on the specific jurisdictional boundaries.

Figure 3.2.2 Natural Climate Variability



The entire County is susceptible to the drought hazard. The image below is an example of drought conditions obtained from the Drought Monitor at the University of Nebraska-Lincoln. Figure 3.2.3 illustrates the Winter 2011/2012 drought condition for the State of Texas, including San Antonio and Bexar County.

Figure 3.2.3 United States Drought Monitor – Texas – January 2012



(Source: University of Nebraska-Lincoln)

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Extent

The extent of a drought is measured using the Palmer Drought Severity Index (PDSI), also known as the Palmer Index. The Palmer Index was developed by Wayne Palmer in the 1960s and uses temperature and rainfall information in a formula to determine dryness. It has become the semi-official drought index.

The Palmer Index is most effective in determining long-term drought (matter of several months), and is less effective for short-term forecasts (a matter of weeks). It uses 0 as normal, and drought is shown in terms of negative values; (e.g., -2 is moderate drought, -3 is severe drought, and -4 is extreme drought). The Palmer Index is also useful for reflecting excess rain using a corresponding level reflected by positive values (e.g., +2 is moderately wet, +4 is extremely wet). The following table provides the classifications, extent, and impacts defined by the Palmer Index.

Table 3.2.1 Palmer Drought Severity Index

Classification	Description	Range of Potential Impacts
4.00 or more	Extremely wet	
3.00 to 3.99	Very wet	
2.00 to 2.99	Moderately wet	
1.00 to 1.99	Slightly wet	
0.50 to 0.99	Incipient wet spell	
0.49 to -0.49	Near normal	
-0.50 to -0.99	Incipient dry spell	
-1.00 to -1.99	Mild drought	Going into drought: short-term dryness slowing planting, growth of crops or pastures; fire risk above average. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered.
-2.00 to -2.99	Moderate drought	Some damage to crops, pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing or imminent, voluntary water use restrictions requested.
-3.00 to -3.99	Severe drought	Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions
-4.00 to -4.99	Extreme drought	Major crop/pasture losses; extreme fire danger; widespread water shortages or restrictions.
-5.0 or less	Exceptional drought	Exceptional and widespread crop/pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells, creating water emergencies.

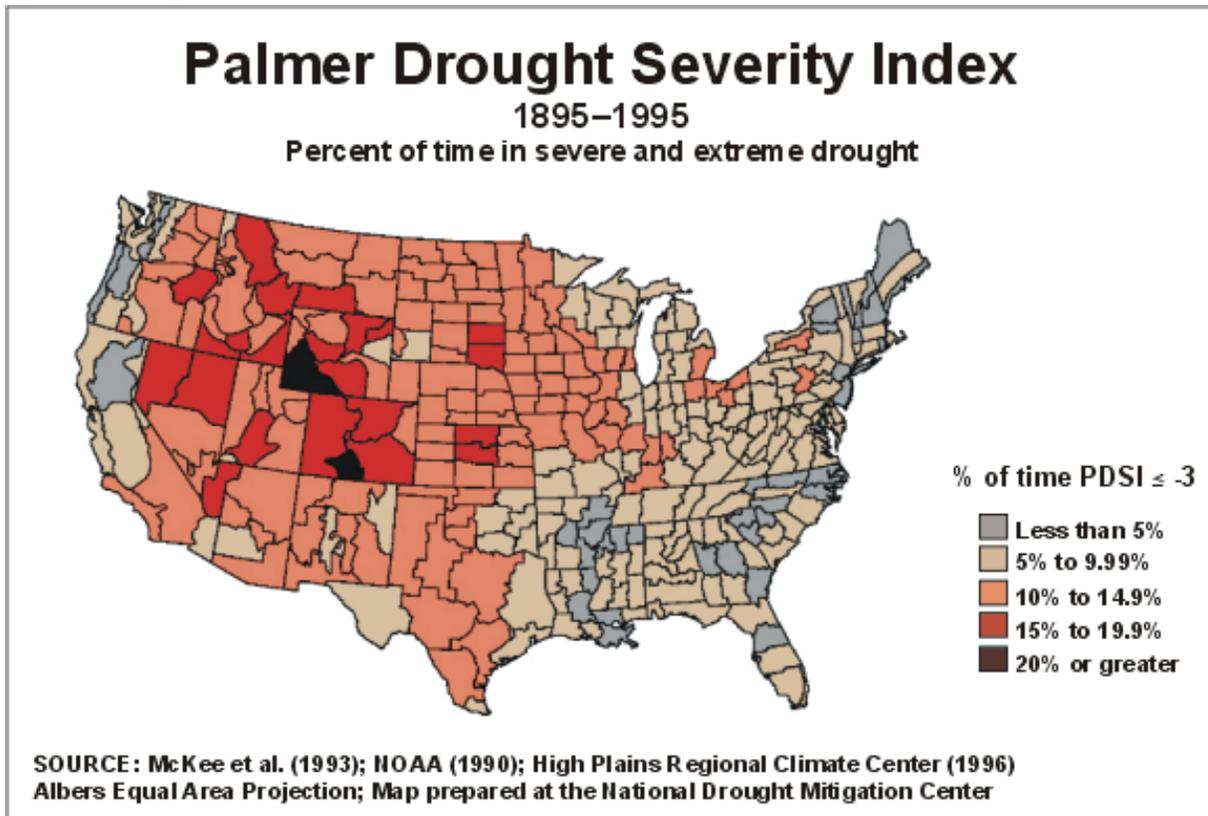
(Source: University of Nebraska – Lincoln)

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The advantage of the Palmer Index is that it is standardized to local climate, so it can be applied to any part of the country to demonstrate relative drought or rainfall conditions. The disadvantage is that it is not as good for short-term forecasts, and is not particularly useful in calculating supplies of water locked up in snow, so it works best east of the Continental Divide. Despite these shortcomings, it remains a useful tool for illustrating the severity of a drought.

Figure 3.2.4 shows the percentage of time between 1895 and 1995 that areas of the United States (US) were classified as being in severe and extreme drought conditions, according to the Palmer Index. As shown in this image, the State of Texas has been in severe or extreme drought conditions for 5% to 14.9% of this period, depending on the location within the State. The San Antonio/Bexar County area has been in severe or extreme drought conditions for 10% to 14.9% of this time period.

Figure 3.2.4 Drought Conditions, 1895-1995



(Source: Pagosa Area Water and Sanitation District, Colorado)

Previous Occurrences

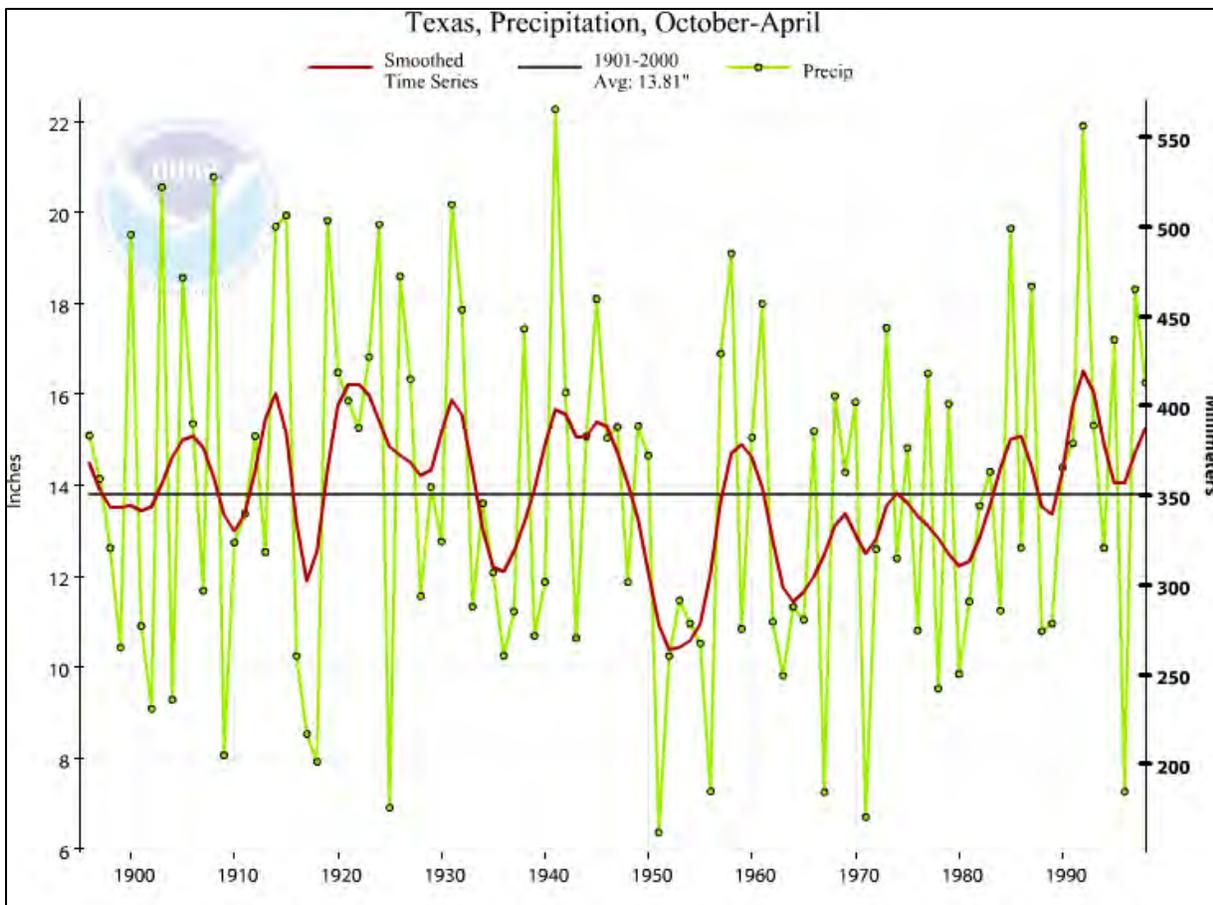
The National Climatic Data Center (NCDC) began collecting drought data in 1996. Prior to that, data was loosely collected by both the National Oceanic and Atmospheric Administration (NOAA) and the Drought Mitigation Center, based on the Palmer Drought Severity Index. Based on information provided by the NCDC Storm Events Database, there have been a total of 27 drought events recorded between 1996 and 2013.

Estimated Recurrence Rate

Using this historical data, it is estimated that the area will experience severe or extreme drought 10-15 years out of every century, usually for multiple years at a time.

The estimated recurrence rate of drought, based on historic occurrences in the City of San Antonio and Bexar County, is considered high.

Figure 3.2.5 Texas Precipitation



(Source: National Climatic Data Center)

Vulnerability

Population

All people in Bexar County are vulnerable to the effects of drought, as people require potable water for their basic survival. The average person will survive only a few days without water, and this timeframe can be drastically shortened for those people with more fragile health – typically children, the elderly, and the ill.

In addition to this direct vulnerability, people are also vulnerable to food shortages when drought conditions exist and potable water is in short supply. Droughts often result in too little water to support food crops, through either natural or artificial irrigation measures. In addition, low yields among food crops can result in price increases, which can make it difficult for lower income population to purchase sufficient food supplies. Also, this same shortage will exist for grass and grain used to feed livestock, as well as the water supplies necessary for the livestock themselves. When food sources or supplies are threatened or affected by drought, and less food is available, the number of hungry people will begin to increase. When the drought persists long enough and is severe enough, this hunger will eventually become famine.

Disease is also a vulnerability that people experience during droughts. A lack of clean water for drinking, public sanitation, and personal hygiene can lead to life-threatening diseases related to hygiene and sanitation practices.

Hospitals, clinics, and other health care providers are also reliant on clean water to provide life-saving medical care. Potable water is used for drinking, sanitation, patient care, sterilization, equipment, heating and cooling systems, and many other essential functions in medical facilities. When the supply of potable water becomes limited due to drought, the quality of medical care available may become compromised, and the rate of infection or death among patients may increase. (Source: *Centers for Disease Control and Prevention*)

Property

Drought presents a significant threat to agricultural property and lands, which are typically dependent on a large, reliable supply of water for irrigation and livestock support. While many larger agricultural operations have a local supply of water, a prolonged or severe drought may quickly diminish those supplies, resulting in crop degradation or loss, low yields, and livestock death.

Perhaps the greatest vulnerability to property is the decrease in the supply of water for fire suppression purposes. While fire is not necessarily a result of droughts, the loss of available water, and the resulting loss of available water pressure within delivery systems, makes fire suppression more challenging. In extreme circumstances, fire suppression may be approached from a strategic perspective, with some structures and properties being allowed to burn, while resources are directed to other structures and properties that have a higher priority to the population.

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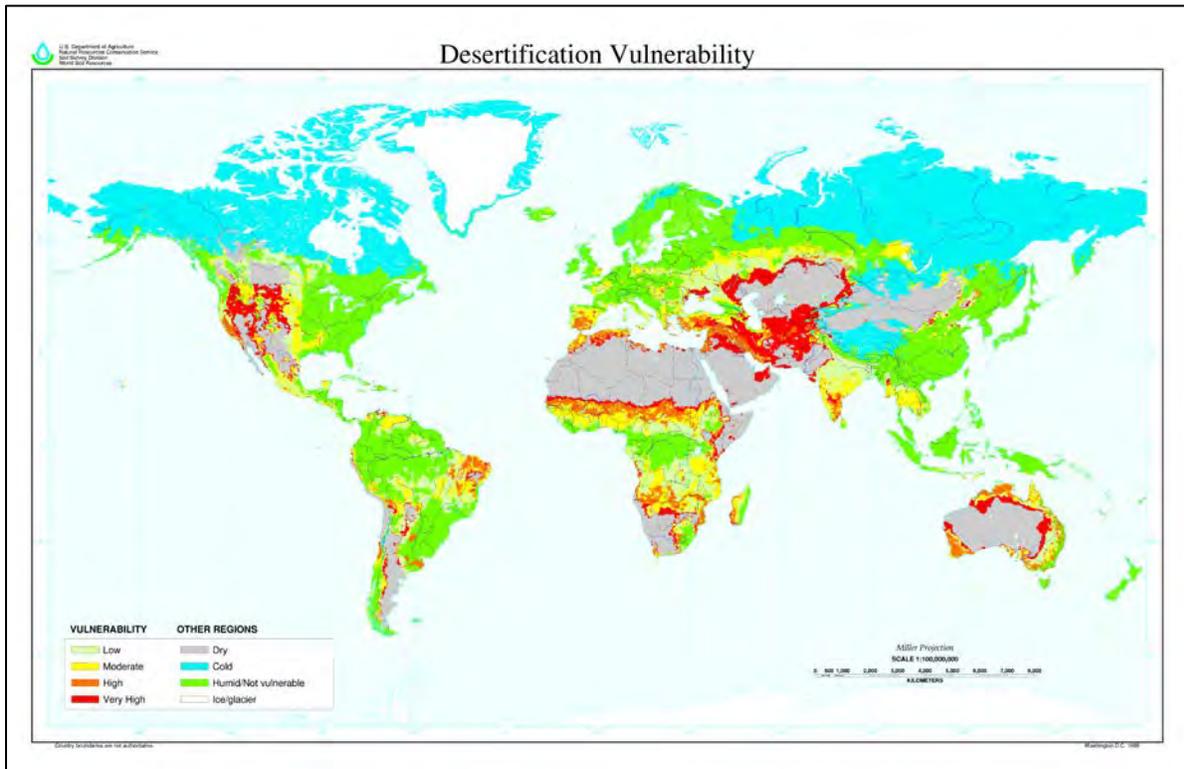
Environment

Habitat damage is a vulnerability of the environment during periods of drought, for both aquatic and terrestrial species. Severe and prolonged drought can result in a reduction in the number of species, or can lead to the extinction of a species altogether. This is especially true for those species and habitats that are already experiencing distress from other factors, such as urbanization.

During periods of extreme or prolonged drought, the environment becomes vulnerable to severe erosion and land degradation. The most famous example of this vulnerability is the Dust Bowl of the 1930s, during which more than 100,000,000 acres of land in Texas, Oklahoma, Colorado, New Mexico, and Kansas was subjected to brutal wind-driven erosion of the top soil. An extended and severe drought led to extreme crop failure, which left millions of acres of plowed farmland exposed to high winds and unrelenting sun, which resulted in catastrophic erosion and degradation of the land.

If the drought persists long enough and is severe enough, desertification may occur. Desertification, at its most basic definition, is the process by which an area becomes a desert. It can be the result of a prolonged or severe drought, and involves the rapid depletion of plant life and loss of top soil. According to the US Department of Agriculture's (USDA) Natural Resources Conservation Service, much of the American West is currently vulnerable to desertification, as seen in the image below.

Figure 3.2.6 Areas Vulnerable to Desertification



(Source: United States Department of Agriculture, Natural Resources Conservation Service)

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Though the vulnerable areas do not specifically include Bexar County, they do include large portions of the region in which the County is located. The County is vulnerable to the effects of desertification, if only indirectly at this time.

City/County Operations

City County operations vulnerability to the effect of drought is likely to be minimal, unless an extreme water shortage emerges as a result of the drought. Given the water reserves, diverse sources, and general conservation practices in the area, it would take an exceptional and prolonged drought to expose this vulnerability. According to a June 2012 interview with the Operations Manager for San Antonio Water System (SAWS), there has never been a point at which SAWS was concerned about running out of water, mostly because of conservation efforts and man-made aquifer storage. Though this may change in the future if drought conditions worsen, as of now this is a vulnerability that is monitored through normal operations.

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *Centers for Disease Control and Prevention*
When Every Drop Counts: Protecting Public Health during Drought Conditions
<http://www.cdc.gov/nceh/ehs/publications/Drought.htm>
- *Federal Emergency Management Agency*
<http://www.fema.gov>
- *National Climatic Data Center*
<http://www.ncdc.noaa.gov/oa/ncdc.html>
- *National Oceanic and Atmospheric Administration*
<http://www.noaa.gov/>
- *National Weather Service*
<http://www.weather.gov>, and
What is Meant by the Term Drought? *Forecast Office, Flagstaff, AZ* <http://www.wrh.noaa.gov/fgz/science/drought.php?wfo=fgz>
- *Pagosa Area Water and Sanitation District, Colorado*
Palmer Drought Severity Index
<http://www.pawsd.org/Drought-index.html>
- *United States Department of Agriculture, Natural Resources Conservation Service*
Global Desertification Vulnerability Map
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/worldsoils/?cid=nrcs142p2_054003
- *University of Nebraska – Lincoln*
Drought Monitor
<http://droughtmonitor.unl.edu/>, and
Drought Reporter
<http://droughtreporter.unl.edu>

Regional/State Resources and Documents:

- *Legislative Reference Library of Texas*
Governor's Proclamations and Executive Orders
<http://www.lrl.state.tx.us/legeLeaders/governors/search.cfm>
- *Texas Forest Service*
Outdoor Burn Bans
<http://www.srh.noaa.gov/hgx/?n=drought>
- *Texas Water Development Board*
Drought in Texas
<http://www.twdb.state.tx.us/apps/droughtinfo/default.aspx>

Local Resources and Documents:

- *San Antonio Express-News*

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Drought Rated as Texas' 3rd Worst

<http://www.mysanantonio.com/business/article/Drought-rated-as-Texas-3rd-worst-1416012.php>

- *San Antonio Water System*

Conservation

<http://www.saws.org/conservation/>, and

Water Management Plan Update, 2009

http://www.saws.org/your_Water/WaterResources/2009wmp/docs/SAWS2009WaterMgmtPlanUpdate.pdf, and

Water Management Plan Update Fact Sheet

http://www.saws.org/your_water/WaterResources/2009wmp/docs/2009SAWSWaterManagementPlanFact.pdf, and

Comprehensive Annual Financial Report for the Years Ended December 31, 2011 and 2010

http://www.saws.org/who_we_are/Financial_Reports/CAFR/

3.3 - Extreme Heat

Description

Conditions of extreme heat are defined as summertime temperatures that are substantially hotter and/or more humid than average for location at that time of year. Humid or muggy conditions, which add to the discomfort of high temperatures, occur when a "dome" of high atmospheric pressure traps hazy, damp air near the ground. Extremely dry and hot conditions can provoke dust storms and low visibility. Droughts occur when a long period passes without substantial rainfall. A heat wave combined with a drought is a very dangerous situation.

General Characteristics

The San Antonio/Bexar County area has a humid subtropical climate, characterized by humid summers, where temperatures average around low to mid 90s degrees Fahrenheit (°F). The combination of high temperatures mixed with humidity leads to heat waves or periods of extreme heat, presenting a significant threat to the safety and welfare of citizens and animals.

The major human risks associated with severe summer heat include: heat cramps, sunburn, dehydration, fatigue, heat exhaustion, and heat stroke. People suffer heat-related illness when their bodies are unable to compensate and properly cool themselves. The body normally cools itself by sweating. But under some conditions, sweating just isn't enough. In such cases, a person's body temperature rises rapidly. Very high body temperatures may damage the brain or other vital organs.

Several factors affect the body's ability to cool itself during extremely hot weather. When the humidity is high, sweat will not evaporate as quickly, preventing the body from releasing the heat. Other conditions related to risk include age, obesity, fever, dehydration, heart disease, mental illness, poor circulation, sunburn, and prescription drug and alcohol use.

Figure 3.3.1 Beat the Heat Outreach Program



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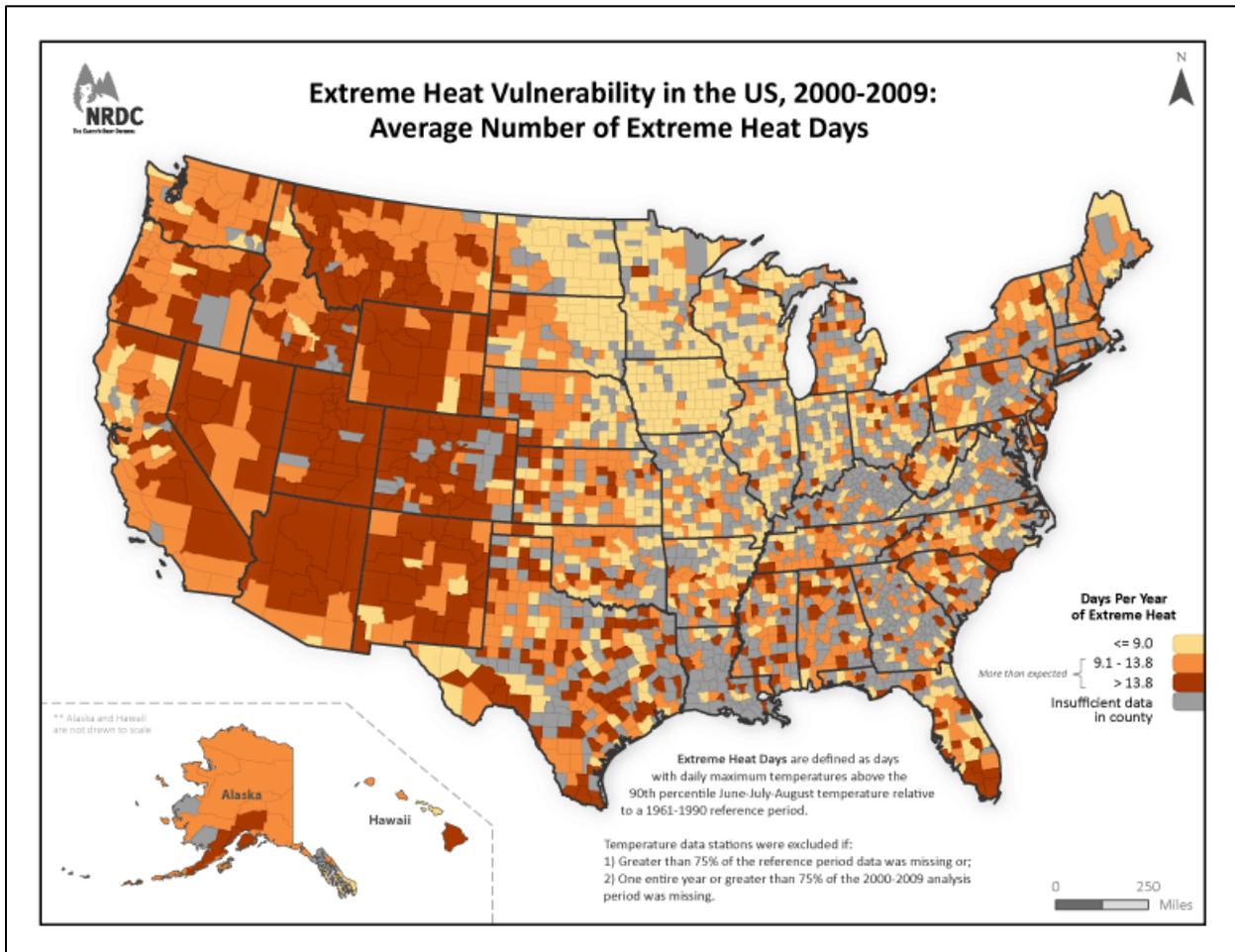
The most vulnerable populations to heat casualties are children and the elderly or infirm, who may frequently live on low fixed incomes and cannot afford to run air conditioning on a regular basis. The latter population is sometimes isolated, with no immediate family or friends to care for them.

Location

Extreme heat is a large scale event hazard, and should be considered in terms of large geographic areas. Though injuries or deaths from extreme heat have been recorded at different locations throughout the San Antonio/Bexar County area, there is no specific geographic scope to the extreme heat hazard.

The entire County is susceptible to the extreme heat hazard. The image below, from the Natural Recourses Defense Council (NRDC), indicates areas of extreme heat vulnerability throughout the Unites States (US). According to the NRDC, Bexar County averaged over 13.8 days per year of extreme heat from 2000-2009.

Figure 3.3.2 Extreme Heat Vulnerability in the United States, 2000-2009



(Source: Natural Recourses Defense Council)

Extent

The magnitude, or intensity, of an extreme heat event is measured according to temperature in relation to the percentage of humidity. According to the National Oceanic Atmospheric Administration (NOAA), this relationship is referred to as the “Heat Index,” and is depicted in Figure 3.3.3. This index measures how hot it feels outside when humidity is combined with high temperatures.

An *Excessive Heat Outlook* is issued by the National Weather Service (NWS) when the potential exists for an excessive heat event in the next 3-7 days. An Outlook provides information to those who need considerable lead time to prepare for the event, such as public utility staff, emergency managers and public health officials.

An *Excessive Heat Watch* is issued by the NWS when conditions are favorable for an excessive heat event in the next 24 to 72 hours. A Watch is used when the risk of a heat wave has increased but its occurrence and timing are still uncertain. A Watch provides enough lead time so that those who need to prepare can do so, such as local officials who have excessive heat event mitigation plans.

An *Excessive Heat Warning/Advisory* is issued by the NWS when an excessive heat event is expected in the next 36 hours. These notifications are issued when an excessive heat event is occurring, is imminent, or has a very high probability of occurring. The Warning is used for conditions posing a potential threat to life. An Advisory is for less serious conditions that cause significant discomfort or inconvenience and, if caution is not taken, could lead to a threat to life.

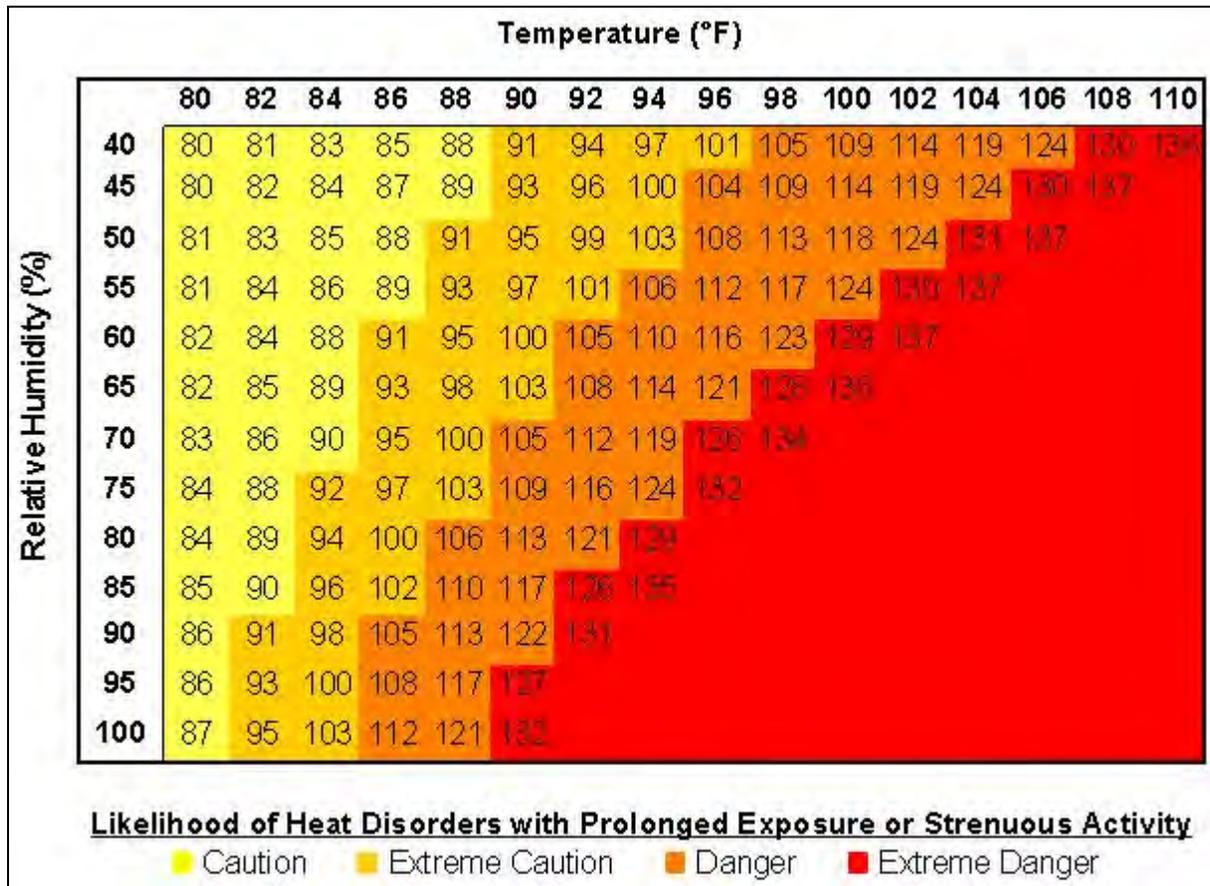
NOAA's heat alert procedures are based mainly on Heat Index values. The Heat Index, sometimes referred to as the apparent temperature is given in °F. The Heat Index is a measure of how hot it feels when relative humidity is factored in with the actual air temperature.

Since Heat Index values were devised for shady, light wind conditions, exposure to full sunshine can increase Heat Index values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

To find the Heat Index temperature, look at the Heat Index chart below. As an example, if the air temperature is 96°F and the relative humidity is 65%, the Heat Index - how hot it feels - is 121°F. The NWS will initiate alert procedures when the Heat Index is expected to exceed 105°-110°F (depending on local climate). The NWS also offers a Heat Index chart for area with high heat but low relative humidity.

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Figure 3.3.3 Heat Index Chart



(Source: National Oceanic and Atmospheric Administration)

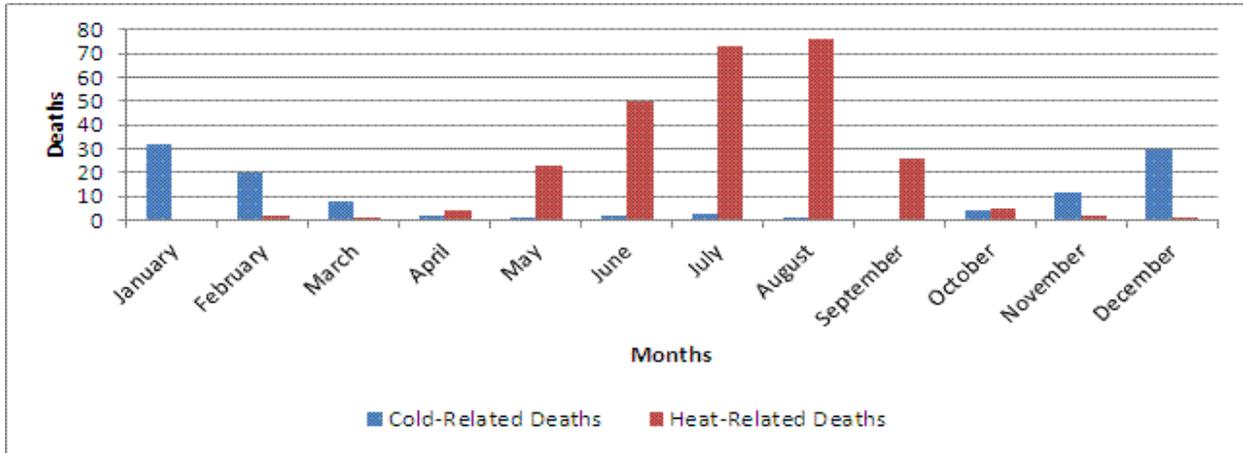
The extent scale in Figure 3.3.3 displays varying degrees of caution depending on the relative humidity combined with the temperature. For example, when the temperature is at 90°F or lower, caution should be exercised if the humidity level is at or above 40 percent.

The shaded zones on the chart indicate varying symptoms or disorders that could occur, depending on the magnitude or intensity of the event. “Caution” is the first level of intensity where fatigue due to heat exposure is possible. “Extreme Caution” indicates that sunstroke, muscle cramps, or heat exhaustion are possible, whereas “Danger” level means that these symptoms are likely. “Extreme Danger” indicates that heat stroke is likely.

Previous Occurrences

According to the Texas Department of State Health Services (TDSHS), from 2003-2008, there were 439 deaths reported among Texas residents with exposure to excessive heat as the cause of death. There were a total of 6 deaths from exposure to excessive heat in Bexar County from 2003 to 2008.

Figure 3.3.4 Temperature Related Deaths among Texas Residents, 2003-2008



(Source: Texas Department of State Health Services)

Table 3.3.5 summarizes heat related deaths in Bexar County recorded by the TDSHS, for the years 2003 through 2008.

Figure 3.3.5 Heat Related Deaths in Texas and Bexar County, 2003-2008

County of Death	2003	2004	2005	2006	2007	2008	Total
Texas	62	53	111	104	43	66	439
Bexar County	2	1	1	1	0	1	6

(Source: Texas Department of State Health Services)

Estimated Recurrence Rate

The estimated recurrence rate of extreme heat, based on historic occurrences in the City of San Antonio and Bexar County, is considered high.

Vulnerability

Population

The most vulnerable segments of the population are people who work outdoors and people who are physically most susceptible to the dangers of extreme hot weather - the very young and the elderly.

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During extremely hot and humid weather, the body's ability to cool itself is affected. When the body heats too rapidly to cool itself properly, or when too much fluid or salt is lost through dehydration or sweating, body temperature rises and heat-related illnesses may develop. Heat-related illnesses can range from heat cramps to heat exhaustion to more serious heat stroke. Heat stroke can result in death and requires immediate medical attention.

Rising temperatures can also make smog pollution worse and increase the number of "bad air days", which puts many at risk for irritated eyes, nose, and lungs, but it is particularly dangerous for people with respiratory diseases like asthma.

Property

Structures are less likely to be seriously harmed or damaged by extreme heat. However, there have been several documented cases studies of impacts to infrastructure due to extreme heat conditions. Highways and roads are damaged by excessive heat causing asphalt roads to soften. Concrete roads have been known to "explode", lifting 3 - 4 foot pieces of concrete from the surface. During the 1980 heat wave hundreds of miles of highways buckled (Source: *National Oceanic and Atmospheric Administration*). Stress is also placed on automobile cooling systems, diesel trucks, and railroad locomotives, which can ultimately lead to an increase in mechanical failures. Rail refrigerated goods experience a significant greater rate of spoilage due to extreme heat.

Environment

The environment can be affected if extreme heat is combined with a drought. Habitat damage is a danger during periods of drought, for both aquatic and terrestrial species. Severe and prolonged drought can result in a reduction in the number of a given species, or can lead to the extinction of a species altogether. This is especially true for those species and habitats that are already experiencing distress from other factors, such as urbanization. There are also air quality impacts associated with rising temperatures.

City/County Operations

City and County operations can be impacted by rolling brownouts if the extreme temperatures cause the demand for electricity to exceed the supply. Other impacts from increased heat include impacts to water quality and quantity, as well as elevated wildfire risk, all of which put stresses on operational resources which can create vulnerabilities in government services.

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *Cooperative Institute for Research in the Atmosphere*
Impacts of Temperature Extremes
<http://sciencepolicy.colorado.edu/socasp/weather1/adams.html>
- *National Atmospheric and Oceanic Administration*
<http://www.noaa.gov/>
- *Natural Recourses Defense Council*
Extreme Heat: More Intense Hot Days and Heat Waves
<http://www.nrdc.org/health/climate/heat.asp>
- *National Weather Service*
NOAA's Watch, Warning, and Heat Advisory for Extreme Heat
<http://www.nws.noaa.gov/om/heat/index.shtml>
- *Time Magazine*
Science and Space, Weather: "Why Bad Heat = Bad Air"
<http://science.time.com/2011/07/22/why-bad-heatbad-air/>
- *United States Environmental Protection Agency*
Agriculture and Food Supply
<http://www.epa.gov/climatechange/impacts-adaptation/agriculture.html>

Regional/State Resources and Documents:

- *Electric Reliability Council of Texas*
Conservation
<http://www.ercot.com/about/conservation/>
- *Texas Department of State Health Services*
Temperature-Related Deaths
<http://www.dshs.state.tx.us/Layouts/ContentPage.aspx?PageID=35617&id=7005&terms=EXTREME+HEAT>

Local Resources and Documents:

- *City Public Service Energy*
<http://www.cpsenergy.com>

Section 3.4 - Extreme Wind

Description

This section focuses on extreme wind events, excluding tornadoes, which are found later in this document. The extreme wind hazard is most often accompanied by other storm hazards, but can also occur as a stand-alone hazard event.

Wind is the horizontal motion of the air past a given point, beginning with differences in air pressures. Pressure, that is higher at one place than another, sets up a force pushing from the high toward the low pressure; the greater the difference in pressures, the stronger the force. The distance between the area of high pressure and the area of low pressure also determines how fast the moving air is accelerated. Meteorologists refer to the force that starts the wind flowing as the "pressure gradient force." High and low pressures are relative. There is no set number that divides high and low pressure. Wind is used to describe the prevailing direction from which the wind is blowing with the speed given usually in miles per hour or knots. (Source: *National Weather Service*)

Extreme winds are most often associated with severe storms, including severe thunderstorms, tropical storms, and hurricanes.

Severe Thunderstorm

The National Oceanic and Atmospheric Administration (NOAA) defines a severe thunderstorm as a storm that produces a tornado, winds of at least 58 miles per hour (MPH) (50 knots (KTS)), and/or hail at least 1 inch in diameter. Structural wind damage may result from a severe thunderstorm. A thunderstorm wind equal to or greater than 40 MPH (35 KTS) and/or hail of at least ½ inch is defined as approaching severe.

According to the NOAA, damage from severe thunderstorm winds account for half of all severe weather damage in the lower 48 states and is more common than damage from tornadoes. These wind storms are often called straight line winds to differentiate damage they cause from tornado damage. This term includes damage caused by downbursts, microbursts, and gust fronts, which vary primarily in intensity and area affected. The National Weather Service (NWS) classifies damaging winds as those exceeding 50-60 MPH.

Tropical Storm/Hurricane

According to NOAA, a hurricane is an intense tropical weather system of strong thunderstorms with well-defined surface circulation and sustained winds of 74 MPH or higher. Hurricanes begin as a tropical disturbance in the open ocean. The following chart illustrates the terms used to define the various tropical weather systems.

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Table 3.4.1 Tropical Weather System Definitions

Term	Definition
Tropical Disturbance	A discrete tropical weather system of apparently organized convection originating in the tropics or subtropics, having a non-frontal migratory character, and maintaining its identity for 24 hours or more. It may or may not be associated with a detectable perturbation of the wind field.
Tropical Cyclone	A warm-core non-frontal synoptic-scale cyclone, originating over tropical or subtropical waters, with organized deep convection and a closed surface wind circulation about a well-defined center. Once formed, a tropical cyclone is maintained by the extraction of heat energy from the ocean at high temperature and heat export at the low temperatures of the upper troposphere.
Tropical Depression	A tropical cyclone in which the maximum sustained surface wind speed (using the United States (US) 1-minute average) is 33 KTS (38 MPH or 62 kilometers per hour (KPH) or less.
Tropical Storm	A tropical cyclone in which the maximum sustained surface wind speed (using the US 1-minute average) ranges from 34 KTS (39 MPH or 63 KPH) to 63 KTS (73 MPH or 118 KPH).
Hurricane/Typhoon	A tropical cyclone in which the maximum sustained surface wind (using the US 1-minute average) is 64 KTS (74 MPH or 119 KPH) or more. The term hurricane is used for Northern Hemisphere tropical cyclones east of the International Dateline to the Greenwich Meridian. The term typhoon is used for Pacific tropical cyclones north of the Equator west of the International Dateline.

(Source: *National Weather Service*)

The ingredients for a hurricane include a pre-existing weather disturbance, warm tropical waters, moisture and relatively light winds aloft. Persistent favorable conditions can produce violent winds, destructive waves, torrential rains and powerful floods. On average, ten tropical systems develop annually over the Atlantic Ocean, Caribbean Sea, and the Gulf of Mexico. Many of these storms remain over open water and never move toward land. In a typical year, six of these storms become hurricanes. In an average three-year period, five hurricanes will strike the US coastline, anywhere from Texas to Maine. Of these, two are typically major or intense hurricanes, with classifications of Category 3 or higher. (Source: *National Weather Service*)

A primary hazard associated with hurricanes is extreme wind. As wind speeds increase, pressure against objects is added at a disproportionate rate. Pressure against a wall rises with the square of the wind speed, which means that a threefold increase in wind speed gives a nine-fold increase in pressure. Thus, a 25 MPH wind causes approximately 1.6 pounds of pressure per foot. For some structures, this increase in force is enough to cause failure. These winds will weaken after landfall, due to loss of warm-water energy source and increased friction as it moves over land.

Straight Line Winds

Straight line winds can have gusts of 100 MPH or more, and are often accompanied by hail or rain. Unlike tornadoes, windstorms have a broader path that is several miles wide and can cover several

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counties. Straight line wind may down trees and power lines, overturn mobile homes, and cause damage to well-built structures.

Straight line winds are responsible for most thunderstorm wind damages. One type of straight line wind, the downburst, is a small area of rapidly descending air beneath a thunderstorm. A downburst can cause damage equivalent to a strong tornado and make air travel extremely hazardous.

Because it is often difficult to distinguish between damage caused by weaker tornadoes and damage caused by straight line winds, the NWS often examines the damage path to determine the exact cause. Straight line wind damage will push debris in the same direction the wind is blowing, while tornado damage will scatter debris in different directions. In addition, the path of straight line wind path can cover many miles while a tornado's damage path is usually narrower and more defined. (Source: *National Severe Storms Laboratory*)

General Characteristics

For the purposes of this document, extreme winds are defined as wind events that exceed 58 MPH (50 KTS) and occur in the absence of a tornado. This section will differentiate the characteristics of wind associated with tornadoes, tropical storms, and hurricanes, as well as describe types of wind events which fall under the NWS definition of straight line winds.

The major differences between tornadoes and other types of wind events include the magnitude of the damage and the areal extent of the damage. A tornado is a narrow, are the most violent of all atmospheric storms. However, extreme non-tornadic wind events have a much wider impact area, and while they will not reach the level of destruction as results from strong tornadoes, the damage can be significant.

Bexar County is typically not directly affected by sustained tropical storm winds, especially hurricane strength. Tropical storms gain their strength from the heat and moisture of the water mass they are over, and therefore winds typically dissipate to severe thunderstorm levels by the time they reach inland communities. Even so, there have been instances of strong, tropical-strength winds creating high levels of damage in the San Antonio/Bexar County area.

The following is a more detailed explanation from the NWS on the difference between characteristics associated with straight line winds.

Downbursts

A strong downdraft with horizontal dimensions larger than 2.5 miles (4 kilometers) resulting in an outward burst or damaging winds on or near the ground. (Imagine the way water comes out of a faucet and hits the bottom of the sink.) Downburst winds may begin as a microburst and spread out over a wider area, sometimes producing damage similar to a strong tornado.

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Although usually associated with thunderstorms, downbursts can occur with showers too weak to produce thunder.

Microbursts

A small, concentrated downburst that produces an outward burst of damaging winds at the surface. Microbursts are generally small (less than 2.5 mile across) and short-lived, lasting only 5-10 minutes, with maximum wind speeds up to 168 MPH. There are two kinds of microbursts: wet and dry. A wet microburst is accompanied by heavy precipitation at the surface. Dry microbursts, common in places like the high plains and the intermountain west, occur with little or no precipitation reaching the ground.

Gust front

A gust front is the leading edge of rain-cooled air that clashes with warmer thunderstorm inflow. Gust fronts are characterized by a wind shift, temperature drop, and gusty winds out ahead of a thunderstorm. Sometimes the winds push air above them, forming a shelf cloud or detached roll cloud.

(Source: *National Weather Service*)

Location

As noted in the characteristics associated with the extreme wind hazard, the impact of extreme winds can cover multiple counties and large metropolitan areas. Therefore, the San Antonio/Bexar County area can be considered to be at equal risk for extreme winds.

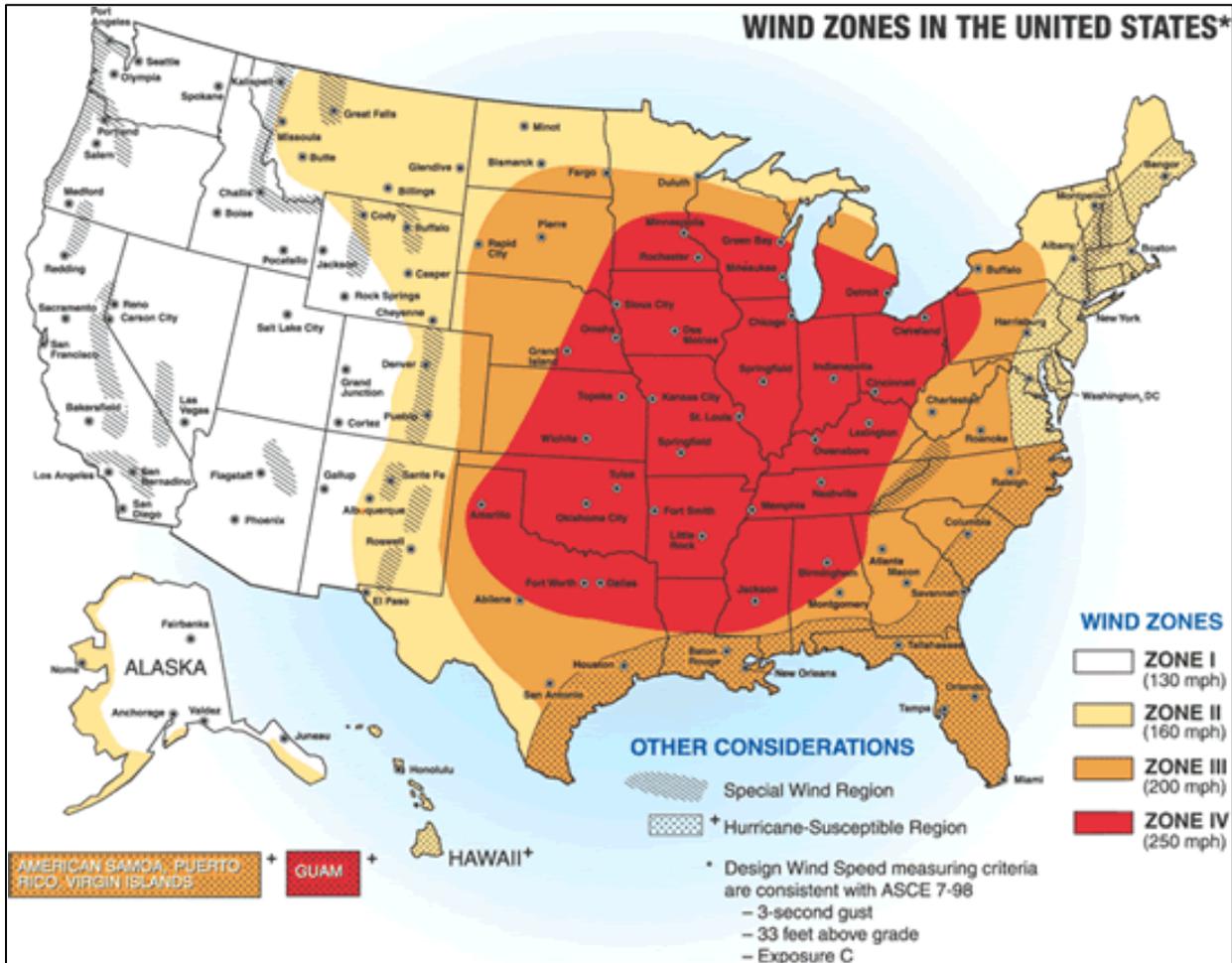
The figure below shows winds zones in the US. Bexar County is located in Wind Zone III, and just out of the “Hurricane Susceptible Region”. Areas in Zone III, however, are susceptible to winds up to 200 MPH.

Figure 3.4.1 Valley-Hi 2011 EF-0/Microburst



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Figure 3.4.2 Wind Zones in the United States



(Source: Federal Emergency Management Agency)

Extent

There is no wind damage scale developed specifically for thunderstorm high winds or straight-line winds. Two scales that provide damage descriptions consider the extent and type of damage that may result from extreme winds. These scales are the Beaufort Wind Scale and the Saffir-Simpson Hurricane Wind Scale.

Though used primarily to describe maritime wind conditions, the Beaufort Scale is also useful for providing a frame of reference for wind conditions on land that fall below the measurements of the Saffir-Simpson Hurricane Wind Scale.

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Table 3.4.2 Beaufort Wind Force Scale

Beaufort Number	Wind Speed in MPH	Seaman's Term	Visible Effects on Land
0	> 1	Calm	Calm; smoke rises vertically
1	1-3	Light Air	Smoke drift indicates wind direction; vanes do not move
2	4-7	Light Breeze	Wind felt on face; leaves rustle; vanes begin to move
3	8-12	Gentle Breeze	Leaves, small twigs in constant motion; light flags extended
4	13-18	Moderate Breeze	Dust, leaves and loose paper raised up; small branches move
5	19-24	Fresh Breeze	Small trees begin to sway
6	25-31	Strong Breeze	Large branches of trees in motion; whistling heard in wires
7	32-28	Moderate Gale	Whole trees in motion; resistance felt in walking against the wind
8	39-46	Fresh Gale	Twigs and small branches broken off trees
9	47-54	Strong Gale	Slight structural damage occurs; slate blown from roofs
10	55-63	Whole Gale	Seldom experienced on land; trees broken; structural damage occurs
11	64-72	Storm	Very rarely experienced on land; usually with widespread damage
12	73<	Hurricane Force	Violence and destruction

(Source: *Mount Washington Observatory*)

Hurricanes and tropical systems are categorized according to the strength of their winds using the Saffir-Simpson Hurricane Wind Scale. This scale ranks a hurricane's sustained wind speed, and estimates potential property damage. It is important to note that lower category storms can inflict greater damage than higher category storms, depending on where they strike, other weather they interact with, and how slow their forward speed is. A prime example is Hurricane Ike, which had winds classified as Category 2, yet was one of the costliest and most destructive hurricanes in US history.

The following table illustrates the wind speed classification and expected wind effects on land from various coastal storm categories, as provided by the National Hurricane Center. These descriptions of land effects are general and are for explanatory purposes only. The actual damage to land from a given storm will rely on a variety of factors, including construction, placement, age, and condition of the structure.

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Table 3.4.3 Saffir-Simpson Hurricane Wind Scale

Category	Expected Wind Speed	Example Storm(s)	Example Effects on Land
Category 1 Hurricane	74 – 95 MPH	Hurricane Dolly (2008, TX)	Older mobile homes could be destroyed, especially if they are not anchored properly, as they tend to shift or roll off their foundations. Newer mobile homes that are anchored properly can sustain damage involving the removal of shingle or metal roof coverings, and loss of vinyl siding. Some poorly constructed frame homes can experience major damage, involving loss of the roof covering and damage to gable ends as well as the removal of porch coverings and awnings. Unprotected windows may break if struck by flying debris. Falling and broken glass will pose a significant danger even after the storm. Large branches of trees will snap and shallow rooted trees can be toppled. Extensive damage to power lines and poles will likely result in power outages that could last a few to several days.
Category 2 Hurricane	96 – 110 MPH	Hurricane Frances (2004, FL)	There is a substantial risk of injury or death to people, livestock, and pets due to flying and falling debris. Older mobile homes have a very high chance of being destroyed and the flying debris generated can shred nearby mobile homes. Newer mobile homes can also be destroyed. Poorly constructed frame homes have a high chance of having their roof structures removed especially if they are not anchored properly. Unprotected windows will have a high probability of being broken by flying debris. Well-constructed frame homes could sustain major roof and siding damage.
Category 3 Hurricane	111 – 130 MPH	Hurricane Ivan (2004, AL)	There is a high risk of injury or death to people, livestock, and pets due to flying and falling debris. Nearly all older mobile homes will be destroyed. Most newer mobile homes will sustain severe damage with potential for complete roof failure and wall collapse. Poorly constructed frame homes can be destroyed by the removal of the roof and exterior walls. Unprotected windows will be broken by flying debris. Well-built frame homes can experience major damage involving the removal of roof decking and gable ends. There will be a high percentage of roof covering and siding damage to apartment buildings and industrial buildings. Isolated structural damage to wood or steel framing can occur. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to a few weeks after the storm passes.
Category 4 Hurricane	131 – 155 MPH	Hurricane Charley (2004, FL)	There is a very high risk of injury or death to people, livestock, and pets due to flying and falling debris. Nearly all older mobile homes will be destroyed. A high percentage of newer mobile homes also will be destroyed. Poorly constructed homes can sustain complete collapse of all walls as well as the loss of the roof structure. Well-built homes also can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Extensive damage to roof coverings, windows, and doors

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Category	Expected Wind Speed	Example Storm(s)	Example Effects on Land
			will occur. Large amounts of windborne debris will be lofted into the air. Windborne debris damage will break most unprotected windows and penetrate some protected windows. There will be a high percentage of structural damage to the top floors of apartment buildings. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months.
Category 5 Hurricane	>156 MPH	Hurricane Andrew (1992, FL)	People, livestock, and pets are at very high risk of injury or death from flying or falling debris, even if indoors in mobile homes or framed homes. Almost complete destruction of all mobile homes will occur, regardless of age or construction. A high percentage of frame homes will be destroyed, with total roof failure and wall collapse. Extensive damage to roof covers, windows, and doors will occur. Complete collapse of many older metal buildings can occur. Most unreinforced masonry walls will fail which can lead to the collapse of the buildings. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Long-term water shortages will increase human suffering.

(Source: National Hurricane Center)

The Saffir-Simpson Hurricane Wind Scale does not address the potential for other hurricane-related impacts, such as storm surge, rainfall-induced floods, and tornadoes. It should also be noted that these wind-caused damage general descriptions are to some degree dependent upon the building's condition (e.g., age, construction, maintenance). All of these issues factor in to a building's ability to withstand wind loads. Hurricane wind damage is also very dependent upon other factors, such as duration of high winds, change of wind direction, and age of structures.

The NWS has developed an extreme wind warning system similar to other events. Watches are issued when conditions are favorable for high winds to develop 12 to 24 hours in advance. Advisories are issued when existing or imminent high winds cover part of or all of the area and pose a mere inconvenience. High wind warnings are issued when existing or imminent high winds cover part or all of the forecast area and pose a threat to life and property.

Previous Occurrences

This section will detail wind events associated with thunderstorms and tropical storms.

No tropical storm or hurricane events were reported to the National Climatic Data Center (NCDC) since 1955; however, hurricane and tropical storm winds were available through other historical records. There have been federal disaster declarations associated with tropical storms and severe

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thunderstorms, yet the impact from these storms has not been associated with wind. These events will be detailed at the end of the section, as they are associated with the hurricane extreme wind hazard.

The area used for compiling previous occurrences will include reports to the NCDC that are attributed to Bexar County. As explained in the description of the hazard, wind storms have a broad extent. Additionally, although the San Antonio/Bexar County area is outside the extent of the hurricane-susceptible zone, there are occurrences of strong tropical storm winds and hurricane force wind events in the area.

Thunderstorm Wind Events - NCDC

There were 179 occurrences of thunderstorm winds recorded by the NCDC since 1955, with 1 fatality and 30 injuries reported in the San Antonio/Bexar County area.

Total property and crop damage for all thunderstorm wind events was estimated at \$3,875,000. It should be noted that NCDC property and crop damage estimates are generally considered to be low-end estimates, with actual damages often exceeding NCDC estimates.

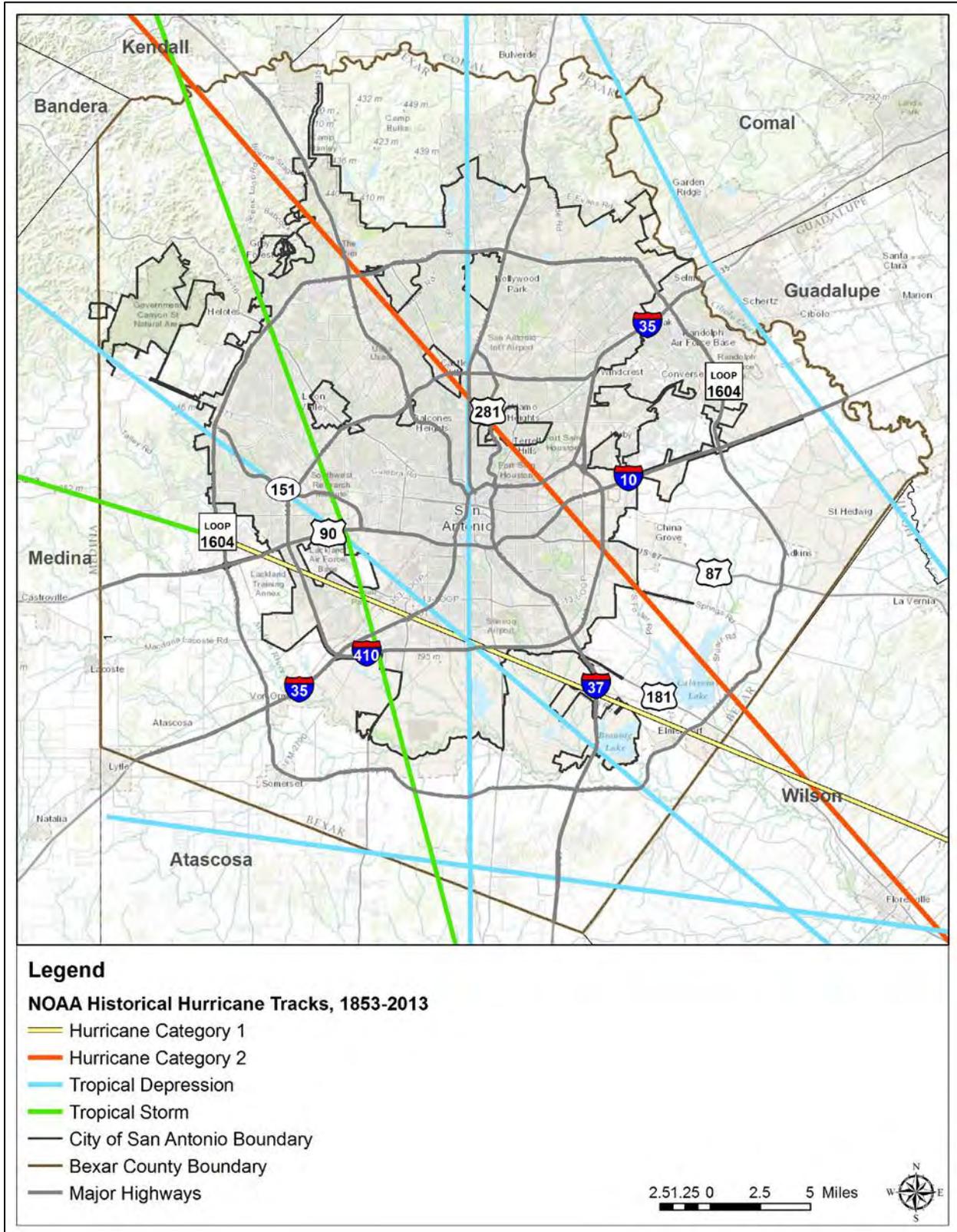
Of the 179 occurrences of thunderstorm winds, 97 have been identified as exceeding 50 KTS, which can be categorized as severe wind.

Tropical Storms/Hurricanes Wind Events - NOAA

As illustrated in the figure below, there have been instances in which tropical storms or hurricanes have directly impacted Bexar County. While this is not a common occurrence, with 7 storms moving over or near the city between 1851 and 2013, it is a possibility.

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Figure 3.4.3 Tropical Storm/Hurricane Wind Event Impacts to Bexar County, 1853-2013



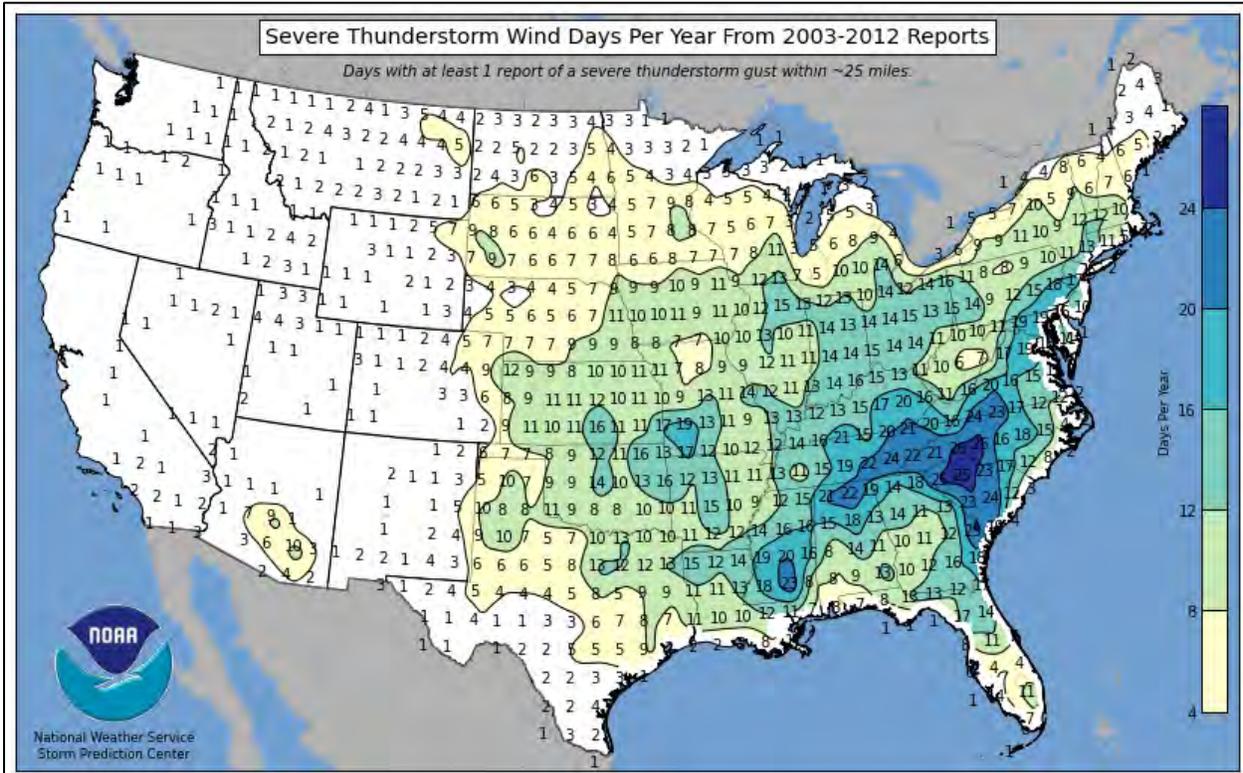
(Source: National Hurricane Center)

Estimated Recurrence Rate

The estimated recurrence rate of extreme wind, based on historic occurrences in the City of San Antonio and Bexar County, is considered moderate.

NOAA's National Severe Storms Laboratory (NSSL) reports there have been 2-3 days per year with winds reaching or in excess of 58 MPH (50 KTS). The following graphic, obtained from the NOAA, illustrates the wind days per year for the entire US, including Bexar County.

Figure 3.4.4 Severe Thunderstorm Wind Days per Year



(Source: National Oceanic and Atmospheric Administration)

Vulnerability

Population

People living in mobile homes, homes built prior to modern building codes, and homes in deteriorating condition are particularly vulnerable to extreme winds. People in automobiles and campgrounds at the time of occurrence are also at risk from flying debris or falling limbs. Generally, injuries are minor. Although rare, fatalities can and do occur.

Extreme wind events can also result in power outages. Without energy, individuals are unable to maintain their daily routines. Without electricity, natural gas, or fuel oil, it is difficult to heat or cool

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homes. Without electricity there are no lights, except for candles, flashlights and/or camping type lanterns. Each of these increases the threat to individuals' safety.

Property

Extreme winds can cause minor to major damage to homes and other buildings. Outdoor furniture, trash cans, yard debris, sheds, and other loose materials in the immediate vicinity of homes can become airborne missiles. Inadequately secured downspouts may be torn from buildings. Loose shingles or other building materials can fly off and, in addition to causing roof damage, may become flying debris. Tree branches may be broken off or trees may be downed and cause damage to homes and other structures. Windows may also be broken.

Environment

Environmental vulnerabilities to extreme wind are often minor, and are usually related to downed trees and the like. In and of itself, downed trees tend to be a minor vulnerability. However, if downed trees were to fall in areas occupied by facilities that use and store hazardous materials, and an unintended or uncontrolled release were to occur, then the resulting damage could be much more severe.

City/County Operations

Critical facilities are those facilities or services that a community relies on for effective and efficient operation, particularly during and after a hazard event, or that would be of critical importance to a community in the event and aftermath of a hazard event. Typically, critical facilities include:

- Fire stations;
- Hospitals/clinics/medical centers;
- Chemical/heavy industrial/hazardous materials facilities or storage locations; and
- Communications facilities, such as radio and television broadcast locations.

As extreme wind events typically cover a large geographic area, it is inevitable that facilities critical to the community will be located within the boundaries of any event. In fact, critical facilities have been damaged by extreme winds. In 1987, three radio towers in China Grove were damaged by extreme winds. The towers that were damaged were between 320 and 500 feet in height. The event resulted in two radio stations being knocked off the air, and therefore unable to broadcast emergency information. (Source: *Houston Chronicle*)

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *Federal Emergency Management Agency*
FEMA P-320 – Taking Shelter from the Storm: Building a Safe Room http://www.fema.gov/plan/prevent/saferoom/tsfs02_wind_zones.shtm
- *HAZUS-MH*
<http://www.fema.gov/plan/prevent/hazus/>
- *National Climatic Data Center*
<http://www.ncdc.noaa.gov/oa/ncdc.html>
- *National Hurricane Center*
<http://www.nhc.noaa.gov/>, and
Tropical Cyclone Report, Tropical Storm Erin
http://www.nhc.noaa.gov/pdf/TCR-AL052007_Erin.pdf
- *National Oceanic and Atmospheric Administration*
<http://www.noaa.gov>
- *National Severe Storms Laboratory, NOAA*
Severe Weather 101
http://www.nssl.noaa.gov/primer/wind/wind_basics.html, and
Severe Thunderstorm Climatology
<http://www.nssl.noaa.gov/hazard/totalthreat.html>
- *National Weather Service*
<http://www.weather.gov>
- *Mount Washington Observatory*
Beaufort Wind
Scale <http://www.mountwashington.org/education/center/arcade/wind/beaufort.html>
- *Texas Hurricane History*
Written by David Roth, National Weather Service, Camp Springs, MD
<http://www.hpc.ncep.noaa.gov/research/txhur.pdf>

Regional/State Resources and Documents:

- *Houston Chronicle*
“3 China Grove radio towers ripped by wind”
<http://www.chron.com>

Local Resources and Documents:

- *San Antonio Office of Emergency Management*
Hurricane Dolly After Action Report
- *San Antonio Office of Historic Preservation*
Local Historic Districts
<http://www.sanantonio.gov/historic/districts.aspx>

Section 3.5 - Flood Description

Of all the natural hazards that occur in the United States (US), flooding occurs most often; at least 90% of disasters in the US involve floods.

The National Flood Insurance Program (NFIP) defines flooding as:

A partial or complete inundation of normally dry land areas from:

- The overland flood of a lake, river, stream, ditch, etc.;
- The unusual and rapid accumulation or runoff of stream waters; or
- Mudflows or the sudden collapse of shoreline land.

Floods are generally the result of excessive precipitation and can be classified under two categories: riverine floods (precipitation over a given river basin for a long period of time) and flash floods (the product of heavy localized precipitation in a short time period over a given location). The severity of a flood event is determined by the following:

- A combination of stream and river basin topography and physiography;
- Precipitation and weather patterns;
- Recent soil moisture conditions; and
- The degree of vegetative clearing.

Flooding can also be caused by inadequate or improper drainage systems, including storm sewers, culverts, and drainage ditches. These systems are usually designed to carry up to a specific amount of water (design capacity). When a heavy rainfall causes the design capacity of the systems to be exceeded, water will begin to back up and fill low-lying areas near system inlets and along open ditches. This is most common in urban areas. As land is converted from fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. Urbanization increases runoff two to six times over what occurs on natural terrain.

Figure 3.5.1 261 Low Water Crossings identified in San Antonio/Bexar County



General Characteristics

The San Antonio/Bexar County area generally experiences two types of flood hazards - riverine flooding and flash flooding.

Riverine

Riverine flooding is defined as a rising and overflowing of rivers and streams onto normally dry land. Riverine flooding is usually the result of heavy or prolonged rainfall or snowmelt occurring in upstream inland watersheds. Melting snow can combine with rain in the winter and early spring; severe thunderstorms can bring heavy rain in the spring or summer. Intense rainfall over a short period of time, or a debris jam can also cause a river or stream to overflow. Riverine floodwaters can occur quickly and move rapidly, as in a flash flood, or waters can rise slowly over a period of hours or even a few days.

Flash Flooding

For purposes of evaluation in this plan, flash flooding is defined as events that happen as a result of heavy rains over a short period of time or storm water run-off that occurs without sufficient warning for the community and/or individuals to take emergency protective measures.

Flash flooding is not unique to the San Antonio/Bexar County area; however, the frequency and severity of flash flooding events is unique and attributable to specific climatic circumstances. The 2010 Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) details these specific climatic circumstances in the region which contribute to the intensity and frequency of the hazard:

Bexar County lies in the center of a special climatic zone influenced by the Balcones Fault scarp escarpment. Humid, southerly winds off the Gulf of Mexico strike the 500-to 800-foot face of the scarp and are lifted orographically to produce intense localized rainfall. This process is aided by frequent cold fronts (northers) and occasional tropical cyclones (hurricanes), especially in the months of August and September. This combination of climatic and physiographic factors has produced some of the most intense rainstorms ever recorded in the conterminous US. Some of these intense rainstorms include 36.4 inches measured in 18 hours at Thrall in September 1921, and 22.0 inches in 2 hours and 45 minutes at D'Hanis in May 1935. A 15-inch rainfall is no longer considered rare, and it is not unheard of to have a 20-inch rainfall. (Source: *Flood Insurance Study*)

Figure 3.5.2 Pinn Rd 2013 Memorial Day Flood



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Location

All streams flowing through Bexar County drain into the San Antonio River basin. Major waterways in the area are the San Antonio and Medina rivers and Cibolo Creek. Secondary streams in the county include Elm, Leon, Salado, Martinez, and Calaveras creeks. Flow patterns are dependent on the stream's location to the fault system. Those south of the fault system have relatively mild slopes, wide, flat floodplains, and flow northwest to southeast. Those north of or crossing the fault have steep slopes, narrow or no floodplains, losing reaches (meaning sections of some streams flowing through limestone areas of Bexar County where discharges decrease as drainage areas increase), and flow generally north to south. The loss of surface water provides a significant source of recharge to ground-water aquifers that supply many springs and wells.

(Source: Flood Insurance Study)

The locations of flood hazard areas in Bexar County area are detailed in the Figure 3.5.3.

Extent

While it is difficult to determine the exact extent of the flood hazard due to varying factors, it is important to note, that generally, a significant portion of flooding occurs in areas outside the identified flood hazard area. FEMA estimates that more than 30% of all floods occur in areas that are not or have not been identified as being within a known flood hazard area.

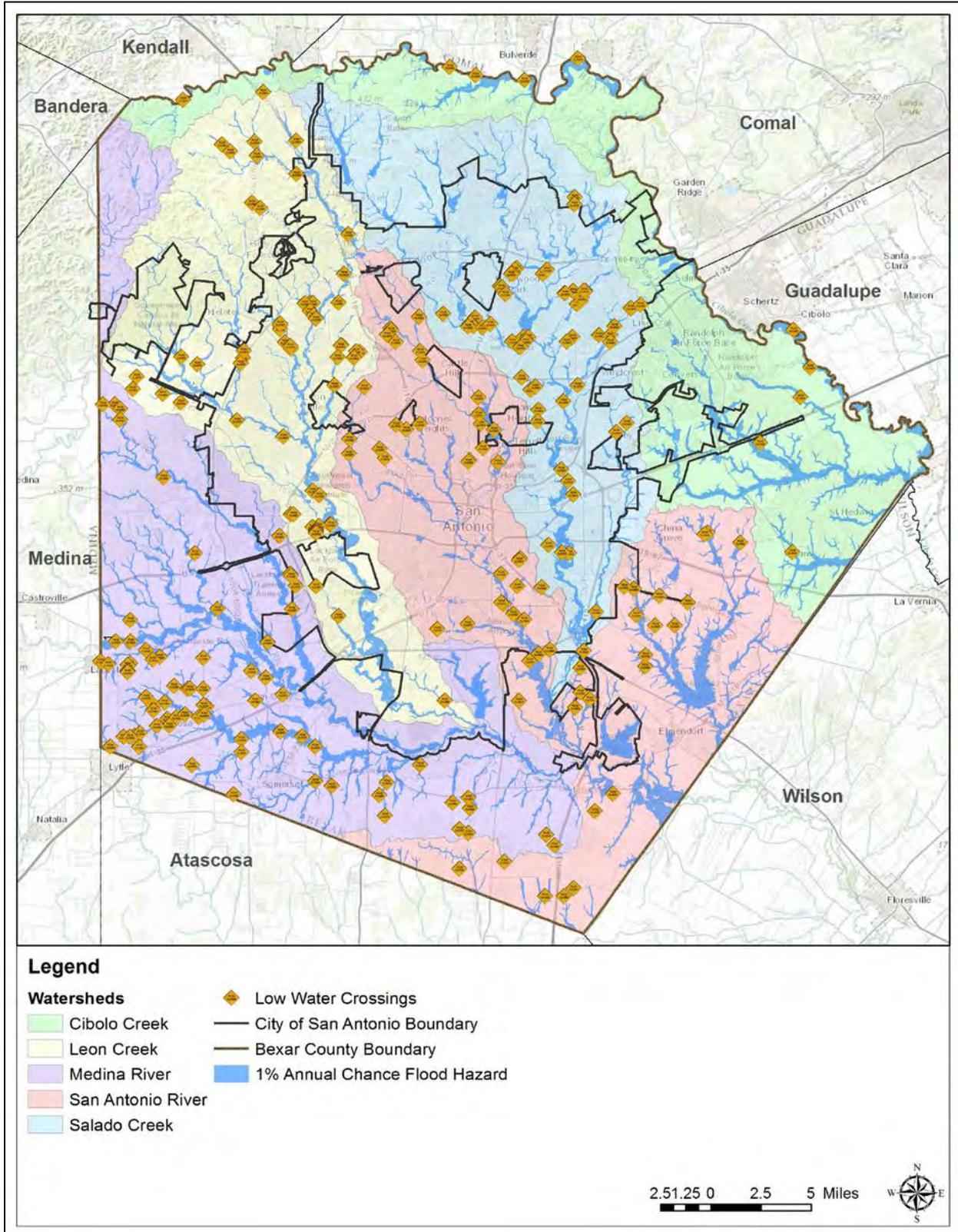
The National Flood Insurance Program

The City of San Antonio and Bexar County are participants in good standing in the NFIP. The NFIP was created by the National Flood Insurance Act of 1968 (PL 90-448). The program enables property owners in participating communities to purchase insurance protection from the government against property losses from flooding, a peril that is generally excluded from private property casualty insurance. NFIP coverage is designed to provide an insurance alternative to meeting the costs associated with repairing damage to buildings and their contents caused by flooding. As of April 2010, the program insured approximately 5.5 million residential structures, the vast majority of which are located in Florida and Texas.

Participation in the NFIP is based on an agreement between local communities and the federal government, which states that if a community will adopt and enforce a floodplain management ordinance to reduce future flood risks to new construction in Special Flood Hazard Areas (SFHA), the federal government will make flood insurance available within the community as a financial protection against flood losses. A Special Flood Hazard Area (SFHA) is defined as an area delineated on a NFIP map as being subject to inundation by the base flood. A base flood is the flood that has a 1-percent chance of being equaled or exceeded in any given year (sometimes called the "100-year" flood). SFHAs are determined using statistical analyses of records of river flow, storm tides, and rainfall; information obtained through consultation with a community; floodplain topographic surveys; and hydrologic and hydraulic analyses.

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Figure 3.5.3 FEMA-Identified Flood Hazard Areas within Bexar County



(Source: Federal Emergency Management Agency and San Antonio Office of Emergency Management)

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The SFHAs and other risk premium zones applicable to each participating community are depicted on Flood Insurance Rate Maps (FIRMs). The Mitigation Division within the Federal Emergency Management Agency manages the NFIP and oversees the floodplain management and mapping components of the program.

Repetitive Loss and Severe Repetitive Loss Properties

The intent of the NFIP is to reduce future flood damage through community floodplain management ordinances and to provide protection for property owners against potential losses through an insurance mechanism that requires a premium to be paid for the protection. The NFIP is meant to be self-supporting, though in 2004 Congress found that Repetitive Loss properties cost the taxpayer about \$200 million annually (these properties are discussed later in this section). Congress originally intended that operating expenses and flood insurance claims be paid for through the premiums collected for flood insurance policies. The NFIP borrows from the US Treasury for times when losses are heavy, and these loans are paid back with interest.

Between 1978 and March 2011, the NFIP paid more than \$38 billion in claims.

FEMA and the NFIP periodically review and update the mapping used to identify the SFHAs, which are identified on FIRMs. FIRMs are the primary means that a community uses to identify its flood hazard areas and are used as a basis to define the areas that are subject to the jurisdiction's Flood Damage Prevention Ordinance. In 2010, FEMA published updated FIRMs for Bexar County and the City of San Antonio. These updated FIRMs included DFIRMS, which are digital maps that can provide more detail and data. As a part of the FIRM update process, an updated Flood Insurance Study was also completed and published.

For those communities that have known flooding concerns, the NFIP maintains a listing of properties identified as either Repetitive Loss (RLP) or Severe Repetitive Loss (SRLP). A 2005 study by the Congressional Research Service (a branch of the library of Congress) reported that, over the life of the NFIP, 1% of the NFIP policies represented RLPs and that group accounted for 30% of the program's losses. The study also identified several major contributors to RLPs including:

- RLPs typically involve older properties that received grandfathering. In other words, NFIP flood mitigation rules and requirements do not apply to such structures since they existed prior to the establishment of the programs. The premiums charged for such properties are heavily subsidized rates; and
- RLPs that suffer only partial losses (less than 50% of their value) do not have to be rebuilt according to floodplain management standards that apply to "substantially damaged" properties. Therefore, their vulnerability to future flood losses is maintained. This creates both a severity and a frequency problem.

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Several years ago, the NFIP instituted a program to specifically address the disproportional exposures caused by RLPs. The program now has established a set of procedures to handle them called "Special Procedures for Targeted Repetitive Loss Properties". The NFIP, through careful study of loss data, identified roughly 11,000 properties. The properties, because of their high loss exposure, are designated as RLPs. The properties consist of a group that meets one of the following criteria:

- The property has received at least four loss payments exceeding \$1,000;
- The property has experienced two losses within any 10-year period and the total payment exceeds that property's current value; or
- The property had, in its history (since 1978), three or more loss payments that, collectively, exceed the property's current value.

A subset of these designated properties is known as SRLP. The definition of severe repetitive loss as applied to this program was established in section 1361A of the National Flood Insurance Act, as amended (NFIA), 42 U.S.C. 4102a. An SRLP is defined as a residential property that is covered under an NFIP flood insurance policy and:

- (a) That has at least four NFIP claim payments (including building and contents) over \$5,000 each, and the cumulative amount of such claims payments exceeds \$20,000; or
- (b) For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.

For both (a) and (b) above, at least two of the referenced claims must have occurred within any 10-year period and must be greater than 10 days apart. (Source: *National Flood Insurance Program*)

The City of San Antonio and Bexar County participates in the NFIP and are working towards joining the NFIP's Community Rating System (CRS). The CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the CRS:

1. Reduce flood losses;
2. Facilitate accurate insurance rating; and
3. Promote the awareness of flood insurance.

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Previous Occurrences

Data regarding previous occurrences is compiled from a variety of sources, including local documents, the current FIS, and other documents and studies detailing flood events. The most significant events will be detailed first, beginning with events associated with presidential disaster declarations, followed by events described as significant in the FIS, and finally a list of National Climatic Data Center (NCDC) events that do not fall into the aforementioned categories yet are still significant.

This listing does not and cannot reasonably account for all previous occurrences of the flood hazard. As with any historical record, the data is limited by what was recorded and preserved. The information presented focuses on events that were large, destructive, or otherwise memorable.

Federal Disaster Declarations

1997 – DR-1179-TX

NCDC lists four flood events in 1997: three in June and the final in October. Total damages reported for this declaration include 10 injuries and \$3,120,000 in property damage. No further details of the type of flooding were available for this declaration.

1998 – DR-1257-TX

During the weekend of October 17 and 18, 1998, torrential rains fell over south and southeast Texas. Up to 22 inches of rain fell, resulting in flash flooding from San Antonio to Austin, which was followed by record-breaking river floods along the Guadalupe and several other south Texas rivers the following week. All of the ingredients for extremely heavy rains came together over south Texas the morning of Saturday, October 17, 1998. A strong upper level trough and surface front were approaching from the west while a persistent low-level southeast flow of very moist air covered south Texas. In addition, a plume of moist air was streaming across the area from Hurricane Madelain off the west coast of Mexico. Storm conditions began about 5 a.m. Saturday over San Antonio and in the words of the NWS “developed explosively”. The storm spread north to Austin. A cold front arrived Saturday night, supporting and intensifying the already heavy weather. Several tornadoes were spawned by the arrival of the front, followed by torrential rains.

As the initial flood wave moved down the rivers Saturday night and Sunday, up to an additional foot of rain fell on the drainage areas. When the event ended, as much as 22 inches of rain had fallen over parts of south and southeast Texas, with many areas receiving more than one foot of rain. By Sunday, October 18, the heavy rains tapered off, and the event became a major riverine flood event, affecting seven river basins, draining approximately 10,000 mi². Three people drowned on the north side of San Antonio after 15 inches of rain fell. The San Antonio airport recorded 11.26 inches of rainfall on October 18, a new record for the day and the month. (Source: *National Oceanic and Atmospheric Administration*)

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The floods in 1998 exceeded the “100-year” flood elevation level throughout San Antonio/Bexar County and neared the “500-year” flood elevation level in several areas. Based on the information from the 1998 Flood Event After Action Report this resulted in significant impacts throughout the area, including:

- 10 inches of rain in 24 hours as a base throughout the area; 19 inches in certain areas;
- 11 lives lost due to vehicles in flooded areas;
- 192 rescues, saving 461 individuals from rising waters;
- 123 major accidents handled by the law enforcement;
- Over 1,150 residential structures and 49 businesses were significantly damaged;
- Over \$115 million in damage to public and private property;
- Over \$71 million in damage to city/county-owned facilities;
- Total costs between \$300 million and \$500 million, according to a US Army Corps of Engineers interim study of the event;
- 3 command centers set up to provide relief and assistance to more than 5,500 flood victims;
- Over 20,000 immunizations administered to flood victims and others assisting in cleanup efforts;
- 480 tons of debris collected from 576 miles of street and roadways; and
- 21,375 tons of debris collected from approximately 8 miles of channel.

Data indicated that the water flow measured 66,000 cubic feet per second (cfs) in Salado Creek during the peak period of the storm. The Salado Creek Watershed Study (adopted in 1997) indicated a 100-year flood flow of 57,946 CFS and a 500-year discharge rate of 73,634 CFS. (Source: *San Antonio Office of Emergency Management*)

2002 – DR-1425-TX

The San Antonio Area rainfall of October 2002 has resulted in 4 fatalities.

Significant Historical Events

Significant events preceding the creation of the NCDIC and existence of disaster declarations are referenced in the most recent Bexar County FIS. “The City of San Antonio ... has recorded disastrous floods in 1921, 1935, 1946, and 1965.” (Source: *Flood Insurance Study*)

1921 Flood Event

The San Antonio River floods of 1921 resulted in the death of 51 people and caused millions of dollars in damage. The flood was caused by some of the heaviest rainfall ever recorded in Texas; the rainfall was the result of a deteriorating tropical system over south central Texas. The San Antonio River winds through southwest Texas, an area that is generally dry. However, on September 7, a storm stalled over the town of Taylor (located northeast of city of Austin, Texas) and dumped a 23.11 inches of rain on the area in less than a day. It was the heaviest single day of rainfall recorded in the state to that time. Heavy rains caused flash flooding along the rivers of South Central Texas, including San Antonio. The immense amount of rain quickly overwhelmed the San Antonio River. Most of the victims were trapped in their

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cars by the surprise flood and drowned. Five to 10- inches of water submerged the city's streets, delaying an evacuation. The city was under water for nearly a week following the flood. The flood was responsible for at least \$5 million in damage in the then-small city.

(Source: *National Oceanic and Atmospheric Administration, Texas Hurricane History*)

1935 Flood Event

Central and South Central Texas experienced heavy rains that in the Spring of 1935 that greatly affected Austin, San Antonio and smaller cities like Junction, Uvalde and D'Hanis.

During this event, while Austin received a deluge, San Antonio was hit even harder with 14.07 inches in May and 8.41 inches the next month – a significant amount of rainfall in a short period of time. The stores around Alamo Plaza (downtown San Antonio) were flooded in late May. (Source: *Texas Escapes Online Magazine*)

1946 Flood Event

Heavy rainfall was recorded over a two-day period. More than 16 inches of rain fell over a 110 mi² area, centered on the City of San Antonio. September 1946 was the wettest September of record for San Antonio and third wettest all time month. Floods in September 1946 cost San Antonio six lives and resulted in \$2.1 million in property damage. The San Antonio River peaked at 33.8 feet. (Source: *National Oceanic and Atmospheric Administration*)

1965 Flood Event

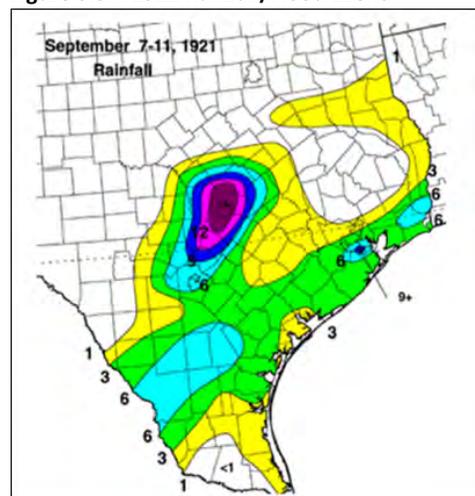
Rainfall exceeding 6 inches in some areas flooded parts of Bexar County. Property damage was estimated at \$1 million. Two people drowned, and 14 were injured. (Source: *National Oceanic and Atmospheric Administration*)

NCDC Summary of Significant Occurrences

The NCDC compiles data on significant weather events, compiled from both NWS reports and observations and reports from other agencies, sources and individuals NCDC data, while valuable, is typically a snapshot of an event, therefore more accurate damage assessment information is available through sources created at a later date; wherever possible NCDC data will be supplemented or replaced with data from latter sources.

There are 204 occurrences listed for flooding/flash flooding in Bexar County since 1996. What follows is a summary of occurrences that reached a level of intensity deemed significant. Significant for purposes

Figure 3.5.4 1921 Rainfall/Flood Event



(Source: *National Oceanic and Atmospheric Administration*)

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of this document is defined as flooding exceeding 6 inches in depth and resulting in more than \$50,000 in damages, or any flooding that generates human injury or fatalities.

1993 – 3 fatalities, ~\$500,000 listed in damages.

1995 – 2 fatalities.

1997 – Listed previously; 10 injuries, ~\$3,120,000 listed in damages.

1998 – Listed previously; 11 fatalities, 600 injuries, ~\$8,000,000 listed in damages.

2000 – ~\$220,000 listed in damages.

2002 – Listed previously; Note: this group of events registered the highest amount of occurrences in a single year, with 18 events listed; five time periods saw the most significant reporting, beginning in April event, continuing with the occurrences that triggered the declaration at the beginning of July, followed by early September, late October, and December occurrences. 4 fatalities, 8 injuries, ~\$445,000 listed in damages.

2007 – August 16 – The NCEM report for this event is as follows: “The area of extremely heavy rainfall associated with the remains of Tropical Storm Erin continued to spread northwestward across Bexar County, with a general 4 to 5 inches rain over the county. Totals of up to 8 inches were reported at several locations in the south and west parts of San Antonio as well as between Helotes and Leon Springs. By 1400 CST, most roads in the northwest part of the county were closed. By 1530 CST that afternoon, more than 39 high water rescues were reportedly under way in San Antonio.” 2 fatalities, ~\$15,000,000 listed in damages.

2010 – 2 fatalities, ~\$50,000 listed in damages.

2013 – 2 fatalities.

Estimated Recurrence Rate

The estimated recurrence rate of flood, based on historic occurrences in the City of San Antonio and Bexar County, is considered high.

Vulnerability

Population

Flooding poses a significant, life-threatening concern to people. Swift-rising or flowing water can lead to injuries or fatalities and routinely causes more fatalities in the US annually than any other natural

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hazard. As indicated in the historical information above, flooding has caused multiple deaths in Bexar County. Rising floodwaters may require evacuation to avoid risk of injury or death, and damage from floodwaters can displace residents from their homes.

In addition to the hazard posed by the flood water itself, people are also vulnerable to illness and injury once flood waters recede. Mold can quickly grow in areas that were inundated, especially in a warm climate. Sewage and hazardous chemicals are often present in floodwaters and are left behind once those waters recede. Food and water sources may be contaminated and unknowingly consumed.

Property

Property in many areas of the city and county are vulnerable to damage in flood events. Property in the SFHA can be considered vulnerable as well as property in locations outside the SFHA.

Repetitive Loss and Severe Repetitive Loss Properties

Data related to FEMA-identified RLPs and SRLPs is maintained by the Texas Water Development Board (TWDB), and was provided by SARA. The data used in this assessment was extracted from the BureauNet in December 2013.

The data was mapped by category of loss and the number of flood losses. The earliest record identified dates from 1979; the most recent record dates from 2013. A total of 139 RLPs were identified within the jurisdiction of the City of San Antonio/Bexar County, and another 12 SRLPs were identified.

The Table 3.5.1 below provides the summary of claims paid. Due to Privacy Act of 1974 restrictions on the use of NFIP data, no additional detail will be included in this document. The following Figure 3.5.5 illustrates the general locations of the RLPs and SRLPs within the City of San Antonio. The properties identified in the map below, by definition, represent a significant portion of the NFIP claims paid within the City of San Antonio in the previous 35 years.

Table 3.5.1 Repetitive Loss and Severe Repetitive Loss Claims Payments

Category of Loss	Number of Losses	Total Claims Paid
Repetitive Loss	139	\$4,403,895.31
Severe Repetitive Loss	12	\$3,292,140.64
Total	151	\$7,696,035.95

(Source: Federal Emergency Management Agency and the Texas Water Development Board)

Environment

Flooding is a natural occurrence, although severity and location in an urban area is often affected by human activity and the built environment. While the environment can generally withstand and recover from impacts of a flood, a major vulnerability of the environment is the amount and type of debris that flooding generates. Construction materials, household chemicals, vegetative and landscaping materials and chemicals – all of these items are frequently found in debris piles following a flood event, and all of these things can cause contamination of the environment.

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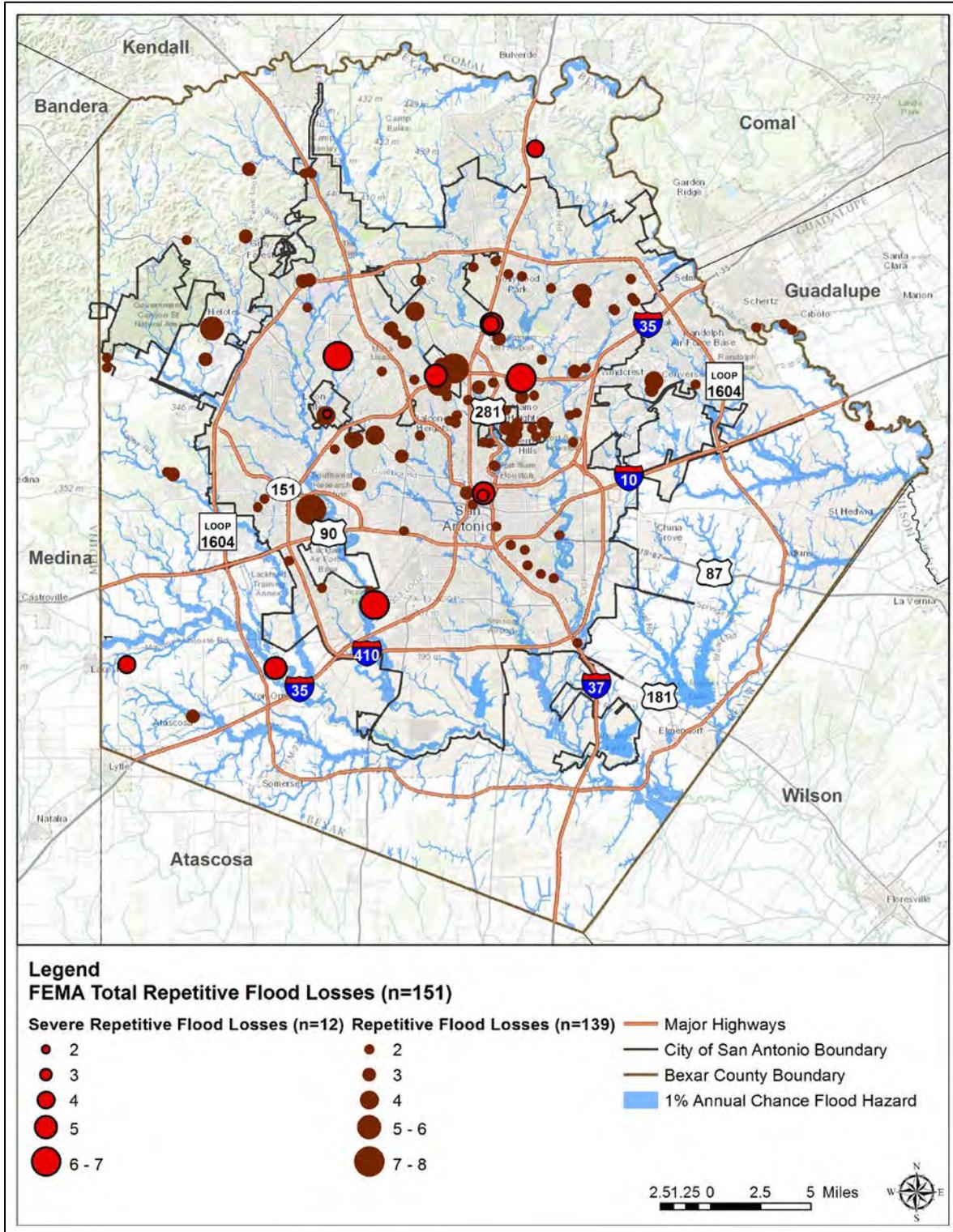
Critical facilities are those facilities/services that a community relies on for effective and efficient operation, particularly during and after a hazard event, or that would be of concern/importance to a community in the event and aftermath of a hazard event. Typically, critical facilities are such things as:

- Fire stations;
- Hospitals/clinics/medical centers;
- Chemical/heavy industrial/hazardous materials facilities or storage locations; and
- Communications facilities, such as radio and television broadcast locations.

As the SFHA comprises a significant portion of the city, it is inevitable that facilities critical to the community will be located within its boundaries. These facilities not only encompass sites that are valued in economic terms but also possess value in social and cultural significance. Table 3.5.2 summarizes critical facilities located in the floodplain.

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Figure 3.5.5 RL and SRL Properties in San Antonio/Bexar County



(Source: Federal Emergency Management Administration, National Flood Insurance Program, San Antonio Office of Emergency Management, Texas Water Development Board)

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Bibliography and Resource Directory

Federal/National Resources and Documents:

- *Federal Emergency Management Agency*
<http://www.fema.gov>, and
Disaster and Emergency Declarations
<http://www.fema.gov/disasters/grid/state-tribal-government/24>, and
Map Service Center
<https://msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1>
- *Flood Insurance Study*
- *HAZUS-MH*
<http://www.fema.gov/plan/prevent/HAZUS-MH>
- *National Climatic Data Center*
<http://www.ncdc.noaa.gov/oa/ncdc.html>
- *National Flood Insurance Program*
2010 Bexar County Flood Insurance Study
- National Oceanic and Atmospheric Administration
Monthly Weather Review
<http://docs.lib.noaa.gov/rescue/mwr/049/mwr-049-09-0494.pdf>
- Texas Flash Flood Coalition
Flash Flood Fatality Information
Presentation to the Texas Department of Homeland Security Conference, February 2010
- *Texas Hurricane History*
Written by David Roth, National Weather Service, Camp Springs,
MD <http://www.hpc.ncep.noaa.gov/research/txhur.pdf>
- *United States Army Corps of Engineers*
2000 Chief of Engineers Design and Environmental Awards
Program http://www.wbdg.org/pdfs/USACE_DesignAwards2000.pdf
- *United States Geological Survey*
Extreme Precipitation Depths for Texas, Excluding the Trans-Pecos Region
<http://pubs.usgs.gov/wri/wri984099/pdf/wri98-4099.pdf>

Regional/State Resources and Documents:

- *Alamo Area Council of Governments*
Regional Multi-Hazard Mitigation Plan Update Draft, 2012
<https://www.aacog.com/index.aspx?NID=405>
- *Flood Safety, Guadalupe-Blanco River Authority*
South Central Texas June 30 – July 7, 2002
<http://www.floodsafety.com/texas/documentaries/j2002/index.htm>
- *Texas Escapes Online Magazine*

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Texas Flood of 1935

<http://www.texasescapes.com/TexasRivers/Texas-Flood-of-1935.htm>

- *Texas Water Development Board*
NFIP Repetitive Loss and Severe Repetitive Loss Data for the City of San Antonio

Local Resources and Documents:

- *San Antonio Flood Emergency SAFE System*
www.safloodsafe.com
- *San Antonio Office of Emergency Management*
1998 Flood Event After Action Report
2010 Floodplain Study
Low Water Crossing Data

Section 3.6 - Hail

Description

Hail is defined as falling ice, roughly round in shape and at least 0.2 inches in diameter. Hail develops in the upper atmosphere as ice crystals that are bounced about by high velocity updraft winds; the ice crystals accumulate frozen droplets and fall after developing enough weight. The size of hailstones varies and is a direct consequence of the severity and size of the storm that produces them – the higher the temperatures at the Earth's surface, the greater the strength of the updrafts and the amount of time hailstones are suspended, the greater the size of the hailstone.

General Characteristics

There are two ideas about hail formation. In the past, the prevailing thought was that hailstones grow by colliding with supercooled water drops. Supercooled water will freeze on contact with ice crystals, frozen rain drops, dust or some other nuclei. Thunderstorms that have a strong updraft lift hailstones to the top of the cloud where they encounter more supercooled water and continue to grow. The hail falls when the thunderstorm's updraft can no longer support the weight of the ice or when the updraft weakens. The stronger the updraft the larger the hailstone can grow.

Recent studies suggest that supercooled water may accumulate on frozen particles near the back-side of the storm as they are pushed forward across and above the updraft by the prevailing winds near the top of the storm. Eventually, the hailstones encounter

downdraft air and fall to the ground.

Hailstones grow two ways: by wet growth or dry growth processes. In wet growth, a tiny piece of ice is in an area where the air temperature is below freezing, but not super cold. When the tiny piece of ice collides with a supercooled drop, the water does not freeze on the ice immediately; instead, liquid water spreads across tumbling hailstones and slowly freezes. Since the process is slow, air bubbles can escape, resulting in a layer of clear ice.

Dry growth hailstones develop when the air temperature is well below freezing and the water droplet freezes immediately as it collides with the ice particle. The air bubbles are frozen in place, leaving cloudy ice.

Hailstones can have layers like an onion if they travel up and down in an updraft, or they can have few or no layers if they are "balanced" in an updraft. One can tell how many times a hailstone traveled to the top of the storm by counting the layers. Hailstones can begin to melt and then re-freeze together, forming large and very irregularly shaped hail. (Source: *National Oceanic and Atmospheric Administration*)

Figure 3.6.1 Hailstones

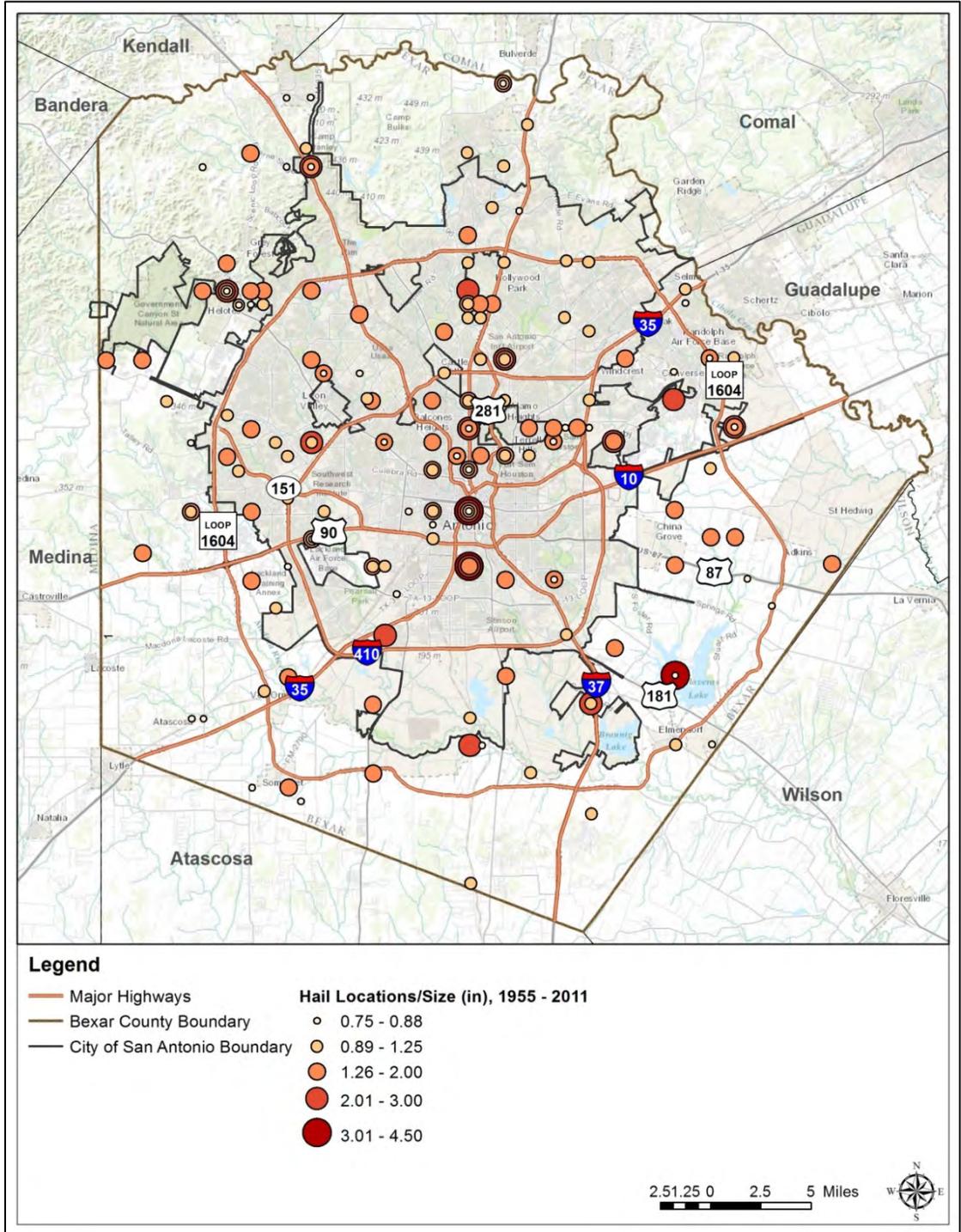


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Location

Hail is not a location-specific hazard; the entire San Antonio/Bexar County area is subject to this hazard. Figure 3.6.2 shows the location of historic hail occurrences in San Antonio/Bexar County.

Figure 3.6.2 Historical Hail Locations in San Antonio/Bexar County, 1955-2011



(Source: National Oceanic and Atmospheric Administration's Storm Prediction Center)

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Extent

The National Oceanic and Atmospheric Administration (NOAA) and the Tornado and Storm Research Organization (TORRO) both have Hailstorm Intensity Scales. Table 3.6.1 describes these combined intensity scales.

Table 3.6.1 Hailstorm Intensity Scales

Combined NOAA/TORRO Hailstorm Intensity Scales				
Size Code	Intensity Category	Typical Hail Diameter (inches)	Approximate Size	Typical Damage Impacts
H0	Hard Hail	up to 0.33	Pea	No damage
H1	Potentially Damaging	0.33-0.60	Marble or Mothball	Slight damage to plants, crops
H2	Potentially Damaging	0.60-0.80	Dime or grape	Significant damage to fruit, crops, vegetation
H3	Severe	0.80-1.20	Nickel to Quarter	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
H4	Severe	1.2-1.6	Half Dollar to Ping Pong Ball	Widespread glass damage, vehicle bodywork damage
H5	Destructive	1.6-2.0	Silver dollar to Golf Ball	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6	Destructive	2.0-2.4	Lime or Egg	Aircraft bodywork dented, brick walls pitted
H7	Very destructive	2.4-3.0	Tennis ball	Severe roof damage, risk of serious injuries
H8	Very destructive	3.0-3.5	Baseball to Orange	Severe damage to aircraft bodywork
H9	Super Hailstorms	3.5-4.0	Grapefruit	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
H10	Super Hailstorms	4+	Softball and up	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

(Source: National Oceanic and Atmospheric Administration and Tornado and Storm Research Organization)

The planning area can expect to experience the entire range of the hazard, from potentially damaging to super hailstones.

Previous Occurrences

According to the National Climatic Data Center, the geographic area of the Bexar County experienced at least 284 hail events from 1950 through 2013 with some hail stones reaching 4.5 inches in diameter, and reported property damage in upwards of 120 million dollars. (Source: *National Climatic Data Center*)

The following are examples of notable hail events in Bexar County that occurred since 1993.

12/23/2002 - Bexar County

In late December 2002, hail sizes up to 4.5 inches had been reported in the City of Elmendorf and in Bexar County. Spotty damage was reported to vehicles and to the roofs and windows of buildings in the Calaveras Lake area.

05/06/2001 - Bexar County

During one of the most devastating hail-and-wind storms in the history of Bexar County, hail in sizes up to 4 inches in diameter, accompanied by winds over 60 mph, destroyed roofs of hundreds of homes, and severely damaged hundreds of cars, as well as breaking thousands of windows in houses and vehicles. The damage was reported to have been the worst in the northwestern part of the city, where hail reached at least 4 inches in diameter. Damages were estimated to reach at least \$60,000,000 for homes, and an additional \$60,000,000 for cars. Additional severe thunderstorm winds struck the western part of the county just before 8 pm and destroyed over a dozen power lines along Grissom Road near Culebra.

03/28/2000 - Bexar County

A small and short-lived tornado struck just northwest of Leon Valley. It was preceded by winds estimated at 40 to 50 mph, along with heavy rain and large hail in sizes up to 2.75 inches. Widespread damage was reported to cars in the Leon Valley due to the very large hail. Also, a very large hail in sizes up to 2.5 inches was reported at Stinson Airport on the southeast side of San Antonio.

03/16/2000 - Bexar County

During this storm event on March 16, 2000, the hail measured roughly 1.25 inches and was reported by the public to have damaged cars on Interstate Highway 37 along the south side of San Antonio.

02/10/1998 - Bexar County

During the February 1998 storm, hail in sizes up to 1.75 inches significantly damaged properties in upwards of \$10,000, and crop damage was reported near \$50,000 in Bexar County.

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Table 3.6.2 provides an overview of historical hail events that have reported property or crop damage (no fatalities or injuries have been reported during these events). (Source: *National Climatic Data Center*)

Table 3.6.2 Historical losses from Hail in San Antonio/Bexar County, 1950-2013

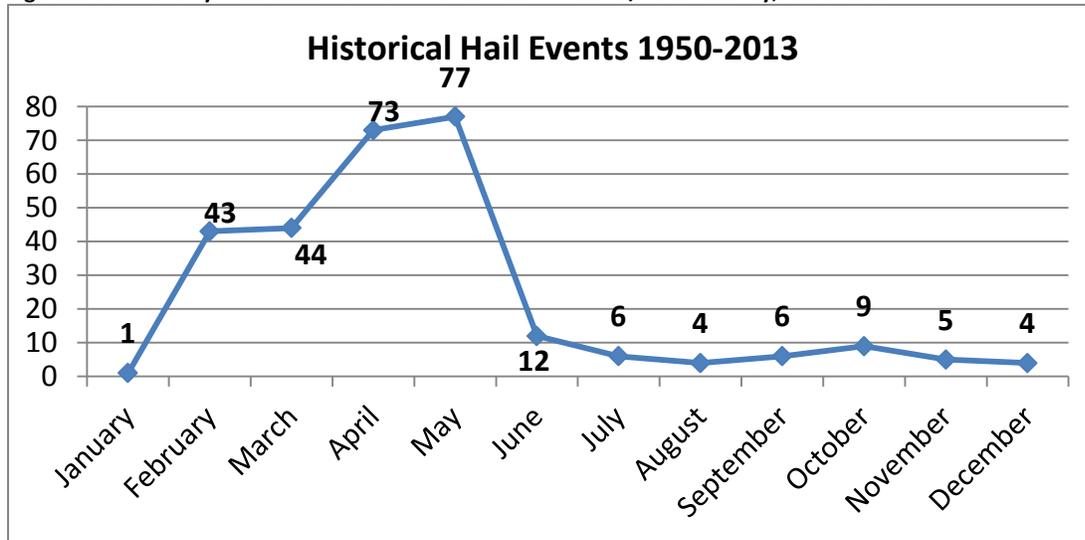
Property Loss, \$	Crop Loss, \$	Hail Size, in	Day	Month	Year
120,000,000	30,000,000	4.00	6	MAY	2001
5,000,000	0	2.75	28	MAR	2000
5,000,000	50,000	1.75	27	MAR	1994
500,000	50,000	1.00	27	MAR	1994
50,000	0	4.50	23	DEC	2002
50,000	0	2.50	16	MAR	2000
50,000	0	1.25	16	MAR	2000
50,000	50,000	0.88	5	APR	1994
10,000	50,000	1.75	10	FEB	1998

(Source: *National Climatic Data Center*)

Estimated Recurrence Rate

Figure 3.6.3 shows the monthly frequency of hailstorms in San Antonio/Bexar County since 1950. According to historical data, a significant number of hail events occur during the late winter and spring months, February through May. The estimated recurrence rate of hail, based on historic occurrences in the City of San Antonio and Bexar County, is considered moderate.

Figure 3.6.3 Monthly Distribution of Hail Events in San Antonio/Bexar County, 1950-2013



(Source: *National Climatic Data Center, San Antonio Office of Emergency Management*)

Vulnerability

Population

People living in mobile homes, homes built prior to modern building codes, and homes in deteriorating condition are particularly vulnerable to hail events. People in automobiles and campgrounds at the time of occurrence are also at risk. Generally, injuries are minor. Although rare, fatalities can and do occur.

Property

Hail events can cause minor to major damage to homes and other structures. Roofs are the most commonly damaged part of a home or business. Damage to the roof can allow water to seep through, causing damage to the interior of the home. Tree branches may be broken off or trees may be downed, causing damage to homes and other structures. Windows may also be broken.

Environment

Environmental vulnerabilities to hail events are often minor, and are usually related to downed trees and the like.

City/County Operations

Critical facilities are those facilities/services that a community relies on for effective and efficient operation, particularly during and after a hazard event, or that would be of concern/importance to a community in the event and aftermath of a hazard event. Typically, critical facilities include:

- Fire stations;
- Hospitals/clinics/medical centers;
- Chemical/heavy industrial/hazardous materials facilities or storage locations; and
- Communications facilities, such as radio and television broadcast locations.

Since a hail event typically covers a large geographic area, it is likely inevitable that facilities critical to the community will be located within the boundaries of a hail event. Some damage to critical facilities is possible during a hail event.

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *National Climatic Data Center*
<http://www.ncdc.noaa.gov/>
- *National Oceanic and Atmospheric Administration*
Climatological or Past Storm Information
<http://www.spc.noaa.gov/climo/historical.html>
Storm Prediction Center
<http://www.spc.noaa.gov/gis/svrgis/>
- *Tornado and Storm Research Organization*
www.torro.org.uk

Regional/State Resources and Documents:

- *Alamo Area Council of Governments*
Regional Multi-Hazard Mitigation Plan Update Draft, 2012
<https://www.aacog.com/index.aspx?NID=405>

Local Resources and Documents:

- *San Antonio Office of Emergency Management*
<http://www.saoemprepare.com/>

Section 3.7 - Hazardous Materials (Transportation and Fixed Site)

Description

A hazardous material is a biological, chemical, or physical agent with the potential to cause harm to the environment or people on its own, or when combined with other factors or materials.

Hazardous materials incidents are technological events that involve large-scale accidental or intentional releases of chemical, biological, radiological, or nuclear materials. Hazardous materials come in the form of explosives, flammable and combustible substances, toxic releases, and waste materials. These substances are most often released as a result of transportation accidents, or because of chemical accidents in plants. Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals are used and stored in homes routinely. These products are also shipped daily on the nation's highways, railroads, waterways, and pipelines.

General Characteristics

Hazardous materials are most often released as a result of accidents in manufacturing or production plants. Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals also are routinely used and stored in homes.

Hazardous materials are monitored and recorded by the United States (US) Environmental Protection Agency (EPA) through the Toxics Release Inventory (TRI), which is a publically accessible database that contains information on toxic chemical releases and other hazardous materials activities. Data is reported annually by certain industry groups and various federal agencies. In 1986, Congress passed the Emergency Planning and Community Right-to-Know Act (EPCRA) to support and promote emergency planning and to provide the public with information about releases of toxic chemicals in their community. Section 313 of EPCRA established the TRI. By making information about industrial management of toxic chemicals available to the public, TRI creates a strong incentive for companies to improve environmental performance.

Figure 3.7.1 Hazardous materials exercise



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Each year, facilities that meet specified thresholds must report their releases and other waste management activities for listed toxic chemicals to the EPA and to their State or tribal entity. A facility must report incidents that meet the following criteria:

1. The facility falls within one of the following industrial categories:
 - a. Manufacturing;
 - b. Metal mining;
 - c. Coal mining;
 - d. Electric generating facilities that combust coal and/or oil;
 - e. Chemical wholesale distributors;
 - f. Petroleum terminals and bulk storage facilities;
 - g. Resource Conservation and Recovery Act (RCRA) Subtitle C treatment, storage, and disposal (TSD) facilities; and
 - h. Solvent recovery services;
2. Has 10 or more full-time employees (or equivalent); and
3. Manufactures or processes more than 25,000 pounds or uses more than 10,000 pounds of any listed chemical during the calendar year.

Tier II data is a publicly available database from the Texas Department of State Health Services Tier II Chemical Reporting Program. Under the community right-to-know regulations imposed at the state and federal levels, all facilities that store significant quantities of hazardous chemicals must share this information with state and local emergency responders and planners. Facilities in Texas share this information by filing annual hazardous chemical inventories with the state, Local Emergency Planning Committees (LEPCs), and local fire departments. The Texas Tier II reports contain facility identification information and detailed chemical data about the hazardous materials stored at the facility.

A facility must report chemicals to the Tier II database if it meets the following criteria:

1. Any company using chemicals that could present a physical or health hazard; or
2. If an industry has an Occupational Safety and Health Administration (OSHA) deemed chemical that exceeds the appropriate threshold at any point in time. These chemicals may be on a list of 356 Extremely Hazardous Substances (EHS), or may be one of the 650,000 reportable hazardous substances that do not appear on the EHS list.

Hazardous materials pose a secondary event risk to communities when they are involved in transportation accidents. Transport by ground, rail and water is a common occurrence in the US.

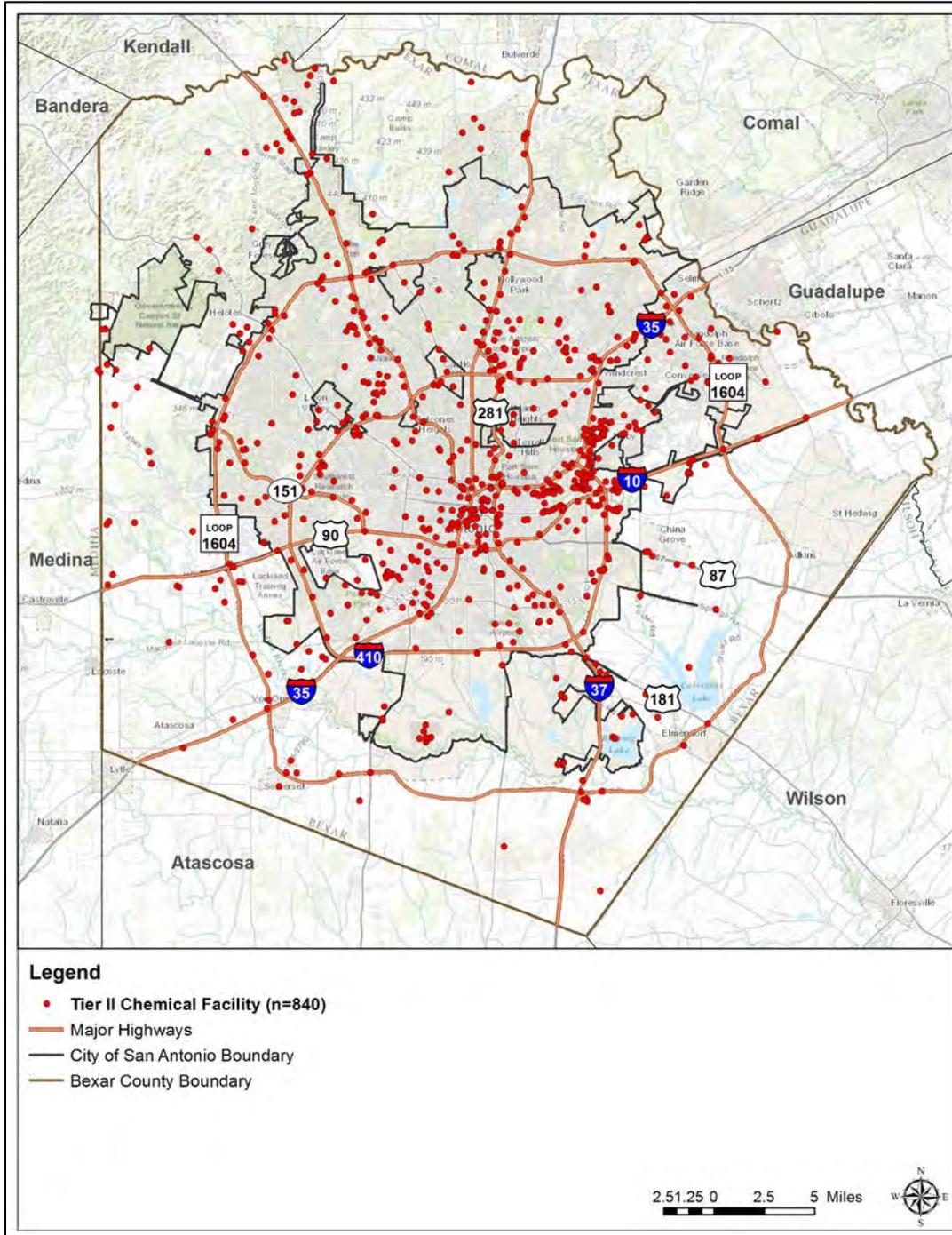
The US Department of Transportation (DOT), through the office of Pipeline and Hazardous Materials Safety Administration (PHMSA), is responsible for planning, preparedness, response, and regulation of the transportation of hazardous materials along routes throughout the US. They also publish the *Emergency Response Guidebook (ERG)*, which is provided as a resource to first responders who will be among the first on the scene when a transportation incident involving hazardous materials occurs. The ERG provides information regarding the classification of the materials involved in the incident, and the protocols for protection of both first responders and the public during the initial response to an incident.

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Location

The following maps show the locations of the hazardous materials incident hazard throughout San Antonio and Bexar County. These maps include both potential fixed site and transportation locations.

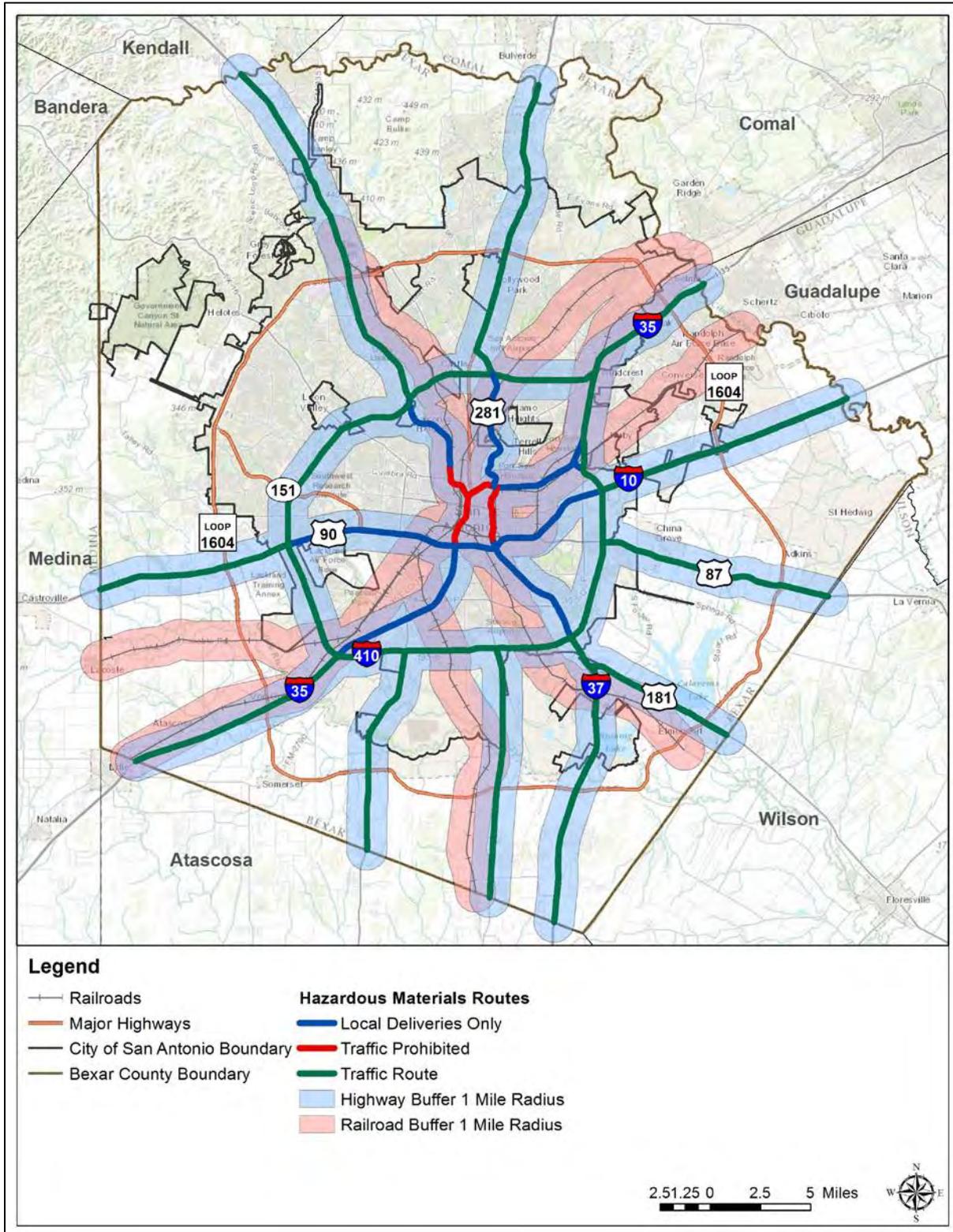
Figure 3.7.2 Potential Hazardous Materials Incident (Fixed Site - Tier II) Hazard Locations



(Source: Texas Department of State Health Services)

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Figure 3.7.3 Potential Hazardous Materials Incident (Transportation) Hazard Locations



(Source: San Antonio Office of Emergency Management)

Extent

Hazardous materials or toxic releases can have a substantial impact. Such events can cause multiple fatalities, completely shut down facilities for days or weeks, and cause affected properties to be destroyed or suffer major damage. In a hazardous materials incident, solid, liquid and/or gaseous contaminants may be released from fixed or mobile containers. Weather conditions will directly affect how the hazard develops. The micro-meteorological effects of the buildings and terrain can alter travel and duration of agents. Shielding in the form of sheltering-in-place can protect people and property from harmful effects; however, in some cases, evacuation may be required.

The duration of a hazardous materials incident can range from hours to days. Warning time for hazardous materials incidents is minimal to none. In addition to the primary release, explosions and/or fires can result from a release, and contaminants can extend beyond the initial area.

Hazardous materials incidents can also occur as a result of or in tandem with natural hazard events, such as floods, hurricanes, tornadoes, and earthquakes, which in addition to causing incidents can hinder response efforts.

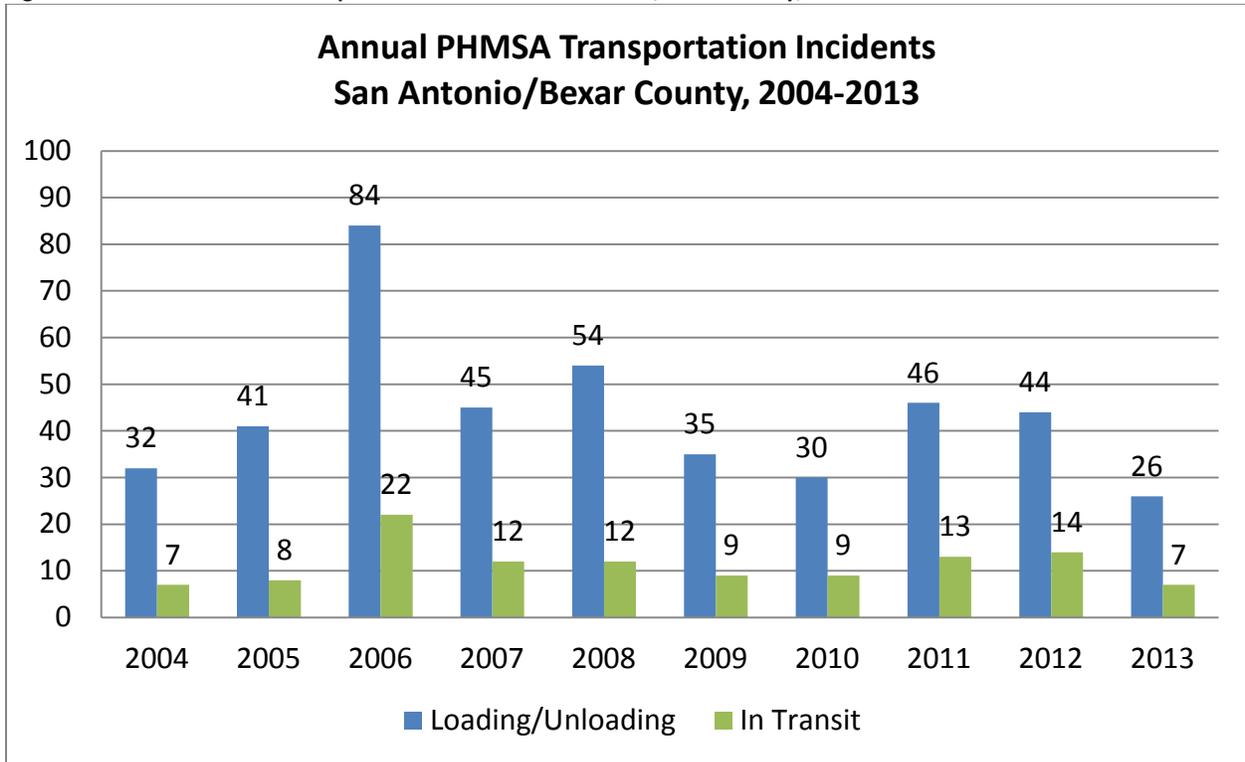
The San Antonio Fire Department and Bexar County Hazardous Materials Response Teams handle responses to hazmat transportation accidents and chemical spills in business and manufacturing facilities. The teams are trained to take corrective actions to stop or mitigate the release of hazardous materials while safeguarding the welfare of residents, emergency response personnel, and the environment. In addition to its hazmat response duties, the teams are trained to deliver basic fire suppression and emergency first aid service, as required. Team members participate in ongoing training for special situations, such as highway transportation emergencies, railroad tank car incidents, and chlorine emergencies.

Previous Occurrences

Hazardous materials incidents involving the transportation sector happen frequently. Every automobile accident is a hazardous materials incident, as automobiles involve a variety of fluids that meet the definition of hazardous materials. The figures below provide information from the DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA). A total of 550 transportation incidents have been recorded in the study area over the last 10 years. The data collected for Bexar County spans 2004-2013 and identifies two types of hazardous materials transportation incidents, in transit and loading and unloading of transport vehicles.

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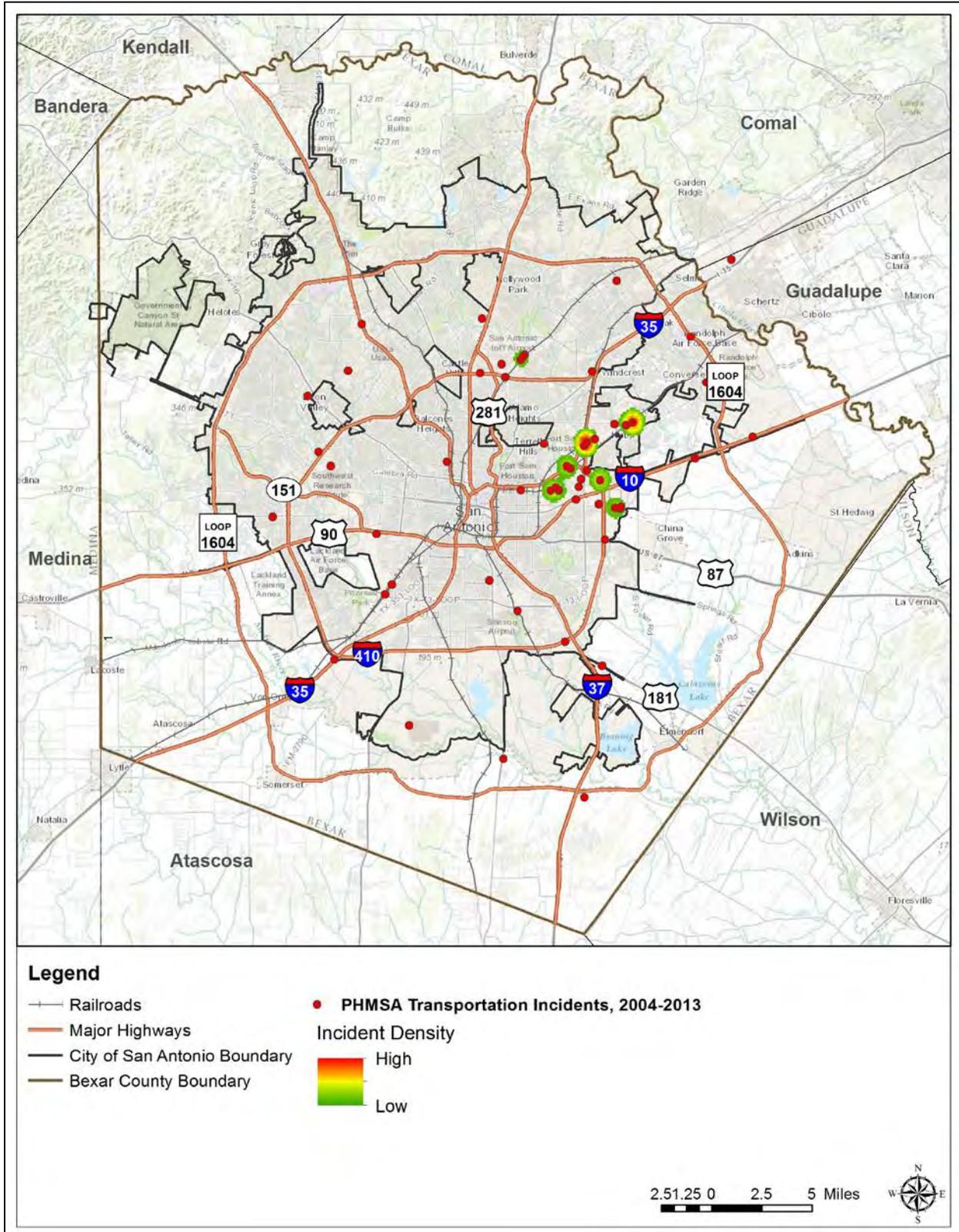
Figure 3.7.4 Annual PHMSA Transportation Incidents San Antonio/Bexar County, 2004-2013



(Source: Pipeline and Hazardous Materials Safety Administration, San Antonio Office of Emergency Management)

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Figure 3.7.5 PHMSA Transportation Incidents San Antonio/Bexar County, 2004-2013

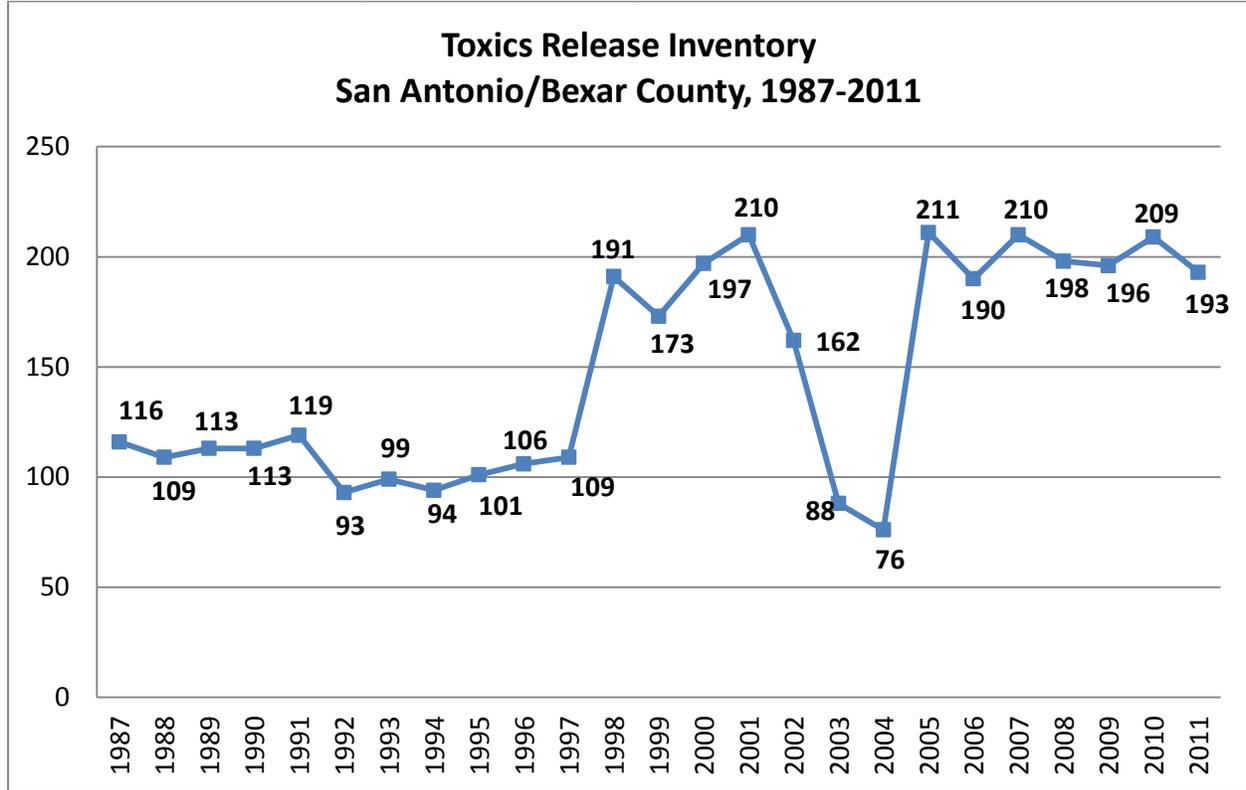


(Source: Pipeline and Hazardous Materials Safety Administration)

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The figures below provide information from the EPA's TRI database. A total of 3676 toxic chemical releases have been recorded in the study area over the last 24 years. The data collected spans 1987-2011 and identifies fixed facilities that have reported toxic chemical releases in Bexar County.

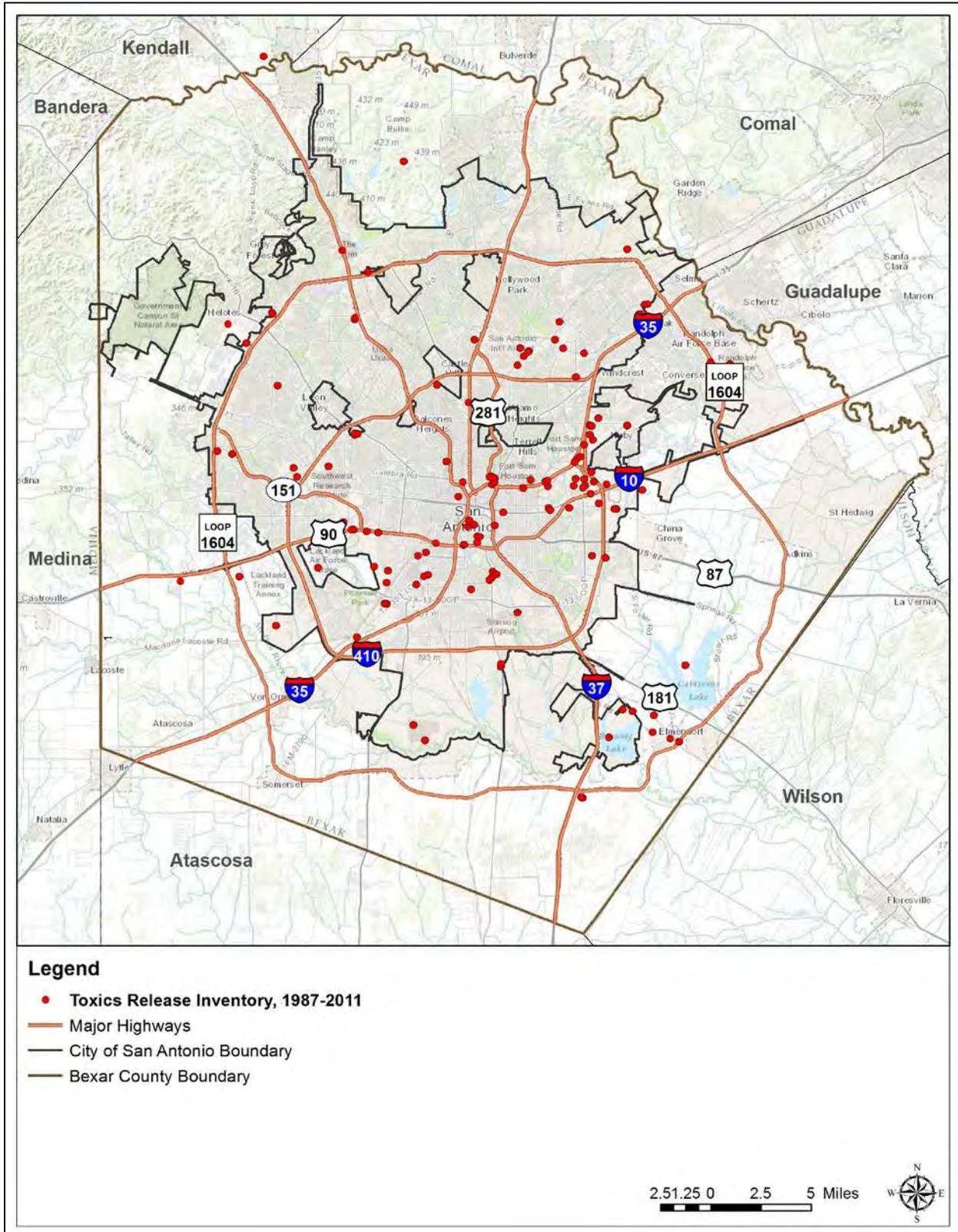
Figure 3.7.6 Toxics Release Inventory San Antonio/Bexar County, 1987-2011



(Source: United States Environmental Protection Agency)

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Figure 3.7.7 Toxics Release Inventory San Antonio/Bexar County, 1987-2011



(Source: United States Environmental Protection Agency's Toxics Release Inventory)

Estimated Recurrence Rate

The estimated recurrence rate of hazardous materials incidents, both transportation and fixed site, based on historic occurrences in the City of San Antonio and Bexar County, is considered high.

Vulnerability

People

Based on the prevalence and geographic proximity of hazardous materials transportation routes and fixed locations, the majority of the City/County is considered vulnerable. Vulnerability to the community depends on a variety of factors, including:

- Type and amount of chemical(s) released;
- Weather conditions;
- Prevailing winds;
- Time of day; and
- Season.

Each of these factors can influence populations that are vulnerable to the release.

Property

The assets that are vulnerable to any hazardous materials incident, transportation or fixed location related, will also depend on the same factors:

- Type and amount of chemical(s) released;
- Weather conditions;
- Prevailing winds;
- Time of day; and
- Season.

Each of these factors, in addition to proximity to the release, will influence which assets are vulnerable to the release. Concern may not be limited to just the duration of the hazmat event; it would likely extend past the event, to include concerns regarding contamination of the property or facility from the event.

Environment

The environment is often vulnerable in a hazardous materials incident; depending on the specifics of the event, the environment can be heavily damaged by a particular event. These incidents, with their unpredictable and uncertain nature, often produce unexpected vulnerabilities as the event unfolds. The consequences for the environment will depend on a variety of factors, as indicated above.

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City/County Operations

As stated above, any City/County operations could be vulnerable in a hazardous material incident. The operations that are vulnerable to any hazardous materials incident will depend on a variety of factors, including:

- Type and amount of chemical(s) released;
- Weather conditions;
- Prevailing winds;
- Time of day; and
- Season.

Each of these factors, in addition to proximity to the release, will influence the makeup of the operations that are vulnerable to the release. In addition, access to a particular area or location may be limited by a hazardous materials event, which may result in limited operational or response capacity.

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *Environmental Systems Research Institute*
Community Analyst
<http://www.esri.com/software/arcgis/community-analyst>
- *United States Census Bureau*
- *United States Department of Transportation*
Pipeline and Hazardous Materials Safety Administration
<http://phmsa.dot.gov/pipeline>
- *United States Environmental Protection Agency*
On-Scene Coordinator
http://www.epaosc.org/site/site_profile.aspx?site_id=726444, and
Toxics Release Inventory
<http://www2.epa.gov/toxics-release-inventory-tri-program>

Regional/State Resources and Documents:

- *Alamo Area Council of Governments*
Regional Multi-Hazard Mitigation Plan Update Draft, 2012
<https://www.aacog.com/index.aspx?NID=405>
- *Texas Department of State Health Services*
Tier II Chemical Reporting Program
<http://www.dshs.state.tx.us/tiertwo/>

Local Resources and Documents:

- *Bexar County*
Bexar County Ordinance, Article XVI. – Non-Radioactive Hazardous Materials
Route http://library.municode.com/HTML/11508/level3/PTIICO_CH19MOVETR_ARTXVINDIHAMARO.html#PTIICO_CH19MOVETR_ARTXVINDIHAMARO_S19-600DE
- *City of San Antonio*
Municipal Ordinance, # 94321
<http://library.municode.com/index.aspx?clientID=11508&stateID=43&statename=Texas>
- *City of San Antonio Fire Department*
Annual Report 2010
<http://www.sanantonio.gov/safd/PDFs/2010%20annual%20report.pdf>, and
Hazardous Materials Response Team
<http://www.sanantonio.gov/safd/hazmatteam.asp?res=1680&ver=true>

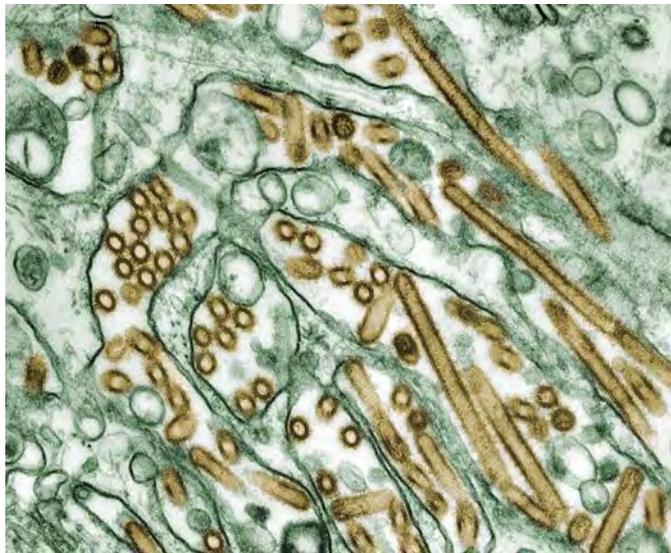
Section 3.8 - Infectious Disease

Description

Infectious pathologies are also called communicable diseases or transmissible diseases due to their potential of transmission from one person or species to another by a replicating agent (as opposed to a toxin). An infectious disease is a clinically evident illness resulting from the presence of pathogenic microbial agents, including pathogenic viruses, pathogenic bacteria, fungi, protozoa, multi-cellular parasites, or aberrant proteins known as prions. Transmission of an infectious disease may occur through one or more pathways, including physical contact with infected individuals. These infecting agents may also be transmitted through liquids, food, body fluids, contaminated objects, airborne inhalation, or through vector-borne spread.

Figure 3.8.1 Avian influenza A H5N1 virus

Transmissible diseases that occur through contact with an ill person or their secretions, or objects touched by them, are especially infective and are sometimes referred to as contagious diseases. Infectious (communicable) diseases that usually require a more specialized route of infection, such as vector transmission, or blood or needle transmission, are usually not regarded as contagious.



The term “infectivity” describes the ability of an organism to enter, survive, and multiply in a host, while the infectiousness of a disease indicates the comparative ease with which the disease is transmitted to other hosts. An infection however, is not synonymous with an infectious disease, as an infection may not cause important clinical symptoms or impair host function.

Examples of communicable or infectious diseases include plague, malaria, tuberculosis (TB), syphilis, hepatitis B, influenza, and measles.

Infectious disease is usually classified as endemic, epidemic, or pandemic. An endemic is present at all times, at a low frequency (e.g., chicken pox in the United States (US)). An epidemic is a sudden severe outbreak of disease (e.g., the bubonic plague during the Late Middle Ages) and a pandemic is an epidemic that becomes very widespread and affects a whole region, a continent, or the entire world (for example, the 1957 flu pandemic caused at least 70,000 deaths in the US and 1-2 million deaths worldwide). The term “pandemic” refers to geographic scope rather than intensity. A flu virus can become a pandemic depending on the geographic spread of the virus, and can occur when a new flu virus emerges.

General Characteristics

The following graphic from the San Antonio Office of Emergency Management illustrates the characteristics and differences between seasonal and pandemic flu:

Figure 3.8.2 Pandemic vs. Seasonal Flu Characteristics

Pandemic or Seasonal Flu?	
Seasonal Flu	Pandemic Flu
Occurs yearly, October- March	Occurs in cycles of 10-40 years, any time of the year
Affects 5-20% of the population, particularly the elderly, infants, and people with existing medical conditions	Affects 25-50% of the population, particularly healthy young adults
In the US, kills 36,000- 40,000, with most deaths in the high risk groups	In the US, 70,000 deaths(1957-58) to 500,000 Deaths (1918)
Vaccine available based upon currently circulating virus strains	Caused by a new virus strain, no vaccine would be immediately available. New vaccine production requires at least six months

(Source: *San Antonio Office of Emergency Management*)

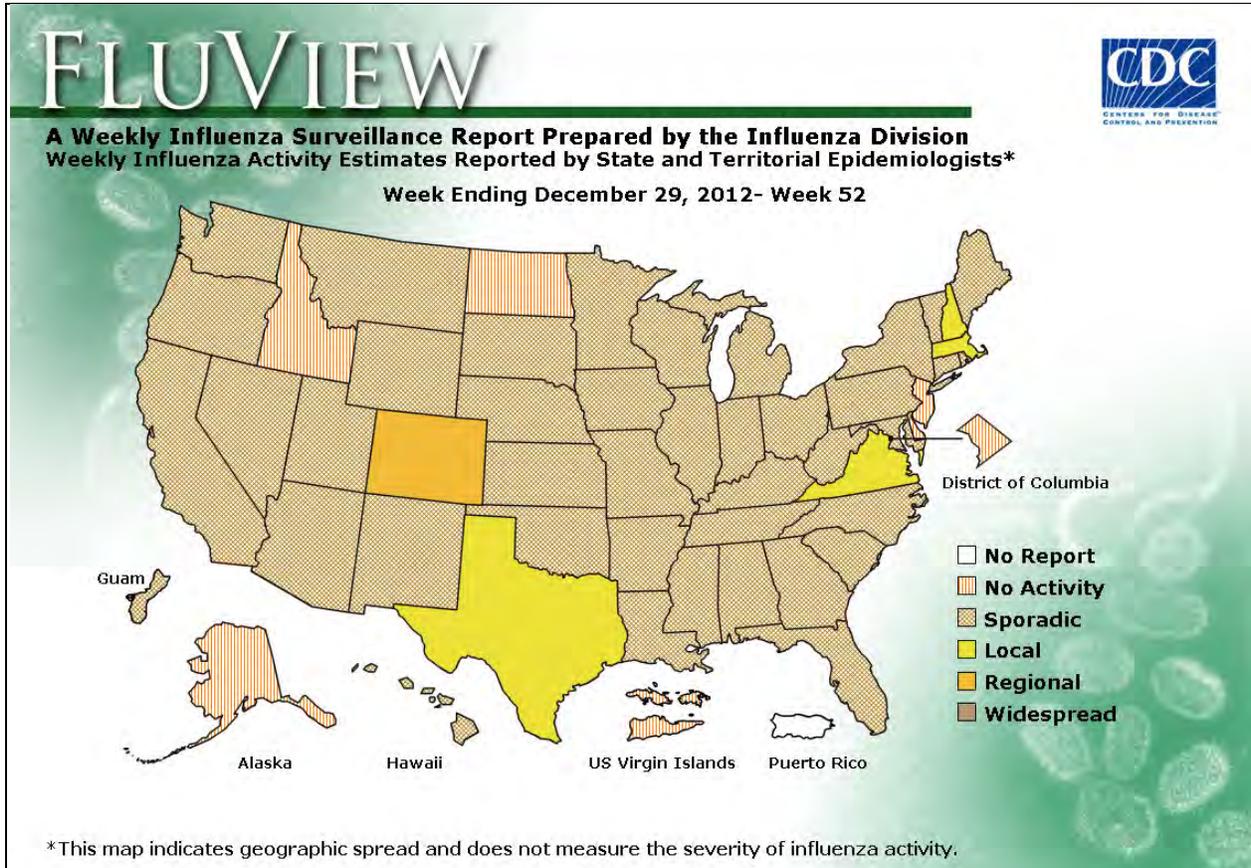
The influenza outbreaks that happen nearly every year are important events. Influenza and similar respiratory illnesses affect hundreds of thousands of people each year and kills tens of thousands. One of the most important features about influenza viruses is that their structure changes slightly but frequently over time, a process known as “genetic drift.” This process results in the appearance of different strains that circulate each year. The composition of the influenza vaccine is changed annually to help protect people from the strains of influenza virus that are expected to be the most common ones circulating during the coming influenza season. Currently, only three influenza virus strains are in general circulation in humans (H1N1, H1N2, and H3N2); H2N2 circulated in 1957 and 1968, causing the Hong Kong influenza pandemic, but has not been seen since. (Source: *Texas Department of State Health Services*) A key difference between seasonal influenza and a strain that continues to spread among the human population is the potential for far fewer people to have any immunity to the new strain, creating more severe illness and potentially more rapid spread. (Source: *Centers for Disease Control and Prevention*)

The next pandemic, an event considered by many experts to be inevitable and overdue, will require an estimated three weeks to three months to reach North America, following international identification. In addition, experts believe that the next pandemic will involve sustained transmission of highly pathogenic avian influenza.

Location

The entire San Antonio/Bexar County area is at risk to the pandemic/communicable disease hazard. Each week, the US Centers for Disease Control and Prevention (CDC) publishes a surveillance report for influenza. As part of this report, the CDC produces graphics to illustrate the locations and intensity of flu activity throughout the US and its territories. The figure below is an example of such a graphic, issued for the week ending December 29, 2011.

Figure 3.8.3 Weekly Influenza Surveillance Report



(Source: Centers for Disease Control and Prevention)

In the image above, Texas is indicated to have “Local” activity levels. This indicates that there is laboratory confirmation of an outbreak of influenza in a single region of the state.

Extent

National experts have not come to a consensus for the anticipated severity or duration of the next influenza pandemic. Some scientists and public health officials estimate a lower attack rate than others. In general, experts estimate that an international outbreak (pandemic) due to a new variation of influenza may have a 25%-50% attack rate. Based on that estimate, between 325,000 and 750,000 residents in the San Antonio/Bexar County area could be infected. Of those, 13,000 to 30,000 may require hospitalization. The estimates of case fatality rates range from 1.5% to 5%, suggesting that at a minimum, almost 5,000 people could die as a result of the next influenza pandemic.

It is thought that pandemic influenza will occur in two waves separated by three to nine months, with each to last about one month. A second wave in the San Antonio/Bexar County area would cause an additional 5% of the population, approximately 75,000 people, to develop the influenza. Of these, it is estimated that 4% may be hospitalized and a case fatality rate of 1.7%, suggesting that at a minimum, almost 1,300 people could die. Additional waves may occur each with fewer numbers ill, hospitalized, and dying. These numbers depend on virus transmissibility, virulence, other factors, such as vaccine availability and public understanding of and willingness to practice personal protective behaviors and adherence to health department guidance aimed at reducing exposure and transmission. (Source: *San Antonio Metropolitan Health District, Pandemic Influenza Plan*)

The CDC has proposed a classification scale to determine the severity of pandemics and communicable disease outbreaks. This scale is known as the Pandemic Severity Index (PSI). The index focuses less on the likelihood of the disease spreading worldwide, - that is, to become a pandemic - and more upon severity of the epidemic. The main criterion used to measure pandemic severity will be case-fatality ratio (CFR), the percentage of deaths out of the total reported cases of the disease.

The analogy of “category” levels was introduced to provide an understandable connection to hurricane classification schemes, with specific reference to the recent aftermath of Hurricane Katrina. Like the Saffir-Simpson Hurricane Scale, the PSI ranges from 1 to 5, with Category 1 pandemics being most mild (equivalent to seasonal flu) and level 5 being reserved for the most severe worst-case scenario pandemics, such as the 1918 Spanish flu pandemic.

Table 3.8.1 Pandemic Severity Index

Category	Case-Fatality Ratio	Example Illness
1	Less than 0.1%	Seasonal flu, Swine flu (H1N1)
2	0.1% to 0.5%	Asian flu, Hong Kong flu
3	0.5% to 1%	No example illness provided
4	1% to 2%	No example illness provided
5	2% or Higher	Spanish flu

(Source: *Centers for Disease Control and Prevention*)

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Previous Occurrences

The San Antonio Metropolitan Health District (SAMHD) has compiled a report on infectious disease from 2008-2012. The number of cases and rates are included in Table 3.8.2. Rates for each year were configured using the number of cases per 100,000 total population. Rates based on fewer than 20 cases are likely to be unstable and imprecise. On average, 1,115 cases of infectious disease are reported annually.

Table 3.8.2 Historical Infectious disease for San Antonio and Bexar County, 2008-2012

Disease	2008		2009		2010		2011		2012	
	Cases	Rate								
Campylobacteriosis	129	8.0	123	7.4	223	13.0	113	6.4	208	11.6
Cryptosporidiosis	40	2.5	0	0.0	4	0.2	16	0.9	11	0.6
Cyclosporiasis	0	0.0	0	0.0	0	0.0	1	0.1	12	0.7
Hepatitis A, acute	24	1.5	3	0.2	6	0.3	6	0.3	2	0.1
Hepatitis B, acute	101	6.2	83	5.0	78	4.5	13	0.7	6	0.3
Malaria	2	0.1	1	0.1	1	0.1	3	0.2	1	0.1
Measles (Rubeola)	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Mumps	0	0.0	0	0.0	32	1.9	5	0.3	2	0.1
Neisseria Meningitidis	10	0.6	5	0.3	4	0.2	4	0.2	3	0.2
Pertussis	53	3.3	42	2.5	24	1.4	23	1.3	69	3.9
Salmonellosis	267	16.5	204	12.4	264	15.4	263	15.0	245	13.7
Shigellosis	314	19.4	239	14.5	97	5.7	200	11.4	263	14.7
Streptococcus	51	3.1	41	2.5	76	4.4	96	5.5	108	6.0
Tuberculosis	81	5.0	93	5.6	87	5.1	97	5.5	71	4.0
Varicella (Chickenpox)	457	28.2	236	14.3	90	5.2	91	5.2	60	3.4

(Source: San Antonio Metropolitan Health District)

Occurrences of the biological event hazard are fairly common. In recent history, there have been a number of *E. coli* and similar outbreaks traced to issues or deficiencies in the nation's food supply. In Texas, there have been several occurrences of biological hazards, as reported by the CDC. In 2005, there were cases of dengue fever reported in South Texas, near the border with Mexico. Also in 2005, in the Houston area, approximately 1,100 evacuees from Hurricanes Katrina and Rita were infected with norovirus. During the winter of 2009 and early spring of 2010, 429 cases of mumps were reported in the greater Houston area.

In 2001, several cases of anthrax were reported in both humans and cattle in South Texas and in the San Antonio and Bexar County area, including Bandera County, where one fatality occurred, according to the CDC.

In the spring of 2012, Tuberculosis (TB) was detected at James Madison High School in San Antonio. Initially, two cases were confirmed, and a third case followed. By the time school released for the

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summer in June 2012, more than 400 students and almost 30 faculty members had been tested for TB, with the majority producing negative results. (Source: *San Antonio Metropolitan Health District*) Early detection and quick action on the part of the SAMHD resulted in a contained event rather than in an epidemic.

Throughout history, pandemics, especially pandemic flus, have occurred. The 1918 flu pandemic, sometimes referred to as the Spanish flu, was particularly virulent. It was also one of the first pandemics to be documented in detail, with records later organized on a state-by-state basis.

No one knows exactly how many people died during the 1918-1919 influenza pandemic. During the 1920s, researchers estimated that 21.5 million people died as a result of the pandemic. More recent evaluations have estimated global mortality from the pandemic at anywhere between 30 and 50 million. An estimated 675,000 Americans were among the dead.

Texas first reported the disease on the 23rd of September 1918. However, the disease was probably present in the state before that date. As early as September 12, newspapers were reporting that fears of the disease spreading into the state were common. On September 23, state officials reported the presence of influenza in Williamson County, Kaufman County, and Bosque County. By the 4th of October, 35 counties reported influenza; these counties reported anywhere from one to two thousand cases. A week later, the disease was reported present in 77 counties, with the number of cases varying from one to four thousand cases per county. During the week of October 18, the state failed to report; this failure may have been due to officials being overwhelmed. On October 25, 1918, the state reported a total of 26,062 cases and 517 deaths since the beginning of the pandemic. By October 29, the state had reported 106,978 cases and 2,181 deaths in just the state's urban centers. Because state officials were overwhelmed, and because the states did not have an effective system for collecting data, these numbers were probably inaccurate; the actual number of cases and deaths was probably much higher.

In 1918, the Texas State Board of Health made the following suggestions on how to prevent flu outbreaks in schools: "Every day ... disinfectant should be scattered over the floor and swept. All woodwork, desks, chairs, tables and doors should be wiped off with a cloth wet with linseed, kerosene and turpentine... Every pupil must have at all times a clean handkerchief and it must not be laid on top of the desk... Spitting on the floor, sneezing, or coughing, except behind a handkerchief, should be sufficient grounds for suspension of a pupil... A pupil should not be allowed to sit in a draft. A pupil with wet feet or wet clothing should not be permitted to stay at school." (Source: *United States Department of Health and Human Services*)

Two other major flu pandemics occurred in 1957 (the "Asian influenza") and 1968 (the "Hong Kong flu"). The most recent pandemic, "Swine flu" H1N1, occurred in 2009. The outbreak began in Mexico and, due to proximity and high traffic from Mexico, San Antonio became a focal point of the pandemic. (Source: *San Antonio Metropolitan Health District*)

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The first case of H1N1 in the US was detected in a California child whose family had recently traveled to Texas. Though the virus was initially identified in California, it was quickly detected in Texas. A school district in the San Antonio metropolitan area - the Schertz-Cibolo-Universal City Independent School District - became the first in the US to close for an extended period of time as a result of the pandemic. Closure of schools, businesses, and public gathering places is a tool to reduce disease spread by discouraging close contact in a population in which the illness is known to be present or suspected. (Source: *Centers for Disease Control and Prevention*)

Estimated Recurrence Rate

Plagues, epidemics, and pandemics have occurred in human and animal populations for thousands of years. As humans began to gather and congregate in urban areas, the potential for pandemics and epidemics increased. As trade routes became established and contact with other cities became more frequent, the potential for transmission of illnesses increased. In modern society, the ease of global travel has created a situation where viruses and bacteria can spread quickly from one continent to another.

The estimated recurrence rate of infectious disease, based on historic occurrences in the City of San Antonio and Bexar County, is considered moderate.

Vulnerability

Population

The asset that is most vulnerable to the impacts from pandemic or communicable disease is the human population. As more and more people fall ill, they will transmit the illness to others many times before they even realize they have been exposed, let alone contracted the illness. This will result in increased absenteeism and could place a strain on the community's medical centers. The elderly, infants, and infirm often are more vulnerable to biological hazards than other individuals, although in some influenza outbreaks, including the 2009 pandemic, young adults were highly vulnerable as well.

A pandemic event can be expected to result in stress for responders, health care providers, and communities. Hospitals will need to provide psychological and stress management support to those who are symptomatic, those who believe they are ill, and to staff who are dealing with the increased workloads and personal concerns.

The public will require information on how to recognize and cope with the short- and long-term risks of sustained stress during mass vaccinations, for those debilitated by influenza, and their caregivers. Special attention and resources will be needed to ensure that special populations are identified prior to the event, and that unique service and transportation needs are incorporated into the local pandemic influenza emergency management plan. A vital part of pandemic planning is the development of

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strategies and tactics to address these potential problems. (Source: *San Antonio Metropolitan Health District*)

Property

As the infectious disease hazard is one that affects living beings, the vulnerability of property to this hazard is minimal. Equipment and systems that rely upon individuals to function are vulnerable.

Environment

The environment is not usually considered to be vulnerable to disruption from infectious disease. However, some specific plant or animal species may be vulnerable to a virus or strain, and it is possible that some animal or human viruses or strains may jump from one group to the other, as occurred with the West Nile Virus.

City/County Operations

City/County operations are vulnerable to this hazard because of their dependence on human population. If a significant portion of the workforce is affected, delivery of services and general continuity of operations may suffer as a result. Interruptions would likely occur both within individual departments and within City/County operations as a whole.

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *Centers for Disease Control and Prevention*
Geographic Spread of Influenza as Assessed by State and Territorial Epidemiologists
<http://www.cdc.gov/flu/weekly/index.htm#ISTE> , and
Swine Influenza A (H1N1) Infection in Two Children –Southern California, March – April 2009
<http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5815a5.htm> , and
Weekly Report: Flu View
<http://www.cdc.gov/flu/weekly/downloadimage.htm?w=52>
- *Columbia University, Mailman School of Public Health*
Sacks and Randee. “Crisis of Confidence in Government Widens: Majority of Public Doubts Government’s Abilities in Face of Hurricanes, Pandemic Flu, and Threats of Terrorism”, 2005
<http://hdl.handle.net/10022/AC:P:13578>
- *Federal Reserve Bank of St. Louis*
Page One Economics Newsletter, February 2008: The Economic Impact of an Influenza Pandemic on the United States
http://research.stlouisfed.org/pageone-economics/pages/newsletter_summary.php?year=2008
- *GlobalSecurity.org , Homeland Security*
Flu Pandemic Mitigation – Social Distancing
http://www.globalsecurity.org/security/ops/hsc-scen-3_flu-pandemic-distancing.htm
- *National Public Radio*
Districts Weigh Closing Schools as Virus Spreads
<http://www.npr.org/templates/story/story.php?storyId=103613643&ft=1&f=1004>
- *United States Department of Health and Human Services*
The Great Pandemic, the United States in 1918-1919
<http://www.flu.gov/pandemic/history/1918/index.html>
- *World Health Organization*
Fact Sheet #211: Influenza
<http://www.who.int/mediacentre/factsheets/2003/fs211/en>

Regional/State Resources and Documents:

- *Alamo Area Council of Governments*
Regional Multi-Hazard Mitigation Plan Update Draft, 2012
<https://www.aacog.com/index.aspx?NID=405>
- *Texas Department of State Health Services*
Pandemic Flu
www.dshs.state.tx.us/preparedness/flu_public.shtm

Local Resources and Documents:

- *San Antonio Metropolitan Health District*

**City of San Antonio and Bexar County Office of Emergency Management
Hazard Identification, Risk Assessment (HIRA) and Consequence Analysis**

Madison High School Contact Investigation Update 04-12-12, and
Operational Pandemic Flu Plan (Draft), October 2009, FOUO, and
Pandemic Influenza Preparedness Plan, November 2005, FOUO, and
STATUS Madison High School 05-08-12

- *San Antonio Office of Emergency Management*

Section 3.9 - Pipeline Failure

Description

The energy infrastructure of the United States (US) is composed of many components, including the physical network of pipes for oil and natural gas, electricity transmission lines, and facilities that convert raw natural resources into energy products, as well as rail networks, trucking lines, and marine transportation. Much of this infrastructure is aging, and in addition to the challenges of keeping the infrastructure up-to-date with the latest technological advances and consumer needs, the potential for an energy pipeline failure must be considered.

The two million miles of oil pipelines in the US are the principal mode for transporting oil and petroleum products, such as gasoline. Virtually all natural gas in the US is moved via pipeline as well. Much of the oil pipeline infrastructure is old, requiring regular safety and environmental reviews to ensure its integrity and reliability. The potential risk of pipeline accidents is a significant national concern.

The energy infrastructure is vulnerable to physical and cyber disruption, either of which could threaten its integrity and safety. Disruptions could originate with natural events, such as geomagnetic storms and earthquakes, or could result from accidents, equipment failures or deliberate interference. In addition, the nation's transportation and power infrastructures have grown increasingly complex and interdependent. Consequently, any disruption could have far-reaching consequences.

Figure 3.9.1 Huebner and Blanco Gas Explosion



General Characteristics

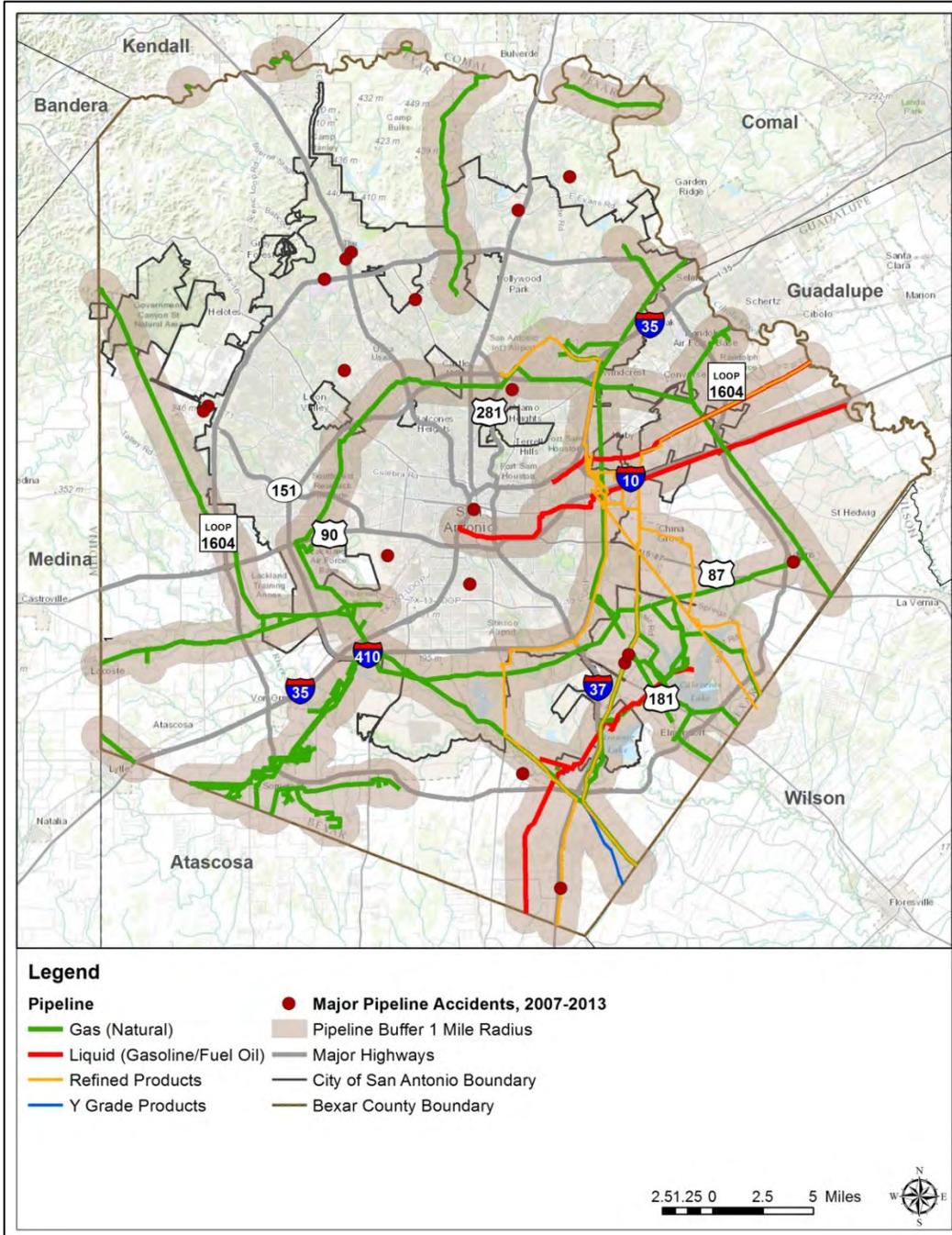
Energy pipeline failures are often sudden events, involving the release of dangerous and hazardous chemicals, and often involving explosions or fire. These events can result in property damage, injury and death, as well as both short and long-term environmental harm and damage.

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Location

Figure 3.9.2 shows the location of identified energy pipelines and pipeline accidents in San Antonio/Bexar County. Note that these maps may not show the location of all energy pipelines in the planning area.

Figure 3.9.2 Pipeline Location and Pipeline Accidents, San Antonio/Bexar County, 2007-2013



(Source: Pipeline and Hazardous Materials Safety Administration and Railroad Commission of Texas)

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Extent

The US Department of Transportation's (DOT) Pipeline and Hazardous Material Safety Administration (PHMSA), acting through the Office of Pipeline Safety (OPS), administers the Department's national regulatory program to assure the safe transportation of natural gas, petroleum, and other hazardous materials by pipeline. The OPS develops regulations and other approaches to risk management to assure safety in design, construction, testing, operation, maintenance, and emergency response of pipeline facilities. Since 1986, the entire pipeline safety program has been funded by a user fee assessed on a per-mile basis on each pipeline operator OPS regulates.

Previous Occurrences

Pipeline incidents can be caused by a number of factors including corrosion, equipment failure, as well as damage from excavations, incorrect operation, and natural forces. Incidents are generally categorized by the severity (i.e., significant or serious) and type of affected pipeline system components that include gas distribution (main line and service line), gas transmission and gathering, and hazardous liquids.

The PHMSA defines significant incidents as those incidents reported by pipeline operators when any of the following occur:

1. Fatality or injury requiring in-patient hospitalization;
2. \$50,000 or more in total costs, measured in 1984 dollars;
3. Highly volatile liquid releases of 5 barrels or more or other liquid releases of 50 barrels or more; and
4. Liquid releases resulting in an unintentional fire or explosion.

The PHMSA defines a serious pipeline incident as an event involving a fatality or injury requiring in-patient hospitalization.

Table 3.9.1 summarizes 18 major (cost or repair of \$5,000 or greater and/or reported injuries or fatalities) pipeline incidents in Bexar County, 2007-2013. These include one significant and one serious incident.

Table 3.9.1 Major Pipeline Incidents in Bexar County, 2007-2013

	Date	Operator	City	Cost or Repair	Injured	Fatalities	Type	Facility Affected
1	4/11/2012	NUSTAR LOGISTICS, L.P.	San Antonio	\$50,001 or more	none	none	Liquid	Transmission
2	8/23/2010	ENTERPRISE PRODUCTS OPERATINGLLC	Adkins	\$25,001 - \$50,000	none	none	Gas	Transmission
3	6/29/2009	CPS ENERGY	San	\$25,001 -	1	none	Gas	Distribution

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	Date	Operator	City	Cost or Repair	Injured	Fatalities	Type	Facility Affected
			Antonio	\$50,000				
4	9/28/2007	CPS ENERGY	San Antonio	\$25,001 - \$50,000	none	none	Gas	Distribution
5	8/14/2013	CPS ENERGY	San Antonio	\$5,001 - \$25,000	none	none	Gas	Distribution
6	2/26/2013	120784 - CPS ENERGY	San Antonio	\$5,001 - \$25,000	none	none	Gas	Distribution
7	5/5/2012	ENTERPRISE PRODUCTS OPERATINGLLC	San Antonio	\$5,001 - \$25,000	none	none	Gas	Transmission
8	12/23/2011	CPS ENERGY	San Antonio	\$5,001 - \$25,000	none	none	Gas	Distribution
9	12/16/2009	CPS ENERGY	Unknown	\$5,001 - \$25,000	none	none	Gas	Distribution
10	11/17/2009	CPS ENERGY	San Antonio	\$5,001 - \$25,000	none	none	Gas	Distribution
11	1/22/2009	NUSTAR LOGISTICS, L.P.	Elmendorf	\$5,001 - \$25,000	none	none	Liquid	Transmission
12	9/1/2008	CPS ENERGY	San Antonio	\$5,001 - \$25,000	none	none	Gas	Unknown
13	7/1/2008	CPS ENERGY	San Antonio	\$5,001 - \$25,000	none	none	Gas	Unknown
14	6/11/2008	CPS ENERGY	San Antonio	\$5,001 - \$25,000	none	none	Gas	Unknown
15	6/5/2008	CPS ENERGY	San Antonio	\$5,001 - \$25,000	none	none	Gas	Unknown
16	4/22/2008	GREY FOREST UTILITIES	San Antonio	\$5,001 - \$25,000	none	none	Gas	Distribution
17	3/31/2008	GREY FOREST UTILITIES	San Antonio	\$5,001 - \$25,000	none	none	Gas	Distribution
18	9/28/2007	GREY FOREST UTILITIES	San Antonio	\$5,001 - \$25,000	none	none	Gas	Distribution

(Source: Pipeline and Hazardous Materials Safety Administration and Railroad Commission of Texas)

Estimated Recurrence Rate

The estimated recurrence rate of pipeline failure, based on historic occurrences in the City of San Antonio and Bexar County, is considered moderate.

Vulnerability

Population

Based on the location of pipelines in Bexar County, a large area of the county is considered vulnerable. The populations that are vulnerable to pipeline failure hazard will depend on a variety of factors, including:

- Type of pipeline and volume released;
- Weather conditions;
- Prevailing winds;
- Time of day; and
- Presence of ignition source.

Each of these factors will influence the makeup of the populations that are vulnerable to the release.

However, any population near a pipeline will be vulnerable to exposure from the chemical(s) released, and will be vulnerable to the health effects of that exposure and/or explosion.

Property

The assets that are vulnerable to any pipeline failure will depend on a variety of factors, including:

- Type and amount of chemical(s) released;
- Weather conditions;
- Prevailing winds;
- Time of day; and
- Presence of ignition source.

Each of these factors, in addition to proximity to the release, will influence the makeup of the assets that are vulnerable to the hazard. Concern may not be limited to just the duration of the event; it would likely extend past the event, to include concerns regarding contamination of the property or facility from the event.

Environment

The environment is often vulnerable to the effects of a pipeline failure; depending on the specifics of the event, the environment can be less or more heavily damaged. Pipeline failures – with their unpredictable and uncertain nature – often produce unexpected vulnerabilities as the event unfolds. The consequences for the environment will depend on a variety of factors, including:

- Type and amount of chemical(s) released;
- Weather conditions;
- Prevailing winds;
- Time of day; and
- Presence of ignition source.

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City/County Operations

Critical facilities are those facilities or services that a community relies on for effective and efficient operation, particularly during and after a hazard event, or that would be of critical importance to a community in the event and aftermath of a hazard event. Typically, critical facilities include:

- Fire stations;
- Hospitals/clinics/medical centers;
- Chemical/heavy industrial/hazardous materials facilities or storage locations; and
- Communications facilities, such as radio and television broadcast locations.

A pipeline failure could potentially impact facilities critical to the community in areas near pipeline infrastructure.

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *Environmental Systems Research Institute*
Community Analyst
<http://www.esri.com/software/arcgis/community-analyst>
- *National Pipeline Mapping System* <http://www.npms.phmsa.dot.gov/application.asp?tact=npms&page=subapp.asp?app=aboutnpms&act=about>.
- *Pipeline and Hazardous Materials Safety Administration*
Pipeline Incidents and Mileage Reports
<http://primis.phmsa.dot.gov/comm/reports/safety/psi.html?nocache=6920>, and
Pipeline System Components
<http://opsweb.phmsa.dot.gov/pipelineforum/facts-and-stats/incidents-and-mileage-report/>,
and
Significant incidents
<http://primis.phmsa.dot.gov/comm/reports/safety/sida.html?nocache=9119>, and
Serious Pipeline Incidents
<http://primis.phmsa.dot.gov/comm/reports/safety/SerPSI.html?nocache=2522>, and
Significant Pipeline Incidents Definition
http://primis.phmsa.dot.gov/comm/reports/safety/sigpsi.html?nocache=4369#_all
- *Railroad Commission of Texas*
Online Research Queries
<http://www.rrc.state.tx.us/data/online/index.php>
Texas Pipeline Damage Query
<http://webapps.rrc.state.tx.us/TPD/mainQueryAction.do>
- *United States Census Bureau*

Regional/State Resources and Documents:

- *Railroad Commission of Texas*
<http://www.rrc.state.tx.us/data/online/index.php>

Local Resources and Documents:

- *City of San Antonio Office of Emergency Management*

Section 3.10 – Terrorism

Description

Throughout human history, there have been many threats to the security of nations. These threats have brought about large-scale losses of life, the destruction of property, widespread illness and injury, the displacement of large numbers of people, and devastating economic loss.

Terrorism is violence committed by groups or individuals in order to intimidate a population or government into granting their demands.

Defining what is and what is not terrorism has proven to be a difficult task. United States (US) Department of State defines terrorism as:

(1) The term “international terrorism” means terrorism involving citizens or the territory of more than one country;

(2) The term “terrorism” means premeditated, politically motivated violence perpetrated against noncombatant targets by sub-national groups or clandestine agents;

(3) The term “terrorist group” refers to any group, or which has significant subgroups which practice, international terrorism;

(4) The terms “territory” and “territory of the country” refer to the land, waters, and airspace of the country;

(5) The terms “terrorist sanctuary” and “sanctuary” refer to an area in the territory of the country:

(A) that is used by a terrorist or terrorist organization—

(i) To carry out terrorist activities, including training, fundraising, financing, and recruitment; or

(ii) As a transit point; and

(B) the government of which expressly consents to, or with knowledge, allows, tolerates, or disregards such use of its territory and is not subject to a determination under—

(i) Section 2405(j)(1)(A) of the Appendix to title 50;

(ii) Section 2371 (a) of this title; or

(iii) Section 2780 (d) of this title. (Source: *United States Department of State*)

Figure 3.10.1 Port Surveillance



General Characteristics

The Federal Bureau of Investigation (FBI) categorizes terrorism as one of two types: domestic or international. Domestic terrorism involves groups or individuals whose activities are directed at elements of our government or population without foreign direction. International terrorism involves groups or individuals whose terrorist activities are foreign-based and/or directed by countries or groups outside the US, or whose activities transcend their national boundaries.

A terrorist attack can take several forms, depending on the technological means available to the terrorist, the nature of issue motivating the attack, and the points of weakness of the terrorist's target. Bombings are the most frequently used terrorist method in the US. A terrorist using a chemical or biological weapon is of particular concern to officials. Special training and equipment is needed in order to safely manage a weapon of mass destruction (WMD) incident.

Location

Terrorism, being a technological hazard, is not tied to specific geography or topography, but rather is usually tied to specific features of a community. These features are usually of high value to the community, or are necessary for the community's operations or livelihood. Several such locations exist in the planning area, including:

- Manufacturing facilities;
- Military installations;
- Universities;
- Public utilities, including water reservoirs and treatment facilities;
- Government facilities; and
- Food storage, processing, and distribution centers.

Terrorists most often search for highly visible targets that they can strike while avoiding detection. However, the motivation behind terrorist events can be varied and the target's surrounding area is considered at risk.

Extent

The US Department of Homeland Security (DHS) monitors terrorism threats on a national level, and is responsible for maintaining the National Terrorism Advisory System (NTAS). This system provides public information about terrorist threats by updating their webpage with timely, detailed, information. Alerts will provide a summary of the potential threat, information about actions taken to ensure public safety, and recommended steps that local governments can take to help prevent, mitigate, or respond to the threat. NTAS alerts are only issued when credible information is available. See Figure 3.10.2 for a sample alert.

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These alerts indicate if there is an imminent or elevated threat to the country.

- An imminent threat warns of a credible, specific, and impending terrorist threat.
- An elevated threat warns of a credible terrorist threat.

NTAS alerts contain a provision indicating a specific date when the alert expires. The NTAS replaces the previous color-coded Homeland Security Advisory System (HSAS).

Figure 3.10.2 NTAS Alert Sample

**U.S. DEPARTMENT OF
HOMELAND SECURITY**

National Terrorism Advisory System

Alert

DATE & TIME ISSUED: XXXX

SUMMARY

The Secretary of Homeland Security informs the public and relevant government and private sector partners about a potential or actual threat with this alert, indicating whether there is an “imminent” or “elevated” threat.

DURATION

An individual threat alert is issued for a specific time period and then automatically expires. It may be extended if new information becomes available or the threat evolves.

DETAILS

- This section provides more detail about the threat and what the public and sectors need to know.
- It may include specific information, if available, about the nature and credibility of the threat, including the critical infrastructure sector(s) or location(s) that may be affected.
- It includes as much information as can be released publicly about actions being taken or planned by authorities to ensure public safety, such as increased protective actions and what the public may expect to see.

AFFECTED AREAS

- This section includes visual depictions (such as maps or other graphics) showing the affected location(s), sector(s), or other illustrative detail about the threat itself.

HOW YOU CAN HELP

- This section provides information on ways the public can help authorities (e.g. camera phone pictures taken at the site of an explosion), and reinforces the importance of reporting suspicious activity.
- It may ask the public or certain sectors to be alert for a particular item, situation, person, activity or developing trend.

STAY PREPARED

- This section emphasizes the importance of the public planning and preparing for emergencies before they happen, including specific steps individuals, families and businesses can take to ready themselves and their communities.
- It provides additional preparedness information that may be relevant based on this threat.

STAY INFORMED

- This section notifies the public about where to get more information.
- It encourages citizens to stay informed about updates from local public safety and community leaders.
- It includes a link to the DHS NTAS website <http://www.dhs.gov/alerts> and <http://twitter.com/NTASAlerts>

If You See Something, Say Something™. Report suspicious activity to local law enforcement or call 911.

The National Terrorism Advisory System provides Americans with alert information on homeland security threats. It is distributed by the Department of Homeland Security. More information is available at: www.dhs.gov/alerts. To receive mobile updates: www.twitter.com/NTASAlerts
If You See Something Say Something™ used with permission of the NY Metropolitan Transportation Authority.

(Source: United States Department of Homeland Security)

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As terrorism is a technological hazard, the severity of the hazard within the planning area is impossible to predict. Scenarios range from minor disruptions to catastrophic damages and fatalities. There is no scale to measure the severity of an act of terrorism and a great deal of variability between events. Terrorism can be targeted at specific individuals or the area as a whole. They may be premeditated or sudden.

There are a variety of methods by which terror can be inflicted on a population.

Table 3.10.1 Profiles for Terrorism and Technological Hazards

Description	Application Mode	Duration	Extent of Effects	Mitigating or Exacerbating Conditions
Conventional Bomb/ Improvised Explosive Device	Detonation of explosive device on or near target; delivery via person, vehicle, or projectile.	Instantaneous; Additional "secondary devices" may be used, lengthening the time duration of the hazard until the attack site is determined to be clear.	Extent of damage is determined by type and quantity of explosive.	Effects generally static other than cascading consequences, incremental structural failure, etc.
Chemical Agent	Liquid/aerosol contaminants can be dispersed using sprayers or other aerosol generators; liquids vaporizing from puddles/containers; or munitions.	Chemical agents may pose viable threats for hours to weeks depending on the agent and the conditions in which it exists.	Contamination can be carried out of the initial target area by persons, vehicles, water and wind. Chemicals may be corrosive or otherwise damaging over time if not remediated.	Weather conditions and availability of shielding can greatly impact effectiveness of chemical agents.
Arson/ Incendiary Attack	Initiation of fire or explosion on or near target via direct contact or remotely via projectile.	Generally minutes to hours.	Extent of damage is determined by type and quantity of device/accelerant and materials present at or near target.	Effects generally static other than cascading consequences, Incremental structural failure, etc.
Armed Attack	Tactical assault or sniping from remote location.	Generally minutes to days.	Varies based upon the perpetrators' intent and capabilities.	Inadequate security can allow easy access to target, easy concealment of weapons and undetected initiation of an attack.

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Description	Application Mode	Duration	Extent of Effects	Mitigating or Exacerbating Conditions
Biological Agent	Liquid or solid contaminants can be dispersed using sprayers/aerosol generators or by point or line sources such as munitions, covert deposits and moving sprayers.	Biological agents may pose viable threats for hours to years depending on the agent and the conditions in which it exists.	Depending on the agent used and the effectiveness with which it is deployed, contamination can be spread via wind and water. Infection can be spread via human or animal vectors.	Weather conditions can greatly impact effectiveness of biological agents.
Cyber-terrorism	Electronic attack using one computer system against another.	Minutes to days.	Generally no direct effects on built environment.	Inadequate security can facilitate access to critical computer systems, allowing them to be used to conduct attacks.
Agro-terrorism	Direct, generally Covert contamination of food supplies or introduction of pests and/or disease agents to crops and livestock.	Days to months.	Varies by type of incident. Food contamination events may be limited to discrete distribution sites, whereas pests and diseases may spread widely. Generally no effects on built environment.	Inadequate security can facilitate adulteration of food and introduction of pests and disease agents to crops and livestock.
Radiological Agent	Radioactive contaminants can be dispersed using sprayers/aerosol generators, or by point or line sources such as munitions, covert deposits and moving sprayers.	Contaminants may remain hazardous for seconds to years depending on material used.	Initial effects will be localized to site of attack; depending on meteorological conditions, subsequent behavior of radioactive contaminants may be dynamic.	Duration of exposure, distance from source of radiation, and the amount of shielding radiation between source and target determine exposure to radiation.

(Source: Federal Emergency Management Agency)

Depending on the method of attack, the impact of a terrorist act on life and property is potentially devastating. Life, property, and infrastructure are all potentially at risk to devastating impacts. The economic impacts to the planning area could be catastrophic, depending on the severity of the attack and the property and infrastructure that is damaged or destroyed.

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Previous Occurrences

Suspected terror plots have been thwarted in San Antonio in recent years, including a break-in and a bomb scare at the Bexar County Courthouse on October 19, 2011 that made national news. Salem al-Hazmi, 9/11 terrorist on American Airlines flight 77, was reported to have resided and trained in San Antonio. Most recently, on September 18, 2012, the San Antonio International Airport was evacuated over a bomb threat called from a parking garage. The San Antonio Regional Fusion Center and Intelligence Office has reported 483 potential terrorist threats to state and federal agencies since 2006. (Source: *San Antonio Office Emergency Management's Threat Hazard Identification and Risk Assessment, 2012*)

In 2007, the Texas Department of Public Safety, which is responsible for homeland security in Texas, reported that individuals with ties to Hezbollah, Hamas, and al-Qaida were arrested crossing the border from Mexico. From March 2006 to September 2007, almost 350 individuals "from terrorism-related countries" were arrested at the border.

In February 2010, after writing an anti-government, anti-big business, and anti-tax system rant, a computer engineer smashed a small aircraft into an office building in Austin, Texas, where nearly 200 employees of the Internal Revenue Service were starting their workday. The pilot and two building occupants were killed in the attack.

Estimated Recurrence Rate

The estimated recurrence rate of terrorism, based on historic occurrences in the City of San Antonio and Bexar County, is considered low.

Vulnerability

Since it is impossible to predict the exact location of terrorist event, the entire population and property in the San Antonio area are vulnerable to a threat of terrorism. The most common method to assess vulnerability to a specific hazard is to score a likelihood of occurrence of different types of threats from a hazard. Haystack Technology's Risk Analysis Center (RAC) platform was used to generate a terrorism threat list report that summarizes likelihood of terrorism threats for the San Antonio/Bexar County area (Table 3.10.2). The RAC platform report was generated based on its built-in analytics and risk data (CI/KR priority I data for San Antonio and Bexar County) entered into the system.

While it is difficult to prevent a terrorist attack, communities are able to lessen the likelihood of terrorist incident by improving their readiness to respond to an incident through training, exercises and maintenance of a local mitigation plan.

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Table 3.10.2 Terrorism Threat List Report for San Antonio/Bexar County

Threat Name	Type	Likelihood
Vehicle Born Improvised Explosive Device (IED)	Intentional/Terrorism	High
IED	Intentional/Terrorism	High
Arson/Incendiary attack	Intentional/Terrorism	High
Cyber Attack	Intentional/Terrorism	High
Chemical agent	Intentional/Terrorism	High
Biological (non-contagious)	Intentional/Terrorism	High
Sabotage/Theft	Intentional/Terrorism	High
Conventional attack	Intentional/Terrorism	High
Hostage Taking/Assassination	Intentional/Terrorism	High
Aircraft as weapon	Intentional/Terrorism	Moderate
Biological (contagious)	Intentional/Terrorism	Moderate
Radiological Dispersal Device	Intentional/Terrorism	Moderate
Food & Water Contamination	Intentional/Terrorism	Low
Nuclear Device	Intentional/Terrorism	Low
Agro-terrorism	Intentional/Terrorism	None
Maritime attack	Intentional/Terrorism	None

(Source: Haystax Technology Risk Analysis Center Analytic Program)

Population

Over 1.7 million residents inhabit Bexar County, with a population density of 1,325 per square mile, making it the fourth largest county in Texas. A condensed urban area with a high number of residents is often considered a possible target for a terrorist attack aimed at maximizing soft target casualties.

Property

Property and structures near high density locations, such as downtown San Antonio, medical centers, military bases and sports facilities, would be more likely to be impacted by a terrorist attack.

Environment

Loss of agriculture and forest areas due to arson campaign, intentional spills of hazardous materials into water and soil, or release into the air are few examples of environmental vulnerability to terrorism.

City/County Operations

Critical facilities are those facilities or services that a community relies on for effective and efficient operation, particularly during and after a hazard event, or that would be of critical importance to a community in the event and aftermath of a hazard event. Typically, critical facilities include:

- Fire stations;

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- Hospitals/clinics/medical centers;
- Chemical/heavy industrial/hazardous materials facilities or storage locations; and
- Communications facilities, such as radio and television broadcast locations.

Numerous critical facilities have been hardened to minimize the impact of a terrorist attack.

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Bibliography and Resource Directory

Federal/National Resources and Documents:

- *Environmental Systems Research Institute*
Community Analyst
<http://www.esri.com/software/arcgis/community-analyst>
- *Federal Emergency Management Agency*
Integrating Manmade Hazards Into Mitigation Planning FEMA 386-7
<http://www.fema.gov/media-library-data/20130726-1524-20490-3869/howto7.pdf>
- *United States Department of Homeland Security*
National Terrorism Advisory System
<http://www.dhs.gov/how-do-i/check-national-terrorism-advisory-system-ntas>
- *United States Department of State*
US Code Title 22, Ch.38, Para. 2656f(d)
<http://www.state.gov/documents/organization/65464.pdf>

Regional/State Resources and Documents:

- *Haystax Technology*
<http://www.haystax.com/>
Advanced Threat Analytic Program
Regional Risk Assessment

Local Resources and Documents:

- *San Antonio Office of Emergency Management*
Threat Hazard Identification and Risk Assessment, 2012

3.11 - Tornado

Description

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud extending to the ground. Tornadoes are most often generated by thunderstorm activity (but sometimes result from hurricanes and other coastal storms) when cool, dry air intersects and overrides a layer of warm, moist air forcing the warm air to rise rapidly. The damage caused by a tornado is a result of the high wind velocity and wind-blown debris. According to the National Weather Service (NWS), tornado wind speeds normally range from 40 to more than 300 miles per hour. The most violent tornadoes have rotating winds of 250 miles per hour or more and are capable of causing high level of destruction.

Each year, on average, of over 800 tornadoes is reported nationwide, resulting in an average of 80 deaths and 1,500 injuries. (Source: *National Oceanic and Atmospheric Administration*) They are more likely to occur during the spring and early summer months of March through June and can occur at any time of day, but are likely to form in the late afternoon and early evening. Most tornadoes are a few dozen yards wide and touch down briefly, but even small, short-lived tornadoes can inflict tremendous damage. Highly destructive tornadoes may carve a path over a mile wide and several miles long.

General Characteristics

By definition, a tornado is a violently rotating column of air, pendant from a cumuliform cloud or underneath a cumuliform cloud, and often (but not always) visible as a funnel cloud. Technically, for a vortex to be classified as a tornado, it must be in contact with the ground and the cloud base.

Two different notifications are used to warn the public, officials, and first responders regarding impending or imminent tornadic conditions. The first is a tornado watch, which is issued by the NWS when conditions are favorable for the development of tornadoes in and close to the watch area. Watches normally are issued well in advance of the actual occurrence of severe weather. During the watch, the public should review tornado safety rules and be prepared to move to safety if threatening weather approaches.

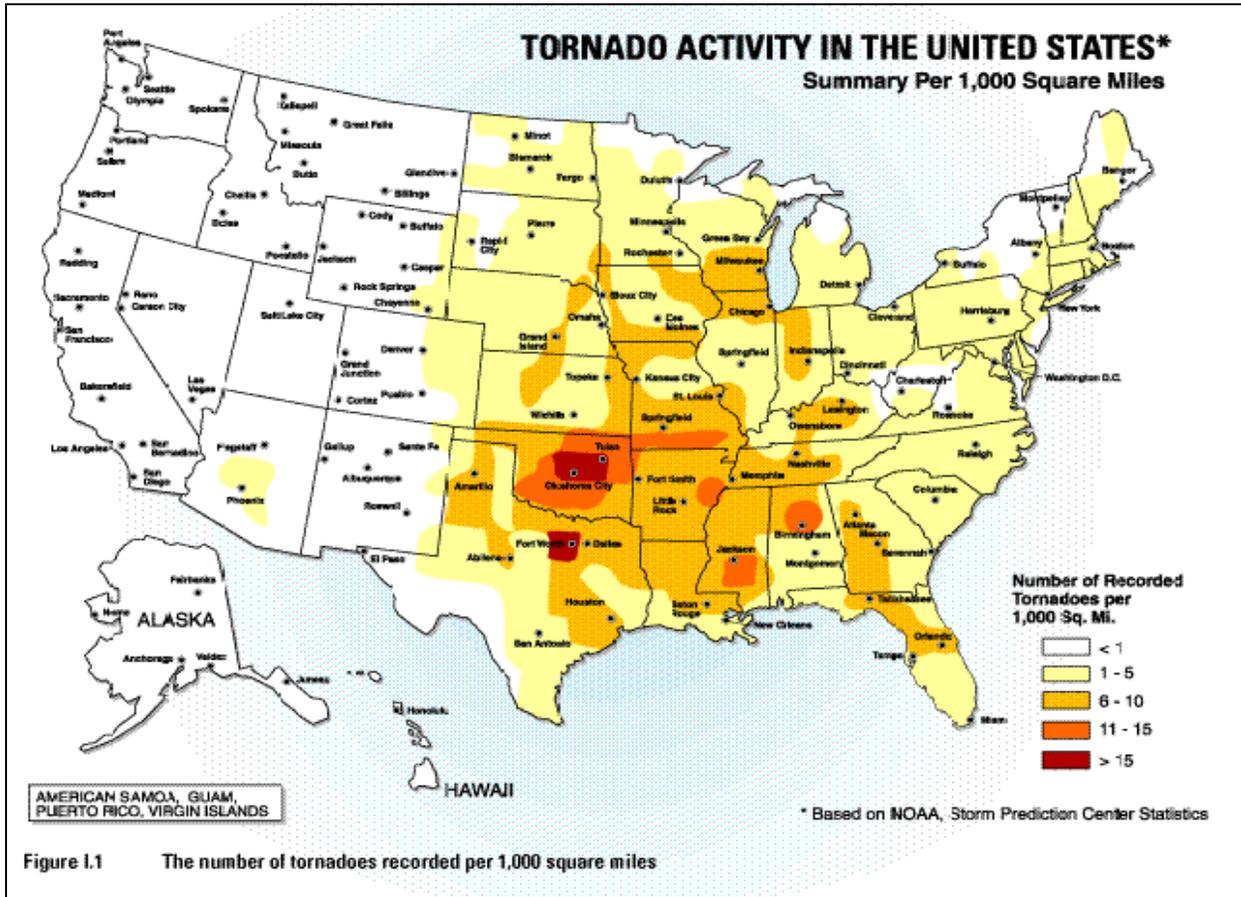
The second notification is a tornado warning, issued when a tornado is indicated by radar or sighted by spotters; therefore, people in the affected area should seek safe shelter immediately. A warning can be issued without a tornado watch being already in effect, and is usually issued for duration of around 30 minutes.

In the United States (US), the NWS is the federal government agency that issues tornado watches and warnings. Warnings are issued by the local office of the NWS, whereas the Storm Prediction Center (SPC) in Norman, Oklahoma, which is part of the NWS, issues watches and forecasts. Media and subscription organizations create and provide forecasts regarding severe weather and tornadoes.

Location

Federal Emergency Management Agency (FEMA), using data provided by the SPC, has mapped tornado activity in the US. The shaded areas in Figure 3.11.1 show the number of recorded tornadoes per 1,000 miles². As seen in the figure below, the San Antonio/Bexar County is in an area of low activity.

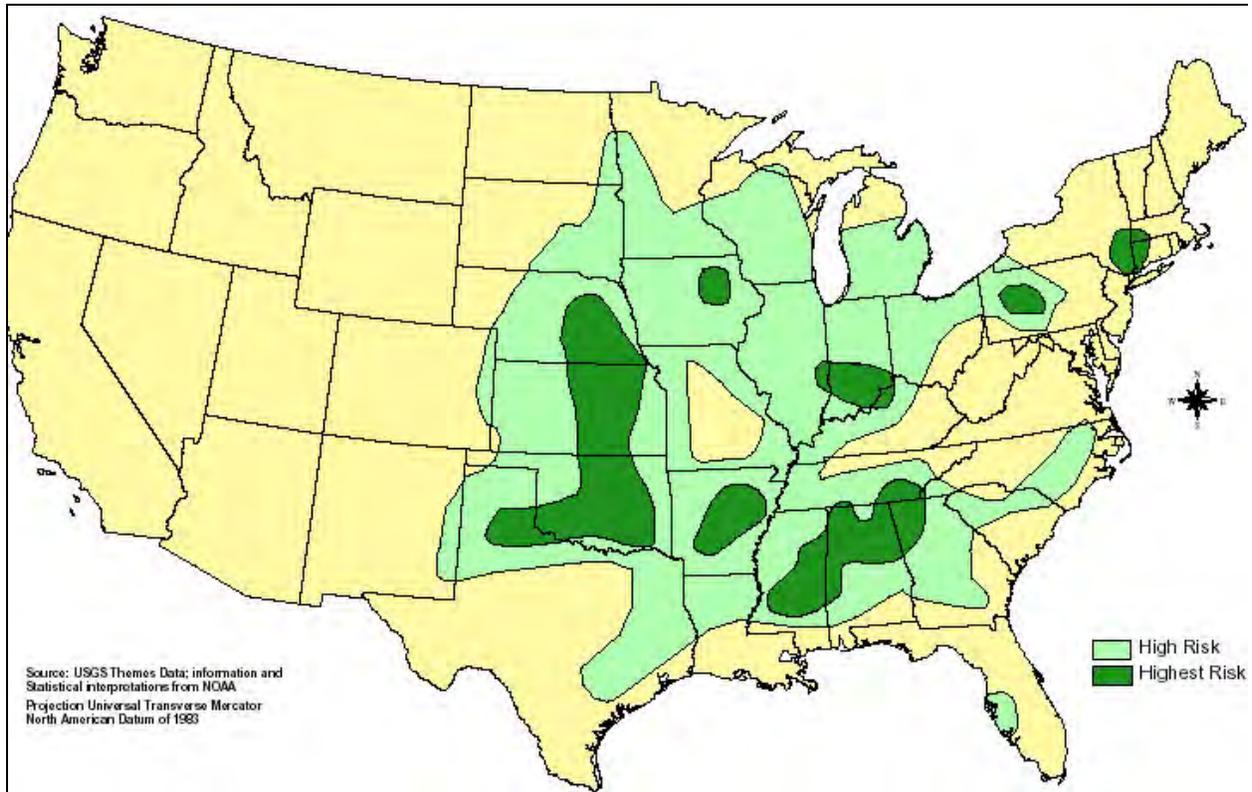
Figure 3.11.1 Tornado Activity in the United States



(Source: Federal Emergency Management Agency)

More tornadoes occur in the US than in any other country. Within the US, the majority of tornadoes occur in an area commonly referred to as “Tornado Alley.” This region extends roughly from North Dakota south to Dallas and from the Rocky Mountains through the Tennessee Valley. San Antonio is located outside of this high-risk region, as illustrated in Figure 3.11.2 below.

Figure 3.11.2 Tornado Alley



(Source: United States Geological Survey)

Despite this general assessment that Bexar County is outside of the areas of highest risk, any area of the County remains susceptible to a tornado, especially after a hurricane where multiple tornados can be spawned.

Extent

Tornado wind forces are measured and described according to the Fujita Scale. The Fujita Scale largely measures damage to residential structure, which tend to have much more standardized construction than commercial structures. The Fujita Scale is intended to describe the expected damage to well-built residential structures, though poorly built structures can suffer significant structural damage under lesser winds than the scale would suggest. The Storm Prediction Center cautions the following regarding the use of the Fujita Scale:

Do not use F-scale winds literally. These precise wind speed numbers are actually guesses and have never been scientifically verified. Different wind speeds may cause similar-looking damage from place to place -- even from building to building. *Without a thorough engineering analysis of tornado damage in any event, the actual wind speeds needed to cause that damage are unknown.*

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In February 2007, use of the Fujita Scale was discontinued. In its place, the Enhanced Fujita Scale is currently used. The Enhanced Fujita Scale retains the same basic format as its predecessor, but reflects a more refined assessment of tornado damage surveys, standardization, and damage consideration to a wider range of structure types. The new scale takes into account how most structures are designed and is thought to be a much more accurate representation of the surface wind speeds in the most violent tornadoes. It is important to note the date a tornado occurred, as tornadoes which occurred prior to February 2007 are classified by the old scale and will not be converted to the Enhanced Fujita Scale. The following tables illustrate the Fujita Scale in use prior to February 2007, and the currently used Enhanced Fujita Scale.

Table 3.11.1 Fujita Tornado Scale, Pre-February 2007

F-Scale Number	Intensity Phrase	Wind Speed	Type of Damage
F0	Gale tornado	40-72 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.
F1	Moderate tornado	73-112 mph	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	Significant tornado	113-157 mph	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
F3	Severe tornado	158-206 mph	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted
F4	Devastating tornado	207-260 mph	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	Incredible tornado	261-318 mph	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel reinforced concrete structures badly damaged.
F6	Inconceivable tornado	319-379 mph	These winds are very unlikely. The small area of damage they might produce would probably not be recognizable along with the mess produced by F4 and F5 wind that would surround the F6 winds. Missiles, such as cars and refrigerators would do serious secondary damage that could not be directly identified as F6 damage. If this level is ever achieved, evidence

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F-Scale Number	Intensity Phrase	Wind Speed	Type of Damage
			for it might only be found in some manner of ground swirl pattern, for it may never be identifiable through engineering studies.

(Source: Storm Prediction Center)

Table 3.11.2 Enhanced Fujita Tornado Scale (Post-February 2007)

Enhanced Fujita Category	Wind Speed	Potential Damage
EF0	65-85 mph	Light damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
EF1	86-110 mph	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135 mph	Considerable damage. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136-165 mph	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166-200 mph	Devastating damage. Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	200+ mph	Destruction of engineered and/or well constructed residence; slab swept clean.

(Source: Storm Prediction Center)

Previous Occurrences

This section includes previous occurrences derived from the National Climatic Data Center (NCDC) database, historical records, news accounts, and the written records of the City of San Antonio and Bexar County. There were three hurricanes that spawned devastating tornadoes; two of these events prompted federal disaster declarations. These incidents will be addressed first, followed by a summary of NCDC information.

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Federal Disaster Declarations

1988 – DR-816-TX

The following recovered newspaper account describes conditions and damages associated with the tornadoes delivered by Hurricane Gilbert:

Gilbert, which set off twisters across South Texas, including one or more blamed for at least \$35 million in damages locally, proved that Bexar County isn't immune to the effects of tropical storms.

Gilbert hit Jamaica as a Category 4 storm, killing 45 people, then crossed Mexico's Yucatan Peninsula at Category 5, before striking about 65 miles south of Brownsville at Category 3, causing flooding that killed more than 200 people in Mexico and leaving tens of thousands homeless.

On Friday afternoon, September 16, the storm's effects were felt in San Antonio. Winds snapped a utility pole that crashed through a window of an East Side home, killing a 42-year-old man. The next day 13 tornadoes were counted, but there might have been duplicate sightings — formed in Bexar County on a Saturday morning. Nearly 400 houses were damaged or leveled. (Source: *San Antonio Express-News*)

2008 - DR-1780-TX

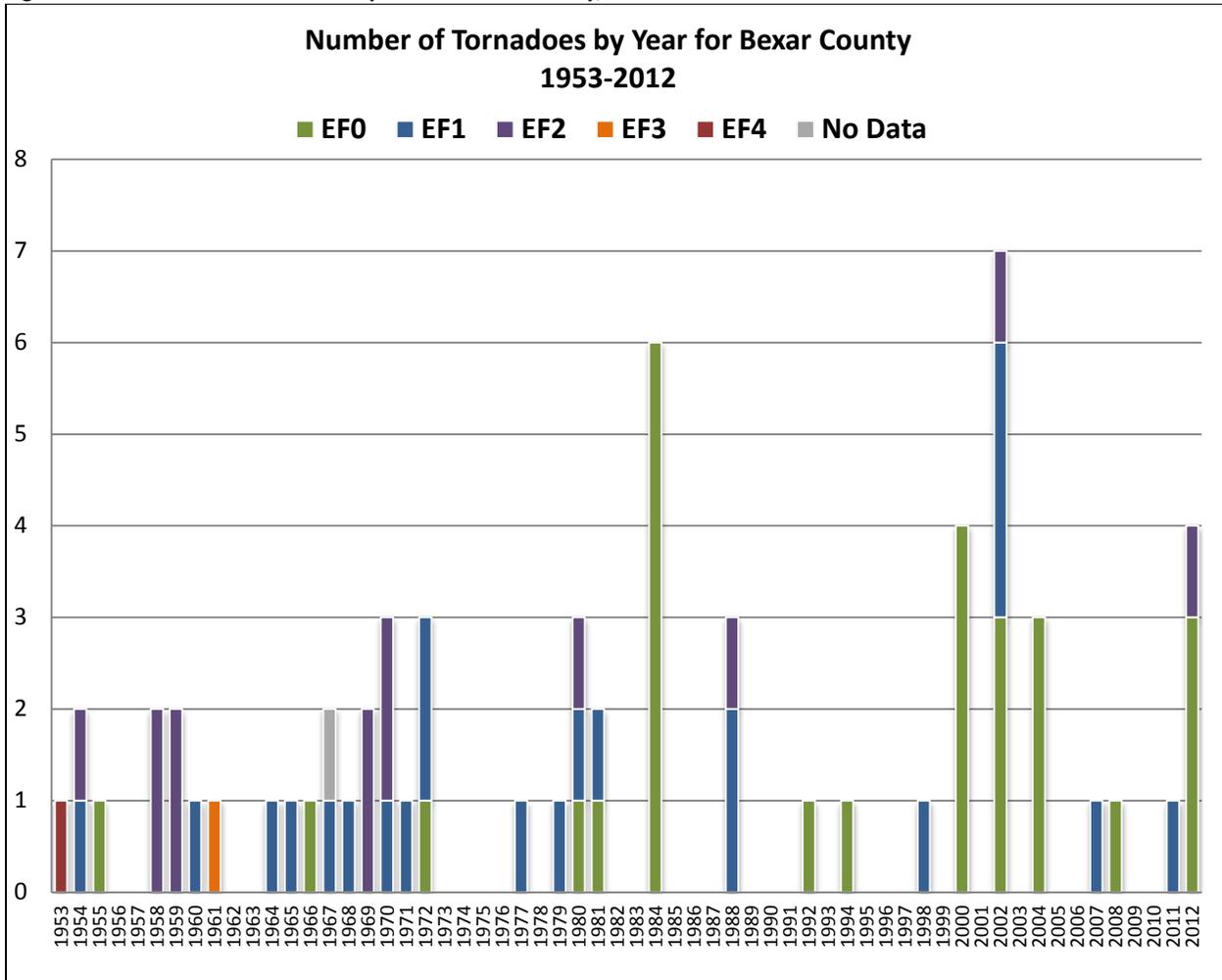
In conjunction with Hurricane Dolly's feeder rain bands, a severe wind event occurred at the 900 block of Steves Avenue in San Antonio. Initial uncertainty surrounded what type of wind event caused the damage, but it was suspected to be either straight line winds or a small tornado. The wind event was later confirmed as an EF0 tornado, which caused an estimated \$800,000.00 in damages to 84 properties.

NCDC

According to data collected by the NCDC, at least 74 tornadoes were recorded between the years of 1950 and 2012 in San Antonio/Bexar County. Three fatalities and 72 injuries are attributed to these tornados, with property damage estimated at more than \$60 million. As is the case with most NCDC data, events are often reported more than once as the system moves through an area, so it is possible that some of these events are duplicates. However, with tornadoes this is not as serious as issues as with other hazards, as the damages follow a narrow path along the tornado track. Figure 3.11.3 illustrates the occurrence of tornadoes by category within San Antonio/Bexar County between 1950 and 2012.

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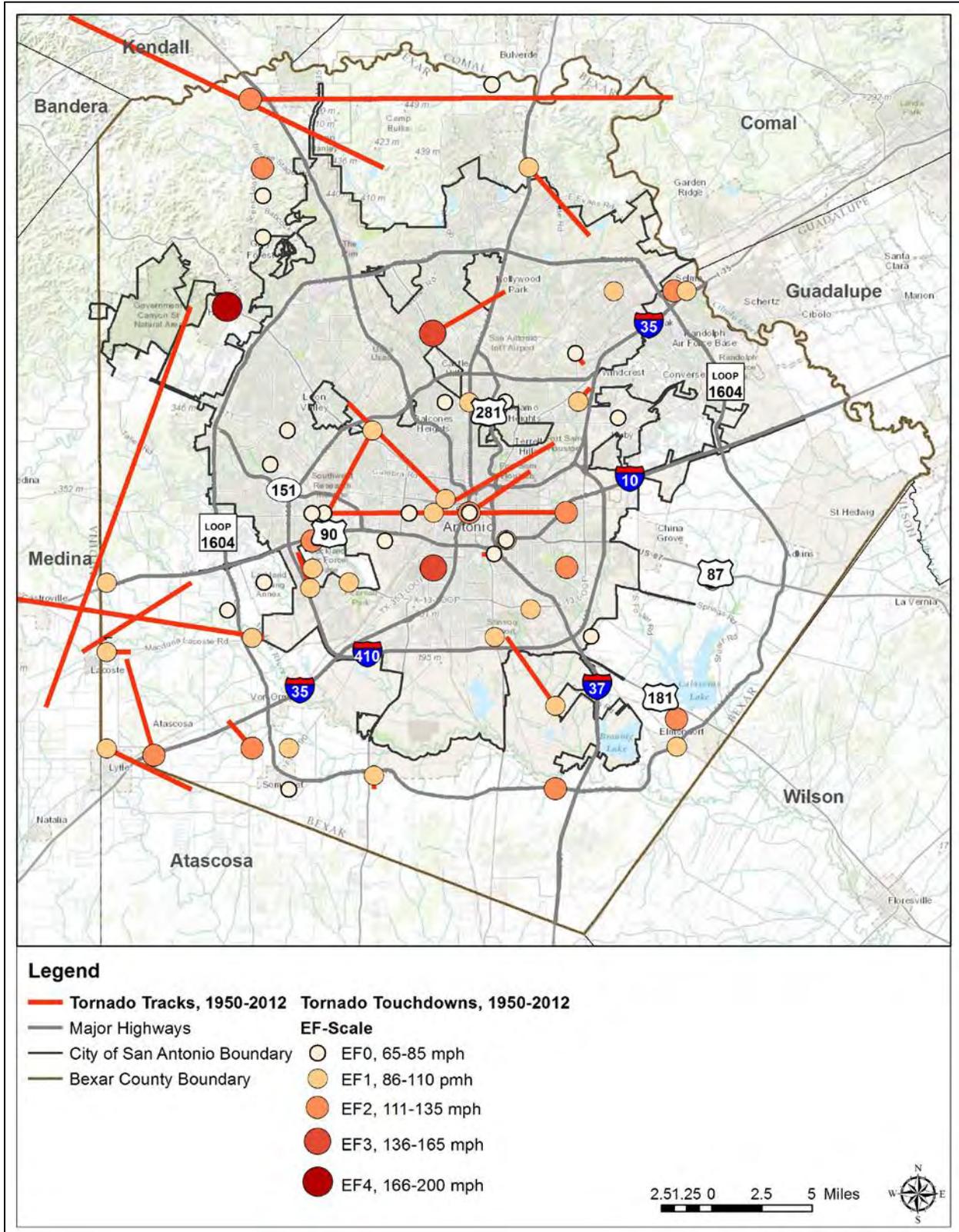
Figure 3.11.3 Number of Tornadoes by Year for Bexar County, 1953-2012



(Source: National Climatic Data Center)

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Figure 3.11.4 Tornado Touchdowns and Tracks in San Antonio/Bexar County, 1950-2012



(Source: National Oceanic and Atmospheric Administration)

Estimated Recurrence Rate

The estimated recurrence rate of tornadoes, based on historic occurrences in the City of San Antonio and Bexar County, is considered moderate.

Vulnerability

Population

As has been discussed, tornadoes are the most violent of atmospheric hazards; therefore any person in the path of such a storm would be vulnerable.

Even lesser tornadoes have proven to be hazardous due primarily to the speed of onset and extremely short warning times associated with tornadoes in general and with hurricane spawned tornadoes especially. Therefore, the most vulnerable are populations that cannot take cover quickly.

Other vulnerable segments of the population include:

- People in automobiles;
- People in campgrounds;
- People who do not understand the meaning of warnings, particularly if there are language barriers;
- People who do not heed weather radio warnings;
- People who are unable to reach shelter areas due to distance of shelter or physical limitations;
- The elderly; and
- The very young.

In some cases, these populations may be more vulnerable due to lack of adequate structural protection, even if they are able to take cover. Structural concerns of vulnerability are not isolated to specific or vulnerable populations, however; as with the extreme wind event hazard, a significant segment of the building stock that is vulnerable to tornadoes begins with manufactured housing units and is followed by older properties built with lesser quality materials or those constructed prior to modern or current building codes and techniques, such as those recommended by the International Code Council. In addition, basements and storm shelters are uncommon in Bexar County, leaving most residences without a safe place to shelter their occupants.

People living in manufactured homes (mobile homes) are particularly vulnerable to tornadoes, especially if building codes do not cover manufactured homes, or if the structures are old enough to be “grandfathered”, and are not required to meet code requirements. Less-well maintained older homes are also vulnerable.

Following a string of particularly violent tornadoes in Oklahoma and Kansas in 1999, FEMA assessed the

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performance of buildings during the tornadoes. They found that manufactured homes and those that did not meet established building codes sustain the greatest damages.

Property

Property and structures are highly vulnerable to tornadoes. The lighter the property or structure, the less wind speed will be required to cause damage or destruction. Vehicles, roofs, and overhead power lines are commonly damaged in small tornadoes, as these types of property do not contain sufficient mass to resist the strong, violent winds of a tornado. In general, the more forceful the tornado, the more property damage will result.

Environment

Though tornadoes can damage plant and wildlife the same as man-made property, the environment will repair itself and recover from the event. Trees may be lost or downed, but other plant and tree species will begin to grow to fill in the area that was devastated. As with other severe weather hazards, damage to the environment can be caused by accidental release of hazardous materials from damaged facilities or systems.

City/County Operations

Critical facilities are those facilities or services that a community relies on for effective and efficient operation, particularly during and after a hazard event, or that would be of critical importance to a community in the event and aftermath of a hazard event. Typically, critical facilities include:

- Fire stations;
- Hospitals/clinics/medical centers;
- Chemical/heavy industrial/hazardous materials facilities or storage locations; and
- Communications facilities, such as landline and cellular phone transmission and radio and television broadcast locations.

Tornadoes are typically limited to impacting smaller geographic areas. Though it is unlikely that a large number of critical facilities would be damaged in a single event, all critical facilities in the San Antonio/Bexar County area are vulnerable to this hazard.

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *Federal Emergency Management Agency*
Disaster and Emergency Declarations
<http://www.fema.gov/disasters/grid/state-tribal-government/24>, and
Taking Shelter from the Storm: Building a Safe Room for your Home or Small Business, FEMA P-320
<http://www.fema.gov/safe-room-resources/fema-p-320-taking-shelter-storm-building-safe-room-your-home-or-small-business>, and
Wind Zones in the United States
http://www.fema.gov/plan/prevent/saferoom/tsfs02_torn_activity.shtm
- *National Climatic Data Center*
<http://www.ncdc.noaa.gov/oa/ncdc.html>
- *National Oceanic and Atmospheric Administration*
<http://www.noaa.gov/>
- *National Severe Storms Laboratory*
http://www.nssl.noaa.gov/primer/wind/wind_basics.html
- *National Weather Service*
Severe Weather
<http://www.noaawatch.gov/themes/severe.php>, and
National Weather Service Glossary
<http://www.weather.gov/glossary>
- *National Weather Service Forecast Office – Austin/San Antonio*
<http://www.srh.noaa.gov/ewx/?n=satorjava.htm>
- *Storm Prediction Center*
Enhanced F Scale for Tornado Damage
www.spc.noaa.gov/efscale/ef-scale.html, and
Tornado FAQ
<http://www.spc.noaa.gov/faq/tornado>
- *TornadoChaser.Net*
Where is Tornado Alley
<http://www.tornadochaser.net/tornalley.html>
- *United States Geological Survey*
Tornado Alley
<http://www.tornadochaser.net/images/frequency.jpg>

Regional/State Resources and Documents:

- *Alamo Area Council of Governments*
Regional Multi-Hazard Mitigation Plan Update Draft, 2012
<https://www.aacog.com/index.aspx?NID=405>

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Local Resources and Documents:

- *San Antonio Express-News*
Then and Now: The Tornadoes of 1988
Tornado Rakes S.A.
Neighborhood http://www.mysanantonio.com/news/local_news/article/Tornado-touched-down-during-overnight-storms-2209975.php
- *San Antonio Office of Emergency Management*
Hurricane Dolly After Action Report

Section 3.12 - Wildfire

Description

A wildfire is any uncontrolled fire occurring in a wildland area (e.g., grassland, forest, brush land); uncontrolled fires are those not intentionally undertaken by authorized agencies. Wildfires are part of the natural management of the Earth's ecosystems, but may also be caused by human factors. Over 80% of forest fires are started by negligent human behavior, such as smoking in wooded areas or improperly extinguishing campfires. The second most common cause for wildfire is lightning.

A wildfire may be composed of three different types of fire: ground, surface, and crown. The relative proportion of each type can provide clues to the overall severity of a particular wildfire. A surface fire is the most common of these three classes and burns along the floor of a forest, moving slowly and killing or damaging trees. Surface fire severity can be low to high. High-severity surface fires are the most common killer of trees (kills more than 70 percent of trees) during a wildfire event. A ground fire (muck fire) is usually started by lightning or human carelessness and burns on or below the forest floor. Ground fires consume mostly the duff layer and don't produce visible flames. Ground fires can also burn out stumps and follow and burn decaying roots and decayed logs in the soil. A fire burning in tree roots often goes undetected except when it follows a root near the soil surface. In such cases, it can emerge, ignite surface fuels, and become a surface fire. Ground fires can often smolder for days or weeks, producing little smoke. Crown fires spread rapidly by wind and move quickly by jumping along the tops of trees. Crown fires are the most dangerous and destructive of wildland fires. Wildland fires usually produce dense smoke that fills the area for miles around.

Figure 3.12.1 2011 Bexar County Wildfires



The common denominator is fuel. We have little or no control over most factors governing the type of fire and fire behavior. One element we can control is fuel. Reducing the amount of fuel and changing its arrangement before a wildfire erupts can affect fire behavior.

State and local governments can impose fire safety regulations on home sites and developments to help curb wildfire. Land treatment measures, such as fire access roads, water storage, helipads, safety zones, buffers, firebreaks, fuel breaks, and fuel management, can be designed as part of an overall fire defense system to aid in fire control. Fuel management, prescribed burning, and cooperative land management planning can also be encouraged to reduce fire hazards.

General Characteristics

A report from the United States (US) Fire Administration studied fires in the Wildland-Urban Interface (WUI). The WUI is the area where the built environment meets or intermingles with undeveloped areas and wildland vegetation. This makes the WUI a focal area for human-environment conflicts such as wildland fires, habitat fragmentation, invasive species, and biodiversity decline. (Source: *University of Wisconsin*)

As a WUI fire is the wildland fire hazard type that is most likely to impact the City of San Antonio and Bexar County, the findings of this report will be used to characterize this type of hazard. The report begins with four findings, followed by a narrative description of the hazard:

- Development in the WUI is growing. In the western US alone, 38% of new home construction is adjacent to or intermixed with the WUI.
- A dichotomy exists in dealing with WUI fires. On one hand, environmentalists and foresters believe that a natural fire (or even a prescribed burn) is healthy for forests. On the other hand, homeowners in these areas expect fire protection of their structures.
- WUI fires pose great challenges to the fire service. Firefighting tactics for wildland fires differ considerably from those used in structure fires; access to and availability of water are often limited in WUI areas.
- Fire prevention programs in WUI areas are extremely important. Homeowners must accept a measure of responsibility and be fully aware of the risks when deciding to locate in such an environment.

Current population growth and the expanding development of North America into traditionally nonurban areas have increasingly brought humans into contact with wildfires. Between 2004 and 2012, primary structure losses totaled more than 13,000 in the US. Generally, these homes were located in areas where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels, also known as the WUI or intermix.

Both the definition and the development of the WUI are controversial subjects for government officials, developers, and the fire service.

Nationally, the continuing development of the WUI raises serious public policy and land use issues. Agencies at the local, state, and federal levels need to work together to define areas as being in the WUI, evaluate appropriate development of these areas, and find ways to provide services (including fire protection) to developments on these lands. Individual communities and homeowners must be willing

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to accept a high degree of responsibility for protecting their homes from wildfire. (Source: *United States Fire Administration*)

Location

Large sections of Bexar County are vulnerable to the wildfire hazard. The following Figures 3.12.2 and 3.12.3 show the land cover with locations of fire stations included, and the WUI areas in Bexar County. As is evident in those maps, the northern and southern boundaries of the City of San Antonio have the greatest proximity to the WUI and are therefore the most at risk to experience the wildfire hazard. To fully understand the WUI map, term definitions are helpful; these definitions are found in Table 3.12.1.

Table 3.12.1 WUI/Land Use Definitions

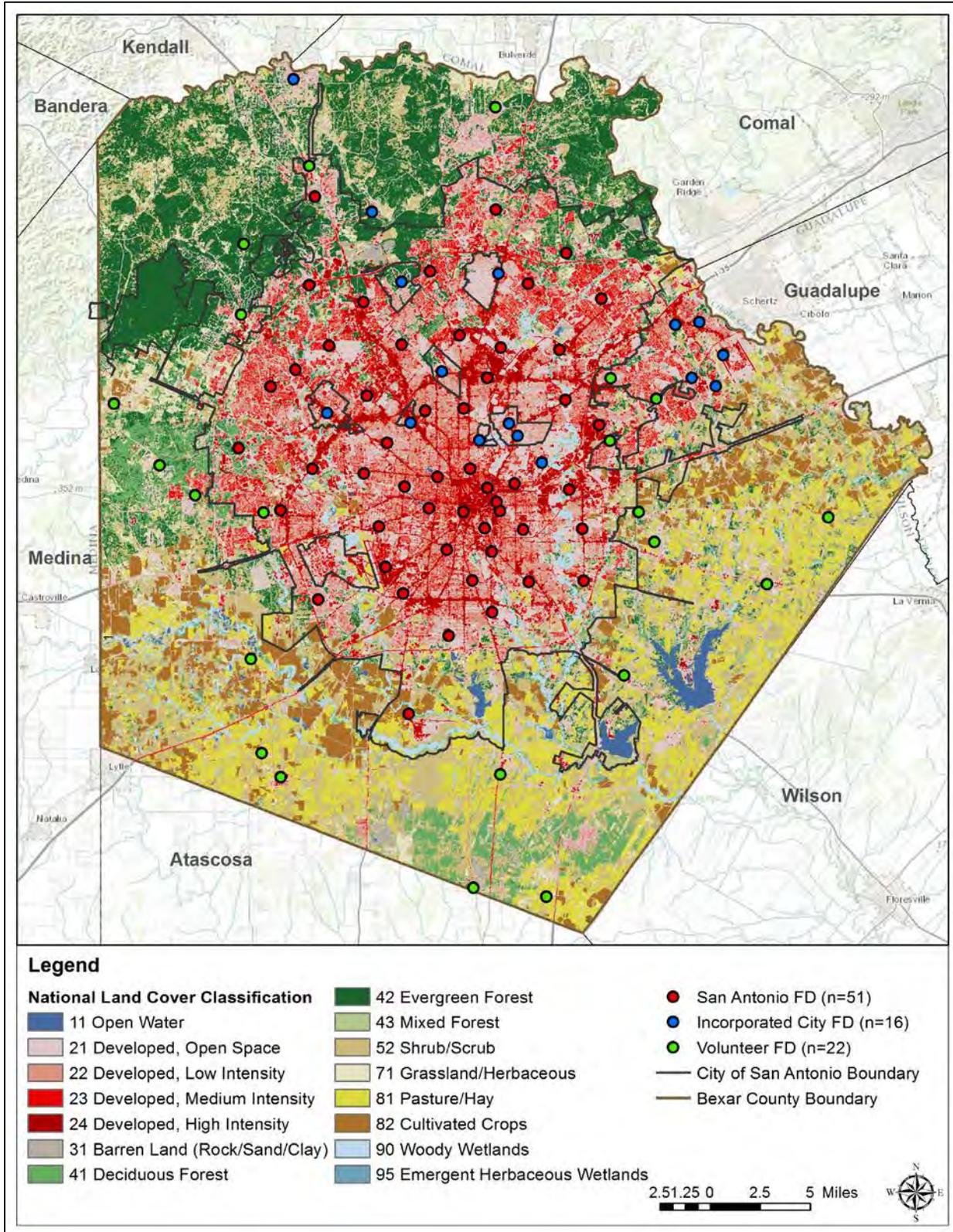
Term	Definition
Low Density Interface:	Areas with housing density ≥ 6.177635 housing units / km ² and < 49.42108 housing units / km ² ; and vegetation $\leq 50\%$, within 2.414km of an area with $\geq 75\%$ vegetation.
Medium Density Interface:	Areas with housing density ≥ 49.42108 housing units / km ² and < 741.3162 housing units / km ² ; and vegetation $\leq 50\%$, within 2.414km of an area with $\geq 75\%$ vegetation.
High Density Interface:	Areas with housing density ≥ 741.3162 housing units / km ² ; and vegetation $\leq 50\%$, within 2.414km of an area with $\geq 75\%$ vegetation.
Low Density Intermix:	Areas with housing density ≥ 6.177635 and < 49.42108 ; and vegetation $> 50\%$.
Medium Density Intermix:	Areas with housing density ≥ 49.42108 and < 741.3162 ; and vegetation $> 50\%$.
High Density Intermix:	Areas with housing density ≥ 741.3162 ; and vegetation $> 50\%$.

(Source: *United States Fire Administration*)

Figure 3.12.4 shows the location of wildfires requiring response from the San Antonio Fire Department (SAFD) throughout the city of San Antonio and Bexar County from 2007 to 2013. As this map shows, there were 76 non-routine wildfire incidents during this period. These include 6 extreme wildfire incidents (25 and over response units assigned), 61 moderate wildfire incidents (14-24 response units assigned), and 9 significant wildfire incidents (8-13 response units assigned).

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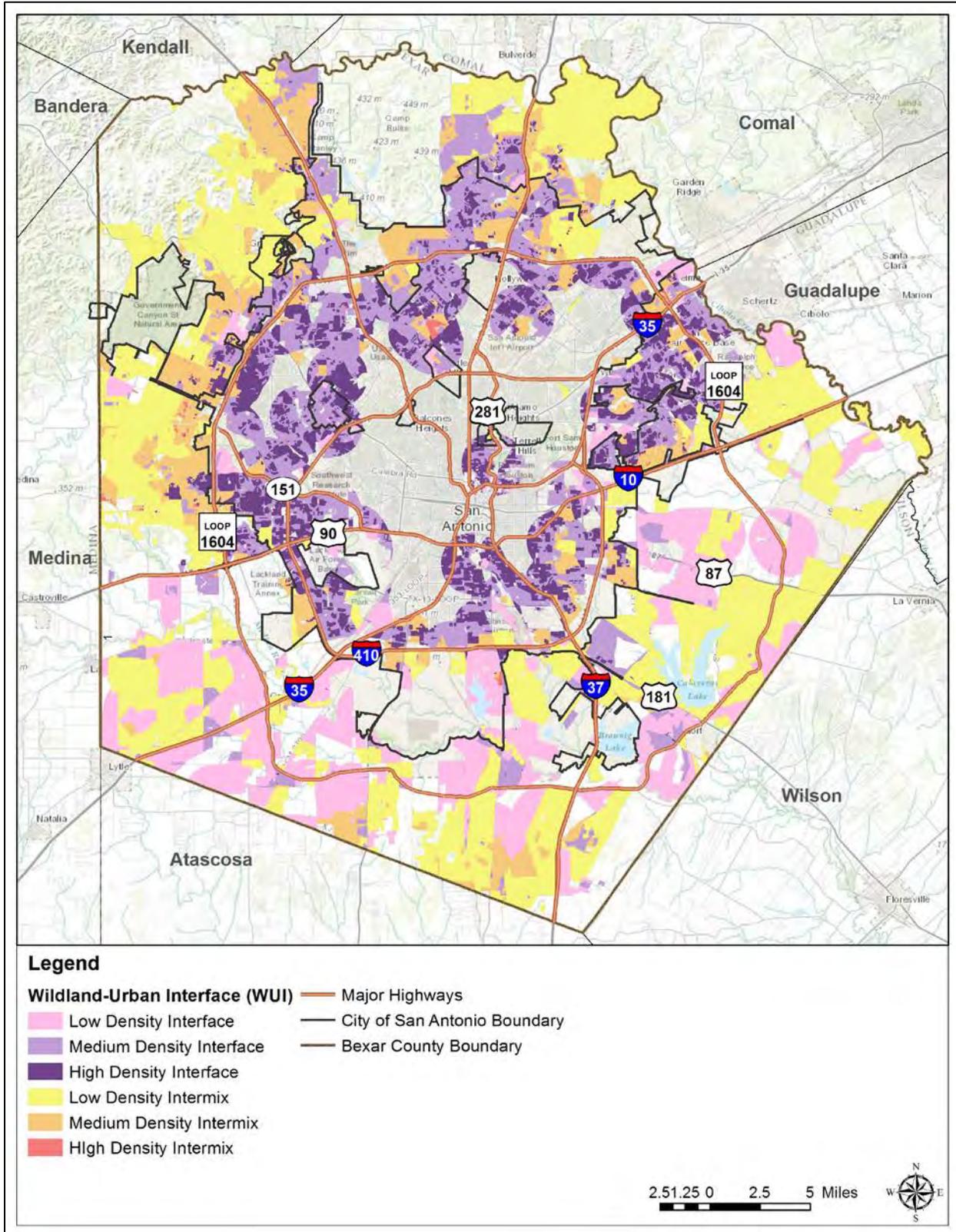
Figure 3.12.2 Land Cover in Bexar County with Fire Stations Marked



(Source: United States Geological Survey)

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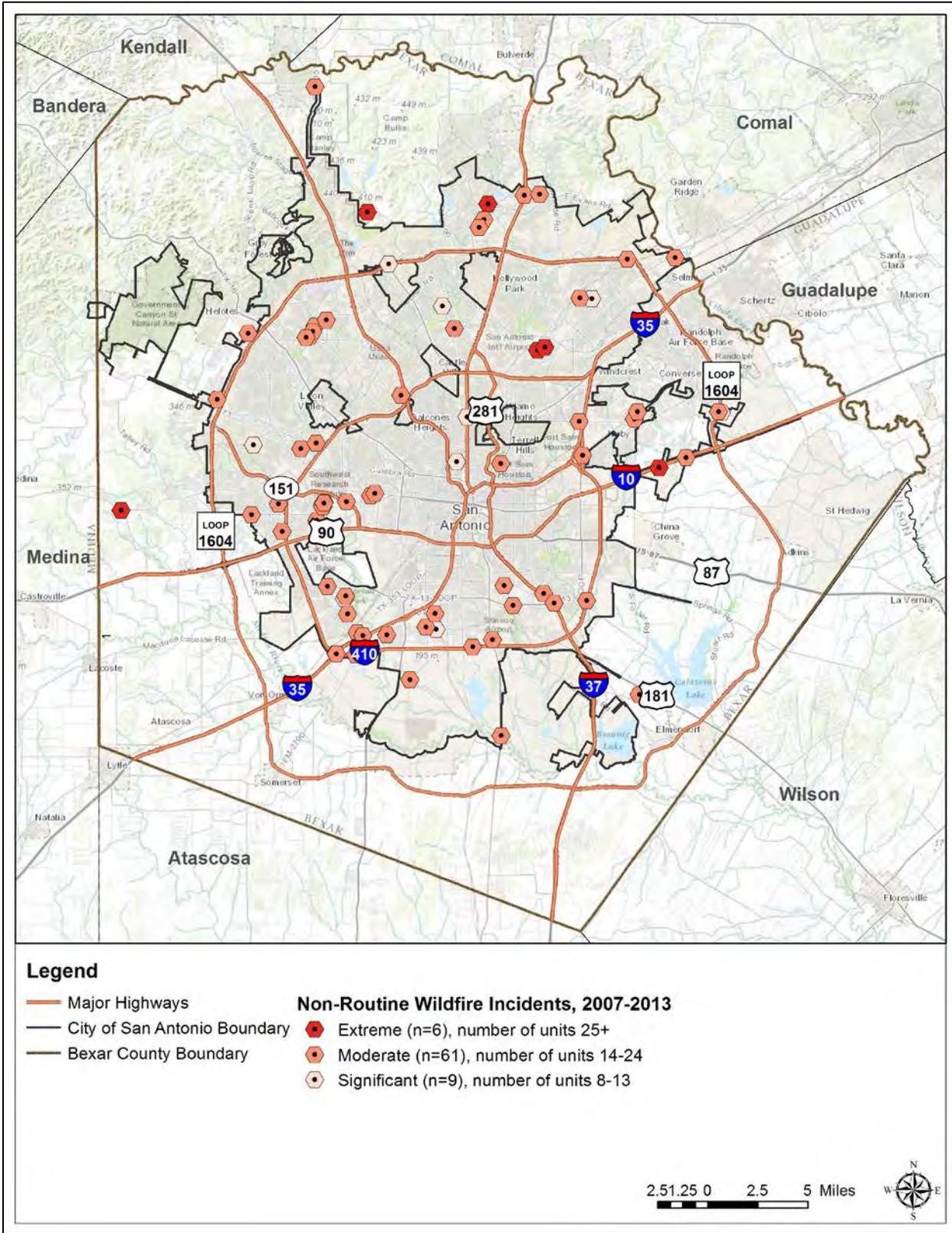
Figure 3.12.3 Wildland-Urban Interface (WUI) Areas, Bexar County



(Source: University of Wisconsin)

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Figure 3.12.4 Wildfire Locations within San Antonio/Bexar County, 2007-2013



(Source: San Antonio Office of Emergency Management)

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Extent

Fire danger rating is a description of the combination of both constant and variable factors that affect the initiation, spread, and difficulty to control a wildfire in an area. Since 1974, the US National Park Service has used five fire danger ratings to describe danger levels in public information releases and fire prevention signing. Table 3.12.2 provides details of the National Fire Danger Rating System.

Table 3.12.2 National Fire Danger Rating System

Rating	Basic Description	Detailed Description
Class 1: Low Danger (L) Color Code: Green	Fires not easily started	Fuels do not ignite readily from small firebrands. Fires in open or cured grassland may burn freely a few hours after rain, but wood fires spread slowly by creeping or smoldering and burn in irregular fingers. There is little danger of spotting.
CLASS 2: Moderate Danger (M) Color Code: Blue	Fires start easily and spread at a moderate rate	Fires can start from most accidental causes. Fires in open cured grassland will burn briskly and spread rapidly on windy days. Woods fires spread slowly to moderately fast. The average fire is of moderate intensity, although heavy concentrations of fuel, especially draped fuel, may burn hot. Short-distance spotting may occur, but is not persistent. Fires are not likely to become serious and are relatively controllable.
Class 3: High Danger (H) Color Code: Yellow	Fires start easily and spread at a rapid rate	All fine dead fuels ignite readily and fires start easily. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High intensity burning may develop on slopes or in concentrations of fine fuel. Fires may become serious and their control difficult, unless they are hit hard and fast while small.

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Rating	Basic Description	Detailed Description
<p>Class 4: Very High Danger (VH)</p> <p>Color Code: Orange</p>	<p>Fires start very easily and spread at a very fast rate</p>	<p>Fires start easily from all causes and immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high-intensity characteristics, such as long-distance spotting and fire whirlwinds, when they burn into heavier fuels. Direct attack at the head of such fires is rarely possible after they have been burning more than a few minutes.</p>
<p>Class 5: Extreme (E)</p> <p>Color Code: Red</p>	<p>Fire situation is explosive and can result in extensive property damage</p>	<p>Fires under extreme conditions start quickly, spread furiously and burn intensely. All fires are potentially serious. Development into high-intensity burning will usually be faster and occur from smaller fires than in the Very High Danger class (4). Direct attack is rarely possible and may be dangerous, except immediately after ignition. Fires that develop headway in heavy slash or in conifer stands may be unmanageable while the extreme burning condition lasts. Under these conditions, the only effective and safe control action is on the flanks, until the weather changes or the fuel supply lessens.</p>

(Source: *United States National Park Service*)

Historically, WUI fires have caused significant property loss. One of the most destructive fires occurred in the hills of Oakland, California, in October 1991. Twenty-five lives were lost, and more than 3,000 structures were destroyed by a WUI fire. The fire overwhelmed the firefighting forces of the area and consumed nearly everything in its path.

WUI fires are not only a problem in western states. In September of 2011, Texas experienced the most destructive wildfire in its history. The Bastrop County Complex fire took two lives, destroyed more than 1,600 homes and caused nearly \$325 million of insured property damage. (Source: *Texas Forest Service*)

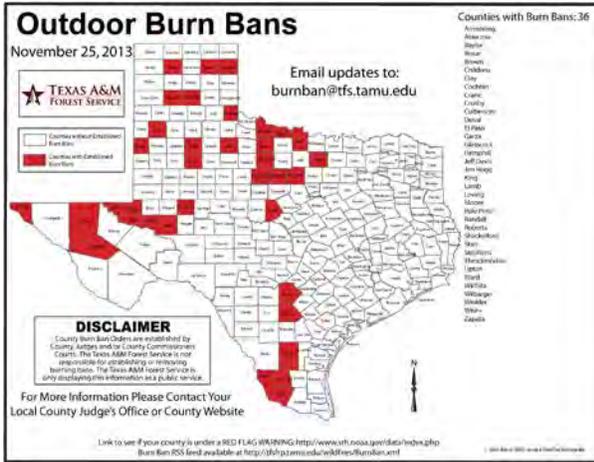
Wildfires are a threat throughout the State of Texas. It is reported that more than 80 percent of Texas wildfires occur within 2 miles of a community, posing a threat to life and property. Wildfires are of particular concern in areas that are experiencing severe drought, which historically has included the San

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Antonio/Bexar County area. While droughts do not cause wildfires, and wildfires do not cause droughts, the two are linked, as droughts exacerbate the threat of wildfire.

As discussed in the drought section of this document, a significant number of counties in the State of Texas are enforcing burn bans. Figures 3.12.5 and 3.12.6, compiled by the Texas Forest Service, illustrate the areas of Texas enforcing such a ban.

Figure 3.12.5 Burn Ban Counties – November 2013 (Non-Drought Year Example)



(Source: Texas Forest Service)

Figure 3.12.6 Burn Ban Counties – April 2011 (Drought Year Example)



(Source: Texas Forest Service)

Previous Occurrences

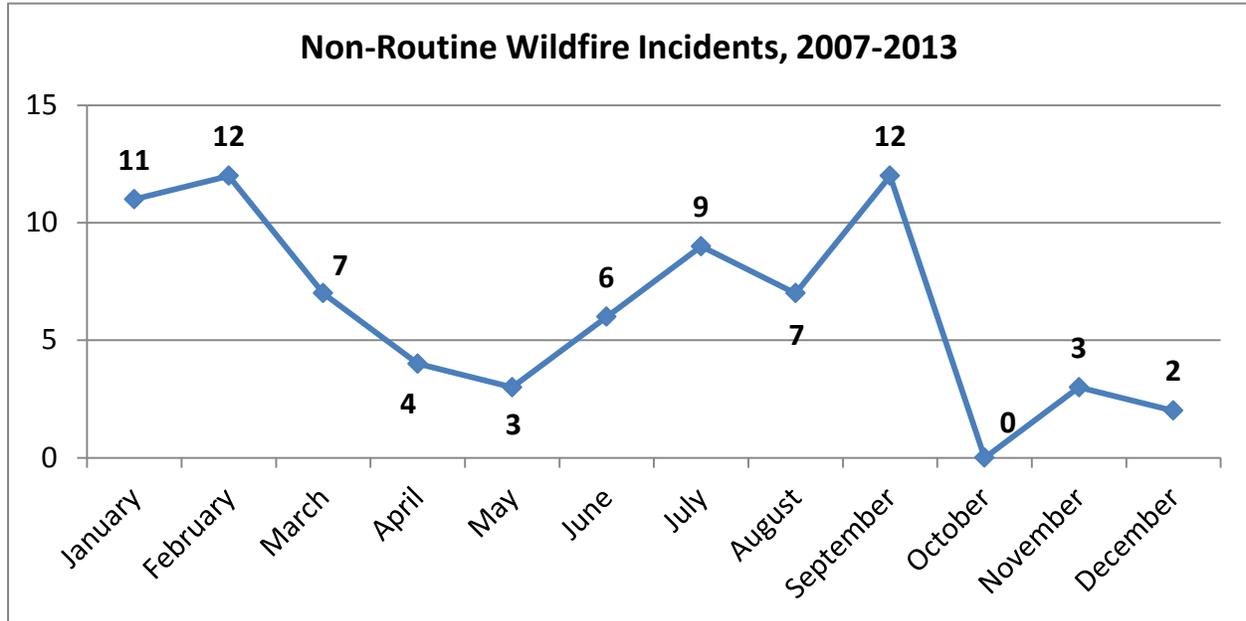
The SAFD maintains records of all fires, including wildfires, in the City of San Antonio and wildfires to which the SAFD responds that are outside of the city limits. The number of previous occurrences of the wildfire hazard is too vast to discuss each occurrence here, as grassfires and the like (which meet the definition of wildfires) are a common occurrence. This section will discuss previous significant

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occurrences of wildfires. As illustrated by Figure 3.12.4, there were 76 non-routine wildfires in San Antonio/Bexar County between 2007 and 2013 that required SAFD response.

As expected, the warmer, drier summer months are when the majority of wildfires occur, though a significant number also occur in the drier winter months due to low relative humidity and high winds ahead of cold fronts. Figure 3.12.7 displays the distribution of previous occurrences of the wildfire hazard over the past several years.

Figure 3.12.7 Monthly Distribution of Wildfires in San Antonio/Bexar County, 2007-2013



(Source: San Antonio Office of Emergency Management)

2007 – New Year’s Eve. On New Year’s Eve 2007, the SAFD received 260 calls for grass fires in one evening alone.

2011 – Camp Bullis. Residents from about 100 homes in Fair Oaks Ranch were evacuated briefly. Approximately 150 acres were burned; no structures were damaged. Fair Oaks Fire Department responded to the fire, however San Antonio, Bexar County and numerous other agencies were asked to assist.

2011 – Wetmore. A wildfire blackened 125 acres in a densely populated area on the Northeast side of San Antonio and caused mandatory evacuations. The fire started in the grass behind homes in the 10500 block of Merritime Court, near Wetmore Road and Broadway, and winds whipped the fire through the dry ground cover of the Salado Creek greenbelt. (Source: San Antonio Express-News)

2011 – Potranco. A fire which started in west Bexar County prompted the evacuation of 200 residents from the Potranco Run subdivision; most opted to stay with family. 14 SAFD units,

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along with the Bexar County Fire Department, worked to control the spreading fire. About 258 acres were burned. (Source: *KENS5*)

2011 – Stone Oak. A fire displaced residents from three apartment complexes in Stone Oak for nearly seven hours. The wildfire charred more than 210 acres, prompting a mandatory evacuation. More than 50 families evacuated to a temporary shelter. The Stone Oak fire was one of two that kept area firefighters busy that Labor Day. Another brush fire started around 7:30 p.m., scorched more than 200 acres behind the Verizon Wireless Amphitheater, before it was brought under control around 9 p.m. No one was injured, and no evacuations were ordered.

A San Antonio Water System (SAWS) truck that accidentally caught fire around 1:30 p.m. sparked the Stone Oak wildfire. The SAWS pickup truck was parked off the road near Oakland Bend. The vehicle was stuck and the two employees who were working on a sewer project there called 911 for help. “The underneath part of the truck rubbed against grass and heat from the vehicle caused the fire to start,” a SAWS spokesperson said. (Source: *San Antonio Express-News*)

Estimated Recurrence Rate

The estimated recurrence rate of wildfire, based on historic occurrences in the City of San Antonio and Bexar County, is considered moderate.

Vulnerability

Population

Though it is unlikely that a large percentage of the population would be injured or killed as a result of a single event, the entire population in the City of San Antonio/Bexar County is vulnerable to the wildfire hazard. Those people who reside near or adjacent to the WUI or near open spaces have an increased level of vulnerability, but the entire population is at risk from the effects of wildfire (i.e., smoke). According to a Texas wildfire risk assessment, approximately 300,000 people, or 25% of the population, live in the WUI.

Property

Though it is unlikely that a large number of structures would be damaged in a single event, all structures are potentially vulnerable to wildfire. Those structures that are located near or adjacent to the WUI, or near open grassland spaces have an increased vulnerability to this hazard.

Environment

The environment is vulnerable to the wildfire hazard. Deforestation, animal and plant death, pollution of air and water, and erosion caused by loss of plant cover may cause damage to the environment as a result of wildfires and attempts to suppress them.

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Wildfires are a natural part of the environmental life cycle. Fires create cleared areas for new species and plant growth and allow sunlight and rain to reach areas of the forest that were previously heavily shaded. This usually attracts new animal life to the area.

City/County Operations

Critical facilities are facilities or services that a community relies on for effective and efficient operation, particularly during and after a hazard event, or that would be of critical importance to a community in the event and aftermath of a hazard event. Typically, critical facilities include:

- Fire stations;
- Hospitals/clinics/medical centers;
- Chemical/heavy industrial/hazardous materials facilities or storage locations; and
- Communications facilities, such as landline and cellular telephone and radio and television broadcast locations.

Though it is unlikely that a large number of critical facilities would be damaged in a single event, all critical facilities are vulnerable. Those structures that are located near or adjacent to the WUI, or near open grassland spaces have an increased vulnerability to this hazard.

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *Bureau of Land Management, United States Department of the Interior*
National Fire Plan
http://199.134.225.50/nwcc/t2_wa4/pdf/RuralAssistance.pdf, and
Office of Fire and Aviation
<http://www.blm.gov/es/st/en/prog/fire.html>
- *Environmental Systems Research Institute*
Community Analyst
<http://www.esri.com/software/arcgis/community-analyst>
- *Federal Emergency Management Agency*
Disaster and Emergency Declarations
<http://www.fema.gov/disasters/grid/state-tribal-government/24>
- *Property and Environment Research Center*
Forest Policy Up in Smoke: Fire Suppression in the United States
<http://www.perc.org/pdf/Forest%20Policy%20Up%20in%20Smoke.pdf>
- *United States Census Bureau*
- *United States Fire Administration*
Fire Statistics
<http://www.usfa.fema.gov/statistics/>
State Fire Death Rates and Relative Risk
<http://www.usfa.fema.gov/statistics/estimates/states.shtm>, and
Topical Fire Research Series, V.2, Issue 16 March 2002, and
Fires in the Wildland/Urban Interface
<http://www.usfa.fema.gov/downloads/pdf/statistics/v2i16-508.pdf>
- *United States Geological Survey, Land Cover Institute*
National Land Cover Data 2006
http://www.mrlc.gov/nlcd06_data.php
- *United States National Park Service*
Wildland Fire
<http://www.nps.gov/fire/wildland-fire/>
- *University of Wisconsin, Spatial Analysis for Conservation and Sustainability (SILVIS) Lab*
Wildland/Urban Interface Definitions
<http://silvis.forest.wisc.edu/old/Library/WUIDefinitions.php>, and
Wildland/Urban Interface 2010 data Download
<http://silvis.forest.wisc.edu/maps/wui/2010/download>

Regional/State Resources and Documents:

- *Alamo Area Council of Governments*
Regional Multi-Hazard Mitigation Plan Update Draft, 2012

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<https://www.aacog.com/index.aspx?NID=405>

- *Legislative Reference Library of Texas*
Governor's Proclamations and Executive Orders
<http://www.lrl.state.tx.us/legeLeaders/governors/search.cfm>
- *Texas Commission on Environmental Quality*
<http://www.tceq.texas.gov/>
- *Texas Forest Service*
Southeast Texas Drought Information
<http://www.srh.noaa.gov/hgx/?n=drought>
- *Texas Interagency Information Council*
New Wildfires Flaring up in Texas as Drought Worsens
<http://summitcountyvoice.com/2011/09/02/new-wildfires-flaring-up-in-texas-as-drought-worsens>
- *Texas Interagency Coordination Center*
Texas Forest Fire Activity
<http://ticc.tamu.edu/Response/FireActivity/>

Local Resources and Documents:

- *City of San Antonio Fire Department*
Annual Report, 2010 and 2011
- *KENS5.com*
Evacuees Head Home after Raging Grass Fire Threatens Far West Bexar Co.
<http://www.kens5.com/news/Fire-crews-report-to-grass-fire-in-West-Bexar-County-129544333.html>
- *KWTX.com*
Mulch Fire Finally Out
<http://www.kwtx.com/home/headlines/6736941.html>
- *San Antonio Express-News*
Evacuated Stone Oak Residents Return to Their Homes
http://www.mysanantonio.com/news/local_news/article/Evacuated-Stone-Oak-residents-return-to-their-2156301.php#ixzz1gZhiGHIY, and
Firefighters Contain Camp Bullis-area Fire
http://www.mysanantonio.com/news/local_news/article/Firefighters-contain-Camp-Bullis-area-fire-2159647.php#ixzz1gZmCUE4b, and
Warehouse Fire Caps Grueling Day for Local Firefighters
http://www.mysanantonio.com/news/local_news/article/Warehouse-fire-caps-grueling-day-for-local-2157024.php
- *San Antonio Office of Emergency Management*
Wildfires
<http://saoemprepare.com/BeInformed/NaturalDisasters/Wildfires.aspx>

Section 3.13 - Winter Storm and Extreme Cold

Description

A winter storm can range from a moderate snow over a period of a few hours to blizzard conditions with blinding wind-driven snow that lasts for several days. Some winter storms may be large enough to affect several states, while others may affect a much smaller area. Many winter storms are accompanied by low temperatures and heavy and/or blowing snow, which can severely impair visibility.

Winter storms may include snow, sleet, freezing rain, or a mix of these wintry forms of precipitation. Sleet raindrops that freeze into ice pellets before reaching the ground usually bounce when hitting a surface and do not stick to objects; however, sleet can accumulate and cause a hazard to motorists. Freezing rain is rain that falls onto a surface with a temperature below freezing, forming a glaze of ice. Even small accumulations of ice can cause a significant hazard, especially on power lines and trees. An ice storm occurs when freezing rain falls and freezes immediately upon impact. Communications and power can be disrupted for days, and even small accumulations of ice may cause extreme hazards to motorists and pedestrians.

A freeze is weather marked by below the freezing temperatures (32 degrees Fahrenheit (°F) or 0 degrees Celsius (°C)). Exposure to low temperatures can endanger human health, and agricultural production is seriously affected when temperatures remain below freezing.

While the danger from winter weather varies across the country, nearly all Americans, regardless of where they live, are likely to face some type of severe winter weather at some point in their lives. Winter storms can range from a moderate snow over a few hours to a blizzard with blinding, wind-driven snow that lasts for several days.

The National Weather Service refers to winter storms as the “Deceptive Killers” because most deaths are indirectly related to the storm. People die in traffic accidents on icy roads and of hypothermia from prolonged exposure to cold. It is important to be prepared for winter weather before it strikes.

Figure 3.13.1 Severe Winter Storm Event



General Characteristics

Winter weather is usually characterized by three types of weather events: snow, ice, and extremely low temperatures.

Snow

Various intensities of snowfall are defined differently:

- **Blizzard** describes winds of 35 miles per hour (MHP) (56 kilometers per hour (KPH)) or more with snow and blowing snow that reduce visibility to less than one-quarter mile (0.4 kilometer) for at least three hours;
- **Blowing snow** describes wind-driven snow that reduces visibility. Blowing snow may be falling snow and/or snow on the ground that is picked up by the wind;
- **Snow squall** describes a brief, intense snow shower accompanied by strong, gusty winds. Accumulation from snow squalls can be significant; and
- **Snow shower** describes snow that falls at varying intensities for short durations with little or no accumulation.

Ice

Heavy accumulations of ice can bring down trees and topple utility poles and communication towers. Ice can disrupt communications and power for days while utility companies repair damage. Even small accumulations of ice can be severely dangerous to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces.

Ice forms in different ways:

- *Sleet* is rain that freezes into ice pellets before it reaches the ground. Sleet usually bounces when hitting a surface and does not stick to objects; however, it can accumulate like snow and cause roads and walkways to become hazardous.
- *Freezing rain* (also known as an ice storm) is rain that falls onto a surface that has a temperature below freezing. The cold surface causes the rain to freeze so the surfaces (e.g., trees, utility wires, vehicles, and roads) become glazed with ice.

Extreme Temperature – Severe Cold

What constitutes severe cold varies in different parts of the country. In some northern regions, cold temperatures are not considered severe until they are well below 0°F (–18°C). In most southern regions, near-freezing temperatures (around 32°F or 0°C) are considered severe cold.

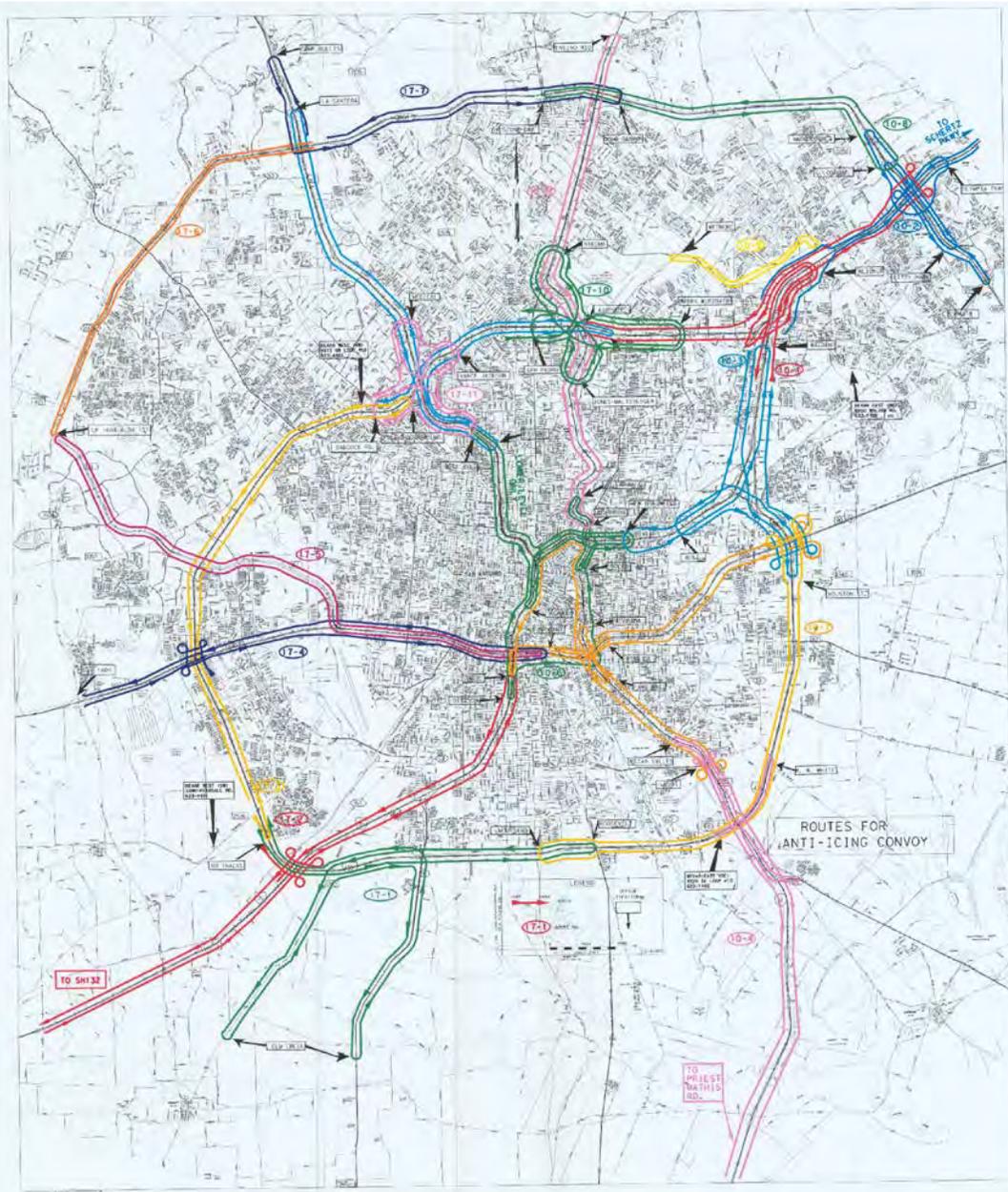
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Location

Severe winter storms are typically large in area and will likely impact the entire San Antonio/Bexar County area when they occur.

The map below, provided by the Texas Department of Transportation, illustrates one possible scenario for roadway anti-icing activities. In this map, the routes to receive anti-icing treatment are defined. Note that the activities defined in this map cover major roadways throughout the entire area.

Figure 3.13.2 Anti-Icing Routes for the City of San Antonio/Bexar County Area



(Source: Texas Department of Transportation)

Extent

Severe winter weather can immobilize a region and paralyze a city, stranding commuters, closing airports, stopping the flow of supplies, and disrupting emergency and medical services. This is particularly true for areas that are unaccustomed to severe winter weather, such as Bexar County. Accumulations of snow and ice can knock down trees and power lines, causing electricity loss and impassable roadways. Homes, businesses, and farms may be isolated for days.

Winter storms are often tracked several days in advance. As a result, emergency services staff and the general public are usually kept well informed and prepared for the event, although the exact location of severe winter weather, such as snowfall accumulation, may not be precise. The National Weather Service (NWS) issues winter weather advisories, which widely distributed through the Emergency Alert System (EAS) via local radio, television, and Internet sources. The following are the types of winter weather notifications issued by the NWS:

A *Winter Weather Advisory* is issued if light freezing rain, freezing drizzle, sleet, or snow, or any combination is occurring or forecast within 18 hours. Most roadways remain open due to light nature of the precipitation and/or warm ground conditions. Minor impacts are expected such as slick bridges/overpasses or light accumulations on grassy surfaces.

A *Winter Storm Watch* is issued when ice, sleet, or snow accumulation is forecast to cause adverse travel conditions such as widespread road closures and numerous traffic accidents. Ice accumulation on exposed surfaces, trees, and power lines, may cause significant power outages. A Winter Storm Advisory is issued 24-48 hours in advance of the event.

A *Winter Storm Warning* is issued when ice, sleet, or snow accumulation is occurring or expected on roadways, causing adverse travel conditions such as widespread road closures and numerous traffic accidents. Ice accumulation on exposed surfaces, trees, and power lines, may cause significant power outages. A Winter Storm Warning is issued up to 24 hours in advance of the event. (Source: *National Weather Service*)

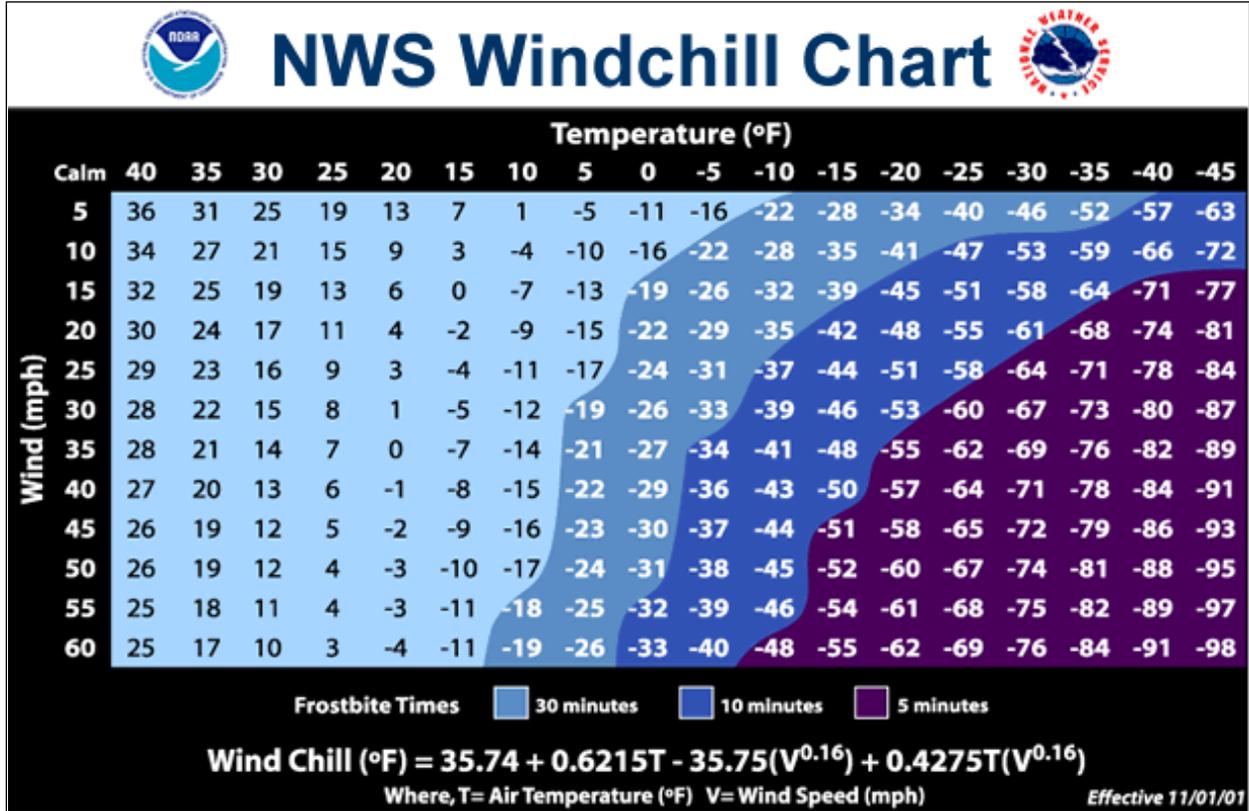
A *Blizzard Watch* is an advisory issued by the NWS that means winds greater than 35 MPH, mixed with falling or blowing snow, and visibilities of 1/4 mile or less is forecast for a period of 3 hours or more. A blizzard watch is issued 36 to 12 hours before an expected blizzard event.

A *Blizzard Warning* is an advisory issued by the NWS that means sustained winds or frequent gusts of 35 MPH or greater with heavy snow is forecast for a period of 3 hours or more. A blizzard tends to reduce visibilities to 1/4 of a mile or less. A *Severe Blizzard Warning* is a variety issued in some cases of winds above 45 MPH and temperatures below 10°F. Many local weather offices will activate the EAS and broadcast the alarm tone on relevant National Oceanic and Atmospheric Administration's (NOAA) Weather Radio stations for both varieties of warning. (Source: *National Weather Service*)

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The NWS also uses a scale to determine the wind chill. Wind chill refers to the perceived temperature felt when the effect of wind speed is factored together with the actual temperature. The wind chill temperature is usually lower than the air temperature. The figure below depicts the NWS methodology for determining wind chill, using wind speed and actual temperature.

Figure 3.13.3 NWS Wind Chill Methodology

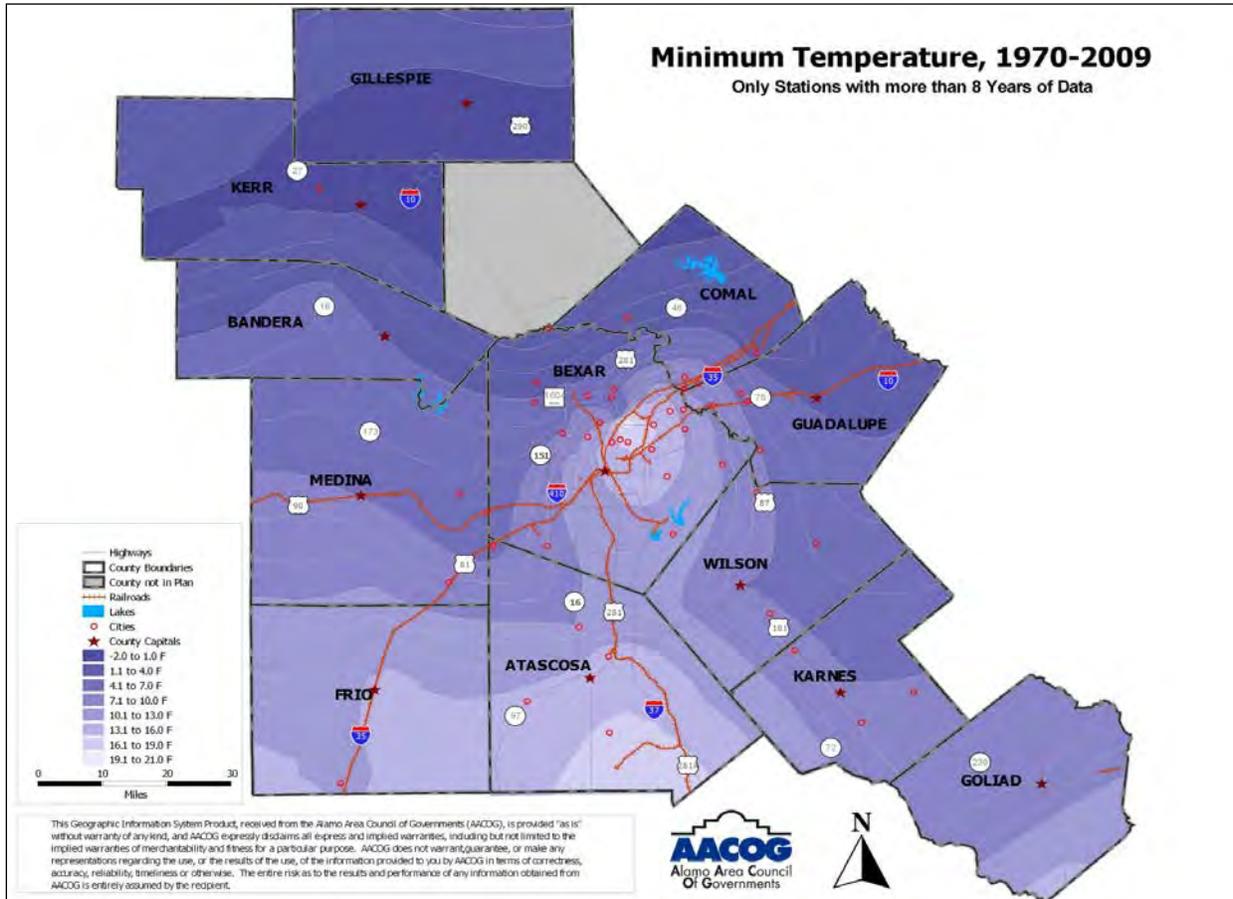


(Source: National Weather Service)

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Figure 3.13.4 below illustrates the minimum recorded temperatures in the San Antonio metropolitan area, between the years 1970-2009.

Figure 3.13.4 Minimum Recorded Temperatures in Bexar County

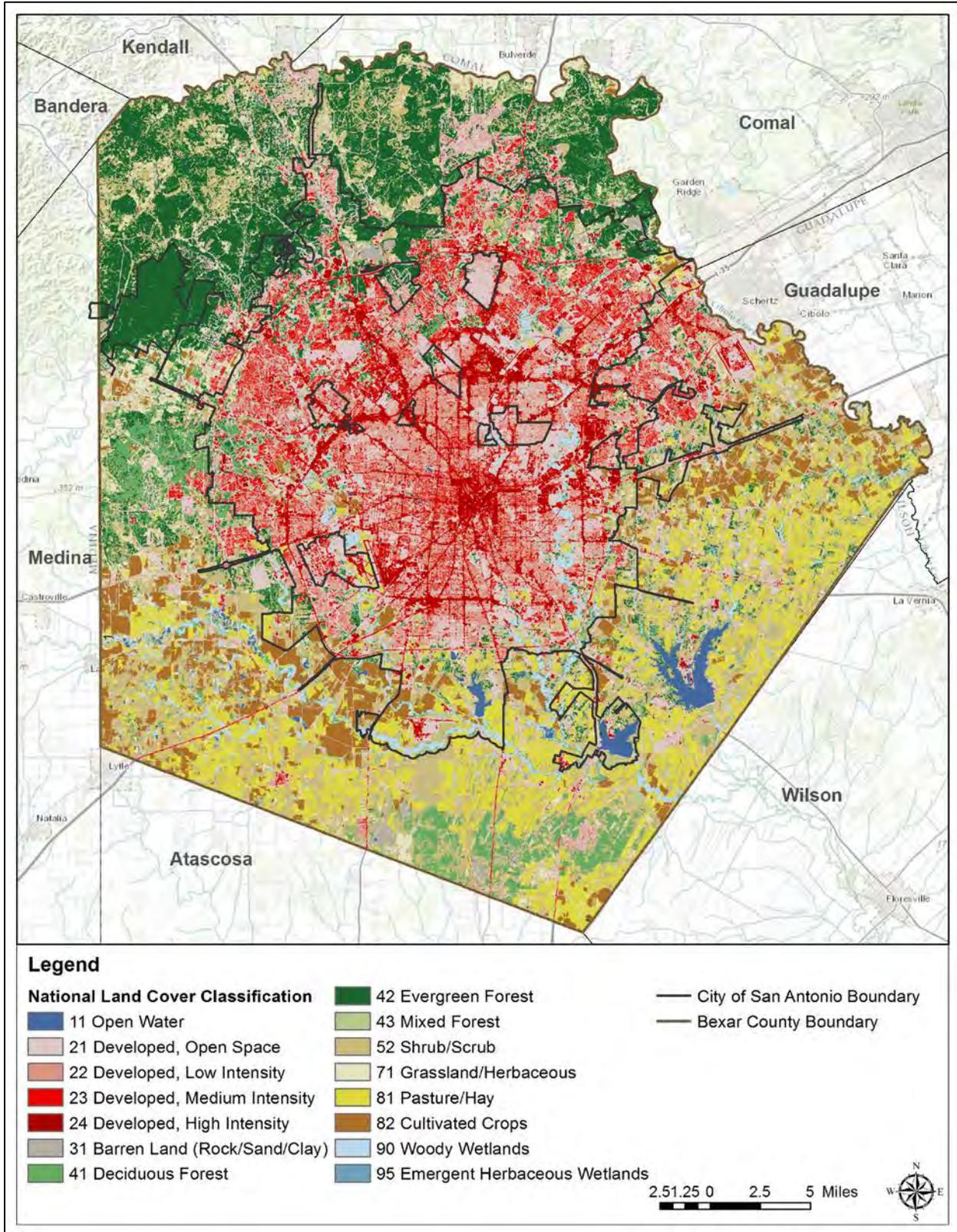


(Source: Alamo Area Council of Governments Regional Multi-Hazard Mitigation Plan, 2012)

Although infrequent, severe winter storms can cause significant damage when they do occur. The San Antonio/Bexar County area does not have an abundance of supplies or equipment for responding to a winter storm. Therefore, any winter storm can have a dramatically intense impact on everyday life, though the impacts tend to be short-lived. Slick or iced-over roadways can lead to hazardous travel, particularly to a population that is unaccustomed to such conditions. Ice can accumulate on power lines and lead to widespread and often long-term power outages, which can significantly impact vulnerable populations. Similarly, ice can accumulate on tree limbs and lead to toppled trees or fallen limbs, which can land on structures and damage roofs and add to the damage to power distribution lines. While Bexar County is largely an urban area, certain areas retain dense tree cover. These areas have the potential to create hazardous conditions, as they have during previous winter storm events. The figure below shows the land cover types, found in San Antonio/Bexar County.

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Figure 3.13.5 San Antonio/Bexar County Land Cover



(Source: United States Geological Survey)

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Previous Occurrences

Though not usually a common or annual event, severe winter weather does occur in the San Antonio/Bexar County area.

December 12, 2000

Temperatures plunged rapidly into the 40s °F and 50s °F with the arrival of a cold front. Northerly winds gusting to 30 and 35 MPH further emphasized this dramatic temperature change. By mid-afternoon, temperatures over the Texas Hill Country had fallen below freezing, and light rain and drizzle became freezing rain and freezing drizzle. The combination of freezing rain, freezing drizzle, and sleet continued to spread across the San Antonio metropolitan area, forcing the closure of numerous bridges and overpasses. Storm damage generally consisted of accidents on slick roads and trees and tree limbs falling onto power lines.

November 29, 2001

Frigid arctic air moved southward into south central Texas as an upper level disturbance approached from the west. The disturbance began to produce widespread rain and showers that became a combination of sleet and snow as it fell through the cold near-surface air in Bexar County. Ice up to up to an inch thick was reported throughout the area, and hundreds of automobile accidents were reported.

January 2007

This massive winter weather event was actually a series of events that affected the majority of the country. Most of the State of Texas was impacted at some point during this winter weather event, including Bexar County. A wintry mix and extremely cold temperatures were the hallmarks of the storm, which resulted in the cancellation of many flights at the San Antonio International Airport. A large portion of IH- 10 was closed due to snow and icy conditions, as were most schools. Fortunately, power outages in the area were limited, with fewer than 5,000 customers temporarily losing power.

January/February 2011

A massive winter storm event impacted the majority of the central United States (US) and New England. In the San Antonio/Bexar County area, sleet coated the roads overnight, followed by snow in the early morning hours. Major roads were closed, and there were several traffic accidents. At least 20 vehicles, including a tractor-trailer and a bus, were involved in a pileup on IH 10, one of hundreds of accidents reported in the City. Schools were closed throughout the region. By late afternoon, however, temperatures had risen and most of the roads had been cleared.

NCDC

The National Climatic Data Center (NCDC) maintains records of snow and ice events, collected at the county level. The following is a summary of impacts from 8 winter storm events occurred in Bexar County between 1996 and 2011.

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Table 3.13.1 Snow and Ice Event, Bexar County

Date	Fatalities	Injuries	Property Damage	Crop Damage
02/01/1996	0	0	\$1,500,000	\$50,000
01/11/1997	0	0	\$1,000,000	\$20,000
12/23/1998	0	0	NA	NA
12/12/2000	0	0	NA	NA
11/28/2001	0	0	NA	NA
02/24/2003	0	0	NA	NA
12/09/2008	0	0	0	0
02/03/2011	0	0	0	0

(Source: National Climatic Data Center)

Estimated Recurrence Rate

The estimated recurrence rate of winter storm and extreme cold, based on historic occurrences in the City of San Antonio and Bexar County, is considered low.

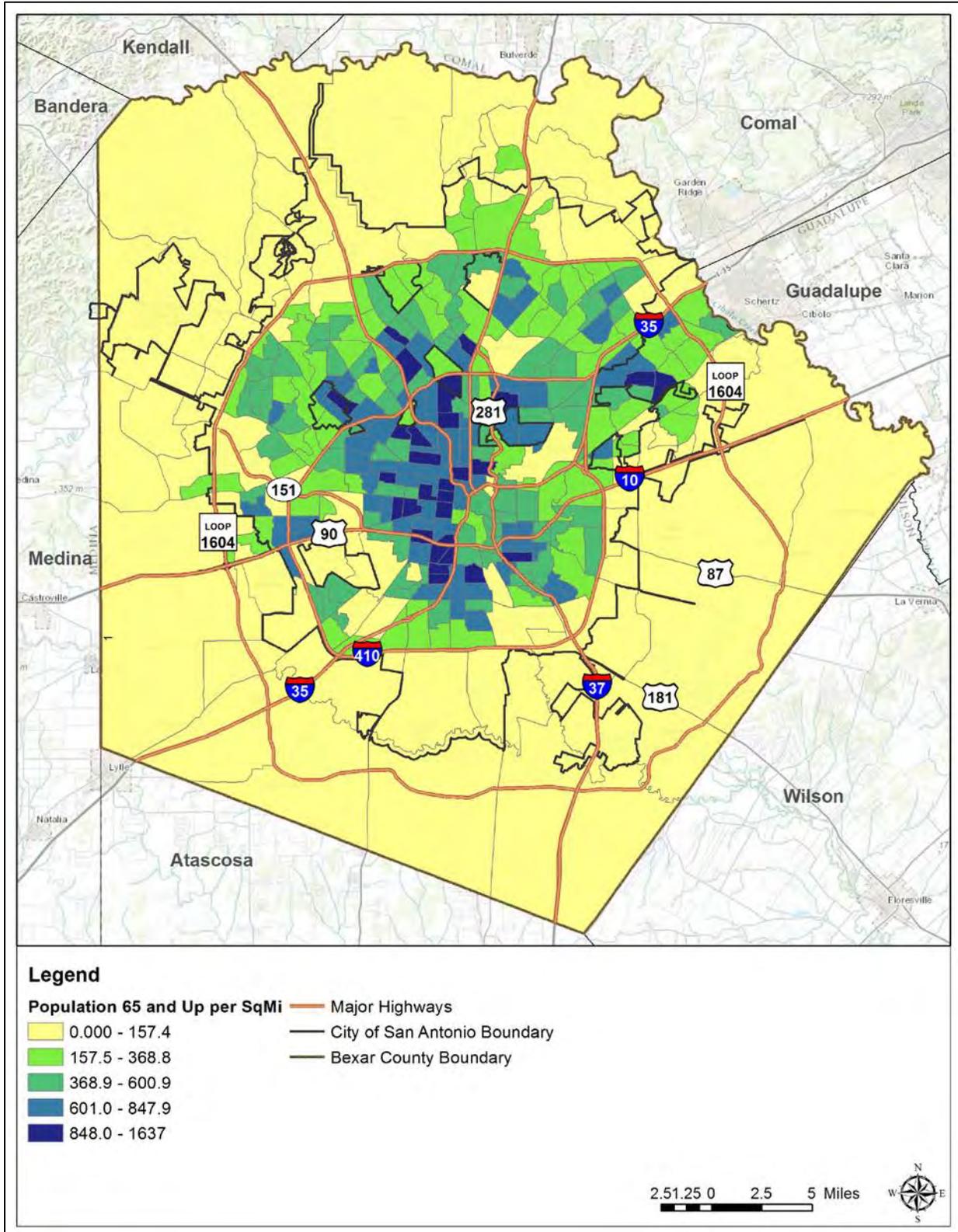
Vulnerability

Population

The population of Bexar County is vulnerable to severe winter storms. The most vulnerable segments of the population are people who must travel, people who work outdoors or whose work requires them to travel, and people who are most susceptible to the dangers of extreme cold weather - the very young, the elderly, and those with pre-existing health conditions, such as heart and respiratory diseases. Figure 3.13.6 uses US Census data to show the distribution of population that is over 65 years of age.

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Figure 3.13.6 Population over 65 Years of Age in San Antonio/Bexar County



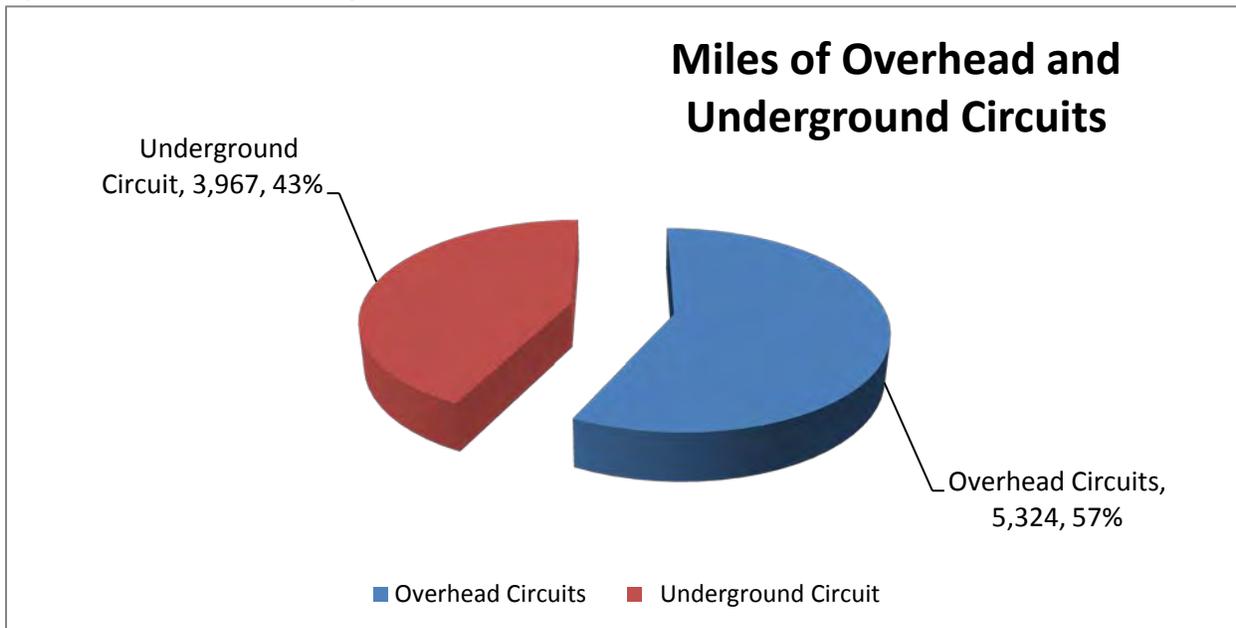
(Source: Environmental Systems Research Institute's Community Analyst 2013 Estimates, United States Census Bureau)

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Property

While structures are unlikely to be seriously harmed or damaged by the types of severe winter storms that occur in the area, utilities that support them may be interrupted or damaged. Bexar County is served by predominantly overhead power lines, which are vulnerable to icing and damage during winter storm events. Even those lines that are buried underground, and are therefore protected from damage, receive power from overhead or above ground sources. There are an estimated 9,291 miles of power lines that provide electrical power to Bexar County. More than 57%, or 5,324 miles, of these lines are above ground, with the remaining 3,967 miles buried underground (Figure 3.13.7). As noted above, Bexar County includes areas with tree canopy, which can add to vulnerability of structures and utility infrastructure because of trees or tree limbs brought down by ice or snow.

Figure 3.13.7 Overhead and Underground Electrical Circuits



(Source: *City Public Service Energy*)

Extreme cold weather may cause water mains or water pipes to freeze. While the typical severe winter storm does not last long enough for this to be a significant concern, it remains a possibility, given the right weather event and pre-existing conditions.

Environment

The vulnerability of the environment lies in icing on trees and limbs, which could lead to downed limbs and damaged trees. Species that are native to the area are not, by and large, accustomed to severe cold weather for an extended period of time. Such an event could lead to tree, shrub, and plant damage or death. Agricultural crops also may be vulnerable to losses in extreme cold or ice conditions.

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City/County Operations

City and County operations are vulnerable to severe winter storms because of potential for poor roadway conditions or road closures, power and communications outages because of icing and downed trees, and limitations on mobility because of snow, ice or extreme temperatures. Personnel may not be able to report in person for normal work schedules. The ability of emergency services personnel to quickly respond may also be impacted. Fire presents a great danger, as water supplies and delivery systems may freeze and mobile firefighting equipment may not be able to get to the fire.

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *American Red Cross*
Talking about Disaster: A Guide for Standard Messages. Washington, D.C., 2007
- *Centers for Disease Control and Prevention*
Extreme Cold: A Prevention Guide to Promote Your Personal Health and Safety
http://www.bt.cdc.gov/disasters/winter/pdf/cold_guide.pdf
- *Environmental Systems Research Institute*
Community Analyst
<http://www.esri.com/software/arcgis/community-analyst>
- *National Climatic Data Center*
<http://www.ncdc.noaa.gov/oa/ncdc.html>
- *National Weather Service*
Winter Weather Tip Sheet
<http://www.nws.noaa.gov/om/winter/winter1.shtml>, and
Wind Chill Chart
http://www.erh.noaa.gov/er/iln/tables.htm#wind_chill
- *New York Times*
Snow and Ice Paralyze Texas from Rio Grande to Oklahoma Border, 2011
<http://www.nytimes.com/2011/02/05/us/05storm.html>
- *United States Census Bureau*
- *United States Geological Survey, Land Cover Institute*
National Land Cover Data 2006
http://www.mrlc.gov/nlcd06_data.php
- *USA Today*
Storms Give Texas an Expected Shiver, 2007
http://www.usatoday.com/weather/stormcenter/2007-01-18-ice-storm_x.htm

Regional/State Resources and Documents:

- *Alamo Area Council of Governments*
Regional Multi-Hazard Mitigation Plan Update Draft, 2012
<https://www.aacog.com/index.aspx?NID=405>
- *Texas Department of State Health Services*
Temperature-related Deaths
<http://www.dshs.state.tx.us/chs/vstat/hotcolddths/occcounty.shtml#cold>
- *Texas Department of Transportation*

Local Resources and Documents:

- City Public Service Energy
- *San Antonio Convention and Visitor's Bureau*

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Trends Analysis Projections Report

<http://partners.visitsanantonio.com/english/Resources-Reports/Industry-Reports>

- *San Antonio Office of Emergency Management*
Winter Storm and Extreme Cold
<http://saoemprepare.com/BeInformed/NaturalDisasters/WinterStormsExtremeCold.aspx>
- San Antonio Master Plan, 2011

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Section 4 – Hazard Risk Ranking

The risk of a hazard is a combination of the hazard likelihood and the consequences of its occurrence. According to this definition, risk can be illustrated through the equation below:

$$\text{Risk} = \text{Likelihood} \times \text{Consequences}$$

The likelihood is defined as a frequency of an event - the number of times an event will occur over a specific period of time. Likelihood can be expressed using qualitative measurement:

- **High:** > 50% chance of occurring in a given year (1 occurrence every year to 2 years);
- **Moderate:** 5-50% chance of occurring in a given year (1 occurrence every 2 to 20 years); and
- **Low:** < 5% chance of occurring in a given year (1 occurrence every 20 to 100 years or more).

The consequence component of a hazard risk describes the impacts the hazard may have on humans, built structures, and the environment. The consequences of a hazard event are usually characterized by three categories:

- Fatalities (human cost);
- Injuries (human cost); and
- Damages (economic cost).

Once the hazard risk is evaluated for all existing hazards, identified risks can be further compared to each other and ranked according to severity. The ranking of risk allows determining which mitigation and preparedness options are the most effective and appropriate to minimize hazard risk.

Table 4.1 summarizes the results of San Antonio/Bexar County self-assessment for hazard risk ranking. Each hazard was assigned a rank of “High”, “Moderate”, or “Low” according to vulnerability of the study area to the hazard. The ranking was based on the review of previous occurrences (i.e., federally declared disaster and emergency declarations, governor’s disaster proclamations, historical significant events), and human and economic impacts. Likelihood component of hazard risk was evaluated in terms of recurrence rate that was measured as high, moderate, and low using qualitative method described above. Consequence component of hazard risk was assessed based on number of fatalities and injuries, and economic losses reported from previous occurrences, as well as using judgment of subject matter experts when quantitative data was not available. Results of hazard risk assessment are consistent with San Antonio/Bexar County history of presidential disaster and emergency declarations, and governor’s proclamations (Figure 4.1).

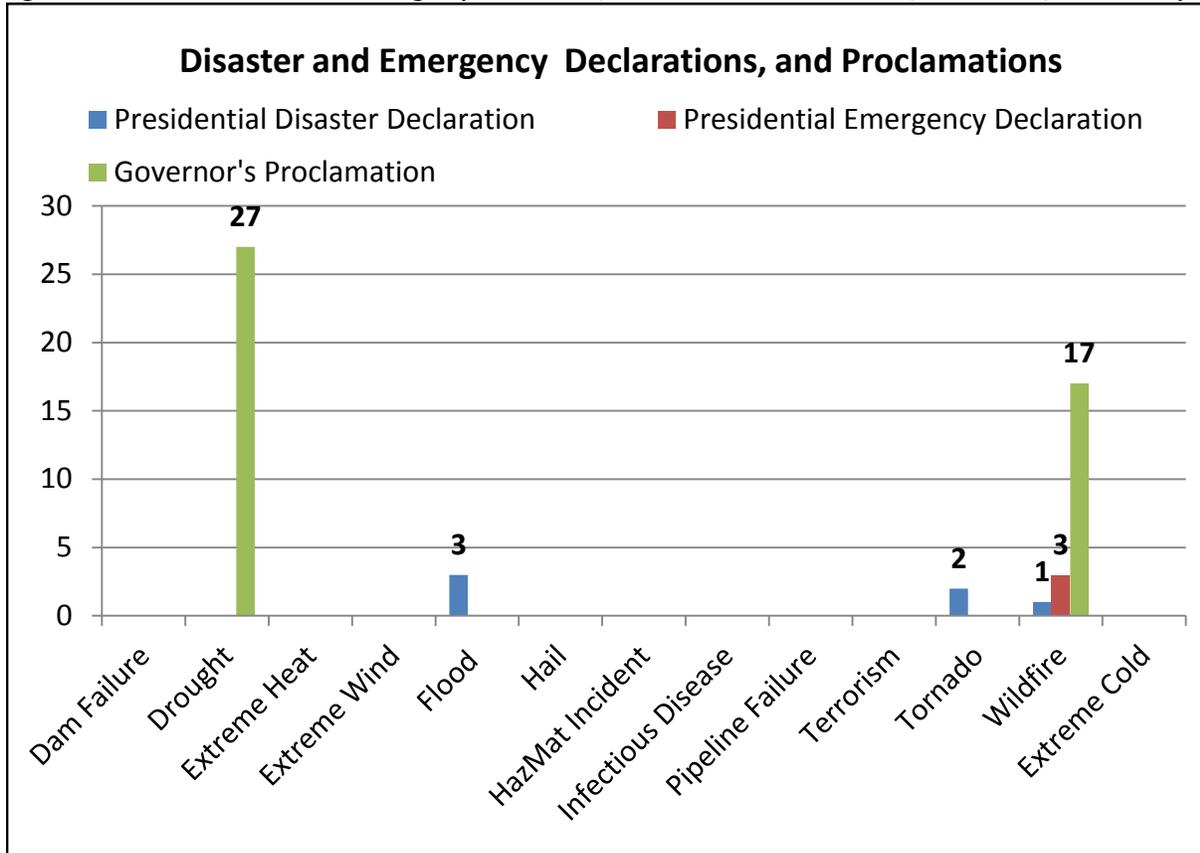
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Table 4.1 Hazard Risk Ranking, San Antonio/Bexar County

Hazard	Risk
Flood	High
Wildfire	High
Drought	High
Extreme Heat	Moderate
Extreme Wind	Moderate
Hail	Moderate
Hazardous Materials	Moderate
Infectious Disease	Moderate
Pipeline Failure	Moderate
Terrorism	Moderate
Tornado	Moderate
Winter Storm and Extreme Cold	Moderate
Dam Failure	Low

(Source: San Antonio Office of Emergency Management)

Figure 4.1 Presidential Disaster and Emergency Declarations, and Governor’s Proclamations, San Antonio/Bexar County



(Source: San Antonio Office of Emergency Management)

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Hazard Identification, Risk Assessment**

Bibliography and Resource Directory

Federal/National Resources and Documents:

- *Federal Emergency Management Agency*
Comparative Emergency Management Course. Session 9: Risk Assessment, Analysis, and Evaluation
<http://training.fema.gov/EMIweb/edu/compEmMgmt/index.asp>
Disaster and Emergency Declarations
<http://www.fema.gov/disasters/grid/state-tribal-government/24>
Understanding Your Risks, Identifying Hazards and Estimating Losses, FEMA 386-2
<http://www.fema.gov/media-library-data/20130726-1521-20490-4917/howto2.pdf>

Regional/State Resources and Documents:

- *Legislative Reference Library of Texas*
Governor's Proclamations and Executive Orders
<http://www.lrl.state.tx.us/legeLeaders/governors/search.cfm>

Local Resources and Documents:

- *San Antonio Office of Emergency Management*