



CLIMATE RESILIENCE ACTION PLAN

for City Assets and Operations

APRIL 2018





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Executive Summary



2011 Wildfires

Since passage of a ground-breaking City Council Resolution in 2007, the City of Austin has been a leader in the effort to reduce the negative impacts of climate change. Austin has an aggressive carbon neutrality goal for municipal operations, as well as a net-zero goal for community-wide greenhouse gas emissions. However, impacts from climate change are being experienced today; strategies for resilience are needed for Austin to be prepared for those impacts.

The Council-adopted Austin Community Climate Plan includes a recommendation to continue climate resilience planning efforts to protect City operations and assets, and in 2015, Mayor Steve Adler signed the Compact of Mayors, now known as the Global Covenant of Mayors for Climate and Energy. The

Global Covenant provides a standard for measuring and reporting emissions, climate risk, and climate change mitigation efforts.

Climate resilience is the ability to effectively manage both immediate shocks and long-term stressors related to climate change and weather extremes. Prepared and responsive city systems are the fundamental components of resilience for Austin's overall community. While immediate response is required in the event of a catastrophe or natural disaster, ongoing adaptation through long-range planning and strengthening City assets and operations will ensure that Austin is always prepared for changing climate conditions.

This Climate Resilience Action Plan provides an overview of climate projections for Austin, an assessment of potential extreme weather impacts to City-owned assets and operations, and strategies to mitigate those impacts. City-owned assets and operations that are critical for overall resilience include 1) **Utility Infrastructure** needed to deliver energy, water, wastewater, and telecommunications utility services to the community; 2) **Transportation Infrastructure**, such as critical arterial roadways, that support the transportation and mobility of citizens; and 3) **Community Facilities**, including recreation and activity centers, libraries, and neighborhood centers, that may be utilized as relief and assistance centers in the event of a disaster.

Four key climate hazards emerged as the most critical for both short- and long-term planning efforts: (1) **Extreme Heat**, (2) **Drought**, (3) **Flooding**, and (4) **Wildfire**. Climate projections for Austin suggest that there will be an increase in average annual temperatures, with high temperature extremes becoming more common. Precipitation patterns are expected to become more variable, leading to longer periods of drought interspersed with heavy rainfall events.

***Impacts from
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Climate resilience
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those impacts.***

Austin can expect
more extreme
weather in the future



high temperatures



extended periods
of drought



increasing risk
of wildfires



intense rainfall
events

Potential climate change impacts to City assets and operations include:

- **Increased heat** could impact electricity generation capacity, cause heat stress on outdoor workers and machinery, create excessive heat at facilities in need of upgrades, and increase peak energy and water demand.
- **Longer droughts** could cause shifting soils, resulting in damage to roads, bridges, building foundations, and underground utilities. Water shortages could also reduce the availability of cooling water for electricity generation.
- **Greater risk of wildfire** could create safety risks for emergency personnel and staff, interrupt utility service where there is a lack of redundant energy supplies, disrupt the transportation system, and challenge egress and ingress routes during major wildfire events.
- **Flooding from heavier precipitation** could create safety risks for emergency personnel and staff, impede access to utility facilities, damage facilities and infrastructure, disrupt the transportation system, challenge egress and ingress routes during major flooding events, overwhelm stormwater drainage systems, and disrupt utility service where there is a lack of redundant energy supplies.

This Climate Resilience Action Plan builds on current departmental efforts to increase resilience. Initiatives like Water Forward, Austin Water's 100-year plan to ensure a diversified, sustainable, and resilient water future, demonstrate the City of Austin's commitment to addressing the impacts of climate change in our community.

Recommendations

The following strategies were identified through a climate resilience planning process that included staff from across 15 City Departments. These strategies are designed to ensure that City assets and operations are prepared for and adaptive to extreme weather events and climate change:

- **Strengthen Emergency Response:** Ensure that emergency response plans incorporate possible climate changes that could impact the protection of staff, infrastructure, and facilities during emergencies and extreme weather events.
- **Expand Staff Safety Plans:** Incorporate climate risks into staff safety plans and procedures to provide a safe and healthy work environment for City staff.
- **Evaluate and Upgrade Existing Facilities and Infrastructure:** Determine facility and infrastructure upgrade needs and reinforce City assets to withstand climate impacts by providing utility redundancies, weatherizing buildings, and making other needed facility improvements.
- **Future-Proof New Facilities and Infrastructure:** Integrate climate change considerations into future infrastructure and capital improvements decision-making to create climate resilience co-benefits.

The City of Austin is already proactively anticipating potential future hazards, and these recommendations are not meant as a critique of existing efforts. Rather, this planning process acknowledges that due to ever-changing climate conditions, these processes could be reinforced and strengthened to increase resilience.



2013 Halloween Flood

Part I

Background and Climate Hazards

The need for resilience to extreme weather events and changing climate conditions is now strikingly evident with ongoing and repeated events in Austin, such as extreme heat, drought, flooding, and wildfires. Recognizing this urgency, several City commitments support creating a unified action plan to increase climate resilience.

Imagine Austin

The *Imagine Austin Comprehensive Plan* identifies the need to address climate change and make Austin more resilient:

“The challenges of a growing population, finite natural and fiscal resources, and a changing climate will require Austinites and their local government to become ever more resilient. Resilience — the ability to adapt to challenges and change — will be a hallmark of successful communities in the 21st century.”

To achieve *Imagine Austin*’s vision of a city that is a leading exemplar of sustainability, social equity, and economic opportunity, the City of Austin must prioritize climate resilience and turn weaknesses into opportunities.

Austin Community Climate Plan

City Council’s adoption of the Austin Community Climate Plan in June of 2015 reconfirmed Austin’s climate leadership by setting a community-wide goal of net-zero greenhouse gas emissions by 2050. The Plan also recognizes the importance of adaptation to increase resilience in the face of extreme weather and climate change impacts.

Recommendation 5 of the Austin Community Climate Plan states that the City of Austin should:

“Invest in further study of climate projections for Central Texas and research the most current science on global climate change trends. Continue climate resilience planning efforts by conducting vulnerability assessments to identify the people and assets most at risk from the impacts of climate change, as well as strategies that will protect people, the local economy, City operations and assets, ecosystems, and community infrastructure.”

The Global Covenant of Mayors

In 2015, Mayor Steve Adler signed the Compact of Mayors, an agreement launched by United Nations Secretary-General Ban Ki-Moon and his Special Envoy for Cities and Climate Change, Michael R. Bloomberg. The Compact falls under the leadership of the C40 Cities Climate Leadership Group (C40), ICLEI Local Governments for Sustainability (ICLEI), and the United Cities and Local Governments (UCLG) – with support from UN-Habitat, the United Nations’ lead agency on urban issues.

Now known as the Global Covenant of Mayors for Climate and Energy, the international climate agreement establishes a common platform to capture the impact of the collective actions of cities through standardized measurement of emissions and climate risk. The Global Covenant also requires consistent, public reporting of city efforts, including conducting assessments and creating a plan to become more resilient.

The City of Austin is successfully meeting the *mitigation* objectives set by the Global Covenant of Mayors. This Climate Resilience Action Plan will ensure that the City of Austin meets the *adaptation* goals of the Global Covenant of Mayors. The plan will also place Austin among the few cities that are fully compliant with the Global Covenant of Mayors, pushing the City to the forefront of urban resilience planning and climate preparedness.

Water Forward Integrated Water Resource Plan

Austin's drinking water comes from the Colorado River by way of the Highland Lakes. During the recent drought, water runoff, or inflow, that helps refill the Highland Lakes, was the lowest it has been since the lakes were built. According to climatology studies, Central Texas is likely to see more frequent extreme weather events, including severe prolonged droughts.

With a rapidly growing city and a changing climate, Austin Water is collaborating with other City departments, a Citizen Task Force, and the community to develop a water plan for the next century. This 100-year plan will recommend strategies to best manage our water supply and meet the community's future water needs. A key planning goal is to ensure a diversified, sustainable, and resilient water future in the face of drought and climate change uncertainties—utilizing adaptive management strategies that seek to enhance conservation, maximize local sources, and stretch current supplies.

The plan will provide a road map for ensuring a reliable and sustainable water supply for our community over the next 100 years. As Austin Water develops this plan, the utility will consider:

- Public input
- Strategies to reduce water demand
- Strategies to increase water supply
- Technical and engineering feasibility
- Climate science
- Cost and affordability
- Environmental impacts
- Social equity

***The City of Austin
must prioritize
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and turn weaknesses
into opportunities.***

Development of an Action Plan

Based on these commitments to address the threats facing Austin from climate change, the Office of Sustainability worked with multiple City departments to catalog efforts underway, identify impacts and vulnerabilities to City operations and assets, and develop potential solutions to mitigate those impacts.

Climate Adaptation Workshop

In March of 2017, the Office of Sustainability hosted a Climate Adaptation Workshop led by HR&A Advisors and The Rockefeller Foundation. The workshop brought together City staff, representatives from Travis County, and local academic, private, and non-profit partners to discuss Austin's resilience goals and begin to develop projects and partnerships to help increase Austin's resilience to impacts due to climate change. This joint effort helped the Office of Sustainability identify additional stakeholders to include in the resilience planning process and garner support for the work that culminated in this Climate Resilience Action Plan.

Plan Scope and Goals

The Climate Resilience Action Plan outlines key strategies for the City of Austin's **operations, asset management, and long-range planning** in response to actual and anticipated climate change. It covers the services directly managed by City of Austin departments and *does not* consider resilience strategies and actions for external stakeholders and the broader Austin community.

This Action Plan describes key strategies for the City's physical assets (energy, water, and telecommunications infrastructure, roads, and community facilities) to be implemented by the departments responsible for maintaining them. Through continual improvement initiatives, sustainability goals, and master plans, City departments are already making progress toward improving the City's resilience; this plan is intended to assist departments in aligning current efforts, as well as address cross-departmental gaps.



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Chapter 1

Framing Climate Resilience



2013 Halloween Flood

What is Resilience?

Climate resilience refers to the ability to effectively manage both immediate shocks and long-term stressors related to climate change and weather extremes. Prepared and responsive city systems are the fundamental components of a climate resilient Austin. While immediate response is required in the face of a catastrophe or natural disaster to minimize damage and human losses, ongoing adaptation through long-range planning will ensure that Austin is always prepared for changing climate conditions.

Vulnerability to climate change is a product of three main factors:

Exposure:

The degree to which a system is exposed to climatic variations.
Homes built in floodplains are more exposed to flooding events.

Sensitivity:

The degree to which a system is affected by climate variations.
Children and the elderly are more sensitive to hot summer temperatures.

Adaptive Capacity:

The ability of a system to adjust and moderate damage.
A neighborhood with greater tree canopy coverage and green infrastructure is better suited to adapt to hotter temperatures and intense rainstorms.

Reducing vulnerabilities by minimizing exposure, decreasing sensitivity, and increasing adaptive capacity will contribute to a more resilient and thriving Austin. Ultimately, resilient cities are prepared for extreme weather events; resiliency reduces impacts to the community and requires less recovery time from shocks and stressors.

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A Framework for Building Climate Resilience

The Global Covenant of Mayors outlines three requirements for climate adaptation and resilience: 1) identification of Climate Hazards, 2) development of a Climate Vulnerability Assessment, and 3) creation of a Climate Resilience Plan.

This Climate Resilience Action Plan meets Global Covenant requirements and provides information for three major planning activities:

Part I:

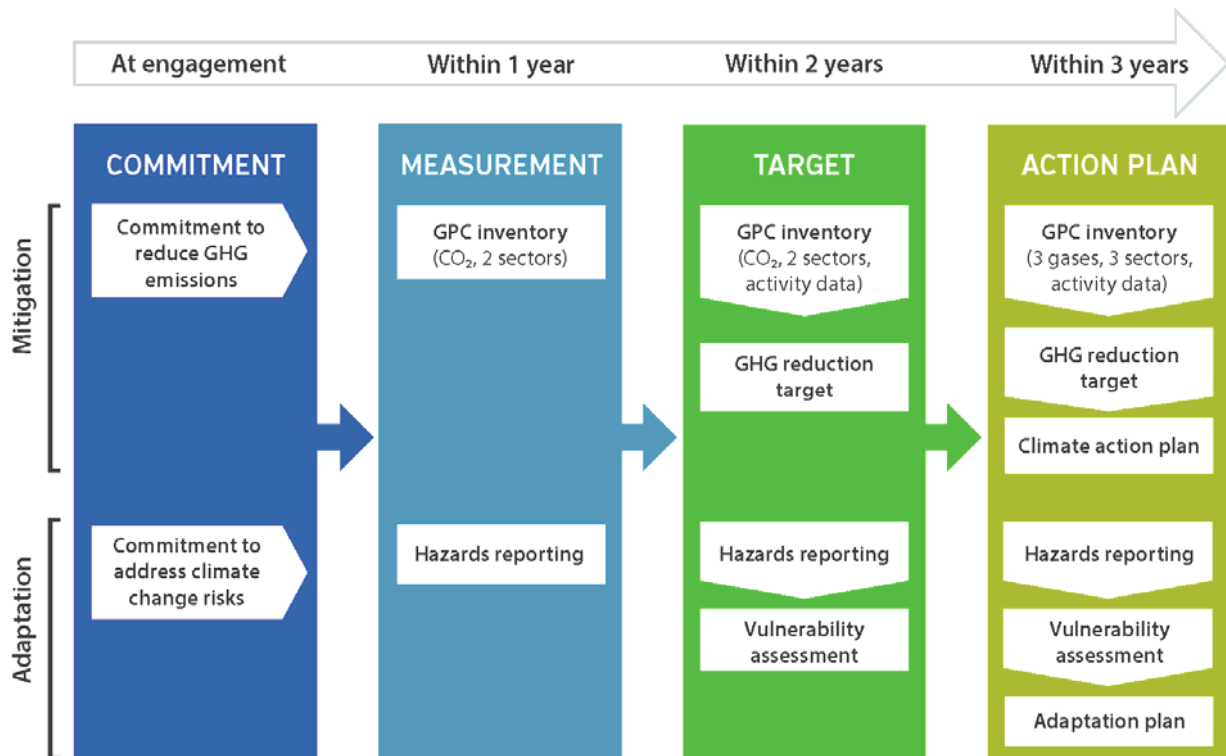
Identification of Climate and Extreme Weather Hazards

Part II:

Vulnerability Assessment of City of Austin Assets and Facilities

Part III:

Strategies to Increase Resilience to Climate Change



Global Covenant of Mayors: Definition of Compliance

Summary of Climate Projections

The Office of Sustainability worked closely with ATMOS Research, led by Dr. Katharine Hayhoe, to conduct geographically specific climate models for Austin through 2100 using the Camp Mabry Weather Station. To address uncertainty around various human activities, preliminary projections for Austin are based on two emissions scenarios:

Lower Scenario:

Global carbon emissions peak and then decline by end of century.

Higher Scenario:

Continued dependence on fossil fuels means that carbon emissions continue to grow throughout the century.

The climate projections summarized here are averaged over 30-year time scales to address natural variability, which can cause climate variations from year to year or even decade to decade.

CLIMATE PROJECTIONS FOR AUSTIN	Historical Observed	Near-term (2011-2040)	Mid-century (2041-2070)		End-of-century (2071-2100)	
			Lower	Higher	Lower	Higher
Temperature						
Summer average high temperature (°F)	93.8	96.9	97.9	100.2	98.6	103.8
Cold nights (minimum temperature < 32°F)	16.6	10.8	7.8	6.4	7.0	3.9
Warm nights (minimum temperature > 80°F)	0.5	5.4	10.5	39.5	17.0	86.7
Hot days (maximum temperature > 100°F)	11.7	31.4	40.1	63.2	46.5	92.3
Very hot days (maximum temperature > 110°F)	0.0	1.3	0.4	11.6	0.9	19.5
Precipitation						
Annual precipitation (inches)	33.7	31.8	33.6	33.3	33.0	31.4
Dry days (<0.01 inches in 24 hours)	277.3	280.3	280.6	282.7	281.4	288.1
Longest dry spell (days)	53.1	53.3	54.4	54.7	54.0	60.4
Wet days (>2 inches in 24 hours)	2.2	2.5	2.8	2.7	2.8	2.8
Wettest 5 days (inches of precipitation)	5.8	7.2	7.6	7.7	7.8	7.8

Projections are based on the draft results reported in the 2014 Third National Climate Assessment and simulations from nine newer global climate models. Additional detail is provided in the Appendix of this document.



2015 Memorial Day Flood

Part II

Vulnerability Assessment

Over the course of the last year, a Climate Resilience Team, consisting of staff from multiple City of Austin departments, held work sessions to discuss impacts to City operations due to extreme weather events, such as extreme heat, drought, flooding and wildfire. During these meetings, the Climate Resilience Team also identified and analyzed potential issues that may arise in the future. With these risks in mind, staff conducted a vulnerability assessment of major City assets and facilities. An important tool for highlighting priority action areas, this vulnerability assessment informs department-specific and citywide resilience strategies.

Contents and Scope

The vulnerability assessment analyzed three distinct sectors*:

1. **Utility Infrastructure:** Large electric utility, water and wastewater assets, and telecommunications network infrastructure.
2. **Transportation Assets:** Critical arterial roads in the jurisdiction of or partially operated by the City of Austin, plus City fleet assets.
3. **Community Facilities:** City recreation, activity, neighborhood centers, and public libraries.

The vulnerability assessment for each of these sectors followed a unique methodology due to the distinct nature of the assets and facilities analyzed.

* Public safety facilities, including stations, training centers, and other facilities operated by the Austin Police Department, Austin Fire Department, and Austin-Travis County Emergency Medical Services, were also analyzed in a separate assessment process.

Chapter 2

Utility Infrastructure



Methodology

The City of Austin owns and operates an expansive inventory of utility assets, including electric, water, wastewater, and telecommunications infrastructure. This vulnerability assessment considered potential climate change impacts to a select number of critical utility infrastructure assets.

Utility assets were designated as critical due to their size or importance for department operations and service delivery. For

Austin Energy, these include major generating facilities, primary control and operations centers, and primary service centers. For Austin Water, water and wastewater treatment plants, and primary control and operations centers were included. Critical telecommunications network nodes managed by the Communications and Technology Management Department are also included in this assessment.

Both Austin Energy and Austin Water also manage a system of critical infrastructure for delivery of electricity and water. The vulnerability of those assets will be further evaluated by those departments independently.

Threats to Utility Infrastructure

The main climate-related threats considered in this vulnerability assessment are divided into two categories: shocks and stressors. Shocks are sudden events, such as flooding and wildfires, while stressors have a longer duration and include drought and extreme heat. Given climate projections for Austin, shocks and stressors have the potential to affect capacity or disrupt the function of City assets.

Approach

The Office of Sustainability worked with a group of engineers, planners, and other asset managers from Austin Energy, Austin Water, Communications and Technology Management, Austin Transportation, Public Works, and other departments to use methodology based on the Vulnerability Assessment Tool (VAST) established by the U.S. Department of Transportation.

Utility assets were evaluated based on the following components of vulnerability:

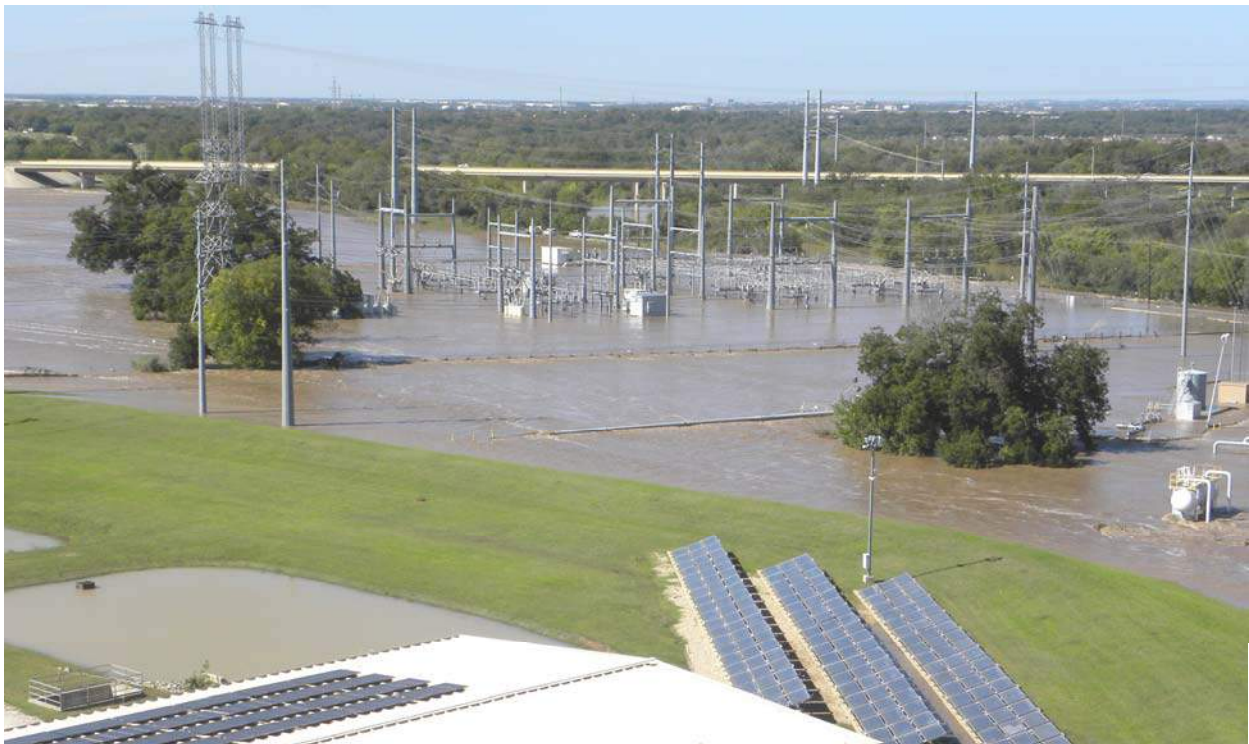
- **Exposure:** Is the asset likely to experience a climate-related hazard?

- **Sensitivity:** What are the impacts of exposure for the asset?
- **Adaptive Capacity:** What is the asset's ability to mitigate impacts or recover after a climate-related event?

Indicators, survey data, and geospatial data were used to measure and assign scores for each of these three components.

Data Sensitivity and Security Concerns

Due to security concerns and protocols regarding the safeguarding of utility data, locational information and other sensitive data are not included in this report.



2013 Halloween Flood

Austin Energy

Austin Energy is proactive in anticipating extreme weather in the future, and has many mechanisms already in place to reduce impacts to electric utility infrastructure. Austin Energy has an established emergency response and incident command framework that is activated when weather events have the potential to affect assets and operations, and multiple internal teams and processes account for weather variability and risk when planning and forecasting. Austin Energy is also a member of the U.S. Department of Energy's Partnership for Energy Sector Resiliency. During this vulnerability assessment, Austin Energy identified the following climate-related concerns as important areas for future resilience planning:

- **Impeded access to facilities during floods.** Past storm events, including the 2015 Halloween Floods, have made some roads impassable to and from critical utility facilities. This raises concerns about staff safety, as well as continuity of operations during severe flood events.
- **Heat impacts on generation capacity.** Austin Energy's generation facilities are sensitive to extreme heat. With average summer high temperatures expected to increase between 4 and 9°F by the end of the century, extreme temperatures may impact generation capacity.
- **Water availability.** Austin Energy power plants, as well as others that support the electric grid, rely on surface water for cooling. Some generation facilities rely on treated water for electricity generation. Any potential impediment to the use of treated or surface water for electricity generation during times of drought could affect capacity.
- **Staff safety during wildfires.** Future wildfire threats near Austin Energy facilities pose emergency response and staff safety concerns.

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Austin Water

Austin Water has been addressing the impacts of a changing climate for over ten years through aggressive conservation programs and operational changes. Austin Water's asset management team is advancing a risk based infrastructure management framework that aims to account for specific threats stemming from climate change, such as drought and floods.

Soon after Austin Water strengthened its conservation and climate programs in 2007, the Austin region experienced an extreme drought worse than the drought of record in the 1950s that was broken by intense flooding. Using the lessons learned from these events, Austin Water has increased its ability to respond to climate-related threats. In the vulnerability assessment of large water and wastewater utility assets, Austin Water identified the following issues as key climate-related concerns:

- **Impeded access to facilities during floods.** Similar to Austin Energy, flooding has also caused access problems at critical Austin Water facilities. In very large flood events, roads leading to and from major facilities have become blocked, limiting access to these facilities.
- **Need for system-wide redundant energy supplies.** With heavy rainfall and intense storm events expected to become more frequent, large water and wastewater facilities with dual electricity feeds may be less vulnerable to potential power failure.
- **Staff safety during wildfires.** Facilities with limited points of access may face egress and ingress challenges during wildfire events.

Communications & Technology Management

Communications & Technology Management manages a citywide telecommunications network consisting of key network nodes housed at several City of Austin facilities. These network nodes are made up of electrical equipment and servers that are highly sensitive to water and extreme heat exposure. Flooding and proper drainage is a major concern and the current condition of these network node facilities is not well known. Inadequate ventilation and outdated weatherization could also impact the performance of the City of Austin's telecommunications network during periods of extreme heat.

Cross-Cutting Utility Issues

The utilities vulnerability assessment for Austin Energy, Austin Water, and Communications and Technology Management revealed several issues that affect multiple departments across the City organization and require further study:

- **Financial Impacts:** Increased average temperatures and drought conditions could affect utility demand and revenue. Financial impacts from climate-related disruptions to utility operations requires further assessment.
- **Understanding Watershed Impacts:** There is a need to better understand the impacts of climate change on Austin's watersheds and their relationship to future flooding risk at utility facilities.
- **Staff Safety:** Increased average temperatures and more extreme summer temperatures may place excessive heat stress on staff working outdoors or in maintenance shops and facilities without air conditioning. Protocols for staff safety in the face of extreme heat and other climate stressors are needed.

Chapter 3

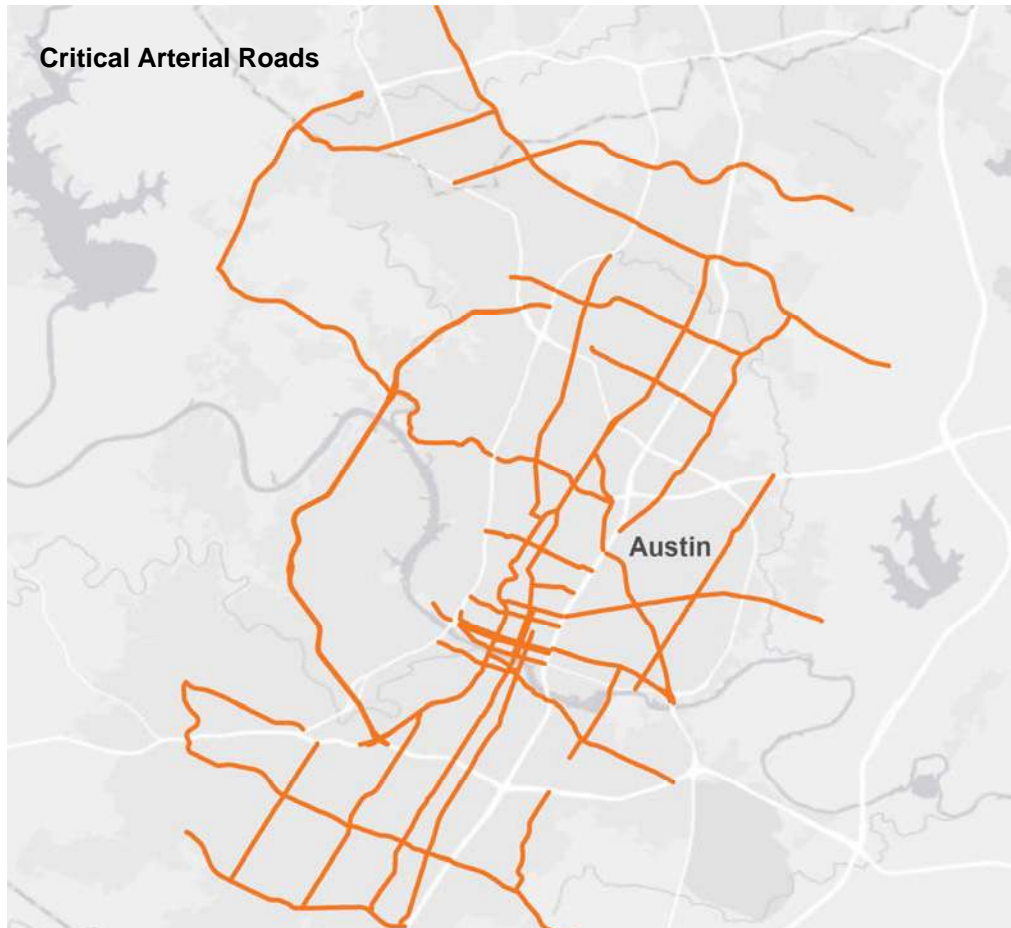
Transportation Assets



2013 Halloween Flood

Methodology

The roadways analyzed as part of this vulnerability assessment were designated as **critical arterials** by the Austin Transportation Department in 2015 due to their importance as the city's most essential travel corridors. These roadways are either under the jurisdiction of the City of Austin or contain traffic signals operated by Austin Transportation. Many of these critical arterials were also included in various Corridor Improvement Projects that are part of the 2016 Mobility Bond-funded projects. Texas Department of Transportation roadways, such as IH-35 and US 183, were not analyzed in this initial assessment.



Threats to the Transportation Network

Staff from the Office of Sustainability, Austin Transportation, Public Works, Watershed Protection, Austin Fire, and Homeland Security and Emergency Management identified the following climate-related threats as areas of concern for Austin's transportation infrastructure:

1. **Flooding:** Flooding is overwhelmingly the main concern that could potentially result in loss of life, road closures and network disruption, physical road damage, and other short- and long-term roadway maintenance and operational issues.

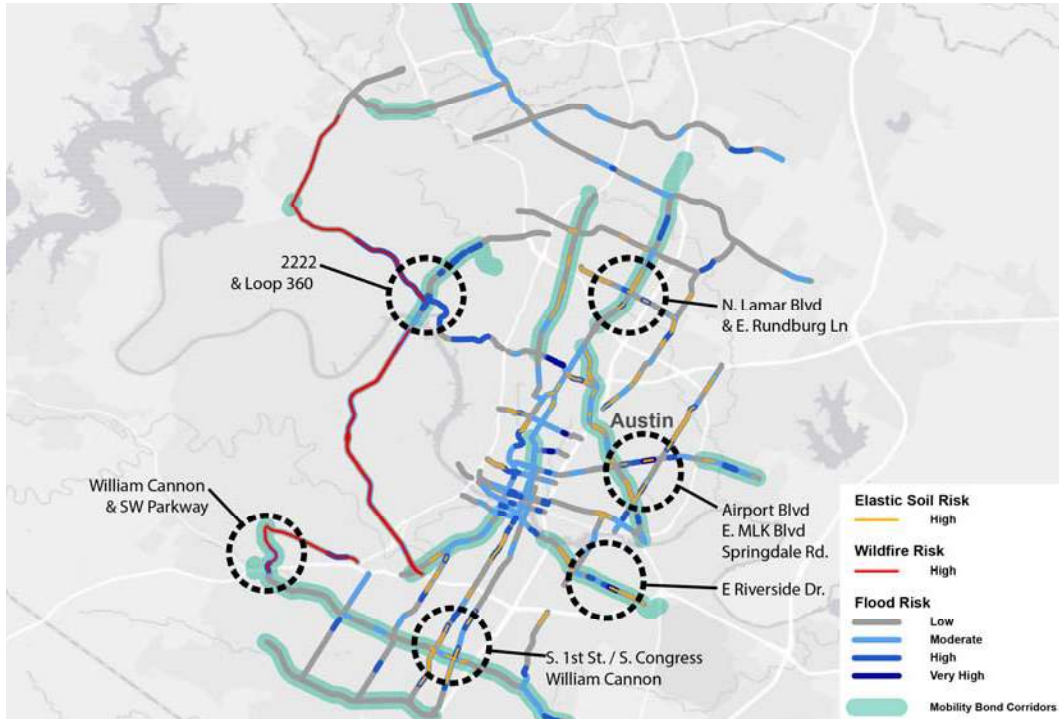
2. **Wildfire:** Flagged as the second highest concern, wildfires can render a road impassable, create traffic jams resulting from evacuations, and pose a threat to those travelling on roadways.
1. **Highly elastic soils:** Primarily a long-term maintenance issue for roadways, given the potential for roadway damage resulting from extreme variations in precipitation and soil moisture (i.e. drought followed by heavy rainfall).

Approach

To determine which portions of the transportation network are most threatened by climate hazards, a map of the critical arterials was overlaid with geospatial data on flood, wildfire, and elastic soil hazards. Each of the critical arterials was divided into multiple segments to allow a detailed analysis. Segments of the critical arterial roadways were then assigned a risk level for each hazard based on various criteria around floodplain proximity, elastic soils, and wildfire threat.

Vulnerable Roadways

The following roadway portions face the highest risk of damage or disruption from climate-related hazards:



Vulnerable Roadway Problem Areas	Primary Threats
2222 @ Loop 360	creek flooding, wildfires
N. Lamar @ E. Rundberg Lane	creek flooding, highly elastic soils
Airport, MLK & Springdale triangle	creek and localized flooding, highly elastic soils
E. Riverside Drive	creek and localized flooding, highly elastic soils
South 1 st & Congress @ William Cannon	creek and localized flooding, highly elastic soils
William Cannon & SW Parkway	creek flooding, wildfires

These problem areas merit deeper investigation and analysis, since many are slated for Mobility Bond projects and are critical to the functioning of the City's roadway network.

Other Assets

The City of Austin also manages a large vehicle fleet and fleet maintenance facilities. Most of the facilities lack air conditioning, which could result in heat stress for fleet maintenance workers. Additionally, some service centers experience issues with drainage and localized flooding, which may be exacerbated by future flood events.

Cross-Cutting Transportation Issues

In analyzing transportation network vulnerabilities, several climate-related concerns for multiple City departments arose:

- **Access to Key Facilities:** While major City facilities, such as water treatment plants or generation facilities, are often “hardened” to withstand flooding and wildfire, roads leading up to these facilities may not be.
- **Financial Impacts:** Climate change will introduce an additional “wear and tear” burden on City road infrastructure through increased average temperatures and precipitation variability. The financial impacts of increased maintenance and road replacement have not yet been quantified by the City. With limited funds for infrastructure improvements, upcoming mobility bond projects and corridor planning initiatives may present an opportunity to prepare the City’s transportation infrastructure for climate change impacts.
- **System Disruption:** Severe weather events, such as intense floods and wildfires, have the potential to significantly disrupt the City’s transportation network. Emergency response actions include identifying egress and ingress routes for community members during flooding and wildfires.



Chapter 4

Community Facilities



Dove Springs Recreation Center— Flood Assistance Center

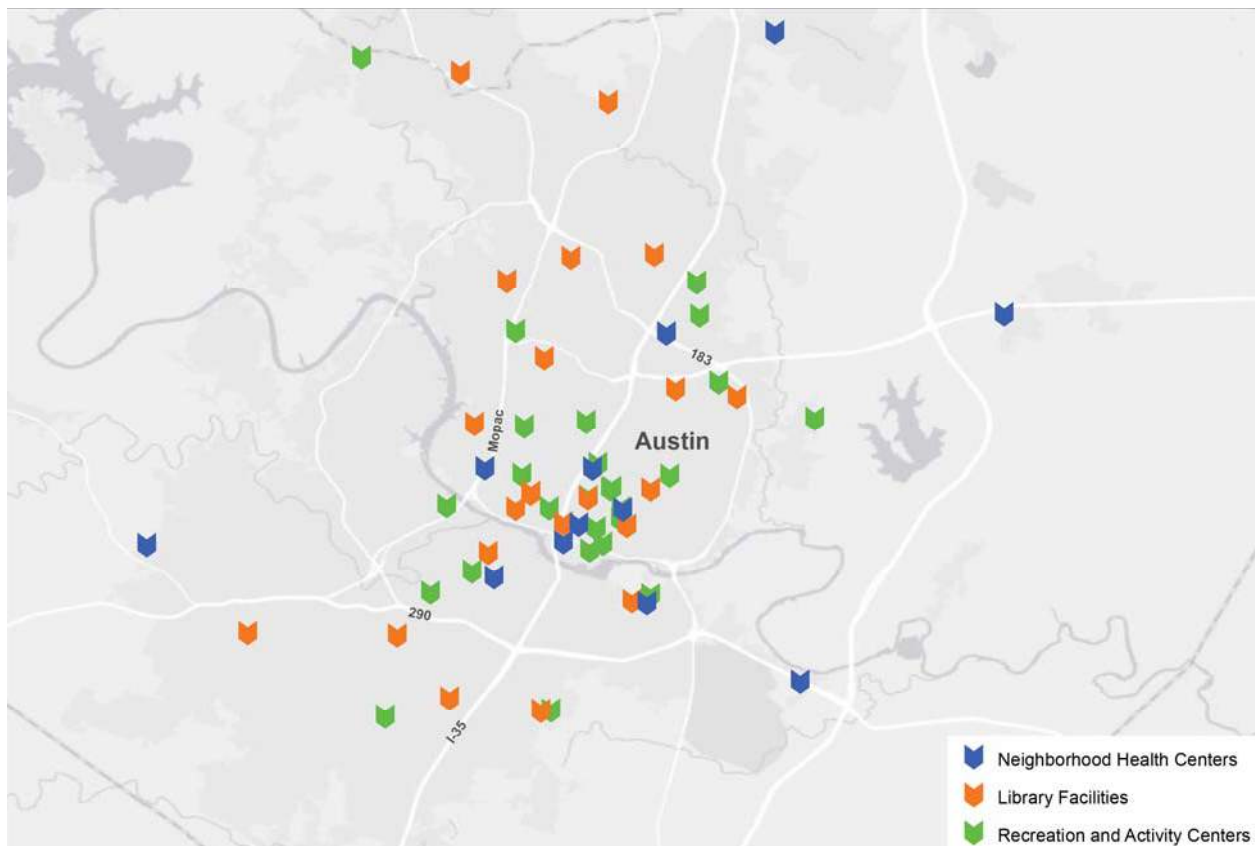
Methodology

The City of Austin owns and operates a variety of community-facing facilities, ranging from recreation and activity centers, to libraries and neighborhood centers. These types of facilities are primarily managed by the Parks and Recreation Department, Austin Public Libraries, and Austin Public Health. The following assessment focuses on facilities that provide public resources and could potentially serve as relief and assistance centers during extreme heat, flooding, or wildfire events. Given the City's recent shelter operations response to Hurricane Harvey,

it is critical for staff to have an understanding of the City's existing and potential shelter response capacities to be prepared for future extreme events requiring the activation of shelters.

Approach

The Office of Sustainability worked with facilities managers and staff from the Parks and Recreation Department, Austin Public Libraries, Austin Public Health, and Homeland Security and Emergency Management to assess vulnerabilities and identify infrastructure and resource needs at community-facing facilities operated by the City of Austin. Data for each facility was collected and analyzed to determine its resilience and adaptation capabilities.



Parks and Recreation

The Parks and Recreation Department manages 27 activity centers and recreational facilities that are capable of housing a significant number of people, with occupant capacity ranging from 50 to 500 people. Data on each facility's capabilities for sheltering or relief was collected and analyzed. Some general findings were:

- 41 percent (11 facilities) were deemed as “suitable” for use as an emergency shelter. These locations have emergency communications capabilities, onsite shower facilities, and gyms with space for cots.
- 85 percent (23 facilities) are “suitable” for use as a cooling station.
- 74 percent (20 facilities) are well-equipped for either canned or refrigerated food storage.
- Only one facility has a generator hookup for backup power in case of an outage.
- 19 percent (5 facilities) are LEED-certified to be energy and water efficient.

Six activity centers and recreational facilities face some level of flooding risk, and eight facilities confront a “low” to “low-moderate” risk from wildfire.



Austin Public Libraries

Austin Public Libraries has 23 locations across the City of Austin, which include the previous Faulk Central Library, the new Central Library, the Austin History Center, and 20 branch libraries. Seven of these facilities face some level of flooding risk, while only two of these locations face a “low” to “low-moderate” wildfire risk as determined by Austin Fire Department wildfire risk maps. Facility sheltering capabilities were analyzed for each location:

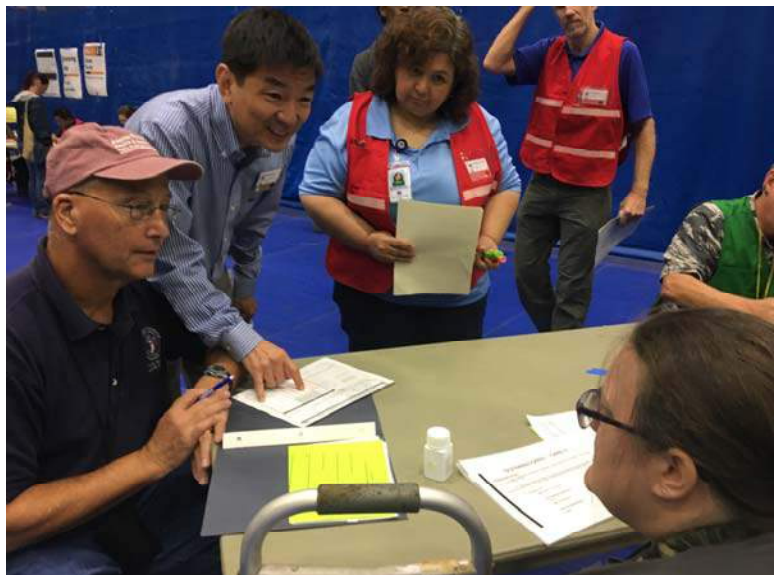
- 83 percent (19 facilities) were identified as “suitable” for use as an emergency shelter with emergency communications capabilities, and meeting spaces with room for cots.
- 91 percent (21 facilities) are “suitable” for use as a cooling station.
- 96 percent (22 facilities) are equipped for refrigerated food storage.
- Two facilities keep a generator onsite for backup power in case of an outage.
- Two facilities are LEED-certified to be energy and water efficient.



Austin Public Health

Austin Public Health manages several neighborhood centers in Travis County; three facilities face some level of flooding risk, and three that are located in more rural areas face a “low-moderate” to “moderate” wildfire risk. Data was collected about sheltering capabilities for each facility with the following findings:

- Only one facility was identified as “suitable” for use as an emergency shelter, with refrigeration and room for cots in case of an extreme event.
- 92 percent (11 facilities) are “suitable” for use as a cooling station.
- 50 percent (6 facilities) are well-equipped for either canned food or refrigerated storage.
- None of the facilities have onsite generation capacity for backup power in case of an outage.
- None of the facilities have onsite showers.



Cross-Cutting Community Facility Issues

In addition to the facility-specific issues highlighted in this vulnerability assessment, the following issues affect departments with community facilities:

- **Emergency Response Awareness:** There is a lack of universal knowledge about City equipment that is available for emergencies, such as portable generators, backup fans, and communications technology. Emergency and evacuation procedures are not always clearly identified at the facility level.
- **Public Access Improvements:** Pedestrian improvements in the right of way are needed to increase non-motorized access to community facilities.
- **Facility and Site Weatherization:** Funding is needed to weatherize facilities and establish additional guidance for tree and landscape maintenance (modifying irrigation practices, pruning deadwood, maintaining defensible space, etc.) in response to climate change concerns.



Part III

Resilience Strategies

The City of Austin is already working to increase Austin's resilience to climate impacts; however, the completed vulnerability assessment identified several areas that need further action. Some of these call for incremental shifts in City operations and planning, while others will require larger investments in infrastructure and facility improvements. All will require cross-departmental collaboration and a commitment by the City to continue planning for resilience in Austin.

The following strategies will ensure that City assets and operations are prepared for and adaptive to extreme weather events and climate change:

1. **Strengthen Emergency Response:** Ensure that emergency response plans incorporate possible climate changes that could impact the protection of staff, infrastructure, and facilities during emergencies and extreme weather events.
2. **Expand Staff Safety Plans:** Incorporate climate risks into staff safety plans and procedures to provide a safe and healthy work environment for City staff.
3. **Evaluate and Upgrade Existing Facilities and Infrastructure:** Determine facility and infrastructure upgrade needs and reinforce City assets to withstand climate impacts by providing utility redundancies, weatherizing buildings, and making other needed facility improvements.
4. **Future-Proof New Facilities and Infrastructure:** Integrate climate change considerations into future infrastructure and capital improvements decision-making to create climate adaptation co-benefits.

Chapter 5

Resilience Action Areas



Four key strategies were identified through a climate resilience planning process that included staff from across 15 City Departments. These strategies are designed to ensure that City assets and operations are prepared for and adaptive to extreme weather events and climate change:

- Strengthen emergency response
- Expand staff safety plans
- Evaluate and upgrade existing facilities and infrastructure
- Future-proof new facilities and infrastructure

1. Strengthen Emergency Response

Austin can expect an increase in extreme events due to climate change, including longer and hotter heat waves, more intense floods, and more severe wildfires. These events will test the City's ability to respond to emergencies and protect infrastructure, facilities, and staff.

Current Efforts

The Office of Homeland Security and Emergency Management coordinates disaster response and recovery efforts for the City of Austin. In August of 2016, Homeland Security and Emergency Management completed an update of the City of Austin Hazard Mitigation Plan, which identifies risk mitigation activities to address hazards the City may face in the future. Some of the primary emergency response goals outlined in the plan include: (1) minimizing disruptions to the City of Austin during a disaster, (2) streamlining disaster recovery by articulating actions to be taken before a disaster strikes, and (3) ensuring that the City of Austin maintains eligibility for the full range of Federal disaster relief.

Other disaster response and recovery efforts by the City of Austin include:

City of Austin Emergency Operations Plan

(Homeland Security and Emergency Management)

Provides guidance and a framework for City-wide strategic decision-making related to emergency operations and disaster situations.

City of Austin Special Operations Plan: Heat Emergencies

(Homeland Security and Emergency Management)

This Special Operations Plan establishes a coordinated approach to providing cooling relief to vulnerable populations during periods of severe heat.

Austin-Travis County Community Wildfire Protection Plan

(City of Austin & Travis County)

Provides guidance for addressing three key wildland fire issues: restoring and maintaining landscapes, creating fire-adapted communities, and risk-based management response to wildfires. The document provides strategies for both homeowners and wildfire officials to help avert a wildfire catastrophe.

Watershed Protection Master Plan

(Watershed Protection Department)

This Master Plan prioritizes services to reduce the impact of flooding, erosion and water pollution in order to protect lives, property and the environment.

Recommendations

Key actions the City of Austin can take to strengthen emergency response capabilities include:

- More effectively utilize City resources during emergencies.
- Better understand the impacts of extreme events on City assets and facilities.
- Establish best practices in emergency and evacuation procedures.

These actions are outlined in greater detail in the table to the right:

1. Strengthen Emergency Response				
Actions		Lead Dept(s)	Status	Resources
Update and Institutionalize Emergency Procedures				
Phase 1 2018-2020	Disaster Training for Leadership. Establish basic disaster response and recovery training for elected officials and City leadership.	Homeland Security and Emergency Management	Initiative in Development	Current Budget
Establish Safe Emergency and Evacuation Routes				
Phase 1 2018-2020	Community Evacuations. Establish and update emergency evacuation routes and procedures for communities prone to extreme flooding and wildfire events. Study ingress/egress to and from flood and wildfire-prone neighborhoods and identify potential safety hubs for residents.	Homeland Security and Emergency Management Watershed Protection Austin Fire	Initiative in Development	Current Budget
	City Staff Evacuations. Analyze emergency and evacuation procedures for City of Austin staff during extreme events. Study ingress/egress to and from City facilities. Work with institutions adjacent to City facilities to plan ingress and egress routes.	Homeland Security and Emergency Management	Initiative in Development	Current Budget
Optimize Coordination of Disaster Response Resources				
Phase 2 2020-2030	Shuttle Mobilization Policy. Create a chain of command to mobilize fleet shuttles during evacuation events.	Fleet Services	Initiative in Development	Current Budget
	Shelters. Investigate the City of Austin's mass sheltering capacities and evaluate the need for additional locations to shelter people displaced by extreme weather events both locally and regionally.	Homeland Security and Emergency Management	Initiative in Development	Current Budget
	Resource Inventory. Create an inventory of City resources available for use during emergencies, including portable generators, traffic management equipment, backup fans, communications technology, disaster comfort kits, and other equipment. Create a chain of command to mobilize resources before, during, and after major events.	Homeland Security and Emergency Management	Initiative in Development	Current Budget
	Resource Needs. Investigate the need for additional resources required to support sheltering efforts, such as translation services, additional bathrooms and shower facilities, case management staff, etc. Establish and update standing contracts with disaster response and recovery service providers and update pay policies for exempt employees.	Homeland Security and Emergency Management	Initiative in Development	Current Budget

2. Expand Staff Safety Plans

Protecting staff is a key priority for the City of Austin. With temperatures and heat indices expected to rise to levels that are dangerous for human health, climate extremes will pose a threat to City staff working outdoors or in other harsh conditions.

Current Efforts

City departments with field crews have policies and protocols in place to protect outdoor workers during heat events and flooding events. Departments also have Continuity of Operations plans in place that take effect during emergencies.

Recommendations

The actions below are further steps the City can take to provide a safe and healthy work environment for staff:

2. Expand Staff Safety Plans				
Actions		Lead Dept(s)	Status	Resources
Phase 1 2018-2020	Hazard Training. Provide climate and weather hazard identification, response, and safety training to City of Austin staff, especially fieldworkers.	Human Resources Department Safety Groups	New Initiative	Current Budget
	Fieldworker Safety. Evaluate work schedules and safety policies for City of Austin fieldworkers during extreme heat days, poor air quality days, and other climate-related health risk days. Establish cross-departmental best practices.	Human Resources Department Safety Groups	Initiative in Development	Current Budget
Phase 2 2020-2030	Workplace Safety. For facilities and maintenance shops without air conditioning or with poor ventilation, consider upgrades to mitigate heat and air quality impacts on workers.	Austin Energy Austin Water Parks and Recreation Fleet Services	New Initiative	Capital Budget Impact TBD



3. Evaluate and Upgrade Existing Facilities and Infrastructure

Climate change will impact older facilities and infrastructure that were built to specifications appropriate at the time of construction but may no longer reflect the challenges of future climate conditions.

Current Efforts

The City of Austin works continuously to create energy and water efficient facilities, improve building standards, and enhance infrastructure. Some examples include:

Facilities Assessments and Capital Renewal Fund

(City of Austin)

Working with consultants, the City of Austin has completed comprehensive assessments of city facilities to understand the state of facility operations and maintenance and guide long-term facility planning and investments. As a result, City Council approved a Capital Renewal Fund to address deferred facilities maintenance and provided initial one time funding in the amount of \$1.4 million. Assuming the current maintenance backlog at \$70 million in facilities, the fund would require \$5.9 million annually to eliminate the backlog by 2036.

2018 Bond Development Process

(City of Austin)

The City of Austin is currently in the process of developing facility and infrastructure upgrade proposals to include in an upcoming 2018 Bond Referendum. Items being considered include stormwater infrastructure improvements, upgrades to existing City facilities and assets, and investments in transportation infrastructure.

Recommendations

To increase the resilience of facilities and infrastructure, the City can invest in retrofitting and strengthening assets, which may include:

- Based on the significance of risks identified in conditions assessments and energy/water audits, upgrade aging building systems at critical facilities to meet current code requirements.
- Strengthen assets to withstand future climate impacts.
- Increase redundancies in water and energy systems where needed.

A variety of retrofit options for City facilities and infrastructure are presented in the tables below and on the following page:

3. Evaluate and Upgrade Existing Facilities and Infrastructure				
Phase 1 Actions		Lead Dept(s)	Status	Resources
Harden Critical Infrastructure				
Phase 1 2018-2020	Pavement Materials. As part of the review of new paving technology, identify potential adjustments to pavement materials and equipment/materials specifications to account for increasing summer temperatures. Consider increasing use and frequency of preventive maintenance treatments that would address accelerated pavement wearing (e.g., seal coats, crack seals).	Public Works	Existing Initiative	Capital Budget Impact TBD
	Access to Community Facilities. Investigate the impacts of higher average temperatures on access to community facilities and update mobility plan to mitigate for heat.	Austin Transportation	Initiative in Development	Capital Budget Impact TBD

3. Evaluate and Upgrade Existing Facilities and Infrastructure

Phase 2 Actions		Lead Dept(s)	Status	Resources
Harden Critical Infrastructure				
Phase 2 2020-2030	Infrastructure Hardening. Study the potential impact of increased flooding of adjacent roads and utility infrastructure and explore hardening options (flood control measures, erosion-resistant materials, etc.).	Public Works Austin Water	Initiative in Development	Capital Budget Impact TBD
	Flood-Proofing Utilities. Investigate options for strengthening and flood-proofing the utilities at the Austin Convention Center.	Austin Convention Center	New Initiative	Capital Budget Impact TBD
	Impacts of Shifting Soils. Investigate impacts of elastic soils on gas tanks and other underground infrastructure at service centers and identify mitigation options.	Fleet Services	New Initiative	Capital Budget Impact TBD
Improve Building Efficiency and Redundancy				
Phase 2 2020-2030	Building Update. Upgrade aging building systems based on current code requirements, conditions assessments and energy/water audits at critical community facilities, including recreation centers, neighborhood centers, and libraries.	Parks and Recreation Austin Public Health Austin Public Libraries	Initiative in Development	Capital Budget Impact TBD
	Redundant Power. Provide critical facilities (shelters) with at least one alternative, independent source of electricity supply to make it capable of operating if a primary source of power experiences an interruption. If an uninterruptible power supply (UPS) or energy storage system is used, it must be capable of providing power for at least 8 hours.	Parks and Recreation Austin Public Health Austin Public Libraries	New Initiative	Capital Budget Impact TBD
	Backup Cooling. Explore options for backup cooling at the Austin Convention Center.	Austin Convention Center	New Initiative	Capital Budget Impact TBD
Mitigate Impacts to Telecommunications				
Phase 2 2020-2030	Network Node Hardening. Investigate network node locations and create a catalog of information on backup power and cooling capabilities for each. Identify opportunities to improve weatherization and mitigate flood impacts.	Communications and Technology Management	New Initiative	Capital Budget Impact TBD
	Wildfire Risk Mitigation for Radio Infrastructure. Determine which radio towers are at risk for wildfire and investigate mitigation options.	Communications and Technology Management	New Initiative	Capital Budget Impact TBD

4. Future-Proof New Facilities and Infrastructure

Any investments in new facilities and infrastructure must be informed by climate projections and the challenges posed by extreme events.

Current Efforts

Plans for future capital improvements by the City of Austin include:

Long-Range Capital Improvement Program Strategic Plan *(Capital Planning Office)*

Provides a 10+ year planning horizon as the basis for identifying both ongoing capital needs and strategic opportunities for capital investment.

Watershed Protection Master Plan *(Watershed Protection Department)*

Assesses erosion, flood, and water quality issues in Austin, and prioritizes projects, programs, and regulations to address those issues.

Austin Strategic Mobility Plan *(Transportation Department)*

A new city-wide transportation plan that will guide Austin's near - and long-term transportation investments.

Long Range Plan for Land, Facilities, and Programs *(Parks and Recreation Department)*

Provides a guide for future growth and development of Austin's parks and recreation system that includes parks, trails, programs, preservation of environmental and ecologically sensitive areas.

Urban Forest Plan *(City of Austin Urban Forestry Board)*

Establishes a broadly scoped, long-range vision for Austin's public urban forest and a framework for the City to use for managing the urban forest over the next 20 years.

Water Forward

(Austin Water Utility)

Ensures a diversified, sustainable, and resilient water future through a range of strategies such as water conservation, water reuse, aquifer storage and recovery, and others. This integrated water resource planning process is also informed by climate models developed by Dr. Katherine Hayhoe.

Austin Energy Resource, Generation and Climate Protection Plan to 2027

(Austin Energy)

Prioritizes investment in renewable energy resources, peak demand reduction, and energy efficiency.

Recommendations

When prioritizing projects and planning for new facilities, the City of Austin should:

- Explore potential financial impacts of climate change on assets and operations.
- Incorporate climate and environmental variables in future infrastructure decision-making.
- Ameliorate climate change impacts through new investments in infrastructure and facilities.

Possible capital improvement projects with climate adaptation co-benefits are included in the following table:

4. Future-Proof New Facilities and Infrastructure

Actions	Lead Dept(s)	Status	Resources
Design for Resilience			
Phase 1 2018-2020	Passive Survivability. Develop Passive Survivability Guidelines for capital projects in areas projected to be impacted by climate hazards.	Austin Energy Green Building	Initiative in Development Current Budget
Phase 2 2020-2030	Resilience Hubs. Co-locate new community facilities in low- to moderate-income areas lacking access to City facilities and services. Ensure new facilities have the capacity to serve as shelters, evacuation centers, and/or disaster response hubs during emergencies and as community centers offering needed City services and resources for the surrounding community.	Austin Parks and Recreation Austin Public Health Austin Public Libraries	Initiative in Development Capital Budget Impact TBD
Plan for Resilient Infrastructure			
Phase 1 2018-2020	Resilient Infrastructure. Continue exploring opportunities to incorporate climate change variables in future infrastructure decision-making and share information among infrastructure and utility departments. Work with the Resilience Leadership Team to identify new opportunities increase the resilience of City of Austin facilities and infrastructure.	Office of Sustainability	Existing Initiative Current Budget
	Water Supply Impacts. Continue to study potential climate impacts on Austin's water supply in collaboration with the Water Utility Climate Alliance, regional climate agencies, and climate scientists.	Austin Water	Existing Initiative Current Budget
	Stormwater Infrastructure. Update Intensity, Duration, Frequency curves used by stormwater infrastructure designers to inform the sizing of new infrastructure.	Watershed Protection	Existing Initiative Current Budget
	Urban Forest Canopy. Develop an urban forest climate change adaptation strategy for the Austin area.	Development Services	Initiative in Development Current Budget
Phase 2 2020-2030	Floodplain Management. For critical infrastructure development and redevelopment, avoid construction in the 500-year floodplain altogether where possible and provide flood proofing if construction must occur in the floodplain such as freeboard above the 500-year floodplain.	Watershed Protection	New Initiative Capital Budget Impact TBD
	Financial Impacts. Evaluate the risk of financial impact of having major utility facilities offline for a prolonged period of time during/after major weather events.	Austin Energy Austin Water	New Initiative Capital Budget Impact TBD

Chapter 6

Next Steps



Implementation Strategy

The Office of Sustainability will continue to work with staff from across the City organization to prioritize recommended actions and develop an implementation plan. In the coming months, the feasibility, impact, and cost of the proposed actions will be assessed, along with any additional strategies to address climate resilience in municipal operations. An upcoming Horizon Issues Paper by the Office of Sustainability will identify the potential budget impacts of selected actions and outline how future needs could be incorporated into future budget planning processes.

To ensure implementation of the actions outlined in this document, the Office of Sustainability proposes the creation of a cross-departmental Resilience Leadership Team. The Resilience Leadership Team will coordinate and oversee departmental resilience actions moving forward. This group, consisting of department Directors, Division Managers, and other relevant project leadership, will support cross-departmental work and continue to identify opportunities to increase resilience across the City organization. The Resilience Leadership Team will begin meeting quarterly in 2018.

The Office of Sustainability will be responsible for tracking ongoing resilience planning efforts and providing updates to the Resilience Leadership Team. Updates to Council about resilience planning and implementation efforts will be provided by the Office of Sustainability as part of regular progress reports about Community Climate Plan activities.

Community Resilience

A changing climate can negatively impact where and how we live, work, play, and learn. Climate hazards do not impact everyone equally, but disproportionately affect Austin's most vulnerable communities. Typically residing in the northeast, east and southeast portions of Austin, these communities are already stressed by limited resources, growth pressures, and higher rates of chronic disease. According to Austin Public Health's *Community Health Assessment*, access to healthcare, healthy food, transportation, and affordability were identified by community members as major barriers to health and wellbeing. These inequities also restrict the ability to adapt to changing climate conditions.

Acute weather events will exacerbate existing stressors, making communities more sensitive to future climate impacts. For Austin to be truly resilient, steps must be taken to address

***Climate hazards
disproportionately
affect Austin's
most vulnerable
communities.***

disparities among communities and ensure equitable outcomes for all Austinites. The following recommendations present an opportunity to increase resilience and reduce vulnerabilities throughout the community. However, these recommendations also have associated resource impacts. Further analysis would need to be done in order to fully determine the resources needed and the timing of these actions.

- 1. Education and Outreach:** Create a working group composed of Homeland Security and Emergency Management, Austin Public Health, and other City department staff to identify opportunities to expand education and outreach to communities that are most impacted by climate change. Outreach to families should include assistance with extreme weather preparedness and disaster/evacuation planning, education on climate-related health risks, and an introduction to available resilience tools and resources.
- 2. Community Resilience Planning:** Explore opportunities to collaborate with research institutions and community organizations to analyze climate stressors for the most vulnerable populations. Working with City departments, develop a framework to connect City services and programs to communities most affected by extreme weather and climate change impacts. Using engagement with community members to gain an understanding of both historic and current stressors, develop strategies to stabilize neighborhoods and enhance residents' ability to prepare for and thrive after a major event.



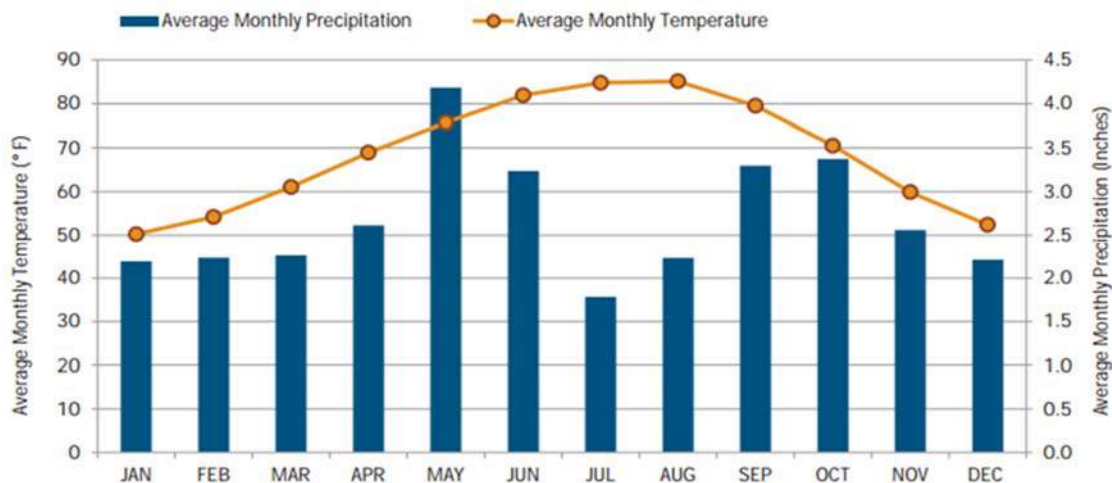
Appendix

Austin and Climate Change

Austin's Existing Climate

The unique topography of the Central Texas region influences Austin's humid subtropical climate. Austin is known for its long, hot summers and short, mild winters with a moderate amount of annual rainfall. Records from the Austin Camp Mabry weather station indicate a summertime average temperature of approximately 84°F and a wintertime average temperature of approximately 53°F from 1943 through 2012. Annual average rainfall over that same period was about 34 inches.

Austin Area Climatology (1943-2012)



Graph from the 2013 Austin Urban Forest Plan (Data from NOAA, 2013)

Extreme weather is not uncommon in Austin. Often referred to as “Flash Flood Alley,” the Central Texas Hill Country is among the most flood-prone areas of the United States due to rocky soils, steep terrain, and intense rainfall events. Strong storms can quickly trigger flooding in Austin, especially along the city’s many urban creeks, streams, and rivers. Hot summer days are also a major part of Austin’s climate. High temperatures frequently exceed 90°F in the summertime, with some days reaching over 100°F. Austin’s hot climate, combined with a lack of rainfall, has resulted in many periods of drought.

Climate Projections for Central Texas

The world’s climate is changing as a result of human activities that release carbon dioxide and other heat-trapping gases into the atmosphere. Over the coming century, global temperatures, precipitation, and other important aspects of climate are expected to continue to change in response to both past and future emissions.

Climate projections are necessary for the City of Austin to effectively plan and manage assets and operations to endure future climate hazards. While climate models are uncertain and limited in their ability to make predictions about specific extreme weather events, these projections offer greater certainty in the ranges of probability over long time periods.

Research Methods

Dr. Katharine Hayhoe, an associate professor in the Department of Political Science and Director of the Climate Science Center at Texas Tech University; Dr. Christina Patricola, a research scientist at the Lawrence Berkeley National Laboratory; and Dr. Kerry Cook, a professor in the Department of Geological Sciences at the University of Texas at Austin Jackson School of Geosciences, prepared climate projections for the Central Texas region for the City of Austin. Temperature and precipitation projections are from Dr. Hayhoe's analyses. Dr. Patricola and Dr. Cook developed soil moisture projections.

Climate projections are uncertain for four main reasons:

1. **Natural variability**, which causes temperature, precipitation, and other aspects of climate to vary from year to year, and even decade to decade. To address this, climate projections are averaged over 30-year timescales.
2. **Scientific uncertainty**, as it is still uncertain 1) exactly how much the Earth will warm in response to human emissions, and 2) global climate models cannot perfectly represent every aspect of Earth's climate. To address this, future projections are based on simulations from nine different climate models.
3. **Human scenario uncertainty**, as future climate change will occur largely in response to emissions from human activities that have not yet occurred. To address this, future projections use two different emission scenarios; one where global carbon emissions peak and then decline by the end of the century, and a second where continued dependence on fossil fuels continues to increase emissions through the end of the century.

4. **Local uncertainty**, which results from the many factors that interact to determine how the climate of one specific location, such as Austin, will respond to global-scale changes over the coming century. To address this, global climate model simulations were downscaled to the Austin Camp Mabry weather station using the Asynchronous Regional Regression Model.

Dr. Hayhoe's temperature and precipitation projections for Central Texas are based on climate projections for the United States and the Great Plains Region that are included in the draft results in the upcoming 2014 Third National Climate Assessment. Her preliminary projections for Austin are based on two emissions scenarios:

Low Emissions Scenario

The Intergovernmental Panel on Climate Change lower Representative Concentration Pathway (RCP) 4.5 scenario, where global carbon emissions peak and then decline by the end of the century. 4.5 refers to the projected change in radiative forcing in units of watts per square meter. Radiative forcing is a measure of the magnitude of the human influence on the naturally-occurring greenhouse effect.

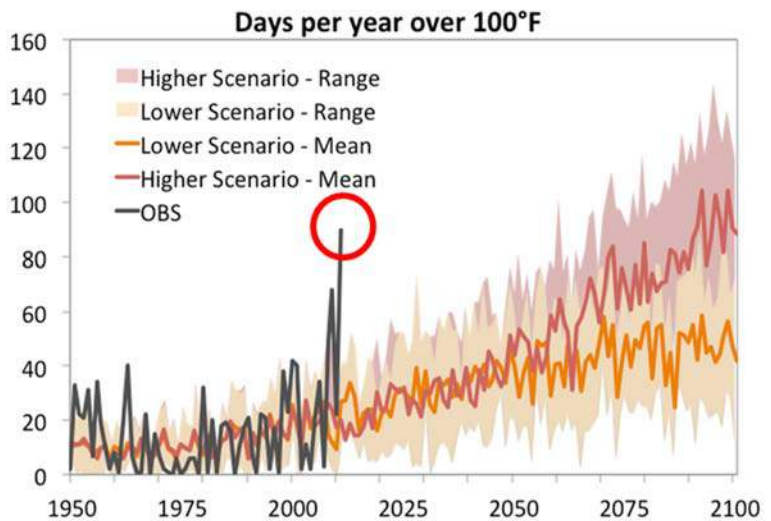
High Emissions Scenario

The Intergovernmental Panel on Climate Change higher Representative Concentration Pathway (RCP) 8.5 scenario, where continued dependence on fossil fuels results in an increase in carbon emissions throughout the century. 8.5 refers to the projected change in radiative forcing in units of watts per square meter. Radiative forcing is a measure of the magnitude of the human influence on the naturally-occurring greenhouse effect.

Temperature Projections

Over the coming century, climate change is expected to affect the United States by increasing annual and seasonal temperatures. Projected increases in annual average temperatures by the end of the century across the South-Central Great Plains are between +5 to 6°F under the lower emissions scenario, and +9 to 10°F under the higher scenario. The number of days per year where minimum and maximum temperatures exceed the historical hottest seven days of the year is also projected to increase

The following graph illustrates the range for future high temperature extremes in Austin:



While it is difficult to predict the exact number of days per year that temperatures will exceed 100°F, the models do trend towards an overall increase in extremely hot days. 2011-like events (circled in red) will likely become much more frequent by the end of the century.

TEMPERATURE PROJECTIONS FOR AUSTIN				
	Current Average	2011-2040 <i>Low & High Emissions Scenarios</i>	2041-2070 <i>Low & High Emissions Scenarios</i>	2071-2100 <i>Low & High Emissions Scenarios</i>
Summer average high temperature	94°F	96°F (low) 97°F (high)	97.5°F (low) 100°F (high)	98°F (low) 103°F (high)
Number of cold winter nights per year (below 32°F)	15	11 (low) 11 (high)	8 (low) 6 (high)	7 (low) 4 (high)
Number of very warm summer nights (low of 80°F)	0 (rare)	3 (low) 8 (high)	10 (low) 40 (high)	17 (low) 85 (high)
Number of hot summer days (over 100°F)	13	15 (low) 20 (high)	25 (low) 50 (high)	35 (low) 80 (high)
Number of very hot summer days (over 110°F)	0 (rare)	0 (low) 2 (high)	1 (low) 12 (high)	1 (low) 20 (high)



Precipitation Projections

As climate changes, precipitation patterns are also expected to change. In general, wetter areas (including most higher latitudes) are projected to become wetter, while drier areas (such as the U.S. Southwest) are projected to become drier. Situated as it is along the Gulf Coast between the Southeast and Southwest regions of the U.S., Texas has seen some increase across the wetter eastern half of the state, with little change to a slight decrease across the drier western half over the last century.

Despite little change in the total amount of projected precipitation, the nature of rainfall is expected to change. In fact, the number of heavy precipitation days have already increased across the Great Plains region. In the future, the number of days per year that exceed the current wettest seven days of the year are projected to become more frequent across the eastern half of Texas. Drought conditions in summer are likely to become more severe as global temperatures increase. A preliminary set of high-resolution climate projections suggest the following trends:

PRECIPITATION PROJECTIONS FOR AUSTIN				
	Current Average	2011-2040 <i>Low & High Emissions Scenarios</i>	2041-2070 <i>Low & High Emissions Scenarios</i>	2071-2100 <i>Low & High Emissions Scenarios</i>
Annual average precipitation (inches)	32	31 (low) 32 (high)	33 (low) 33 (high)	33 (low) 32 (high)
Number of dry days per year (no precipitation)	275	280 (low) 280 (high)	280 (low) 285 (high)	285 (low) 290 (high)
Number of days per year with more than 2 inches of rainfall	2	2.5 (low) 2.5 (high)	3 (low) 3 (high)	3 (low) 3 (high)
Maximum 5 day rainfall (inches)	6	7 (low) 7.5 (high)	8 (low) 8 (high)	8 (low) 8 (high)
Maximum consecutive dry days (no precipitation)	52	70 (low) 66 (high)	70 (low) 70 (high)	70 (low) 75 (high)

Soil Moisture Projections

Soil moisture projections are often used as an indicator for future drought conditions. Projections for Central Texas were developed by Dr. Cook and Dr. Patricola using the Weather Research and Forecasting climate model developed by the National Center for Atmospheric Research. These indicate a reduction in soil moisture by up to 5% by the middle of the century, with summer soil moisture expected to drop between 4% to 10%. These projected decreases in soil moisture indicate drier conditions and suggest an increase in droughts and the potential for more wildfires.

SOIL MOISTURE PROJECTIONS FOR AUSTIN			
	Baseline Average	2041-2060 (Lowest Projected Decrease)	2041-2060 (Highest Projected Decrease)
Annual Soil Moisture	0.2 m ³ /m ³	No change	-5%
Summer Soil Moisture	0.2 m ³ /m ³	-4%	-10%



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