Appendix B

City of San Antonio Sustainability Plan: Climate Vulnerability Assessment

February 2016

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1.0 Executive Summary

Building climate resilience and becoming sustainable is a process and not an outcome. It takes time to diversify and grow the economy of the region so that everyone in the community has access to the jobs and resources they need to live healthy and productive lives. It takes time to transform the energy and transportation systems to enable them to meet the needs of residents and businesses while maintaining flexibility in the face of extreme weather events. It takes time to protect the natural, historic, and cultural resources that make the City of San Antonio a unique and attractive place to live. The City of San Antonio started this journey with a commitment to building a sustainable city while continuing to grow and increase prosperity for its current and future residents. This climate vulnerability assessment is part of the *SA Tomorrow* planning process and an important part of this journey.

For many decades, individual departments such as public works, emergency management, CPS Energy, and others, have been working to serve the City of San Antonio's residents. Working closely with other organizations such as the San Antonio Water System (SAWS), the San Antonio River Authority (SARA), and Bexar County (health department, flood control district, etc.), the City ensures that the region and its residents have the resources they need to thrive and stay safe during extreme weather events. Efforts by the City and these organizations have included:

- *SA 2020,* which helps set the vision for a growing region;
- SAWS' *Water Management Plan* that helps guide the conservation and water supply diversification efforts and ensure water availability for the region;
- *Bexar County Community Health Improvement Plan* that sets a vision for the health of the community; and
- The *Hazard Mitigation Plan* that evaluates the potential risk of different hazards and identifies actions to reduce those risks.

The *SA Tomorrow Plan* is the latest step on the path towards sustainability and resilience. It is an ambitious effort that builds on all of these previous efforts and works to unify them under a shared vision, set of goals, and actions for a sustainable community. This climate vulnerability assessment is one piece of this *SA Tomorrow* planning effort.

The goal of this climate preparedness process is to shift the focus from the past and consider how extreme weather events and changing climate conditions could affect the city in the future. The recently completed *Hazard Mitigation Plan* (2015) identifies both natural and human events that could affect the city, but the assessment is based solely on historical events. As climate conditions change, those historical events are not necessarily adequate predictors of the future. Said another way, planning for these past events may not go far enough to prepare the city for new and emerging threats. Changing climate conditions are relevant to city planning in that they will affect the way the city plans for changes in temperatures (planning for cooling/heating, ensuring public safety, and protecting public health); changes in precipitation (preparing for droughts, planning for municipal water use or designing infrastructure to reduce the impacts of flooding); and increases in other extreme weather events (enhancing emergency management and preparedness).

One example of these potential vulnerabilities can be seen by comparing the relative social vulnerability index (SVI) with an overview of the observed urban heat island effect. The SVI is calculated by census tract and combines 14 variables including persons aged 65 and older, persons aged 17 and younger, single parent households with children under 18, minority status, and persons living in group quarters, to identify areas that are more sensitive and likely less able to prepare for or respond to extreme weather events. The urban heat island map indicates the urban areas that are often much hotter, and stay hotter throughout the night, than rural areas.

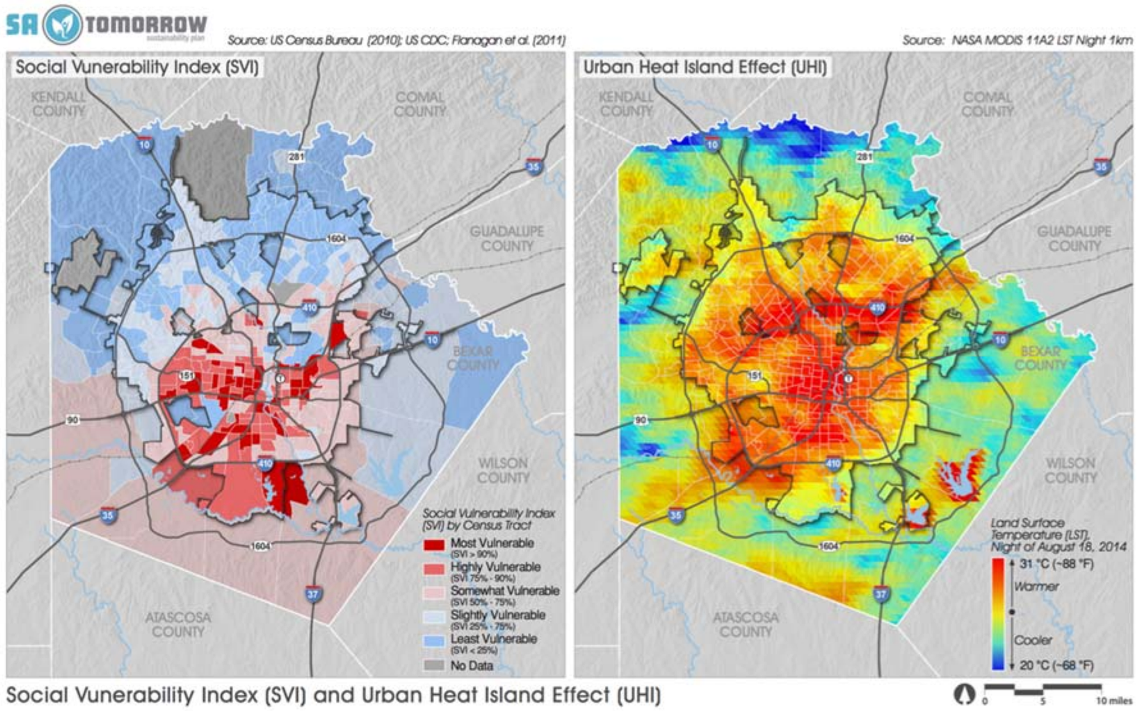


Figure 1: Side by side comparison of the relative social vulnerability index rankings and the urban heat island effect for Bexar County. Comparison can be used to identify areas of enhanced vulnerability to extreme heat events based on increased exposure and higher sensitivity (or lower ability to respond) to those events.

This report describes a process that brought together the best available science with a multi-departmental, multi-organizational team of experts from across the city to identify key concerns and evaluate the potential vulnerability of assets, resources, and segments of the community. A focus of this assessment was on changing climate conditions and extreme weather events. By combining the best available science with the knowledge and expertise of the people who work on these issues, it is possible to gain some insight into how the community could be affected by future events.

Results of this work include: relative climate and weather related vulnerability rankings for Key Areas of Concern *(Section 4.3)*, detailed descriptions of those rankings *(Section 5)*; and a list of strategies that could be used to address these vulnerabilities *(Section 6)*. The table below provides examples of key resilience strategies being reviewed as part of the broader *SA Tomorrow* planning process.

Table 1: Example strategies from the SA Tomorrow Sustainability Plan that could be used to build climate resilience. Listed along with the weather or climate impact they are designed to address and focus area from the SA Tomorrow Sustainability Plan. Additional strategies are provided in Section 6.

Impact Addressed	Key strategies from the SA Tomorrow Plan	Focus Area
Flooding	Adopt a low impact development standard requiring 100% of onsite stormwater management for all new development and significant retrofits.	Green Buildings & Infrastructure
	Initiate a climate education campaign for businesses and property owners, including details about how to make built infrastructure more resilient to existing and projected changes in climate.	Green Buildings & Infrastructure
	Evaluate and adopt ordinances to create buffer zones around floodplains, riparian areas, and other natural priority areas	Natural Resources
	Adopt conservation development friendly ordinances that minimize development in natural greenways, floodplains, near waterways in order to protect watershed and allow for more greenspace	Natural Resources
	Establish a network of "block captains" that can be activated to go door to door to check on the health of high risk neighbors during or after a disaster.	Public Health
Extreme Heat	Review effectiveness of cooling centers and other high heat day strategies and identify underserved areas for increased expansion of existing strategies or new strategies to mitigate the effects of high heat days.	Public Health
	Expand the number of publicly accessible parks and open space areas within the city.	Public Health
	Develop a "Healthy by Design" program for all new affordable housing projects.	Public Health
	Adopt an urban heat island mitigation ordinance for all new developments and major renovation projects.	Green Buildings & Infrastructure
Drought	Update water efficiency standards in city building codes.	Green Buildings & Infrastructure
	Adopt a program to phase large commercial buildings off of potable water use for landscaping.	Natural Resources
	Expand incentives for native plants/low-water use landscaping and other residential water conservation strategies	Natural Resources

Planning for the future is a critical aspect of any sustainability planning effort. It is not enough to look at current conditions. We must look to the future in order to continue to build a safe, healthy, prosperous, and resilient community for all the residents of San Antonio.

2.0 Introduction

The City of San Antonio has been engaging in a process to coordinate the development of their Comprehensive, Strategic Multimodal Transportation, and Sustainability Plans. Known as "SA Tomorrow," the process builds upon previous planning efforts, such as the SA 2020 Plan, to outline key goals for the next 25 years, as the expected population of the county will nearly double, adding an additional 1.1 million people[1]. This expected population growth creates many challenges and opportunities for San Antonio, and the collective planning for these expected changes demonstrates the city's commitment to, "*preserve the San Antonio culture and increase livability through ensuring housing and transportation choices as our city grows*[1]."

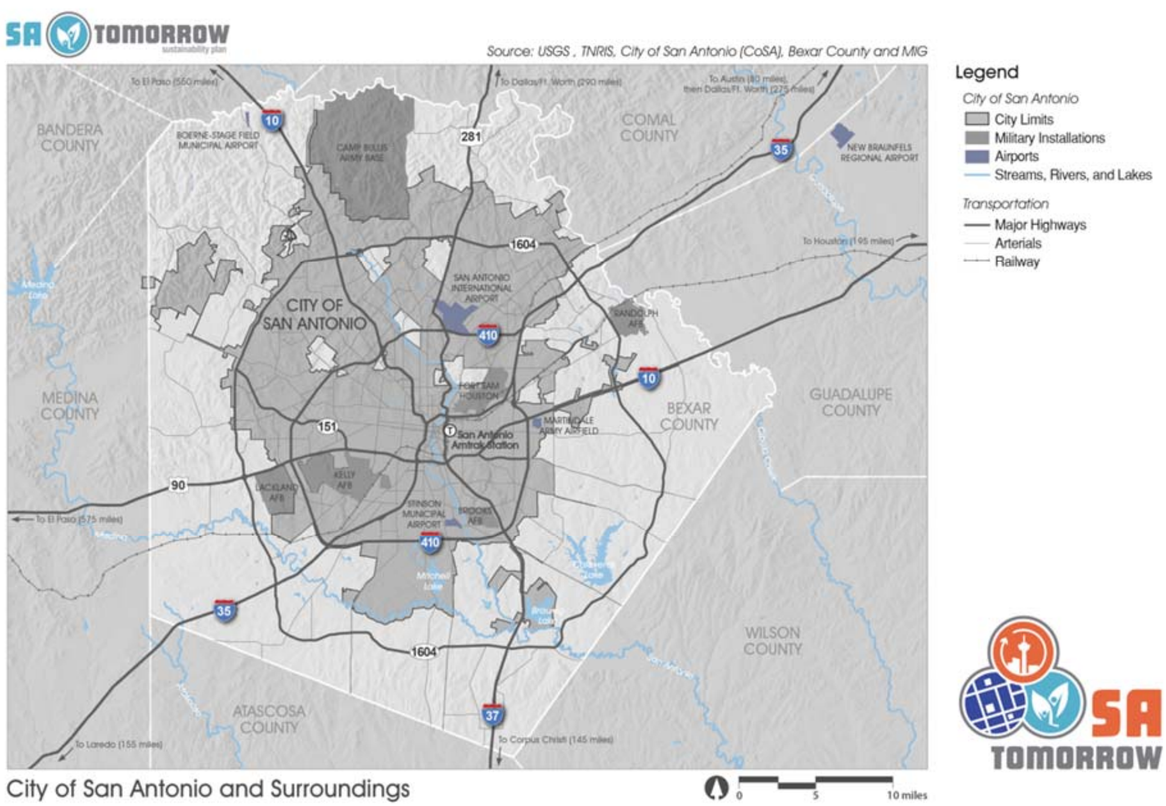


Figure 2: Map of the City of San Antonio, major waterways, and surrounding areas.

The City of San Antonio wants to ensure that all goals outlined under the three plans consider sustainability as it prepares for both current and future conditions. As part of the sustainability planning process, Adaptation International and Kim Lundgren Associates, Inc. (KLA) led a climate change vulnerability assessment to support the City's commitment to building resilience to changing climate conditions and expected increases in extreme weather events.

To support this effort, the City convened a *Resilience Advisory Committee (RAC)*, a diverse committee of city, county, state, private sector, and non-profit agency representatives, to work together and conduct the vulnerability assessment. This report summarizes these efforts to determine where the city is most vulnerable to current and future extreme weather events and begin discussing strategies for how the city might reduce these vulnerabilities and build resilience. The report also highlights some promising practices being used across the country that the city could use, adapt, or build on to be better prepared in the future.

3.0 Climate and the City of San Antonio

The climate is changing around the globe and these changes affect how cities manage themselves and prepare for the future. As part of the Sustainability Plan, ATMOS Research completed an analysis of the past and projected future climate for San Antonio[2]. Climate is relevant to city planning in that it impacts the way in which cities plan for **changes in temperatures** (planning for cooling/heating, ensuring public safety, and protecting public health); **changes in precipitation** (preparing for droughts, planning for municipal water use or designing infrastructure to limit the impacts of flooding); and **increases in other extreme weather events** (enhancing emergency management and preparedness). The analysis by ATMOS Research shows the following *observed* and *projected* climate changes for San Antonio (Table 2).

Table 2: Observed climate trends and projections for San Antonio and the South Central Region[2].

Climate Changes	Observed Changes	Future Projections
Temperature Averages	Warmed +0.5°F (summer) to +0.7°F (winter) per decade from 1960-2014 (**Figure 3**).	*"The number of hot days and warm nights occurring on average each year will continue to increase, with greater increases under a higher as compared to a lower future emissions scenario." (page 17)*
Temperature Extremes	Increases in the number of days over 80°F, 90°F, and 100°F from 1960-2014 (**Figure 4**).	Increases in frequency of the historically hottest days and warmest nights by the end of the century (**Figure 5**).
Precipitation Averages	Increases in the average number of dry days per year, average rainfall intensity (the average amount of rain falling on any given wet day during the year), and the amount of rainfall in the wettest 5 days of the year.	*"Average winter and spring precipitation will decrease towards the end of the century, accompanied by increased risk of dry conditions in spring and longer periods of consecutive dry days." (page 17) (**Figure 6**)*
Precipitation Extremes	Increased variability in precipitation starting in the 1980s.	*"The frequency of heavy precipitation and/or average precipitation intensity may increase across some parts of Texas, although projected increases are likely to be small." (page 17)*

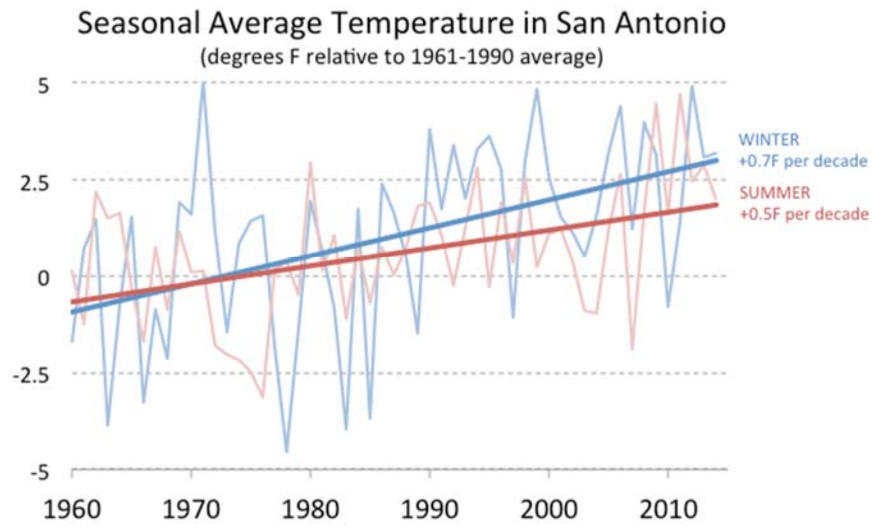


Figure 3: Observed year-to-year values (thin lines) and long-term trends (thick lines) in winter and summer average temperature by season at the San Antonio International Airport weather station from 1960 to 2014. The y-axis shows degrees in Fahrenheit where numbers above zero are warming/positive trends while negative numbers below zero are cooling/negative trends. The x-axis shows time from 1961-2014. All trends are significant[2].

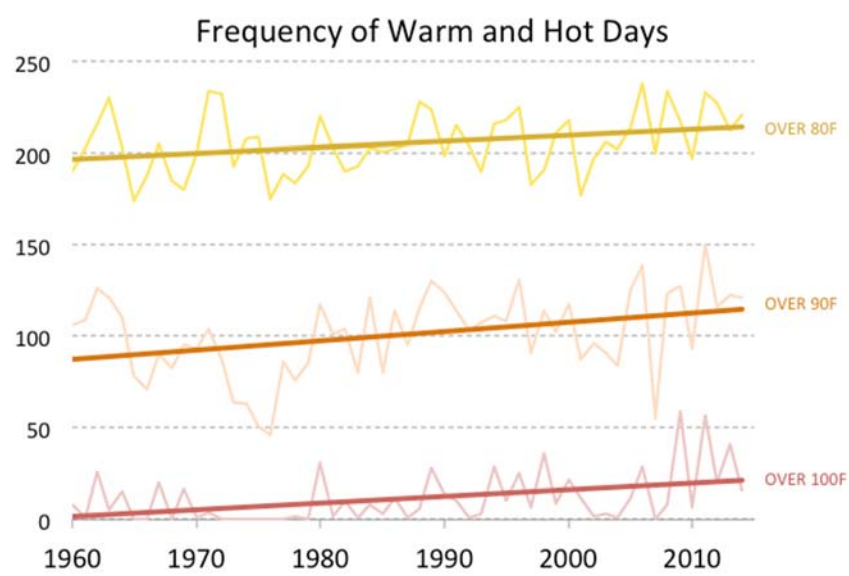


Figure 4: Observed year-to-year values (thin lines) and long-term trends (thick lines) in the number of days per year with maximum temperatures exceeding 80°F, 90°F, and 100°F at the San Antonio International Airport weather station from 1960-2014. The y-axis shows the number of days a year while the x-axis shows time from 1960-2014. All trends are significant[2].

Hot Days **Warm Nights**

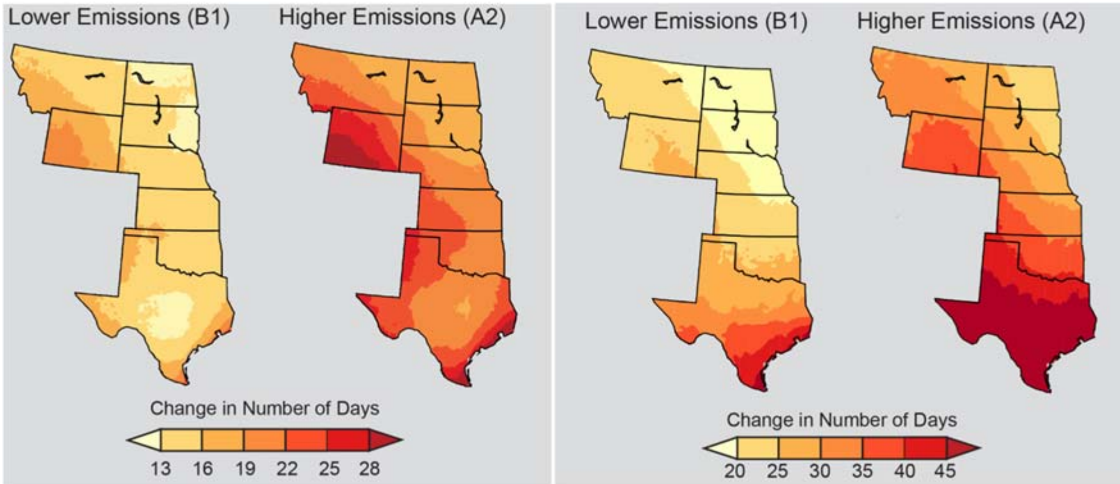


Figure 5: Projected future changes in the frequency of the seven hottest historical days (left) and the seven warmest historical nights (right) of the year for the period 2070-2099 relative to 1971-2000. The lighter yellow and orange colors correspond to smaller annual increases while the darker red colors are larger increases. Each panel of this figure compares projections of what would be expected under a lower greenhouse gas emissions scenario and a higher emissions scenario[3].

Wet Days **Dry Days**

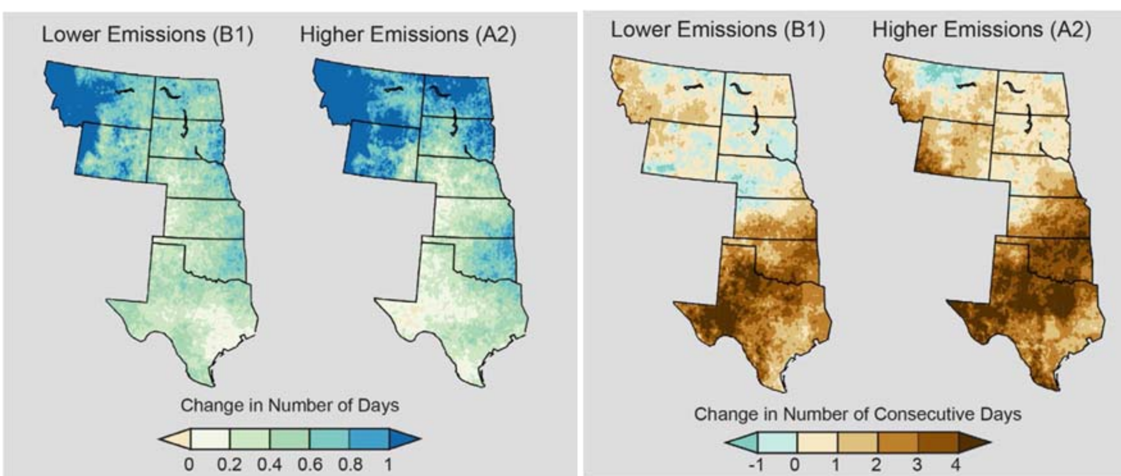


Figure 6: Projected future changes in the frequency of the seven historically wettest days per year (left) and the total number of dry days per year (right) for the period 2070-2099 relative to 1971-2000. For the wet days, the darker blue color represents a greater change in the number of wet days. For the dry days the darker brown represents a greater change in the number of consecutive dry days. Each panel of this figure compares projections of what would be expected under a lower greenhouse gas emissions scenario and a higher emissions scenario[3].

4.0 Collaborative Project Process with the Resilience Advisory Committee

The City of San Antonio formed a Resilience Advisory Committee (RAC) to gain insights into how changing climate conditions and extreme weather events would affect various key facets of the City's operations and assets, as well as the community at-large. For a full list of the Resilience Advisory Committee Members see Appendix 2. The committee participated in a four-step process. First, they participated in an introductory web-based meeting describing the sustainability planning and vulnerability assessment process. Second, committee members received an online survey through the SA Tomorrow "MindMixer" dashboard as a way to solicit initial thoughts about key areas of concern for San Antonio. Third, the project team conducted individual phone calls to RAC members to generate and expand the list of of concerns as well as to engage in discussions about potential extreme weather-related thresholds. These discussions provided valuable information about the specific temperature and precipitation-related thresholds to be considered in the assessment, as well as any future climate work. An "extreme weather event" is:

> *"[An] event that is rare within its statistical reference distribution at a particular place. Definitions of "rare" vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile.* ***By definition, the characteristics of what is called extreme weather may vary from place to place*** *[emphasis added][4]."*

Because of the regional differences for extreme weather events, integrating local knowledge about climate and weather related impacts and thresholds provided the opportunity to hone in on the weather-related events that are most important to San Antonio. Finally, the RAC participated in a one-day workshop on June 25, 2015 to collaboratively conduct the vulnerability assessment.

4.1 Online survey to develop initial list of Key Areas of Concern

The consultant team surveyed local subject matter experts from a variety of sectors (e.g. planning, public health, emergency management, and sustainability) regarding how weather affects their work. A majority of those interviewed felt that extreme weather is a concern. Comments from respondents included:

> *"Extreme weather conditions can have adverse affects on the transportation system—recent heavy rains caused significant damage to the roadways."*

> *"Drought will deplete water supplies and create problems with potable water distribution systems."*

When asked what the chief climate-related concerns were for the city, responses aligned well with issues already being addressed through some of the City of San Antonio planning documents (Figure 7).

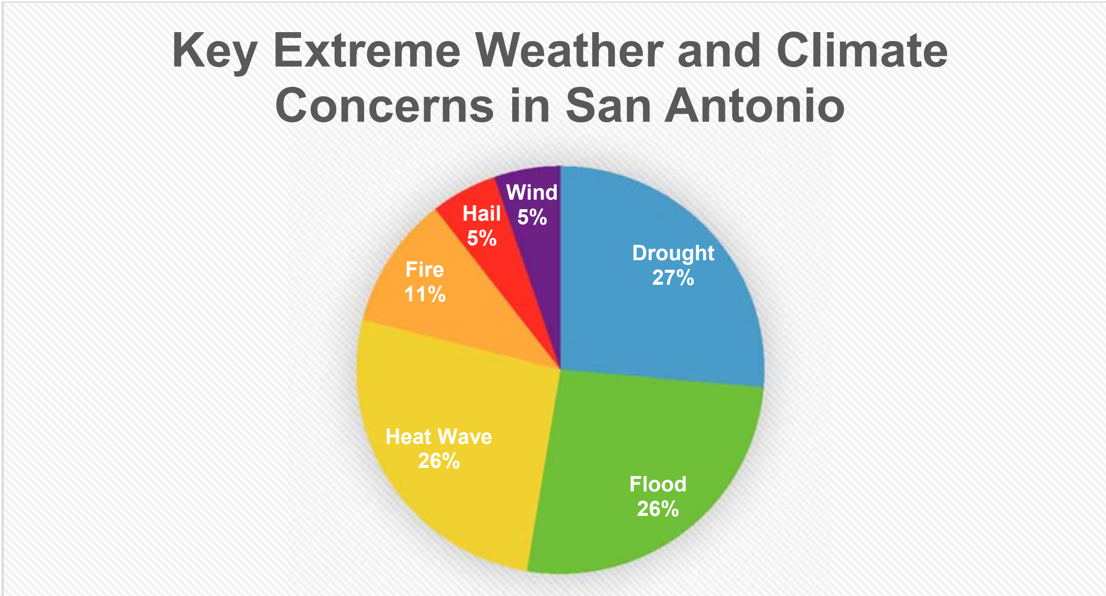


Figure 7: Respondents' chief climate-related concerns for San Antonio from the survey conducted June 8, 2015. Size of the pie wedge shows the percentage of respondents concerned about each extreme weather event listed. Droughts, floods, and heat waves were the top three concerns for the respondents.

Many respondents stated that their departments or organizations are already taking action to address extreme weather and climate-related impacts. For example, SAWS already has a water management plan and Bexar County already has an extreme heat response plan. Respondents also identified various obstacles to fully addressing climate change. These obstacles included: *1)* limited time and budget*; 2)* competing priorities; and *3)* lack of information about what to do or how to move forward. This vulnerability assessment process can be used to address both items 2 and 3 above. It can help prioritize the issues of concern and increase the sharing of information between departments and organizations so that they can better coordinate their efforts to prepare for, respond to, and recover from extreme weather events. Developing a shared understanding and list of concerns won't necessarily solve the budget related issues, but it could be used to prioritize spending on the most critical issues that face the City and the region.

Further, in a survey of City Leadership conducted as part of the larger sustainability planning process, the majority (60%) of respondents agreed that the City should consider climate change and resilience in the development of city polices (Figure 8).

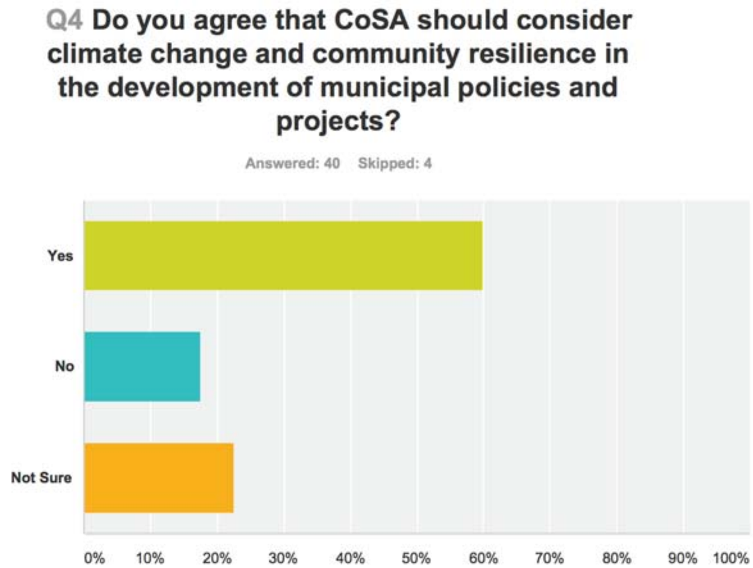


Figure 8: SA Tomorrow Sustainability Plan Leadership agreement on considering climate change and including resilience in the development of municipal policies and projects.

4.2 Collaborative Workshop

On June 25, 2015, at the San Antonio Food Bank, the Resilience Advisory Committee members came together to conduct the vulnerability assessment. The goals for the day were to 1) refine a list of Key Areas of Concern; and 2) conduct a climate vulnerability assessment for these items.

The group began by discussing how climate and extreme weather events impact their work and their concerns about how San Antonio is affected by these events both currently and in the future. The project team gave a presentation of the results of the Climate Analysis conducted by Dr. Katharine Hayhoe specific to San Antonio (results summarized in *Section 3.0: Climate and the City of San Antonio*). Following the climate data presentation, the project team provided a detailed review of existing conditions relevant to Key Areas of Concern generated from the survey results.

The committee generated a refined list of Key Areas of Concern (Table 3) grouped under three categories: increasing temperatures, water (flooding and drought), and other extreme weather events. These are the final areas of concern, which were evaluated for the vulnerability assessment. These categories parallel the top four hazards identified in the *2015 Hazard Mitigation Plan*.

Table 3: Key Areas of Concern Generated by the Resilience Advisory Committee

Temperature	Water	Extreme Weather Events
Poor Air Quality • Impacts to public health due to increases in air pollutants • Potential for non-attainment due to increases in ground level ozone with higher temperatures	**Structures in the 100-year floodplain** • Residences • Multi-family/commercial • Critical/public infrastructure and assets	**Wildfires** – urban/wild land interface including impacts to public health and infrastructure
Extreme heat events and their impacts on the health of vulnerable populations *(elderly, children, poor, chronically ill, homeless & homebound, outdoor workers, pregnant)*	**Critical transportation infrastructure** *(flooding)*	
Extreme heat effects on native species and the tree canopy	**Low water crossings -** high call rescue sites *(flooding)*	
	Wastewater treatment and sewage overflow *(flooding)*	
	Vector borne disease *(drought and flooding)*	
	Geographic distribution of water supply *(drought)*	
	Meeting municipal peak water demand *(drought)*	
	Cooling water availability for power plants *(drought)*	
	Municipal Water quality *(drought)*	
	Local food security *(drought)*	

There are many other ways that extreme weather events can affect the City of San Antonio. Those other events are described in detail in the *2015 Hazard Mitigation Plan*. These other events include (statistics from HMP 2015):

- Tornadoes *(65 events recorded in Bexar County from 1950-2014 ranging from gale force winds to F4 tornadoes);*
- Extreme winds *(impacts deemed to be minor injuries and limited structural damage to mobile homes and wood buildings);* and
- Hail *(common – 208 events in San Antonio between 1955 and 2014 causing an estimated almost $170 million in damages (2014 Dollars))*[5].

While these other extreme weather events are not insignificant for the city, the role of this assessment is to identify the highest priority events affected by changing climate conditions. It is unclear how changing climate conditions could affect tornadoes and hail events and these events were not deemed critical for consideration by the Resilience Advisory Committee.

Additionally, there are other ways that changing climate conditions and extreme weather can affect the city. For example: extreme heat events have the potential to stress the energy grid by requiring more energy for cooling homes and businesses; drought could affect surrounding crop lands and the agricultural yields of farms around San Antonio; and flooding may destroy habitat in riparian corridors. These issues could be explored in more detail in future studies. Based on the expert judgment of the Resilience Advisory Committee, these additional potential impacts did not rise to the top as key concerns for San Antonio at this time.

4.3 Vulnerability Assessment Process

The vulnerability of an asset, resource, or segment of the community depends on its exposure to climate and weather, sensitivity to that exposure, and ability to adapt (Figure 9). The Resilience Advisory Committee members engaged in a guided exercise to complete the vulnerability assessment for each area of concern during the workshop. The use of *sensitivity* (how susceptible the system or asset is to changing climate conditions) and *adaptive capacity* (ability of a system or asset to respond to changing climate conditions) is an internationally recognized means for assessing climate change related vulnerabilities[6]. To see the process of the scoring from the guided activity, go to Appendix 3.

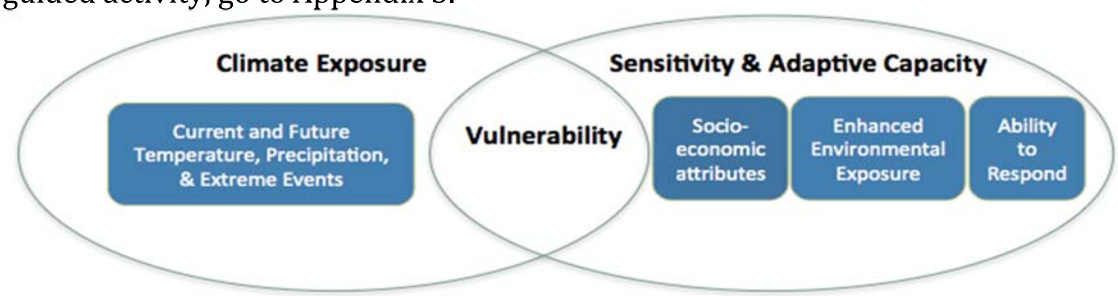


Figure 9: Climate change vulnerability of a system, asset, or resource depends on the climate exposure, sensitivity, and adaptive capacity of that system.

The relative vulnerability rankings identify areas that will need immediate attention and those that can simply be monitored for future changes. Based on the results of the vulnerability assessment, there are clearly three groups of concerns: those with high vulnerability (items in red), those with medium or medium high vulnerability (items in yellow and orange), and those with low vulnerability (items in green). Based on this qualitative assessment, the groups of items that rise to the top are the ones that will require immediate and urgent attention, while those in the last group (such as *impacts on cooling water available for power plants)* are not a pressing need for the city at this time. See Figure 10 for the results of the assessment.

Relative Vulnerability Assessment Ranking

	S0	S1	S2	S3	S4
AC0				• Vector borne diseases	
AC1				• Critical/public infrastructure and assets in the 100-year floodplain (communications, power, etc.) • Critical transportation infrastructure • Low water crossings high call rescue sites	• Extreme heat and impacts to vulnerable populations
AC2			• Single family residences in 100-year flood plain	• Non-attainment due to increased ozone • Impacts to multifamily housing in the 100-year flood plain	• Local food security
AC3			• Municipal water quality during droughts	• Extreme heat impacts on native species • Geographic distribution of the water supply	• Wildfires
AC4			• Cooling water available for power plants	• Waste water treatment and sewage overflow • Meeting municipal water peak demand	

Figure 10: The relative vulnerability ranking of each of the Key Areas of Concern based on their *sensitivity* and *adaptive capacity* rankings. Colors show vulnerability rankings for the different items: red = high vulnerability, dark orange = medium-high vulnerability, light-orange = medium vulnerability, yellow = medium-low vulnerability, and green Items = low vulnerability. Sensitivity ranking vary from S0 = will not be affected to S4 = greatly affected by the exposure. Adaptive Capacity rankings vary from AC0= no ability to adapt to the impact to AC4 = able to accommodate or adjust to the impacts in a beneficial way.

5.0 Results of the Vulnerability Assessment

5.1 High Vulnerability Areas of Concern

5.1.1 Extreme Heat Impacts to Vulnerable Populations

Extreme heat can impact the public's health, particularly for those who are most vulnerable. These impacts are not unfamiliar to the City of San Antonio, which has a long history of dealing with prolonged extreme heat. Extreme heat is identified as a key hazard in the *2015 Hazard Mitigation Plan* and the Metropolitan Health District developed a *Heat Emergency Response Plan* in 2015[7]. The public health effects of exposure to extreme heat are well understood:

- Increases in heat-related morbidity (cramps, rash, exhaustion, fainting, stroke)
- Increases in heat-related mortality (cardiovascular disease, renal failure, respiratory deaths, strokes)[8,9]

These conditions are more pronounced among ***vulnerable populations***, which include the elderly (over age 65), children, low income, chronically ill, pregnant, disabled, socially isolated (homeless, homebound), and outdoor workers[9]. According to the Hazard Mitigation Plan, "*Due to its geography, and its warm, muggy semitropical climate with hot summers, the City of San Antonio can expect an extreme heat event each summer* (HMP, Section 6 page 3)[5]."

The *Hazard Mitigation Plan* does not tell the whole story when it comes to changing climate conditions. As with many of the concerns identified in this vulnerability assessment, analysis of historical occurrences will not accurately guide future projections of these events as the San Antonio climate changes. With observations that the seasonal average temperatures in the summer have increased 0.5°F per decade from 1960-2014, and that there is increased frequency of days over 80°F, 90°F and 100°F from 1960-2014, there is reason to be concerned.

> *"In the summer of 1998, the National Weather Service declared numerous communities in North and South Texas to be under an extreme heat advisory. Throughout Texas, high humidity coupled with temperatures in the high 90's and above caused significant elevations in the heat indices. In addition to the extremely hot and sultry afternoons, the ambient overnight temperatures rarely dropped below 80°F during the summer of 1998. These conditions produced critical heat waves and pushed the heat index into the Extreme Hot Classification which entails a heat index of 130°F or greater. According to the Associated Press, 124 Texans died during this heat wave of which 3 were from Bexar County. History has shown that these conditions are common for South Central Texas (Heat and Emergency Response Plan, 2015, Page 1)[7]."*

One recent extreme heat event cited in the *Hazard Mitigation Plan* occurred in 2009 and resulted in two confirmed fatalities (HMP, Section 6 page 6)[5]. Projections of increases in the historically hottest days and warmest nights by the end of the century for the city are likely to exacerbate already challenging circumstances. There are high numbers of people living in the city that may be vulnerable to this increased frequency of extreme heat events.

Bexar County has an aging population with ***residents over the age of 65*** accounting for 11.3%, or a total of 209,713 residents[10], and projected to reach 14% of the total population by 2020[11]. This is significant because often people of advanced age can be in declining health, may live on a fixed income, and/or may be isolated from the rest of their community or homebound. Because of this, they are at an increased risk from extreme heat events.

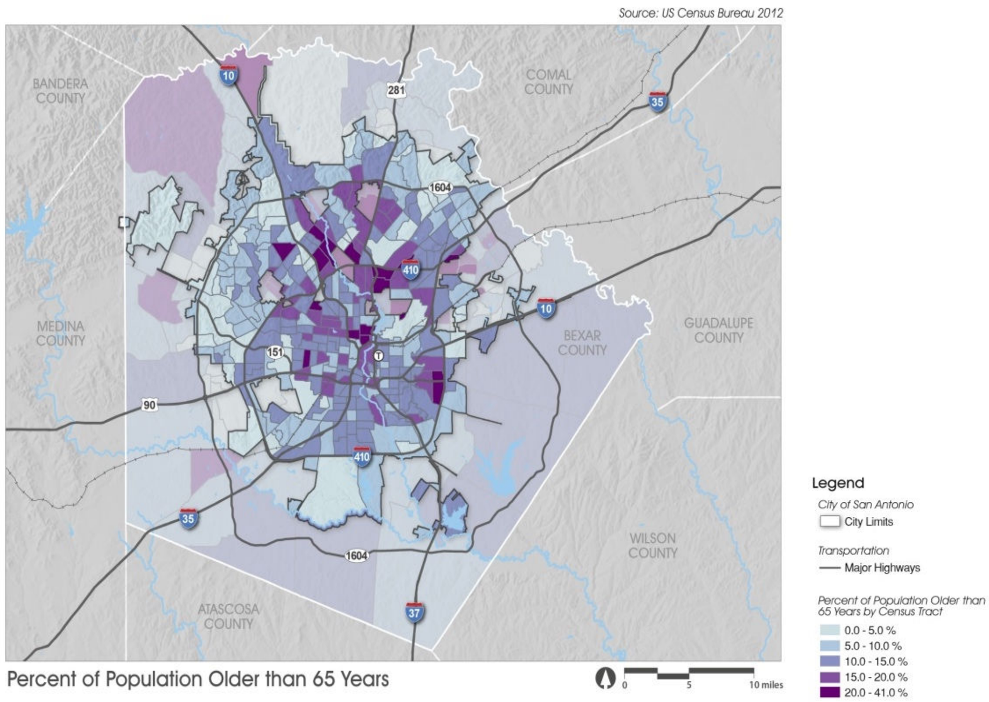


Figure 11: Percent of the population of the City of San Antonio over the age of 65 years by census tract. People over 65-years old are more sensitive to extreme heat events.

"A prolonged heat wave from the end of June through early July [2009] brought record temperatures and heat advisories to South Central Texas. 82 year old twins died in their home in San Antonio. The cause of death was heatstroke according to the medical examiner. The twins did not want to use a fan or air conditioning stating that they were on a fixed income and were trying to save money. High temperatures were at or near 100 degrees in San Antonio that day and previous days as well (HMP, Section 6 page 6)[5]."

Children are considered vulnerable to extreme heat events as well. 133,622 residents, or 7.2% of the population, in 2014 were children 5 years and younger11. Children spend more time outdoors than adults, often being active, and their body's surface area makes up a greater proportion of their overall weight as compared to an adult making them more vulnerable to heat exposure.

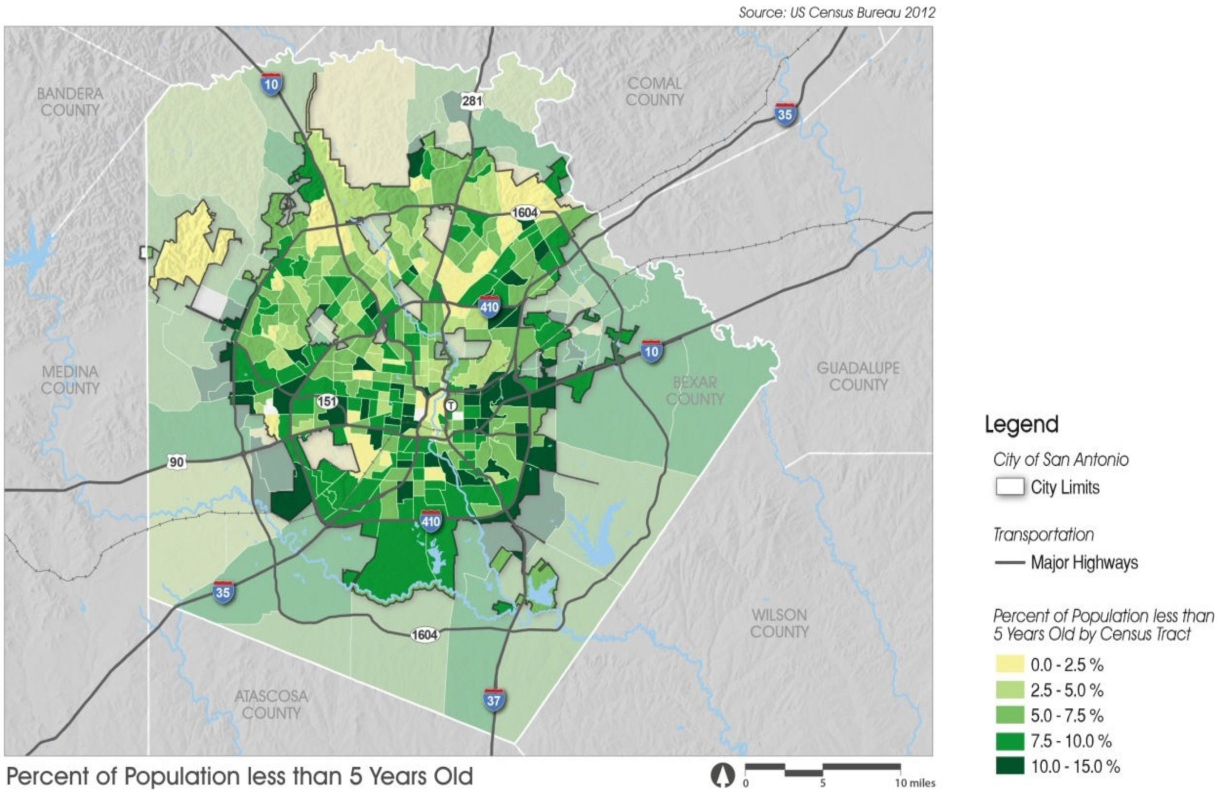


Figure 12: Percent of the population of San Antonio under the age of 5 years by census tract. Children are more sensitive to extreme heat events.

Poverty is another indicator of increased vulnerability as it relates to a lack of overall resources to adapt to a changing climate or deal with extreme events. The poverty rate for the city was 9% in 2000 and 19% in 2010 (3% higher than in the entire metropolitan statistical area), implying a growing challenge for the city (Chapter 2, pages 3-6)[10]. Income is unevenly distributed across the city with some parts of the city experiencing extreme poverty (e.g. Eastside and Southeast/Southwest) as shown in Figure 13. Further, the number and availability of health access points within certain portions of San Antonio is a challenge. During emergencies, access to healthcare, especially for the poor, can be diminished (page 224)[11].

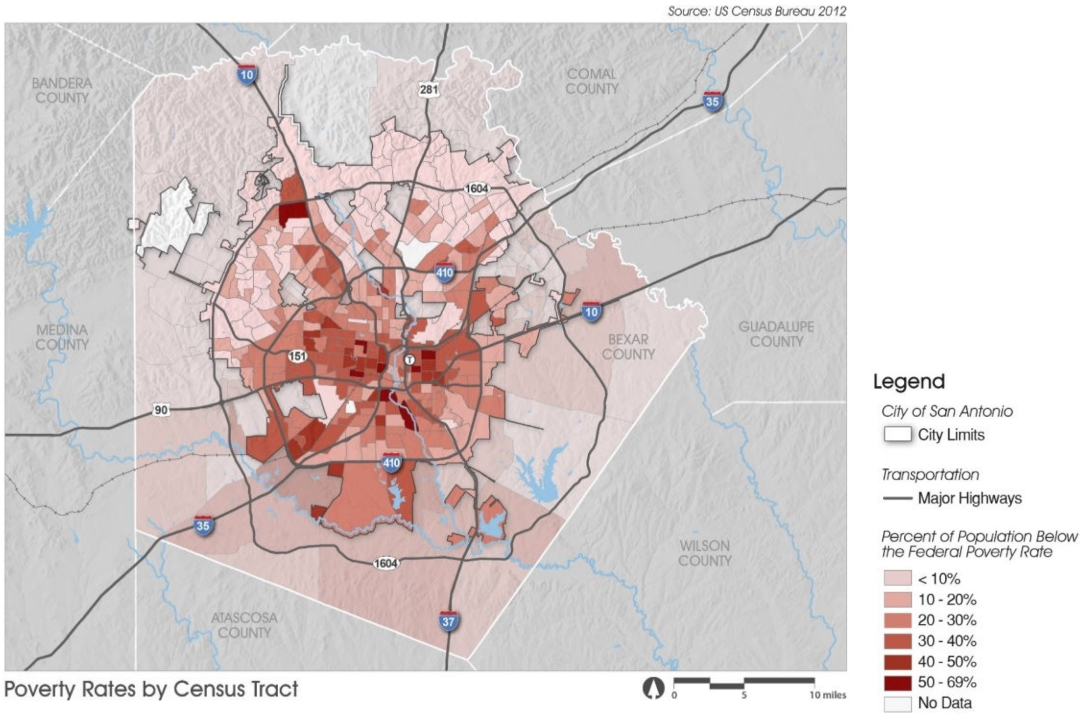


Figure 13: Percent of the population of San Antonio living below the Federal Poverty Rate by census tract. Low-income segments of the population have fewer resources to prepare for and respond to extreme heat events.

The presence of **chronic diseases** can increase the risk from extreme heat. The city has been grappling with a high obesity rate among its residents and according to the 2013 Bexar County Community Health Assessment report, "*a higher proportion of Bexar County adults (68%) than adults in Texas (65%) were overweight or obese in 2012* (page 58)[12]." The rates of **diabetes** in 2013 for Bexar County are 11.4%, down from 14% in 2010 and similar to the rate in the state of Texas[12]. In 2012, 6% of adults in Bexar County reported having **heart disease** and *"…chronic heart disease accounted for the largest proportion of deaths among Bexar County adults age 75 and older in 2011* (page 148)12". These poor health conditions make residents with chronic disease more vulnerable to extreme heat events[9].

The convergence of these social, economic, and health factors may create enhanced vulnerability to changes in climate, and specifically to extreme heat events. To understand the combined effect of these factors, a map of the relative "social vulnerability index" was created using the Agency for Toxic Substances and Disease Registry's Social Vulnerability Index, or SVI[9]. Figure 14 shows the SVI for each of Bexar County's census tracts for 2010. The SVI combines 14 variables including persons aged 65 and older, persons aged 17 and younger, single parent households with children under 18, minority status, and persons living in group quarters. Dividing the data into five groups, the darker red portions depict the areas of the county at the highest social vulnerability, while the darkest blue portions indicate the least vulnerable portions of the county. This information could be used to guide the City as it looks to make decisions about next steps and help target efforts in the more vulnerable areas of the city that are less able to adapt to changing climate conditions.

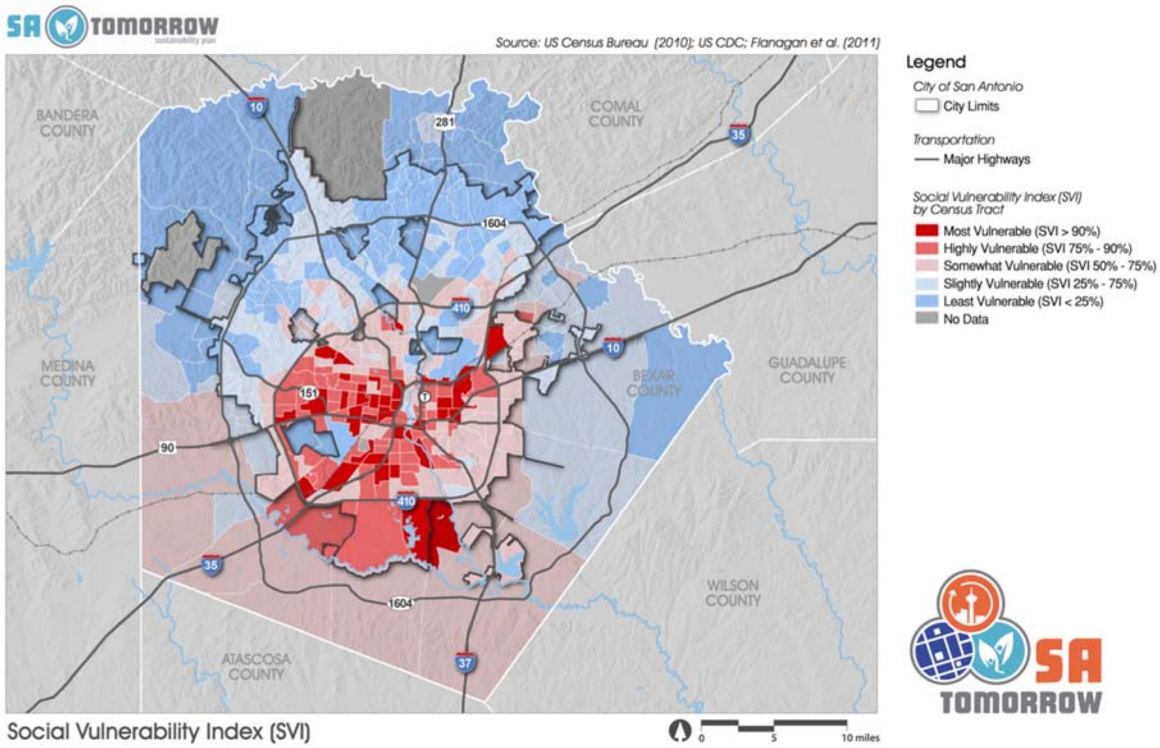


Figure 14: Social Vulnerability Index by Census Tract within Bexar County for 2010.

Finally, a significant contribution to the vulnerability of the residents of the city is due to the "Urban Heat Island Effect" (Figure 15) wherein temperatures in urban areas are often much hotter, and stay hotter throughout the night, than rural areas.

> *"Cities can be up to 10°F warmer than surrounding rural areas and can maintain warmer temperatures throughout the night. Concrete and asphalt in cities absorb and hold heat. Tall buildings reduce potentially cooling airflows. Urban environments may lack trees and other vegetation that provide shade and increase cooling through evaporation. As a result, city-dwellers may experience longer and more severe periods of extreme heat compared to rural or suburban dwellers (page 5)[9]."*

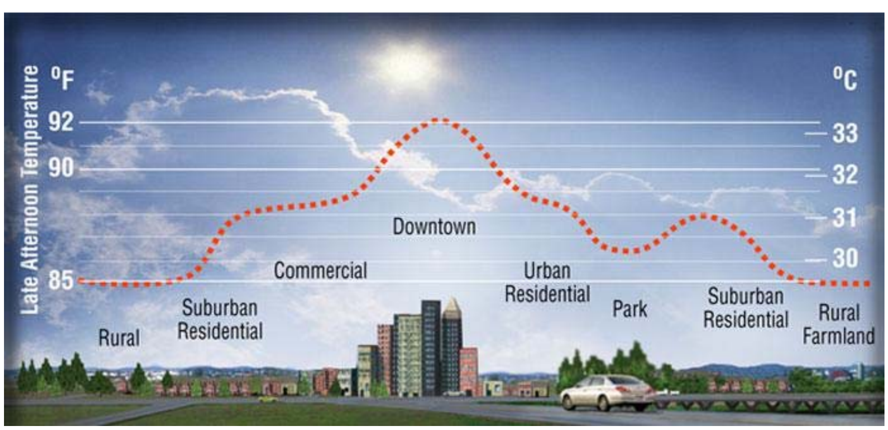


Figure 15: Urban Heat Island Effect[13].

Although roughly equivalent to the national average, the San Antonio's 2012 rate of 17.6 acres of open space per 1,000 residents is a reduction from the 2010 of 20.7 acres per 1,000 residents (Chapter 7, pages 4-7)[11]. This is important because decreases in open space correlate with increases in the urban heat island effect (i.e. open space/tree cover can reduce the urban heat island effect). Heat islands raise air conditioning demand, air pollution levels (particularly smog), and greenhouse gas emissions associated with the energy production required to meet that demand. They also increase the incidence of heat-related illness and mortality[14].

The analysis of the urban heat island effect for the city confirms that the more densely developed areas are "hotter" while the areas of crop or grasslands with forest cover are cooler (Figure 16).

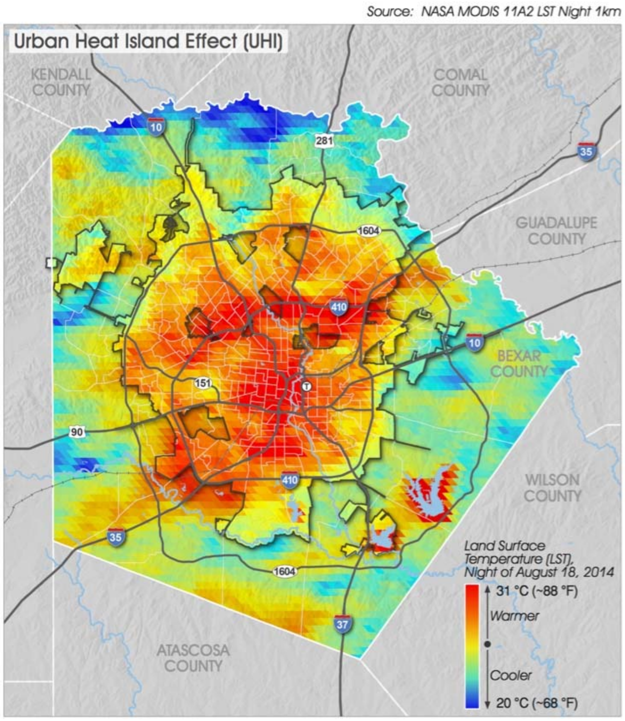


Figure 16: Urban Heat Island Effect for the City of San Antonio.

Looking at the relative SVI rankings alongside the Urban Heat Island map can be a good way to identify areas of enhanced vulnerability to extreme heat events based on increased exposure and higher sensitivity (or lower ability to respond) to those events.

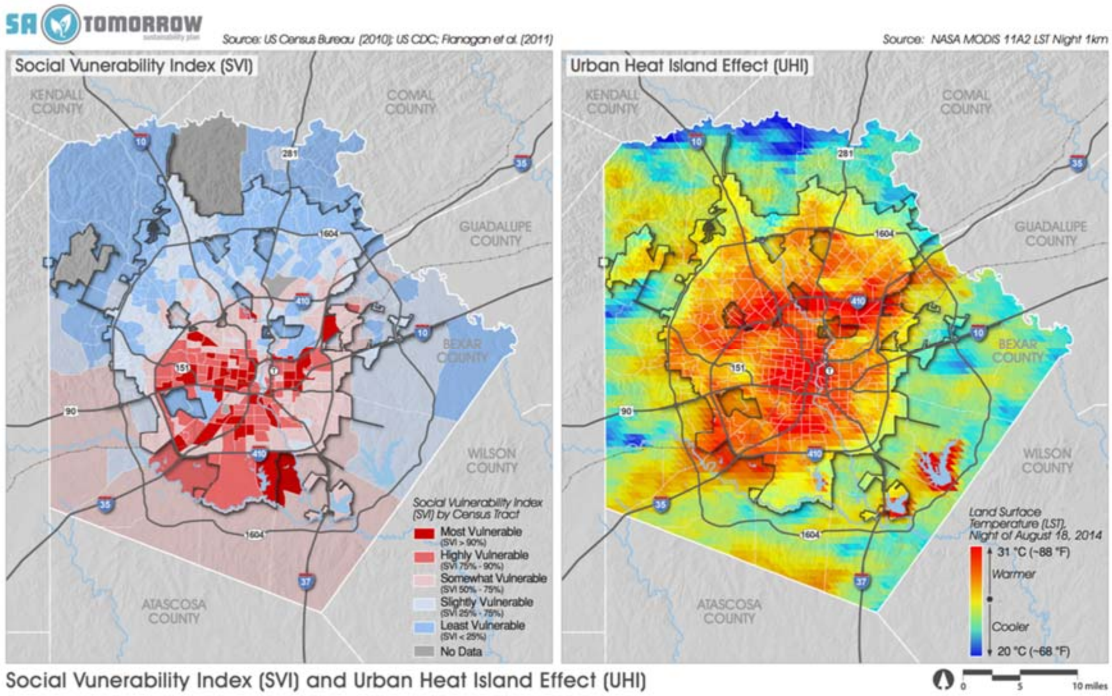


Figure 17: Side by side comparison of the relative social vulnerability index rankings and the urban heat island effect for Bexar County. Comparison can be used to identify areas of enhanced vulnerability to extreme heat events based on increased exposure and higher sensitivity (or lower ability to respond) to those events.

As mentioned, tree cover and green space reduce the urban heat island effect. According to the American Forests Report, San Antonio has a 38% overall tree canopy[15], while the project team's analysis of 2014 data found tree canopy cover of over 34% for Bexar County (excluding the City of San Antonio) and 32% for San Antonio (Figure 18).

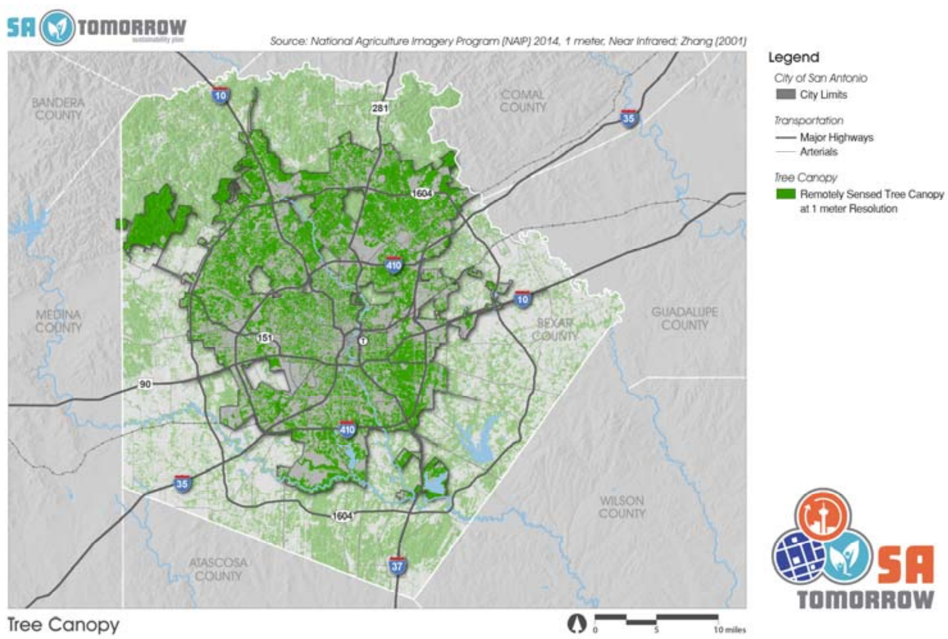


Figure 18: Urban Canopy for San Antonio and surrounding areas.

Importantly, between 2001-2006, San Antonio lost 1,800 acres (3.4%) of tree canopy and 7,600 acres (6.8%) of open space/grasslands while gaining 7,400 acres (5.8%) of additional urban area. The most dramatic tree canopy loss trend occurred in the Edwards Aquifer Recharge and Transition Zone. 3,200 acres (6.0%) of tree canopy and 4,400 acres (10.7%) of open space and grasslands were removed while almost 6,000 acres (20.2%) of urban area were added[15]. The inherent cooling affect of trees is evident in the satellite data used to create the urban heat island maps (Figure 16).

Overlaying the urban tree canopy with the relative social vulnerability index is another way to identify target locations for future tree planting that can be used to cool areas where the populations may be more susceptible to extreme heat events.

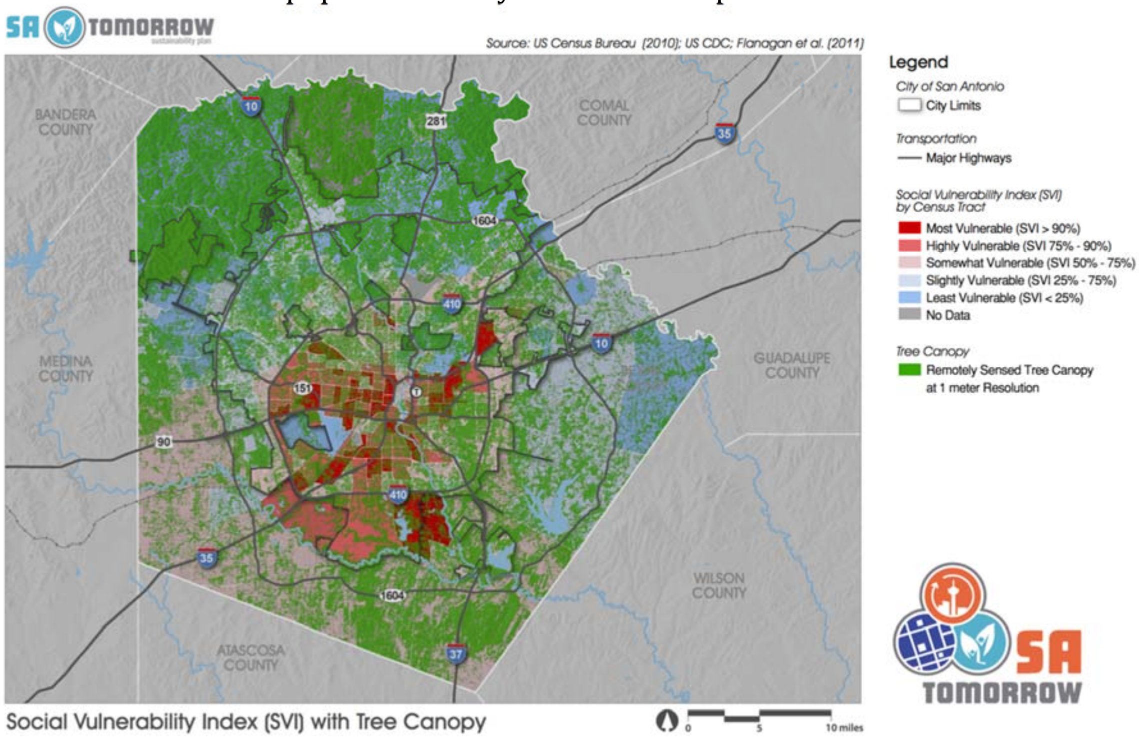


Figure 19: Tree Canopy and relative social vulnerability index for Bexar County.

Social cohesion of a community can have a significant impact on how sensitive that community is to a climate or weather event and the ability of that portion of the community to come together and respond to the climate and weather related challenges[16]. This can be particularly important for low-income communities, though income itself is not the only predictor of social cohesion[17]. A recent study on the impacts of Super Storm Sandy found that *"Communities where residents had stronger and more active social ties were better able to utilize these social networks to adapt, respond, and recover from Sandy* [18] *."* These connections can come through neighborhood involvement and are frequently tied to community and faith based organizations in the neighborhoods. Thus, as described in Section 4.3 it is not only the climate related exposure, but also the sensitivity and adaptive capacity of the affected community that determines the vulnerability.

Based on all the data presented, the RAC determined that extreme heat impacts to human health were a high vulnerability and in need of additional attention. For example, the San Antonio Metro Health District's *Heat Emergency Response Plan* is well developed, and adequately prepares the city to respond during these times of need. However, there was recognition that these events will continue to stress the existing emergency response systems (police, fire, emergency) and require expanding or enhanced educational and outreach programs (some of these systems are already in place) on the part of the San Antonio Metro Health District and partner agencies to ensure that residents receive ample notification and support to deal with them when they arise.

5.1.2 Vector Borne Diseases and Impacts to Public Health

Vector borne diseases are often cited as an emerging or imminent climate-related health effect. Vector borne diseases typically influenced by changing climate conditions are mosquito-related (e.g., West Nile) and tick-related (Lyme disease), as those are the predominant vectors, or organisms, capable of transmitting diseases across species[19]. According to the San Antonio Metro Health District, the vector borne diseases of concern transmitted by mosquitos are West Nile, St. Louis and Eastern Encephalitis, Chikungunya and of those transmitted by ticks is Lyme Disease. In addition to climate effects, because of increased travel to and from the area, and increases in the supply of host animals (e.g. birds and non-human mammals), the potential for the spread of these diseases is heightened.

The key climate concerns affecting the spread of these diseases are the projected increasing winter temperatures, which, according to past trends, would continue to increase 0.7°F per decade during the winter. These changes will result in diminished die-off of vectors during the cold winter months, thereby increasing overall numbers of mosquitos and ticks. Further, already high levels of flooding within the city could increase in intensity, expanding the number of vector habitats and breeding sites, such as standing water from heavy rain or flooding[19]. According to the World Health Organization, *"West Nile Fever has resurged in Europe subsequent to heavy rains and flooding, with outbreaks in Romania in 1996-97, in the Czech Republic in 1997 and Italy in 1998[19]."* From 2002-2013 there were a total of 4,253 cases in Texas with a record high number of 1,868 cases reported in 2012[20]. There were two human cases of West Nile Fever recorded in Bexar County in 2014[20].

It is frequently assumed that mosquito-related illnesses increase only during flooding (more water = more mosquitos), however drought conditions can actually increase vector-borne illnesses. When natural water sources dry up, two species critical to carrying out the transmission of these vector borne illness—birds and mosquitos—concentrate in more urban areas where humans provide water and food during drought. As these drought conditions occur, birds may flock to more urban areas due to the fact that humans store more water and food scraps and waste can be a food source for birds. Because of this, there is increased interaction between birds and mosquitos which breed in these water storage areas. It is this increased interaction that enhances the ability for vector-borne diseases to thrive[21]. In sum, it is the weather extremes (both too much and not enough water) that allow for potential increases in vector-borne diseases.

Table 4: Incidence of cases of Vector Borne Diseases per 100,000 residents of San Antonio[22].

Condition	2010	2011	2012	2013	2014
Chagas, chronic indeterminate	0.000	0.000	0.000	0.110	0.108
Chagas, chronic symptomatic	0.000	0.000	0.000	0.055	0.000
Chikungunya non-neuroinvasive disease*	0.000	0.000	0.000	0.000	0.379
Dengue**	0.000	0.000	0.000	0.331	0.000
Encephalitis, West Nile	0.000	0.000	0.953	0.000	0.216
Malaria*	0.058	0.171	0.056	0.000	0.054
West Nile Fever	0.000	0.000	0.672	0.000	0.108
Lyme Disease	0.000	0.000	0.000	0.000	0.000

Although the prevalence of these diseases is relatively low, this was rated a high vulnerability for San Antonio because of the limited staffing and funding currently available to conduct surveillance efforts and respond to or combat these illnesses in the face of a future changing climate.

5.2 Medium-High Vulnerabilities

5.2.1 Critical infrastructure in the 100-year floodplain

Many of the Key Areas of Concern relate to flooding. According to the Hazard Mitigation Plan:

> *"Texas is prone to extremely heavy rains and flooding with half of the world record rainfall rates (48 hours or less). Central Texas, known as Flash Flood Alley, is particularly vulnerable because storms tend to stall out along the Balcones escarpment. While the City of San Antonio is susceptible to a wide range of natural and human-caused hazards, including flooding, tornadoes and wildfires,* ***San Antonio is considered one of the most flash-flood prone regions in North America*** *(HMP, Section 1 page 2)[5]."*

The city regularly deals with and focuses on being prepared for extreme flooding events. With increases in extreme wet periods projected for the city by the end of the century, flooding is expected to increase. *"Based on recorded historical occurrences and extent, flooding is highly likely, meaning an event will occur within the next year (HMP, Section 7 page 13)[5]."*

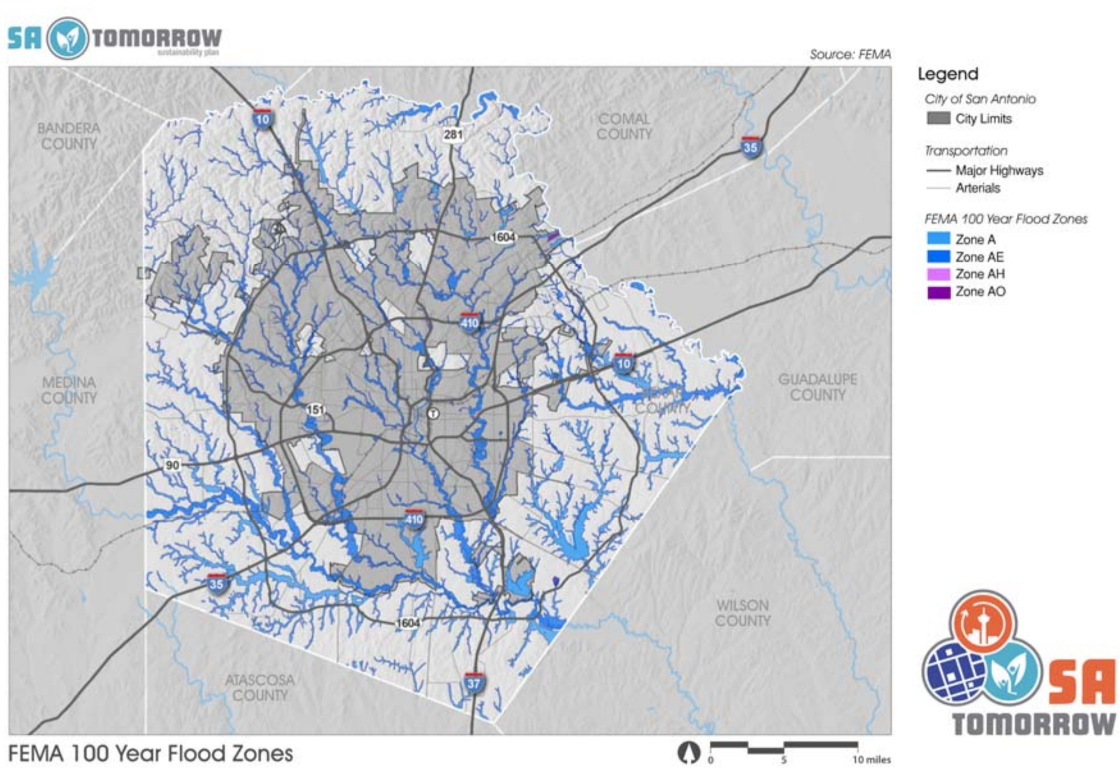


Figure 20: 100-year Flood Zones for San Antonio and surrounding areas.

At a high level, Figure 20 shows the potential flooding areas for the city where the high-risk zones are A and AE (shown in the two blue colors)[23], which cover a significant portion of the city.

These flooding events can be devastating to the city in terms of loss of life, destruction of property, disruption of the economy, and overall quality of life impacts. In San Antonio's recorded 129 flood events over the years 1993-2014, there were 16 deaths, 507 reported injuries, property damage totaling almost $14.7 million and $228,662 of crop damage (2014 Dollars). In the flooding event in May 2013 affected 350 residences, 15 of which were destroyed and 27 suffered major damages. There were also 200 citizen rescues and 3 casualties during that event[5].

> *"According to the NWS [National Weather Service], the City of San Antonio and Bexar County area hold the highest number of fatalities resulting from flash flooding in Texas, with at least 26 fatalities attributed to flooding/flash flooding since 1996. Additionally, more than 852 injuries have been attributed to flooding in the same time period (HMP, section 7 page 17)[5]."*

Floods also increase exposure to contaminated water requiring an emergency response to decrease exposure or contact with contaminated water and creating the potential need for widespread immunization. The flood events in May 2013 required this response[5].

Combining critical socio-economic factors indicative of increased vulnerability, the relative social vulnerability index was again applied to the issue of flooding for the census tracts of Bexar County (Figure 21). The red census tracks indicate higher relative vulnerability and red tracts that overlay with flood zones could be used as a way to focus efforts to reduce vulnerability and build resilience.

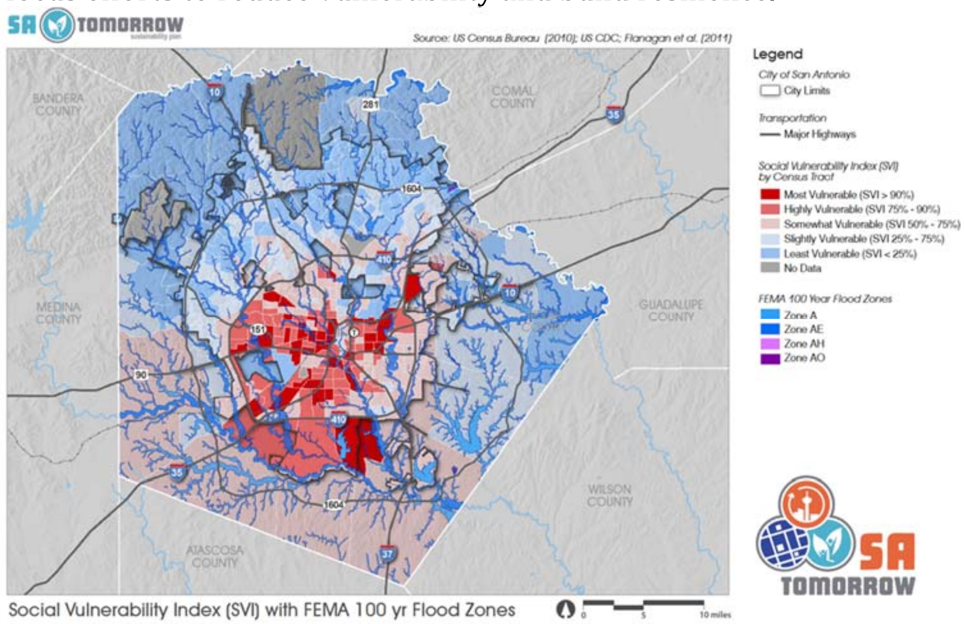


Figure 21: Relative Social Vulnerability Index using 2010 data for all census tracts in Bexar County overlaid with the FEMA 100-year flood zones.

Critical infrastructure concerns for flooding relate to the ability of the City to provide regular power, ensure that communications systems are not affected, keep the water supply from being contaminated, protect health and emergency services, and ensure that transportation systems are still functioning. According to the *Hazard Mitigation Plan*, there are 197 critical facilities located within the floodplain (Section 7 page 16)[5]. Though these facilities are very broadly defined and the City could work to better define the specific "critical infrastructure" that needs to be studied, where those facilities are, and then require specific building codes/regulations of those facilities. Further, the City is making strides through its efforts to reduce repetitive losses as part of the National Flood Insurance Program. According to the Hazard Mitigation Plan, the City is preparing materials to apply to join the Community Rating System (CRS):

> *"…including documenting tasks and projects to prevent and reduce flood losses. These include measures such as updating codes as a preventative measure, acquisition of flood-prone structures, and implementation of other structural flood control projects. The city has acquired over 300 flood-prone or repetitive flood loss properties in previous years and has plans to acquire additional structures that have previously experienced one or more floods, in an effort to protect open space adjacent to floodplains. Additionally, they have identified and included over 85 flood mitigation projects in the current hazard mitigation plan underway (HMP, Section 7 Page 26)[5]."*

5.2.2 Critical Transportation Infrastructure

Concerns were also raised by the Resilience Advisory Committee with respect to the impacts of flooding on transportation infrastructure, which includes damage in the form of washed out roads, water infiltration into roads (damaging the pavement), sediment build up at bridges (degrading the stability of the structures over time), and improperly maintained stormwater systems. These impacts could result in road closures, limit mobility, and affect emergency response efforts. Most major roadways can withstand large-scale flooding but smaller roads can be significantly damaged causing high clean up costs[24].

The *Hazard Mitigation Plan* identifies a number of specific locations that have been affected by past flooding events.

> *"The **San Antonio River at Loop 410** had floodwaters reach 34.21 feet in May 2013" (Section 7 Page 71)[5]."*

> *"Thunderstorms produced heavy rain that caused flash flooding in and around San Antonio and Bexar County. There was record rainfall in the San Antonio area with the San Antonio International Airport recording 9.87 inches of rain (2nd highest 24-hour total record)…Most of the rain fell in six hours with four inches in one hour between 6:00 and 7:00am. A USGS stream and rain gauge on Olmos Creek and Dresden Drive reported 2.58 inches in 15 min between 6:15 and 6:30am…A 24hr total at this gauge was 17 inches of rain. This led to **massive flooding in the Olmos Basin/Creek just inside Loop 410** near the Quarry (Section 7 Pages 11-12)[5]."*

> *"**Most of the flooding across the city was in north central and northwest San Antonio along and just inside Loop 410**…**There were many roads closed including Hwy 281 at Olmos Creek** which remained closed for several days. At 10:00 a.m., there was one foot of water over Ingram and Callaghan Rds.…Areas [in the south portion of Bexar County] that were hit the hardest included the Espada Rd area near the San Antonio River and Loop 410 intersection (Section 7, Page 12)[5] [emphasis added]."*

One specific area of concern that was discussed at the workshop was the VIA Transportation facility. It is located near the source of the San Pedro springs and built over the San Pedro creek. The facility is low lying, sometimes flooded, and central to VIA's ability to maintain its vehicles and offer transportation services to the region.

As discussed in section 5.2.1, flooding is a critical problem for the city and with projections of increasing intensity of precipitation events the committee scored potential critical transportation infrastructure a medium-high vulnerability.

5.2.3 Low water crossings high call rescue sites

Another important effect of increased flooding in the city is the impacts of flooding on low water crossings and high call rescue sites. (See section 5.2.1 for flooding impacts to the city.) According to the *Hazard Mitigation Plan*,

> *"Flood-related rescues often occur at swift water and low water crossing. Swift water rescues are rare, since most calls for assistance are related to stalled or stranded vehicles in or near low water crossings. **New low water crossings may and do emerge as a result of increased development or changes to the hydrology/floodplain of an area** (Section 7 Page 17)[5]."*

As flood frequency decreases and intensity increases, so too might residents become less vigilant in their awareness of their surroundings, placing themselves at increased risk and potentially requiring emergency response. Further, changes to floodplains may introduce new areas where low water crossings are an issue. According to the discussions with the RAC, this is particularly true as more people move to the area. These new residents will need additional flood education to ensure public safety.

5.2.4 Local food security

The issue of food security emerged through discussions with the Resilience Advisory Committee. The U.S. Department of Agriculture defines food security as, *"access by all people at all times to enough food for an active, healthy life[25]."* In these discussions, concerns focused on how climate could affect local solutions to deal with "food deserts" such as the San Antonio Food Bank's community gardens[26] and the San Antonio Housing Authority's fruit orchard[27], as some city residents have a limited ability to access their local grocery store. According to a 2012 report by the San Antonio Metropolitan Health District and the University of Texas, Bexar County's food system has deficiencies despite programs such as WIC and SNAP to enhance access to food, and it is clear that in certain parts of the city there is a substantial food-based need[28]. Figure 22 shows the percentage of the population by zip code that lives within one mile of a grocery store, super market, or farmers market. The darker red zip codes are places where a large percentage of the residents do not live within 1 mile of these healthy food options.

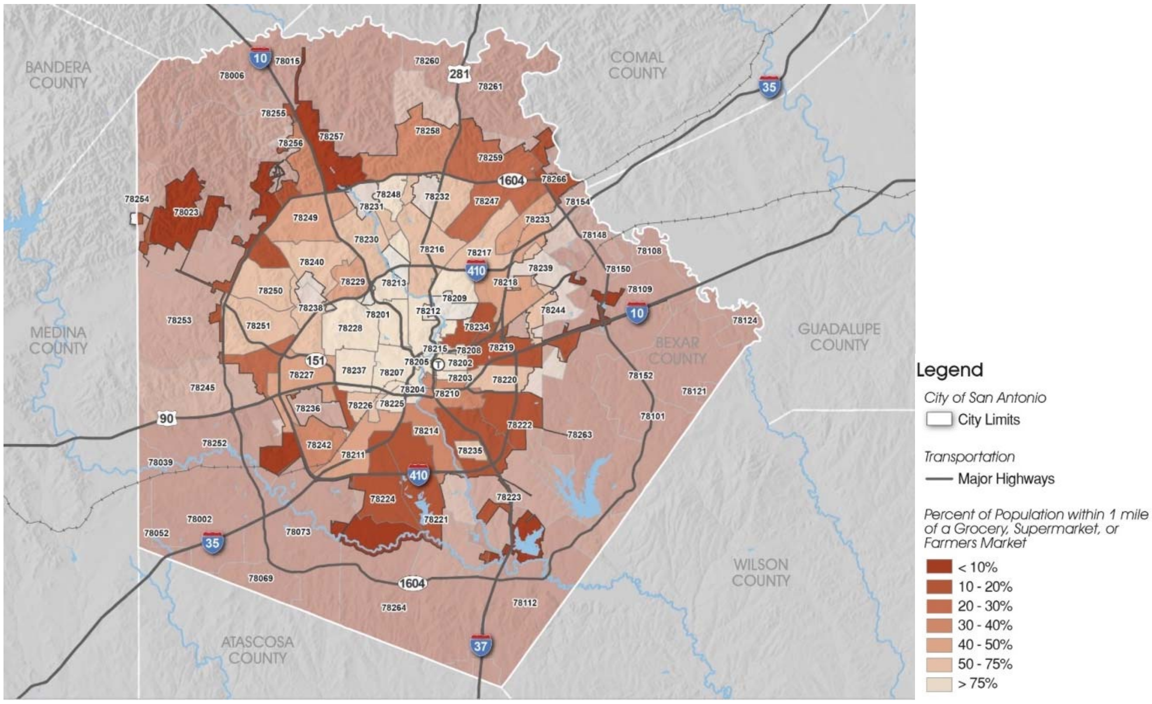


Figure 22: Percent of the Population living within 1 mile of a grocery store, supermarket or farmer's market by zip code in San Antonio.

Within Bexar County there are a total of 160,770 acres classified as improved farm or ranch (58,858 of those acres are within San Antonio city limits). As temperatures continue to warm and the number of hot days and warm nights occurring on average each year increase, agriculture and livestock production may be affected. Further, livestock are affected by extreme heat in that it can make them vulnerable to diseases, threaten feed supplies, and affect their fertility/reproduction[29]. According to the Texas A&M agricultural program, during the 2011 drought, ranchers provided supplemental feeding for livestock or began to liquidate herds (HMP, Section 5 Page 6)[5]. Diminished agricultural and livestock production could have economic impacts on the city.

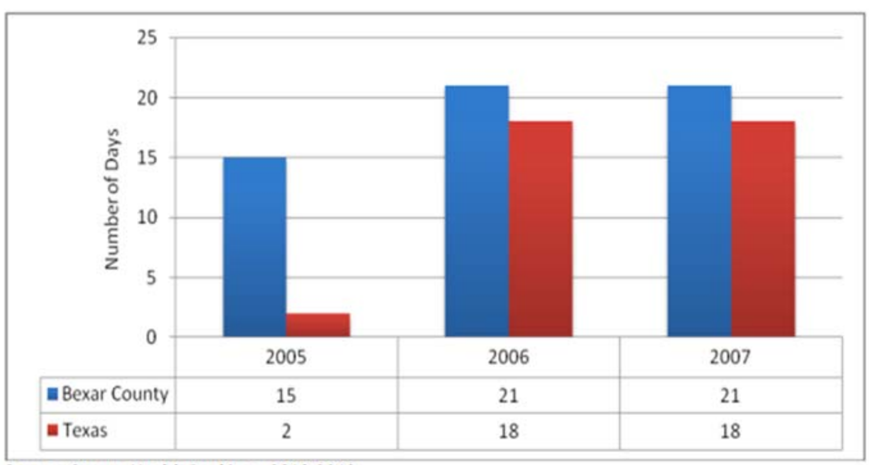
The Resilience Advisory Committee rated this a medium-high vulnerability due to the fact that any efforts to create a more localized food economy would be affected by changes in climate. Further, as changing climate conditions affect the greater national and international food system, those who already lack access to healthy food choices due to their lower socio-economic status might be further affected if those changes increase the price of food that is brought into the city.

5.3 Medium Vulnerabilities

5.3.1 Poor Air Quality and Potential Non-Attainment Due to Ozone

San Antonio is already near the non-attainment threshold for ground level ozone. The U.S. Environmental Protection Agency's definition of "non-attainment" states, *"any area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet) the national primary or secondary ambient air quality standard for the pollutant* [30] *."* Ground level ozone has known human health effects, such as exacerbating asthma, reducing lung function, and creating lung inflammation [31]. Ground level ozone forms when sunlight comes into contact with vehicular emissions. Studies have shown that ground level ozone levels increase when temperatures increase[32]. Thus, higher temperatures result in higher levels of ozone. The projected growth of the city and increase in the number of vehicles (and thus emissions) will also increase ozone levels. There are direct financial implications to consumers, businesses, and industry along with increases in ground level ozone leading to increased school absences, medication use, visits to physicians, emergency room visits, and hospitalizations[31].

Data from 2005-2007 showed an increase in the number of unhealthy days due to ozone for Bexar County, which was higher than the state of Texas overall (Figure 23). Effective December 28th, 2015, The EPA reduced the 8-hour ozone standard from 75 parts per billion to 70 parts per billion[33]. The San Antonio area attainment status is "pending" (based on information from the Texas Commission on Environmental Quality[34]) while the EPA updates the implementation rules and guidance around the new standard. Increasing temperatures, 1.1 million more people moving to the region by 2040, and the increased transportation service needs for those people all have the potential to increase ground level ozone in the region.



Source: County Health Rankings, 2010-2012

Figure 23: Annual number of poor air quality days due to ozone, Texas and Bexar County, 2005-2007[12].

The concerns raised by the committee were that transportation projects to enhance capacity for the growing population could be stalled due to restrictions and funding requirements related to a "non-attainment" designation. As a result, the City might need to find new modes of transportation to increase capacity (e.g. public transit) and work to increase emissions controls to reduce baseline ozone levels.

5.3.2 Wildfires

Although wildfire threat within most of the city is relatively low, continuing development in the north and northwest portion of San Antonio expands the wildland urban interface deeper into more fire prone areas. According to the *Hazard Mitigation Plan*, 22% of the population lives along this wildland urban interface[5]. Figure 24 demonstrates this higher risk in the north, northwest region of the city[35].

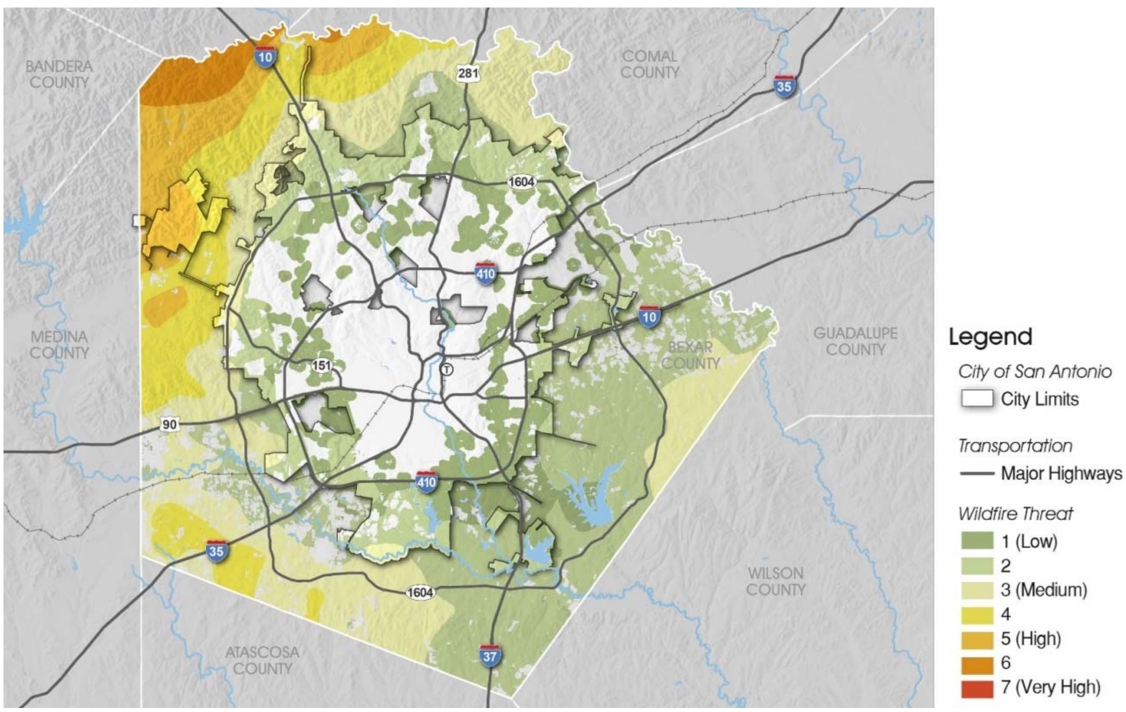


Figure 24: Wildfire risk for San Antonio and surrounding areas[35].

Economic impacts of wildfires can be large. For example, the Bastrop Complex Wildfire in 2011, itself a result of severe drought conditions, resulted in estimated losses of over $209 million[36]. Wildfires do not tend to have much direct impact on transportation infrastructure, though indirect impacts from disruption of evacuation routes, as well as decreased soil stability and subsequent erosion and sedimentation accumulation, can be significant. Further, wildfires could create bottlenecks in the transportation system interfering with wildfire evacuation and thus threatening public health/safety[36].

> *"The San Antonio Fire Department reported 83 wildfire events between 2007 and October 2014 and two wildfire events reported by the National Climatic Data Center (NCDC) in 2011 and 2014, which resulted in $250,000 of property damages. (Section 8 Page 2)[5]."*

Changing climate conditions are likely to increase temperatures and increase the likelihood of dry conditions, further exacerbating wildfire risk. The Resilience Advisory Committee members felt that the city would be more vulnerable to wildfires in the face of these projected changes to climate. Further, as the population increases and there is more development along the wildland urban interface, more property and people will be at risk. This could stress the emergency response systems.

5.3.3 Multi-family residences in 100-year floodplain

The flooding impacts have been outlined thoroughly in Section 5.1.1, and with projections for increased severity of these events, the committee rated these impacts to multi-family housing in the floodplain a medium vulnerability. The committee decided that people living in multi-family residents, while sometimes part of strong social networks in their communities, generally had lower "adaptive capacity" due to generally lower incomes and less access to transportation than those living in single-family homes. The sheer number of people in a single multi-family complex create challenges communicating with and relocating residents during emergency events.

On the positive side, there are efforts underway to identify and reduce flood risk. The city participated in an effort to redraw the flood risk maps as part of a partnership known as the Bexar Regional Watershed Management (BRWM) partners, consisting of Bexar County, the San Antonio River Authority (SARA) and 20 other suburban cities in Bexar County. The result of this effort are interactive online maps, housed by SARA, that allow residents to see where their homes are within the floodplain[37]. The BRWM partnership has also developed a three year rolling capital improvement project plan to prioritize and fund $500 million worth of regional drainage projects over ten years[38].

5.4 Medium-Low Vulnerabilities

5.4.1 Single-family residence in 100-year floodplain

Although facing similar flood risk as multi-family residents, the committee felt that the city had a greater capability to help people living in single-family residences prepare for and respond to flood events. This is largely due to the number of residents and the ability to communicate with these residents.

Further, both the City of San Antonio and Bexar County have taken steps to stop development of additional residences from the floodplain with the aforementioned SARA flood risk maps, a unified development code to ensure appropriate permitting for the floodplain, and other efforts. For these reasons, despite a recognition that flood intensity and severity will increase with changing climate conditions, the committee ranked this Key Area of Concern a medium-low vulnerability.

5.4.2 Extreme heat impacts on native species (trees)

Trees can be vulnerable to extreme heat and preserving the urban tree canopy is a concern. The City Landscaping and Tree Preservation Ordinance requires developers who intend to remove trees or vegetation to obtain a tree preservation permit from the City. In addition, the ordinance has requirements for landscaping, buffers, streetscape planting, and fences[39, 40].

Increasing average temperatures and more hot days and warm nights combined with projections of increasing risk of dry conditions may create drought conditions that will kill trees, especially in circumstances where planting and landscaping practices may not have been up to standard (i.e. root health and depth of planting may not be adequate). The workshop discussion centered on the need for more training and certification for those planting trees as a way to support tree health and preserve and expand the city's canopy.

5.4.3 Geographic distribution of the municipal water supply

The San Antonio Water System (SAWS) has developed a water conservation program that is one of the best in the country[41]. Because of this, and some excellent planning and coordination efforts, the city has been able to provide water for its residents even during times of drought. Yet, as the city continues to grow and a changing climate continues to affect both the supply and demand for water, San Antonio will be increasingly challenged. These challenges will include expanding water supply capacity to meet the projected needs of new residents and newly developed areas, especially under drought conditions. Incorporating changing climate conditions will require enhancing strategic planning to ensure that there is enough water to carry the city through future dry periods.

SAWS has a demographer who utilizes all of the best available information in order to estimate and project the number of people using SAWS water, both for the entire service area, and on much smaller scales. SAWS is working to develop a new pipeline in 2016 to bring water from southern Bexar County to the western side of its service area, to supplement the existing pipeline that services the eastern side of its service area (Figure 25). In addition to the existing innovative Aquifer Storage & Recovery project and existing Local Carrizo project at SAWS Twin Oaks facility in southern Bexar County, SAWS is also developing a brackish groundwater desalination program and additional production from the Carrizo Aquifer in Bexar County, to further diversify its water provision efforts. Phase 1 of the desalination program will be complete in 2016, and the project eventually expects to provide the city with an additional 30 million gallons of water per day[42]. This is the largest planned inland desalination project currently in the United States.

Figure 25: Proposed new pipeline that will bring water from southern Bexar County to the eastern and western sides of its service area, to enhance flexibility[42].

In addition, another proposed water solution, the Abengoa Vista Ridge project, would transport water from Burleson County to San Antonio. The unique aspect of this project is its diversification in supply away from the Edwards Aquifer (Figure 26).

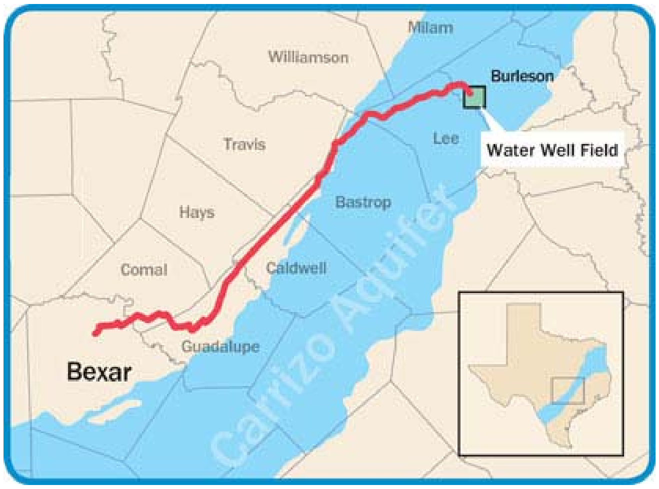


Figure 26: Map of Proposed Vista Ridge Pipeline[43].

While SAWS *2012 Water Management Plan* does not explicitly include projections of changing climate conditions, it does plan for drought using the drought of record from the 1950s. Figure 27, below, shows water demand for a series of nine years (dark black line) along with available water supplies (colored bars). The demand line is sloped upward to account for population growth coupled with a sustained conservation program. The colored bars represent water that would be available if the seven-year drought that occurred during the 1950s were to reoccur in the future. As seen in the figure, it isn't until the 2030s, and the seventh year of the drought, that there is a projected gap between water supply and water demand.

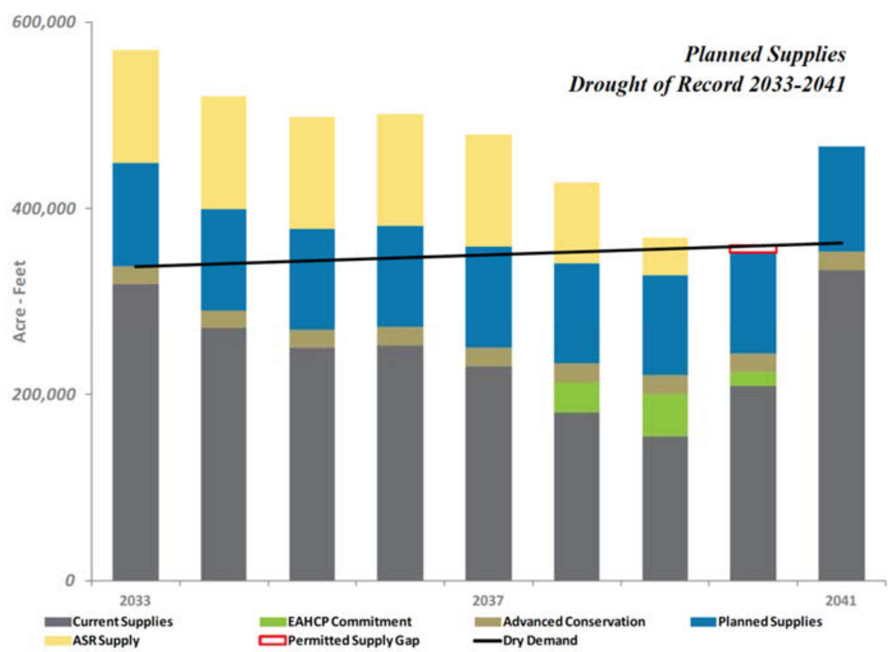


Figure 27: SAWS 2012 Water Management Plan supplies for the years 2033-2041. Dark black line shows water demand by year based on population growth. Colored bars show water supply in the event that the drought of the 1950s was to reoccur[41].

Recognizing the fact that extreme droughts have the potential to occur in the future and considering the ongoing efforts to diversify water supply resources and enhance conservation efforts, the committee rated this Key Area of Concern a medium-low vulnerability.

5.5 Low Vulnerabilities

5.5.1 Municipal water quality during droughts

Another issue raised by the Resilience Advisory Committee was the challenge of ensuring water quality that meets standards during times of drought. According to the *Hazard Mitigation Plan*:

> *"Based on 31 recorded drought events over seven extended time periods within an 18 year reporting period, the City of San Antonio averages two droughts every year. This lends to a highly likely frequency of occurrence, meaning* ***a drought can be expected on an annual year cycle*** *(HMP, Section 5 page 7)[5]."*

Working under the assumption that droughts are inevitable events to plan for, concerns arose during discussions with the Resilience Advisory Committee about the potential for increased water main breaks and their potential to affect water quality. In particular, water quality can be an issue in dead-end water lines where water remains stagnant for longer periods of time. The committee felt that this is a low vulnerability due to the diversification of supply and overall system redundancy. SAWS has acquired and preserved 135,000 acres as part of San Antonio's Aquifer Protection Program in an effort to protect water quality. Thus, while overall vulnerability is low, there are recommendations to consider connecting dead end mains and create codes against cul-de-sacs (one of the sources of dead end mains) to ensure continued water quality during times of drought.

5.5.2 Waste water treatment and sewage overflow

The issue of wastewater treatment and sewage overflow is a potential concern. Heavy precipitation events have led to infiltration of stormwater into the sewer system, even though SAWS does not have a combined sewer-stormwater system. This has been a problem in the past, resulting in a number of sewage overflows including ones in May and October of 2015. A consent decree with the U.S. Environmental Protection Agency was passed to work to mitigate these issues. SAWS has invested funds to fix the collection system, remove obstructions, and is in the process of developing a new sewer system model to better prepare for, track, and respond to these events. This project represents a major investment in the sewer infrastructure over the next 10 years that could greatly decrease the number of sewer overflow events. It is important however that future climate projections be incorporated to ensure these modifications are effective.

5.5.3 Municipal water peak demand

Per capita water use has been decreasing in the City. In 2011, residents used 143 gallons of water per person per day in 2011. That number fell to 126 gallons per person per day in 2013 and 121 gallons per person per day in 2014. These per capita improvements, although significant and important, could be challenged by annual extreme temperatures and drought-like conditions. Consecutive days without rain and high heat conditions, especially when combined with the projected populations growth of 20,000 new residents a year, have the potential to increase peak water demand. Accordingly, despite SAWS aims to continue to set more progressive conservation goals in the next update of its Water Management Plan, the committee felt that this was a Key Area of Concern to consider. According to the Draft Conservation Plan:

> *"There are time periods when SAWS has an excess of water supply needed for the community and time periods when curtailed permits and drought reduce the Edwards supply by up to 44%. The combination of rapidly growing population, a growing economy, prolonged drought periods and decreased water source permits has required San Antonio to be innovative in its approach to water planning (page 2)[41]."*

To plan for a future where more municipal water will be needed, especially during dry months or years, SAWS uses the drought of record (1950-1958) in their simulations of water supply needs. SAWS currently relies solely on historical experience, rather than climate projections, which may not be sufficient to guide preparedness efforts over the longer term. Figure 27 above shows how SAWS uses historic drought conditions to plan for the future. By 2020, SAWS will have developed more water supplies, including the implementation of its brackish groundwater desalination program. Further, they are connecting themselves to other water sources through a regional pipeline network, thereby providing redundancy in the system and creating the ability to shift water from one location to another, enhancing overall resilience within the system.

Resulting from far-reaching efforts to conserve water, municipal water use is on the decline (Figure 28). Because of this, and other forward-thinking efforts on SAWS and the City of San Antonio, the committee rated this Key Area of Concern a low vulnerability.

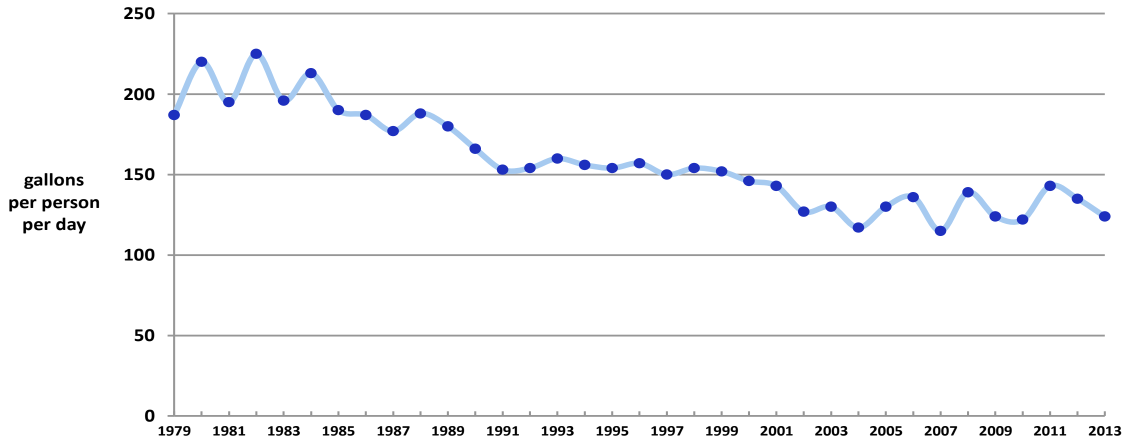


Figure 28: Daily Per Capita Water Use in gallons per person per day in San Antonio from 1979-2013[44].

5.5.4 Cooling water available for power plants

According to the *Hazard Mitigation Plan*, during times of drought,

> *"The service that will be the most directly impacted will be utilities, both water delivery and electric (for those producers that rely on hydroelectric production or nuclear power generation methods, as some providers in the region do). Without a steady supply of water, utilities may cut back energy generation and service to their customers and possibly to prioritize the service that they are able to provide (Section 5 pages 9 -10)[5]."*

One climate related concern is that increasing temperatures will increase evaporation rates for Lake Calaveras and Lake Braunig, two critical water sources for cooling power plants. Without either sufficient water for cooling, or if cooling water temperatures are too high, power production can be reduced or limited. CPS Energy's ability to divert water for cooling is limited by the Texas Commission on Environmental Quality. This could create a potential vulnerability, as there is increasing competition for surface water. Despite this, the committee felt that the vulnerability was low and discussion centered on the need to:

- Develop a direct pipeline from SAWS Dos Rios Water Recycling Center to CPS Energy;
- Increase investment in renewable energy sources to obviate the need for diversion of water; and
- Develop larger or variable speed pumps so that diversions can be better timed with diurnal availability.

6.0 Actions and Next Steps

There are many ways that the City, community organizations, and partners throughout the region can work together to prepare for extreme weather events and anticipate the impacts of a changing climate. When done well, these efforts can greatly reduce the climate related vulnerability of the region and help San Antonio continue to be an attractive and vibrant community far into the future.

When it comes to building resilience, there is no silver bullet or one size fits all strategy that can be used everywhere. The strategies shown below are based on a combination of best practices from other communities as well as input from residents of San Antonio, the Resilience Advisory Committee, the Sustainability Plan Steering Committee, and the City's leadership team. These strategies represent some of the most promising approaches to building resilience to the identified weather and climate related risks. Under each theme, the table highlights key sustainability strategies currently under review as part *SA Tomorrow* planning process and the bulleted list identifies additional relevant practices from other communities.

6.1 Flooding

Flooding 1: Flood Risk Management

Key strategies from the SA Tomorrow Plan	Focus Area
Integrate a climate change questionnaire in the building development review process to assess how climate change could impact new development and major renovations and encourage developers to design their buildings to be resilient to these impacts.	Green Buildings & Infrastructure
Adopt a low impact development standard requiring 100% of onsite stormwater management for all new development and significant retrofits.	Green Buildings & Infrastructure
Create a stormwater utility and produce incentives for existing developments to manage 100% of stormwater onsite.	Green Buildings & Infrastructure

Key Strategies from Other Communities:

- "Identify appropriate flood risk acceptance and develop supporting standards and guidelines. Three options include:
    - *Informed Science Approach*: Use the best available climate science data to determine future flood conditions, and elevate structures above that future flood level.
    - *Freeboard Value Approach*: Elevate structures and facilities two feet for standard projects and three feet for critical projects above the 100-year flood level.
    - *500-Year Elevation Approach*: Elevate structures to the 500-year flood level (a flood with a 0.2 percent chance of occurring in any given year). *FEMA, North Olympic Peninsula, WA.*

- Adopt and enforce updated building codes. Stricter building codes for new construction and existing facilities may help the city protect its building stock from flooding as well as wind, and prolonged power outages. Targeted strategies include building code legislation/regulation changes, adjustments to zoning regulations, incentive programs, and best practices guides. *Salem, MA, Durham, NC, and Lafourche Parish, LA.*
- Limit or restrict development in future flooding areas. The first step is to review the existing regulations and zoning ordinances, review historical flood events and insurance claims, review future flooding levels, and determine implications to tax base and private property rights. *Salem, MA and Seabrook, NH.*
- Retrofit existing structures and study and implement zoning changes to encourage construction only of new resilient buildings in the 100-year floodplain. *New York City, NY* ***or*** Retrofit or elevate structures to the 500-year flood level (a flood with a 0.2 percent chance of occurring in any given year). *Durham, NH and Chester, PA.*
- Establish new road and street grade and building first floor elevation and infrastructure requirements covering the life-cycle of such construction based on the flood elevations projected in this study to 2050 and 2100 (i.e. preferably an elevation that exceeds current city, state, and FEMA standards). *Portsmouth, NH.*
- Improve on-site stormwater management practices such as: creating monetary & non-monetary incentives for stormwater management or re-use, including within Low Impact Development (LID) projects or creating pilot projects to demonstrate the value of on-site stormwater management (examples include green roofs, rain gardens, cisterns, and bioswales). *North Olympic Peninsula, WA*.

<u>Flooding 2: Utilize FEMA's Community Rating System</u>

Key strategies from the SA Tomorrow Plan	Focus Area
Join FEMA's Community Rating System program.	Green Buildings & Infrastructure

Key Strategies from Other Communities:

- Dedicate a staff person to learn more about what is involved in participation in the FEMA Community Rating System (CRS - http://www.fema.gov/national-flood-insurance-program-community-rating-system).
- Assess and review opportunities for continuing education courses offered by FEMA's Emergency Management Institute (EMI), including courses on floodplain management and the NFIP's CRS.
- Evaluate and, if needed, develop more stringent regulations for homeowners in flood zones, so that the community is eligible for a reduction in insurance rates. *North Olympic Peninsula, WA, San Diego, CA, Swinomish, WA, Chester, PA, Lewes, DE, and Dorchester, MD.*

Flooding 3: Outreach to those living within floodplains

Key strategies from the SA Tomorrow Plan	Focus Area
Initiate a climate education campaign for businesses and property owners, including details about how to make built infrastructure more resilient to existing and projected changes in climate.	Green Buildings & Infrastructure

Key Strategies from Other Communities:

- Develop and distribute outreach and educational materials for building owners and tenants about the risk of living in areas vulnerable to floods. *San Diego, CA and Somerset, MD.*
- Mail flood safety information, including evacuation zones and routes, and "turn around, don't drown" key messages about flash flooding, to all residents within the city. *Waveland, MS and Durham, NH.*
- Establish a homeowner education program on flood mitigation measures to encourage owners of repetitive and severe repetitive loss properties citywide to participate in mitigation activities such as flood proofing, elevation, or buyout programs, and prepare a floodplain management plan for the repetitive loss areas. *Waveland, MS and Lafourche Parish, LA.*
- Enhance efforts to educate home and business owners on the value of on-site water conservation, retention, and catchment. *North Olympic Peninsula, WA.*

Flooding 4: Acquire and remove high-risk structures in flood zones

Key Strategies from Other Communities:

- Identify sources of funding, such as FEMA, to purchase high-risk structures for demolishment or flood proofing.
- Explore creative financing programs or cheaper insurance structures to help incentivize residents to move out of vulnerable areas. *North Olympic Peninsula, WA.*

Flooding 5: Floodplain restoration

Key strategies from the SA Tomorrow Plan	Focus Area
Evaluate and adopt ordinances to create buffer zones around floodplains, riparian areas, and other natural priority areas	Natural Resources
Adopt conservation development friendly ordinances that minimize development in natural greenways, floodplains, near waterways in order to protect watershed and allow for more greenspace	Natural Resources

Key Strategies from Other Communities:

- Protect, restore, and enhance floodplains, thereby increasing the ability of the aquatic systems to hold high flows, filter sediment, and allow replenishment of groundwater stores and to address health concerns related to flooding such as controlling disease vectors. *San Luis Obispo, CA and Flagstaff, AZ.*

- Restore proper function to floodplains and stream channels. By reconnecting, re-vegetating, and re-contouring floodplains and stream channels, these systems should be used to provide water storage, groundwater recharge, sediment capture, and flood abatement and also provide essential habitat for aquatic and terrestrial species. *Dane County, WI.*

Flooding 6: Protect Wastewater Treatment

Key Strategies from Other Communities:

- Provide flood protection for key water treatment facilities and assets. Reduce flooding hazard potential along creeks, rivers, or other flowing water intake sources; flood-proof structures or features at water department sites; and protect vulnerable assets in low lying areas. *Santa Cruz, CA.*
- Continue working to reduce inflow and infiltration to wastewater systems. This could include: working to identify current inflow and infiltration to wastewater system and enhancing funding to accelerate repairs and replacement of critical areas. *North Olympic Peninsula, WA.*

Flooding 7: Update Emergency Management and Response Planning

Key strategies from the SA Tomorrow Plan	Focus Area
Establish a network of "block captains" that can be activated to go door to door to check on the health of high risk neighbors during or after a disaster.	Public Health

Key Strategies from Other Communities:

- Prior to a hazard event, identify lead contacts serving vulnerable populations and coordinate actions to maximize safety and information sharing. Leads can assist and provide support during hazard events.
- Establish a network of “block captains” that can be activated to go door to door to check on the health of high-risk neighbors. Some examples of other neighborhood emergency management outreach materials are available from Seattle (here and here) or for Baltimore City.
- Continue to work with residents to create a home emergency kit that ensures that all residents have the resources they need to survive during an event. This kit should include back-up medications, rations of food, and secondary communication technologies.
- Expand training and education of health and social services systems/providers to identify and treat mental health problems after extreme climate events.
  North Olympic Peninsula, WA; Seattle, WA; Baltimore, MD.

6.2 Extreme Heat

Heat 1: Coordinate Social Services for Extreme Heat Events

Key strategies from the SA Tomorrow Plan	Focus Area
Review effectiveness of cooling centers and other high heat day strategies and identify underserved areas for increased expansion of existing strategies or new strategies to mitigate the effects of high heat days.	Public Health
Expand the number of publicly accessible parks and open space areas within the city.	Public Health
Develop a "Healthy by Design" program for all new affordable housing projects.	Public Health
Expand the solar hosting program, increasing installations at low income and affordable housing units.	Energy
Create incentives to encourage the development of affordable housing in transit rich areas throughout the city.	Land Use & Transportation

Key Strategies from Other Communities:

- Facilitate networking and coordination of social services to vulnerable populations in anticipation of extreme heat events. *Chester, PA, Lee County, FL, and New York City, NY.*
- Evaluate and enhance the cooling plan for extreme heat events for each community, with special attention to vulnerable populations, through the expansion and provision of cooling stations throughout the city. Ensure that planning includes provision of transportation services for those who need them. *Chester, PA, Confederated Salish and Kootenai Tribes, and Lee County, FL, Baltimore, MD, Metropolitan Washington Council of Governments, and Benton County, OR.*
- Strengthen and expand the notification system for residents, schools and businesses during extreme heat events. *Chula Vista, CA, Swinomish, WA, and Benton County, OR.*
- Develop public health surveillance programs to monitor heat-related illness. *Chester, PA.*

Heat 2: Decrease the Urban Heat Island Effect

Key strategies from the SA Tomorrow Plan	Focus Area
Adopt an urban heat island mitigation ordinance for all new developments and major renovation projects.	Green Buildings & Infrastructure
Expand the number of publicly accessible parks and open space areas within the city.	Public Health
Develop a Street Tree Strategic Plan.	Natural Resources

Key Strategies from Other Communities:

- Identify "heat island" areas of the community and increase ground cover and shade by creating or expanding urban forests, community gardens, parks, and native vegetation-covered open spaces. Other strategies include green roofs, cool roofs, and cool pavements. *Lee County, FL, Austin, TX, Baltimore, MD, and Metropolitan Washington Council of Governments.*

6.3 Drought

Drought 1: Residential Water Conservation

Key strategies from the SA Tomorrow Plan	Focus Area
Update water efficiency standards in city building codes	Green Buildings & Infrastructure
Pilot a building energy and water disclosure and benchmarking program.	Green Buildings & Infrastructure
Adopt a program to phase large commercial buildings off of potable water use for landscaping.	Natural Resources

Key Strategies from Other Communities:

- Extend or enhance incentives (rebates or grants) to use of drip irrigation, rain barrels and cisterns, and other residential conservation methods. *North Olympic Peninsula, WA.*

Drought 2: Landscaping with Native and Drought Tolerant Plants

Key strategies from the SA Tomorrow Plan	Focus Area
Expand incentives for native plants/low-water use landscaping and other residential water conservation strategies	Natural Resources

Key Strategies from Other Communities:

- Enhance existing outdoor planting incentives (rebates or grants) program for native, drought tolerant plants, and rainwater-capturing landscapes.
- Partnerships with the City of San Antonio's arborists could be strengthened to maintain genetic diversity and make climate resilient and drought tolerant tree species publicly available, especially under the City's Landscaping and Tree Preservation Ordinance.
- Develop financial, regulatory, or other incentive program to promote greater use of native plants at homes and at industrial/commercial sites.
- Provide incentives for removing lawns and invasive species and replacing them with native plans.
  North Olympic Peninsula, WA.

Drought 3: Education on Water Conservation, Retention, and Catchment

Key strategies from the SA Tomorrow Plan	Focus Area
Adopt a low impact development standard requiring 100% of onsite stormwater management for all new development and significant retrofits.	Green Buildings & Infrastructure
Enhance incentives for existing developments to manage 100% of stormwater onsite	Green Buildings & Infrastructure

Key Strategies from Other Communities:

- Create outreach materials to explain to home and business owners the value of on-site stormwater retention, rainwater catchment, availability of incentives, and value to the community and ecosystems.
- Educate on the broader issue of the need for water conservation, retention, and catchment.
  North Olympic Peninsula, WA.

6.4 Wildfire

Wildfire 1: Address the Wildland-Urban Interface

Key Strategies from Other Communities:

- Manage forest density for reduced susceptibility to drought stress. This includes developing a strategy to reduce biomass fuel in the wildland-urban interface. *Jamestown S'Klallam Tribe, WA, and Santa Cruz, CA.*
- Monitor trends in forest condition and climate to proactively identify areas with high susceptibility to wildfire. *Jamestown S'Klallam Tribe, WA.*
- Develop wildfire management overlay zones for high-risk areas that control new development regarding density, building location, and design and fuel management. This may require adding additional staffing to implement these strategies. *La Plata, CO and Boulder County, CO.*
- Adopt and maintain FireWise community standards and fire buffer zones. *Swinomish Indian Tribe, WA.*
- Regulate development in and adjacent to the wildland-urban interface to require new development in high-risk areas to be responsible for fire prevention activities (visible house numbering, use of fire-resistant and fire-retardant building and landscape materials) and to also provide a defensible zone to inhibit the spread of wildfires. *Santa Cruz, CA.*

6.5 Climate Information

In many cases, it can be valuable to obtain climate projections, information, or analysis that is tailored to be useful in specific decisions. For example, some communities (such as Boulder, CO; Chicago, Il; Las Cruces, NM; Miami, OK; and San Angelo, TX) have identified key climate or weather related thresholds of concern and then had analysis done to identify potential changes to the frequency that those thresholds will be crossed in the future given different climate scenarios. This information can be useful in making decisions related to human health, water supplies, emergency management, and other city operations. ***The City, and other local and regional organizations partners who have participated in this assessment, should consider having this additional climate analysis done to help make the climate information more useful and usable by the departments and organizations across the county.***

7.0 Appendices

Appendix 1: Comprehensive Key Areas of Concern List

Temperature

1. Poor air quality/non-attainment due to increased ozone from increased temperatures (specifically affecting transportation projects that could increase capacity).
2. Decreased air quality due to increases in temperatures.
3. Increased rainfall and increased heat index resulting in increase health effects (specifically to vulnerable populations, such as the elderly, chronically ill, young, low income, etc.).

Water

1. Housing development affected by increased precipitation (building deadlines) and drought (landscaping).
2. Drought impacts:
    a. In combination with increased precipitation resulting in erosion/soil shifting
    b. Meeting peak demand for municipal water use (economic effects).
3. Water quality impacts with flooding.
4. Wastewater impacts due to increases in peak flow with flooding and drought cycles (the total costs of the Consent Decree between SAWS and the U.S. EPA is $1.2 Billion and this investment, while not driven by climate change, will likely have some co-benefits that help with reducing infiltration during heavy rainfall events).
5. Drainage costs to deal with flooding.
6. Flooding and drought impacts on crops (especially in dealing with food insecure populations).
7. Storm water pollution prevention during flooding especially during construction (2" rain=2-year storm).
8. Evacuation plans with increases in flooding.
9. Respiratory impacts due to flooding/mold.
10. Project delays due to flooding/extreme rain (Floods of 1998 and 2002 are examples), and building confidence in the flood forecasting system.
11. Economic costs/staffing to deal with increased maintenance of parks due to increases in rain (increased need to mow).
12. City Police Department staffing strains/risks during times of flooding/road closures.
13. Metro Transportation interruptions and impacts to evacuations due to flooding.
14. Drought and the economic effects to drawing new business to City.
15. Drought and fire impacts/incidence.
16. Drought and financial impacts to deal with conservation.
17. Flooding and revenue shortfalls for municipal water usage: less use by the public equates to less money for SAWS.
18. Lots of variability in the impacts due to flooding in the city:
    a. "Significant intersections"
    b. Woodlawn
    c. 281 Basin
    d. Watershed Master Plans' Damage Centers
    e. Floodplain—15,000 structures within the 100-year flood plain
    f. Leon Creek
    g. East Side

h. Plumb Mobile Home Community
i. Low Water Crossings (220 within the city)

Other Extreme Weather Events

1. High winds and their impacts on power supply and resulting oil spills.
2. Ice and transportation impacts (e.g. bridge structures and road closures).
3. Wildfires and secondary impacts from hurricanes and micro-bursts.
4. Extreme/High Winds.

Appendix 2: Resilience Advisory Committee Members

Resilience Advisory Committee Members	
Name	**Organization**
Donovan Agans	University Health System
Leroy Alloway	Alamo Area MPO
Jose Banales	San Antonio Police Department
Robert Brach	Bexar County Public Works
Alison Buck	VIA Metropolitan Transit
Anthony Chukwudolue	City of San Antonio (CoSA) Transportation & Capital Improvements
Steven Clouse	San Antonio Water System
Kyle Coleman	Emergency Management Coordinator, Bexar County OEM
Adam Conner	San Antonio Water System
Rene Dominguez	CoSA Economic Development Office
John Dugan	CoSA Planning & Community Development
Gregg Eckhart	San Antonio Water System
Karen Guz	San Antonio Water System
Nathaniel Hardy	Bexar County Flood Control
Terry Kannawin	CoSA Development Services
Beth Keel	San Antonio Housing Authority
Rachelle Littlefield	San Antonio Office of Emergency Management
Elizabeth Lutz	Bexar County Health Collaborative
James Mendoza	San Antonio Office of Emergency Management
Roger Pollok	CoSA SAMHD
Abigail Rodriguez	VIA
Darcie Schipull	Texas Department of Transportation
Kim Stoker	CPS Energy
Lawrence Trevino	San Antonio Office of Emergency Management
Wayne Tschirhart	SARA
Xavier Urrutia	CoSA Parks and Recreation
Carl Wedige	CoSA Fire
Paul Yura	National Weather Service

Appendix 3: Sensitivity and Adaptive Capacity Levels

The relative vulnerability of the Key Areas of Concern depends on the combination of the *sensitivity* and *adaptive capacity* scores.

Sensitivity Levels	
S0	System will not be affected by the impact
S1	System will be minimally affected by the impact
S2	System will be somewhat affected by the impact
S3	System will be largely affected by the impact
S4	System will be greatly affected by the impact

Adaptive Capacity Levels	
AC0	System is not able to accommodate or adjust to impact
AC1	System is minimally able to accommodate or adjust to impact
AC2	System is somewhat able to accommodate or adjust to impact
AC3	System is mostly able to accommodate or adjust to impact
AC4	System is able to accommodate or adjust to impact in a beneficial way

Appendix 4: Vulnerability Assessment Worksheet Instructions

Vulnerability and Adaptive Capacity Exercise

Instructions

Column 1 **Key Area of Concern –** This lists the Key Area of Concern to analyze and consider for this activity.

Column 2 **Changing Climate Condition –** Input the climate condition that would impact that key area of concern listed in Column 1.

Column 3 **Current Climate/Weather Impacts –** Identify how existing and historic changes in weather and climate have affected or are currently affecting the key area of concern listed in Column 1.

Column 4 **Possible Future Impacts** – Identify possible impacts to the key area of concern if the projected changes in climate (Column 2) take place.

Column 5 **Non-Climate Stressors –** Record any non-climate factors that currently affect (positively or negatively) the key area of concern.

Column 6 **Assign Sensitivity –** Using the orange *Exposure & Sensitivity Levels* table (below) decide how sensitive you believe this key area of concern is to the changing climate condition and input this number into column 6 (i.e.: S4).

Column 7 **Ability to Adapt -** Identify existing attributes or assets of the key area of concern that will help it adapt to the changing climate condition.

Column 8 **Resources Needed -** Identify any external resources or actions that the key area of concern will need to adapt to the changing climate condition.

Column 9 **Assign Adaptive Capacity -** Using the purple *Adaptive Capacity Levels* table, assess how much capacity you believe the key area of concern has to adapt to the changing climate condition and input this number into column 9 (i.e.: AC2).

Repeat steps for each Key Area of Concern

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