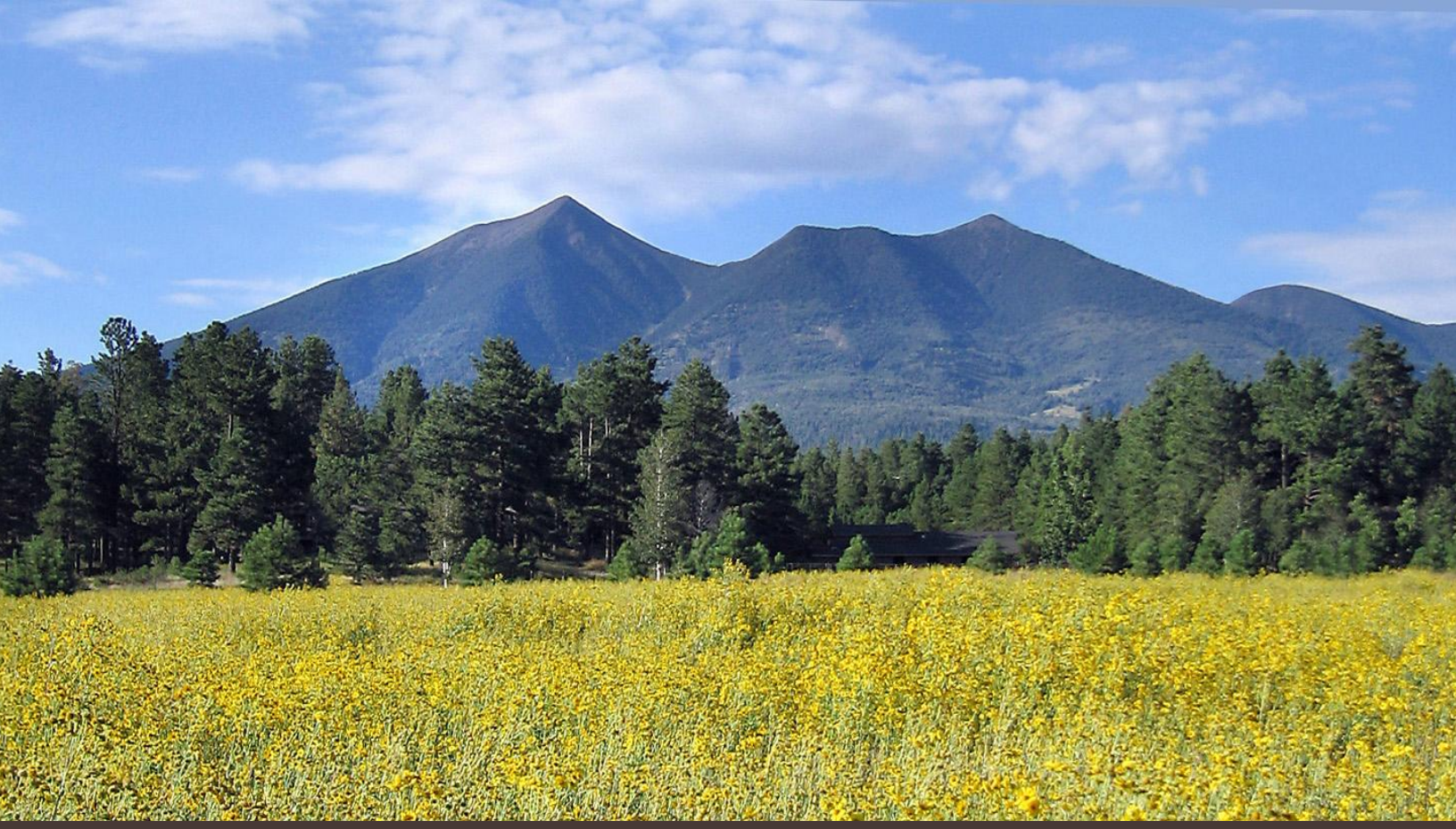

City of Flagstaff

Resiliency and Preparedness Study

SEPTEMBER 2012

CITY OF FLAGSTAFF · ARIZONA · ESTABLISHED 1882 ·

FLAGSTAFF SUSTAINABILITY PROGRAM
WORKING TOWARD COMMUNITY SUSTAINABILITY

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Executive Summary

The City of Flagstaff's Resiliency and Preparedness Study helps address the question: How can we reduce our vulnerability to and build local resilience against risk from climate variability and weather related impacts? The vulnerability and risk assessments help the City build a substantial foundation for addressing precisely this challenge.

The City conducted the Resiliency and Preparedness Study to better understand how the impacts of local climate changes will directly affect City operations. Recently, Flagstaff has experienced record warming, persistent drought-like conditions and severe precipitation events. Building local resiliency within the municipal organization to these changes helps ensure continued prosperity. The Study assessed the level of vulnerability, the degree of risk and the potential impacts of 115 areas of the City's operations that are exposed to local climate variability.

Potential Climate Impacts to City Operations

Potential Climate Impacts to Emergency Services Operations

- Increase in demand for specialized equipment and training for search and rescue.
- Increase in demand for goods and public services from outlying communities.
- Increase in frequency and demand for City fleet services.
- Increase in length of stay and impact (trash, fires) of forest dwellers.
- Increase in demand for Woods Watch patrol.

Potential Climate Impacts to Energy Operations

- Increase of use at public facilities.
- Increase in City's energy costs.
- Increase in frequency and duration of power outages, and increase need for back-up generators.
- Increase in City's energy demand and cost to produce water.

Potential Climate Impacts to Forest Health Operations

- Increase in demand on City resources able to respond to wildfire events.
- Increase in severity and frequency of wildfire events.
- Increase in frequency and duration of forest closures and related tourism.
- Loss of long term storage of water.
- Increase in frequency and number of threatened structures.

Potential Climate Impacts to Public Health Operations

- Increase in number of treated respiratory illnesses, infectious disease and heat stress induced illnesses.
- Increase in storm and flood related injuries.
- Increase in heat related exposure of vulnerable populations.
- Increase of rate and duration of hospitalization.

Potential Climate Impacts to Stormwater Operations

- Increase in severity of peak flooding events.
- Increase in capital costs to manage greater flooding events.
- Increase of under cutting of roads/structures, etc. and sediment in stormdrains.
- Change to the 100 year flood.
- Increase of insurance rates and the number of structures located in flood zones.

Potential Climate Impacts to Transportation Operations

- Reduction in pavement integrity.
- Increase in maintenance costs for asphalt and pavement.
- Increase in potential for collapse of bridges and damage to culverts.
- Increase in frequency and duration of flight cancelations and delays.
- Decrease of accessibility of evacuation routes.
- Reduction of accessibility of roads and highways.

Potential Climate Impacts to Water Operations

- Increase in demand for wastewater infrastructure.
- Increase in demand for reclaimed water resources and subsequent reduction in recharge rate.
- Reduction of overall reliance of surface water resources resulting in an increase reliance on groundwater resources.
- Increase in demand and delivery distance of water resources.
- Decrease of accessibility to water due to damaged water infrastructure.

Vulnerability and Risk to City Operations

System	Key Planning Area	Vulnerability Ranking	Risk Ranking
Water			
	Water Treatment Quality	Medium	High
	Water Resources	High	High
	Water Infrastructure	High	High
Forest Health			
	Forest Management	High	High
	Wildlife and Vegetation	High	Low
	Public Infrastructure	Medium - High	High
Emergency Services			
	Police and Fire Services	Medium - High	Medium
	Emergency Medical Services	Medium - High	Medium
	Disaster Response	High	Medium
	Public Works	High	High
Energy			
	Energy Assurance and Delivery	Medium	Medium
	Energy Demand and Costs	Medium - High	High
Stormwater			
	Infrastructure	Medium - High	High
	Buildings	Low - Medium	Medium
Public Health			
	Public Health Infrastructure	Low	Medium
	People	Low - Medium	Medium
	Public Services	Medium	High
Transportation			
	NAIPTA – Public Transportation	Low Vulnerability	Low
	Transportation Infrastructure	Medium - High	High
	Public Access	Low Vulnerability	Medium
	BNSF	Low Vulnerability	Low
	Airport	Medium - High	Low

City Core Team Recommendations

A Core Team assisted with the development of the Study. The team consisted of regional public partners and experts within the organization, which included a diverse representation of the City's service delivery areas. The Core Team conducted a vulnerability and risk assessment of City operations to weather and climate. In addition, Core Team recommended the following vision for the City's climate adaptation and resiliency efforts:

1. Prepare the City of Flagstaff for climate related risks and impacts.
2. Position the City of Flagstaff for continued prosperity.
3. Recognize the opportunities created by changes to Flagstaff's climate.
4. Protect the City's resources to support the community's interest.

Following the completion of the vulnerability and risk assessments, the Core Team provided policy recommendations that focus on reducing risk and increasing resilience within municipal operations. The following policy recommendations are aimed at preparing the City for climate-related impacts:

1. Build, sustain and leverage partnerships with local and regional stakeholders to ensure collective investment, efficient action and shared responsibility in the building of local resiliency.
2. Consider the exacerbation of impacts to City operations when weather is combined with the circumstances of an aging and growing population as well as differential exposures to pollution, poverty and access to resources.
3. Institutionalize incremental resiliency within City operations by ensuring that key operational decisions integrate resiliency.
4. Take into account design and economic elements along with weather extremes in City planning for new development and supporting existing development needs.
5. Prioritize proactive education within City operations as a means to build individual, organizational and community resiliency to weather impacts and climate related disasters.
6. Develop comprehensive criteria that incorporate City priorities including resiliency into all City planning efforts.
7. Allocate, as appropriate, municipal resources necessary to adapt City operations to weather, including evidence based, ongoing assessment of the City's vulnerability and risk to climate variability.

Introduction

The Southwest is a region marked by rapidly changing socioeconomic and climate systems. The 2010 Census confirms that the Southwest is undergoing a dramatic demographic change, with the population of Arizona growing by almost 25 percent in the last ten years. At the same time much of the region has seen variable and extreme weather. We are in the grip of a drought that has persisted for more than a decade—exacerbated by increasing temperatures, extreme precipitation intensity, snowpack reductions and other climate-related changes. In the past two years, Flagstaff has experienced record warming, severe winter storms, record low moisture, catastrophic wildfires and subsequent flooding events. As climate and related extreme weather conditions change, so will the demand for City services, smart economic growth and community development.

A commitment to climate adaptation and resiliency helps the City of Flagstaff better respond to these increasing service delivery challenges by complementing response and relief efforts with preparedness and prevention measures. Like many cities, Flagstaff's municipal government is developing programs and policies that will affect the City in the long-term, and the City intends to increase the resiliency of City operations to the future effects of climate change. The Resiliency and Preparedness Study introduces a vision and path to create a resilient municipal organization. The intent of the Study is to provide guidance to local decision makers by identifying vulnerable planning areas within the City and assessing the risks of potential climate impacts. The results of these analyses will determine priority planning areas for the City's climate adaptation and resiliency efforts.

Vision for Resiliency – the Role of City Government

Resiliency is built through awareness of how changes in climate conditions can impact the community's critical resources and in turn, the City's priorities. The City conducted a study to assess vulnerability and risk of local systems, such as water, public health and forest health that are affected by climate variability and extremes. This Study is an important step toward building a resilient and prepared community.

Reducing vulnerability to the changing climate requires the City to identify how vulnerable its operating efficiency, public health, infrastructure and economic competitiveness are to climate variability. This also requires the City to know where it lacks sufficient capacity to adapt, and what the risks are if it does not act. Preparing now to be more resilient to these changes is fiscally responsible, while inaction now can lead to higher costs in the future.

The City of Flagstaff has a long history of weathering adversity and emerging as a stronger, more cohesive community. As climate and related extreme weather conditions change, Flagstaff is beginning to innovate in original ways to prepare including completing the Resiliency and Preparedness Study for municipal operations. As a local government critically concerned with drought, climate variability, and the larger issues of sustainability, completing the Study is both timely and critically important. This Study is supported by an existing commitment to climate adaptation and resiliency as detailed in the City's Municipal Sustainability Plan and long-term planning objectives at the City of Flagstaff.

Local governments have the opportunity to bolster their preparedness and resilience to everything from extreme storm events to economic shocks.

One of the biggest challenges in building resiliency is that segments within communities and organizations face varying risks given the differences in the degree to which they can be affected and their ability to cope with climate extremes. Climate related extreme events around the world have shown that when local governments and communities are prepared (i.e. residents are educated and aware, informed, prepared, have access to appropriate resources), then the impacts of adverse effects of extreme climate events can be less severe.

Local governments have the opportunity to bolster their preparedness and resilience to everything from extreme storm events to economic shocks. The tools for doing so range from land use planning to transportation and economic development policy to emergency and disaster preparedness initiatives. By building resiliency within City operations, Flagstaff can be a place where:

- A diverse and thriving economy can adapt to changing weather patterns.
- Natural resources are actively managed to continue to provide important services to users.

- Robust public health and emergency management infrastructure, social networks and other social systems enable the region to minimize the health impacts of climate change.
- Lives, homes and infrastructure are prepared for extreme weather events and related flooding, wildfires, landslide, and other hazards.
- Municipal operations incorporate resiliency and adaptability into existing and future plans, policies and procedures.

Rationale for Resiliency

Flagstaff and other local governments are on the frontlines of managing the impacts associated with climate variability, ranging from increased drought (straining water supplies) to increased flooding (straining stormwater management infrastructure) to more extreme heat and weather events (putting lives and property at risk). While beneficial, the City of Flagstaff can no longer only use historical weather to plan for a prosperous future. In looking to the future, the municipal organization has the opportunity to continue to use historical data while also incorporating projected changes in climate and associated impacts.

Climate variability affects a local government's ability to deliver on its existing commitments.

There are a number of reasons why climate resiliency and preparedness is a smart option for Flagstaff:

The climate has already changed and future changes are highly certain. In many parts of the world, the current climate is already noticeably different from the climate in the past century. In Flagstaff, annual average temperature has increased and projections indicate a rise in the rate of warming. The changing climate has serious direct and indirect impacts and communities that engage in advanced planning can benefit (Hansen 2005).

Climate variability poses a threat to existing community priorities and affects a local government's ability to deliver on its existing commitments. For example, Flagstaff is committed to providing its citizens with access to potable water for a variety of uses. However, if today's agreements and infrastructure projects do not account for future snowpack changes or threats to watersheds, Flagstaff may not be able to achieve this established goal.

Local officials are making major development decisions today that will have long legacies; therefore, today's choices will shape tomorrow's vulnerabilities. It is important to build the capacity to adapt to unforeseen circumstances by increasing diversity, redundancy and network overlaps within municipal operations. Infrastructure designed and built today could last anywhere between 30 and 100 years depending on materials.

Planning now can save money, while inaction will lead to higher costs in the future. Paying for prevention upfront can avoid more significant costs in the future. For example, it has been found that one dollar of hazard mitigation today can prevent the expenditure of four dollars of post-disaster reconstruction in the future (GFDRR 2010). This principle also extends to reducing the future costs of incremental climate change impacts (Snover 2007).

Planning for uncertainty and future variability is not a new process, and can be integrated into current planning frameworks. Flagstaff creates many long-term plans that establish a future vision for the community and municipal organization. These long-term planning efforts incorporate uncertainties in population growth and economic trends. Incorporating climate variability along with other non-weather related uncertainties, the City can be better prepared, enhancing overall organizational resiliency. While there will always be uncertainty about the precise ways in which changes will impact specific operations, the City can make informed decisions about how to adapt based on the best available information and integrate those choices into existing planning efforts.

Adaptation and resiliency can have co-benefits for climate change mitigation and local sustainability efforts that Flagstaff already has adopted. Some actions can achieve greenhouse gas emissions reductions while at the same time helping Flagstaff adapt to expected climate change. Energy efficiency, for example, is a common strategy to reduce greenhouse gas emissions. It can also improve the City's energy management and increase capacity to cope with future climate impacts to the energy sector, and reduce water use.

Future Climate Projections – Flagstaff, AZ

Over the past century, numerous changes in climate have been documented globally. For the sake of this study, climate refers to long term average trends, as well as extremes, in weather. To date, the world has seen annual average temperature increases, altered precipitation patterns, and sea level rise. Temperature increases over the past century have resulted in less snow accumulation in the winter and an earlier arrival of spring in many parts of the world. Global climate change trends – increasing temperatures, altered precipitation patterns, and

rising sea level – are expected to continue into the future, and the rate of change is expected to increase (IPCC 2007).

The life cycles of greenhouse gasses are lengthy and complex. Throughout the next decades, there will continue to be impacts of heat-trapping gas emissions from years past, even if present day concentrations of greenhouse gases do not increase. However, greenhouse gas emissions and concentrations continue to increase further committing us to a large change in climate. Given that regional and local climate conditions can vary significantly from the world wide averages, it is necessary to translate global results into regionally relevant information.

Historical trends provide an important backdrop to future projections and crucial information for calibrating models; however, in order to plan for climate change, future projected changes must be considered. The information below summarizes regional projections for key climate conditions. These climate projections were used as parameters for the City's vulnerability and risk assessments.

Temperature:

A University of Arizona research team, led by Gregg Garfin, compared twenty-two global climate models and statistically downscaled them to the Southern Colorado Plateau and Four Corners states. Their research describes a warmer future, in which annual temperatures by the 2030s are projected to exceed the observed regional average temperature for the range of variability during the time period 1950 – 1999 (Garfin et. al, 2009). The number of extremely hot days is also projected to rise during the beginning of the 21st century (U.S. Forest Service 2010). Looking out to 2100, the rise in temperature is anticipated at 5 – 8 degrees Fahrenheit. In most cases the greatest warming will be seen in the summer and fall months.

Table 1: Temperature Projections – Flagstaff, Arizona

Timeframe	Annual Average Temperature Projections	Other factors	Anticipated Impacts
2100	**+ 5 °F to + 8 °F**	Longer lasting heat waves ~ 2 weeks longer. Greater shifts in summer temperatures.	Longer growing season Fewer frost days More heat waves Increased forest fires Greater water challenges

(Lenart, 2007).

Precipitation: Future precipitation patterns remain difficult to model, due to the complexity of factors affecting these patterns. Researchers at the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory found 0 – 10 % reductions in annual average precipitation by the end of the century as compared to the region's 1970 – 2000 average. The reduction is superimposed on typical southwestern drought cycles as well as on more moist periods. There is likely to be a trend toward less frequent, but heavier precipitation events. (Table 2)

Table 2 : Precipitation Projections – Flagstaff, Arizona

Average Annual Precipitation Projections	Anticipated Impacts
5% decrease in annual average by 2100 compared to 1970 - 2000 for Northern Arizona.	Greater water challenges Increased flooding events

(Lenart, 2007).

Snowpack and Streamflow: Warmer winter temperatures in the Southwest can lead to shorter winters and less snowpack for the region (U.S. Forest Service, 2010). Projections for snowpack across the west show a "precipitous decline in lower-elevation (below 8,200 ft) snowpack" and include shorter winters and less snowpack (Christensen, 2006). This is likely caused by higher temperatures and snow falling as rain. Additionally, climate science projections indicate that spring runoff timing will shift earlier in the season. (Table 3)

Table 3: Snowpack and Streamflow Projections – Flagstaff, Arizona

Snowpack and Streamflow Projections	Anticipated Impacts
Snowpack declines likely due to a shift in the jet stream and El-Nino patterns driving precipitation falls northward.	Greater water challenges Loss in winter recreation

Vulnerability and Risk Assessment

The vulnerability and risk assessment considered the sensitivity of City operations to climate variability. It identified non-climate factors such as population, public safety, and the local economy; determined the degree of impacts; and evaluated the resources currently in place for the City to adapt and respond to the associated impacts of changes in climate. As in other fields that require risk management, the process of priority setting for climate adaptation and resiliency efforts is based on estimation of risk to systems and key planning areas. The Core Team used the information collected during the vulnerability assessment to estimate the consequence, probability and resulting risk of associated impacts of climate change.

City of Flagstaff Core Team

A Core Team of City staff assisted with the vulnerability and risk assessments and consisted of experts within the City's internal operations and represented the following service delivery areas: public safety, economic development, public works, long-term planning, finance, risk management, and utilities.

The Core Team worked through a consensus building process to complete the vulnerability and risk assessments. The team was diverse and illustrates the complexity of the assessment and the potential widespread impacts across the organization. The Core Team also included participation from the National Weather Service's Flagstaff weather forecast office as well as Coconino County emergency management and public health officials.

The City assessed 115 areas of City operations that share three things in common:
1) Each is important to the success and resiliency of the City.
2) Each can be impacted by City government.
3) Each is likely to be affected by weather and climate.

Primary Systems and Key Planning Areas

The Core Team identified 115 elements of City operations that could be impacted by changes in climate. The elements are categorized into primary systems and key planning areas. The key planning areas share three things in common: each is important to the success and resiliency of the City of Flagstaff; can be impacted by City government; and is likely to be affected by climate change.

From a planning perspective, the impacts of changes in climate to City operations are of greater concern than independent changes in the climate. Using the community assets of energy, ecology and water as guidance, seven systems and twenty-three planning areas were identified for assessment. The primary systems include: emergency services, energy, forest health, public health, stormwater, transportation and water.

Table 4 : Primary Systems and Key Planning Areas

Primary System	Key Planning Areas
Emergency Services	Police and Fire Services, Emergency Medical Services, Disaster Response, Public Works
Energy	Energy Delivery and Assurance, Energy Demand and Cost
Forest Health	Forest Management, Wildlife and Vegetation, Public Infrastructure
Public Health	Public Health Infrastructure, People, Public Services
Stormwater	Buildings, Infrastructure
Transportation	Public Transportation, Transportation Infrastructure, Public Access, Rail, Airport
Water	Water Treatment Quality, Water Resources, Infrastructure

Vulnerability Assessment Methodology

The vulnerability assessment was conducted in two parts, through a sensitivity analysis and an adaptive capacity assessment. The level of climate-sensitivity is influenced by the key planning area's current and future stresses, the relevant expected climate change(s), and the projected impacts of that change. (Table 5) A key planning area that would experience little to no impact from climate change received a low sensitivity rating, whereas an area that would be greatly impacted received a high sensitivity rating.

Table 5 : Sensitivity Analysis

Non climate factors that currently affect the Primary System		
Who or what could be impacted	**How do weather and / or climate currently affect this system**	**Description of Potential Climate Change Impact**

The second step of the vulnerability assessment was to determine adaptive capacity. Adaptive capacity was determined by assessing the planning area's ability to accommodate or adapt to the impact in consideration of existing economic, natural, institutional and community resources. (Table 6) The adaptive capacity level was determined subjectively, based on the information gathered for the adaptive capacity assessment. For example, if the planning area demonstrates the ability to accommodate or adapt to the climate impacts, it has a high adaptive capacity level. Conversely, a planning area that will not accommodate or

adapt to the impacts displays a low adaptive capacity.

Table 6: Adaptive Capacity Assessment

What Does This System Currently Have That Will Help it to Adapt?	What Does This System Need in Order to Adapt?

Sensitivity (S) and adaptive capacity (AC) levels were placed in a scoring matrix to provide an overall vulnerability (V) score of potential opportunity (PO) up to 5 with higher scores denoting greater vulnerability. If a planning area has a low sensitivity to climate change and has a high adaptive capacity, the planning area is of low vulnerability. Conversely, if a planning area has a high sensitivity to climate change and a low adaptive capacity, its vulnerability is high. (Table 7)

Table 7 : Vulnerability Ranking

		Sensitivity: Low to High				
		S0	**S1**	**S2**	**S3**	**S4**
Adaptive Capacity Low to High	**AC0**	V2	V3	V4	V5	V5
	AC1	V1	V2	V3	V4	V5
	AC2	V1	V1	V2	V3	V4
	AC3	PO	V1	V1	V2	V3
	AC4	PO	PO	PO	V1	V2

Risk Assessment Methodology

The risk assessment was conducted by determining the planning area's function within City operations, estimating the degree of impact of climate change on each of the key planning areas, and by considering the likelihood that the impacts will occur. The degree of impact was estimated by considering the size of the affected population, whether the impacts could be life threatening and the estimated costs associated with responding to the identified potential impacts. The degree of the impacts was determined using the ranking system in Table 8.

Table 8: Risk Ranking

Degree of Risk	1 point	2 points	3 points
Critical Function	Maintain a non-critical function/ Improve a non-critical function	Improve a critical function/ Mend a non-critical function	Mend a critical function /Maintain a critical function
Citizens Affected	Few/ Less than half of Flagstaff's Population	Half Flagstaff's Population	Entire Flagstaff Population
Life Threatening	No	Uncertain	Yes
Estimated Cost	Low *(up to $1 Million)*	Medium *(~$ 1 - $7 Million)*	High *(~$7 Million +)*
Probability of Impacts	Uncertain	Likely (>66%)	Very Likely (>90%)

As with the vulnerability assessment, the risk was considered on a high-medium-low scale for discussion purposes. A planning area with a ranking of 13 – 15 was deemed high risk. A medium risk designation was given to key planning areas with a ranking of 10 -12, and low risk planning areas were those that had ranking of 7 – 9.

Vulnerability and Risk Assessment Results

The following sections detail the vulnerability and risk assessments for each of the 22 planning areas, grouped by system. The detailed results of the assessments are formatted to document the Core Team's considerations, rankings and prioritization of the two different assessments: vulnerability and risk.

The notion of interdependency is introduced into the assessments for each system. This approach addresses the issue of compounding risks to the City. There are some dependencies between systems which may also contain hidden risks and vulnerability. For example, many of the systems rely on "transportation infrastructure" or "dedicated funding sources" but also may be dependent on the operation of other systems and key planning areas. For example, a localized flooding event may affect the transportation infrastructure system which then affects the delivery of certain goods and services to certain parts of the community.

Vulnerability Assessment Summary

Vulnerable operations are those that are highly exposed to climate conditions, face current and futures (non-climate) stresses, and have little ability to adapt to changing climate conditions. Table 9 summarizes the Core Team's vulnerability assessment of City operations by key planning area. If vulnerability is considered by primary system, and key planning area scores are averaged, the most vulnerable areas of City operations include, in order: forest health, emergency services, water, energy, stormwater, transportation and public health.

Table 9: Vulnerability Assessment Results

High Vulnerability (5 out of 5)	
Water: Resources	Forest Health: Wildlife and Vegetation
Water: Infrastructure	Emergency Services: Disaster Response
Forest Health: Forest Management	Emergency Services: Public Works
Medium - High Vulnerability (4 out of 5)	
Forest Health: Public Infrastructure	Transportation: Infrastructure
Emergency Services: Police and Fire	Transportation: Airport
Emergency Services: EMS	Energy: Demand and Costs
Stormwater: Infrastructure	
Medium Vulnerability (3 out of 5)	
Water: Treatment Quality	Energy: Assurance and Delivery
Public Health: Public Services	
Low – Medium Vulnerability (2 out of 5)	
Stormwater: Buildings	Public Health: People
Low Vulnerability (1 out of 5)	
Public Health: Infrastructure	Transportation: NAIPTA – Public Transit
Transportation: Public Access	Transportation: BNSF

Risk Assessment Summary

The most at risk key planning areas affect critical functions, impact many citizens, pose threats to human life, and are associated with high costs of recovery once impacts are felt. The probability of climate impacts also affects the magnitude of risk. Most key planning areas in this study will be affected by multiple changes that are very likely to occur, although

the assessment scoring system only incorporated one score – the highest possible for that key planning area. In-depth cost calculations were not completed.

The Core Team's risk assessment determined the primary systems at greatest risk to changes in local climate include: water, forest health and energy. Table 10 summarizes the results of the risk assessment by key planning area. If risk is considered by primary system, and key planning area scores are averaged, the most at risk areas of City operations include, in order, include: water, forest health, energy, emergency services, public health, stormwater, transportation and public health.

Table 10: Risk Assessment Results

High Risk (13-15 out of 15)	
Water: Treatment Quality (14)	Water: Infrastructure (13)
Forest Health: Forest Management (14)	Emergency Services: Public Works (13)
Forest Health: Public Infrastructure (14)	Public Health: Public Services (13)
Stormwater: Infrastructure (14)	Transportation: Infrastructure (13)
Water: Resources (13)	Energy: Demand and Costs (13)
Medium Risk (10-12 out of 15)	
Emergency Services: Police and Fire Services (12)	Energy: Assurance and Delivery (12)
Emergency Services: EMS (12)	Public Health: People (11)
Emergency Services: Disaster Response (12)	Stormwater: Buildings (10)
Public Health: Infrastructure (12)	Transportation: Public Access (10)
Low Risk (5-9 out of 15)	
Transportation: Airport (8)	Transportation: BNSF (7)
Forest Health: Wildlife and Vegetation (7)	Transportation: Public Transportation (5)

Primary System and Key Planning Area Summary

The primary systems that resulted in the highest vulnerability and risk rankings were consistent with the individual planning area results. These three systems: water, emergency services and forest health each contain one of the three highest ranked key planning areas. Table 11 summarizes the vulnerability and risk rankings of all the 22 key planning areas assessed.

Table 11: Primary System and Key Planning Area Summary

	System	Key Planning Area	Vulnerability Ranking (0 – 5)	Risk Ranking (0-15)	Combined Ranking (0-20)	Average for System
Water	Water Treatment Quality		3	14	17	17.66
	Water Resources		5	13	18	
	Water Infrastructure		5	13	18	
Emergency Services	Police and Fire Services		4	12	16	16.75
	Emergency Medical Services		4	12	16	
	Disaster Response		5	12	17	
	Public Works		5	13	18	
Forest Health	Forest Management		5	14	19	16.33
	Wildlife and Vegetation		5	7	12	
	Public Infrastructure		4	14	18	
Energy	Energy Assurance and Delivery		3	12	15	16
	Energy Demand and Costs		4	13	17	
Stormwater	Infrastructure		4	14	18	15
	Buildings		2	10	12	
Public Health	Public Health		1	12	13	14
	People		2	11	13	
	Public Services		3	13	16	
Transportation	NAIPTA – Public Transportation		1	5	6	10.80
	Transportation Infrastructure		4	13	17	
	Public Access		1	10	11	
	BNSF		1	7	8	
	Airport		4	8	12	

Next Steps – Recommendations

Focusing on strengthening the municipal organization, the City will need critical functions to be resilient to climate and other disruptions, and be far better integrated with other sectors. The City's actions today to build local government operational resilience will help protect Flagstaff's natural and built resources and the prosperity they provide in the future for the municipal organization and the community it serves. By understanding the vulnerability and risk that the municipal operation faces, staff can begin to identify actions that will reduce adverse impacts and promote coordinated implementation. For example, having recognized that police and fire services, including non emergency operations, are highly vulnerable to the impacts of climate variability, future climate projections can be incorporated into hazard response planning efforts, community education materials can be created, and engagement programs can be tested.

The City of Flagstaff has the opportunity to manage natural and built resources to reduce the adverse impacts of a changing climate on municipal operations. Moreover, the City can explore comprehensive strategies to address multiple vulnerabilities. Supporting regional collaborations and adopting a policy that enhances internal preparedness initiatives are possible ways for the City to increase its capacity to respond across multiple sectors. In fact, awareness of future climate impacts and vulnerabilities raised by this effort has increased the City's capacity to carry out further resiliency and preparedness planning.

Actions today to build local government operational resilience will help protect Flagstaff's natural and built resources and the prosperity they provide in the future for the municipal organization and the community it serves.

Prioritization of Key Planning Areas

Key planning areas of particular importance to the City of Flagstaff were determined by the vulnerability and risk assessment results. Using a ranking matrix based on vulnerability and risk assessments, the Core Team prioritized key planning areas that will help the City build resilience to climate variability within municipal operations. The development of priorities intends to provide the basis by which a high-level strategy and policy to address the top concerns can be defined. The scope of the City of Flagstaff's Resiliency and Preparedness Study included significant areas of municipal

operations. Therefore, the Core Team's recommended priority areas are also supported by the City's existing priorities and goals. Table 11 identifies the Core Team's priorities for action:

Table 11: Core Team Priorities

System	Key Planning Area	Vulnerability Ranking	Risk Ranking	Combined Ranking
Water				
Water Treatment Quality		3	14	17
Water Resources		5	13	18
Water Infrastructure		5	13	18
Forest Health				
Forest Management		5	14	19
Public Infrastructure		4	14	18
Emergency Services				
Disaster Response		5	12	17
Public Works		5	13	18
Energy				
Energy Demand and Costs		4	13	17

City of Flagstaff Recommended Vision Resiliency and Preparedness

The Core Team recommends that the City work to identify actions that it can employ to become a more resilient organization. Using the vulnerability and risk assessments results as guidance, as well as the City's existing Municipal Sustainability Plan, the Core Team recognizes the following vision for climate resiliency and preparedness:

- Prepare the City of Flagstaff for climate related risks and impacts.
- Position the City of Flagstaff for continued prosperity.
- Recognize the opportunities created by changes to Flagstaff's climate.
- Protect the City's resources to support the community's interests.
- Develop and implement policies that contribute to the future well-being of the community.

Resiliency and Preparedness Values

The City plays a vital role in climate resiliency and preparedness planning because changes in local climate can affect the City's ability to deliver on its existing commitments. The Core Team recommends the following values to ensure the City can meet its public planning and operational commitments under a future range of changed climate scenarios:

- Ensure adequate water resources and protect watershed health to meet our organizational and community needs.
- Build, maintain and operate safe infrastructure.
- Provide land use planning and decisions that are sustainable under uncertain future scenarios.
- Ensure continued sustainable economic development.
- Maintain safe, effective mobility in and to the city.
- Effectively manage emergencies and ensure public health and safety.
- Integrate sustainability principles and planning into all aspects of City operations.

Resiliency and Preparedness Policy

The Core Team recommends that the City of Flagstaff take action to build resilience by incorporating planning for future climate changes into all City functions to remain a strong and resilient organization. The Team also recommends that City Council adopt guiding policy statements so that all future City plans and projects incorporate and account for the direct and indirect impacts of changes in precipitation and temperature. Additionally an incremental and integrated approach is recommended to leverage existing operational efforts, City planning processes and strong partnerships. An integrated approach will foster resilience into existing efforts, creating a more meaningful realization of near and long term benefits of preparedness. Examples of this include the incorporation of future climate projections for Flagstaff into the Emergency Management Plan, Multi-Jurisdictional Hazard Mitigation Plan, Capital Improvements plans, building energy codes, budget planning, water policy, transportation planning, etc. The following section highlights the Core Team's policy recommendations and suggested strategies for policy implementation. These strategies are illustrative only and are intended to highlight how some policy statements could be implemented.

> *The Core Team recommends that the City prepare for the direct and indirect impacts of precipitation and temperature change. This will make the City a stronger and more resilient organization.*

Resiliency and Preparedness Policy Recommendations

1. The City of Flagstaff will build, sustain and leverage partnerships with local and regional stakeholders to ensure collective investment, efficient action and shared responsibility in the building of local resiliency.

2. The City of Flagstaff will consider the exacerbation of impacts to City operations when weather is combined with the circumstances of an aging and growing population as well as differential exposures to pollution, poverty and access to resources.

3. The City of Flagstaff will institutionalize incremental resiliency within City operations by ensuring that key operational decisions integrate resiliency.

4. The City of Flagstaff will take into account design and economic elements along with weather extremes in City planning for new development and supporting existing development needs.

5. The City of Flagstaff will prioritize proactive education within City operations as a means to build individual, organizational and community resiliency to weather impacts and climate related disasters.

6. That the City of Flagstaff will develop comprehensive criteria that incorporate City priorities including resiliency into all City planning efforts.

7. The City of Flagstaff will allocate, as appropriate, municipal resources necessary to adapt City operations to weather, including evidence based, ongoing assessment of the City's vulnerability and risk to climate variability.

The Core Team recommends an incremental and integrated approach in order to leverage existing operational efforts, City planning processes and strong partnerships. An integrated approach will foster resilience into existing efforts, creating a more meaningful realization of near and long term benefits of preparedness.

Resiliency and Preparedness Policy – Recommended Strategies and Actions

Policy 1: ***The City of Flagstaff will build, sustain and leverage partnerships with local and regional stakeholders to ensure collective investment, efficient action and shared responsibility in the building of local resiliency.***

- Continue existing partnerships with local and regional stakeholders to ensure collective investment, efficient action and shared responsibility in the building of local resiliency, including: Four Forest Restoration Initiative, Northern Arizona University, Coconino County, Western Adaptation Alliance, Arizona Department Water Resources, Arizona Department of Emergency Management, U.S. Forest Service, Greater Flagstaff Forest Partnership, Governor's Forest Health Council, Arizona State Forestry Division, Coconino Plateau Water Advisory Committee.
- Pursue new partnerships.
- Continue to support the coordination and integration of City and County systems to provide emergency management services and planning committees.

Policy 2: ***Consider the exacerbation of impacts to operations when weather is combined with the circumstances of an aging and growing population as well as differential exposures to pollution, poverty and access to resources.***

- Target City employees that may be adversely impacted (outdoor workers, emergency responders, etc.).
- Continue to coordinate with social service and public health agencies that assist with vulnerable residents, including transient populations.
- Identify resources necessary to support Woods Watch programming.
- Integrate cooling and warming centers into planning efforts for emergency shelters.
- Support FireWise programming in vulnerable and at risk neighborhoods.

Policy 3: ***Institutionalize incremental resiliency within City operations by ensuring that key operational decisions integrate resiliency.***

- Develop criteria for the City's master planning efforts that support goals.
- Identify and recognize efforts that currently support preparedness and resiliency.
- Integrate resiliency and preparedness goals into all Divisions' strategic plans.
- Incorporate resiliency lens into Planning Cabinet activities.
- Integrate resiliency into Capital Improvement Plan budgets by identifying operations and maintenance plans that counter weather impacts.
- Identify efforts that support resiliency during the budget review process, including program accomplishments, initiatives and performance measures.

Policy 4: Take into account design and economic elements along with weather extremes in City planning for new development and supporting existing development needs.

- Update internal review procedures to take into account design, economic, environment and climate elements when planning for new development and supporting existing development.
- Incorporate efficient and renewable energy processes and technologies into existing and future City operations.
- Identify opportunities to reduce the incremental water and energy use as a result of population growth.
- Research opportunities to update and offset engineering design standards to ensure a level of preparedness for weather related impacts.
- Coordinate with NOAA to adjust design storm features in the City's Stormwater manual.
- Promote the development of activity centers, redevelopment and infill.
- Apply defensible property principles to City facilities and infrastructure.

Policy 5: ***Prioritize proactive education within City operations as a means to build individual, organizational and community resiliency to weather impacts and climate related disasters.***

- Coordinate climate preparedness goals into existing public information programming.
- Work with City Extended Leadership Team to coordinate the introduction and implementation of resiliency efforts.
- Receive input from staff on best management practices that promote sustainability.
- Identify partnership opportunities to reach students and the community on the importance of being prepared.
- Coordinate educational trainings with the Citizens Emergency Response Team, Police Department's Community Support trainings and Citizens Police Academy.
- Coordinate with County Emergency Manager to host "train the trainer" opportunities.
- Support a cross training and educational for City staff through the County Emergency Management and Arizona Department of Emergency Management.
- Coordinate with Fire Department to support cross training for City employees and practice within an all risk environment.

Policy 6: ***Develop comprehensive criteria that incorporate City priorities including resiliency into all City planning efforts.***

- Continue to integrate resiliency efforts into water resource management and infrastructure planning policies that address climate impacts on water supply and infrastructure.
- Incorporate resiliency and uncertainty into the City's economic development and master planning efforts.
- Integrate resiliency goals into long term capital improvement plans, including infrastructure and facility projects.
- Ensure climate variability and resiliency efforts are integrated into the role of the Emergency Operations Center Cabinet.
- Integrate resource scarcity into municipal energy management.
- Incorporate future climate projections into emergency response and hazard mitigation.
- Incorporate adverse weather impacts in future landfill expansion.
- Identify opportunities to encourage resiliency and climate preparedness through the Regional Plan update and the subsequent annual review process.

Policy 7: ***Allocate, as appropriate, municipal resources necessary to adapt City operations to weather, including evidence based, ongoing assessment of the City's vulnerability and risk to climate variability.***

- Pursue opportunities such as Payment for Watershed Services as a method to finance ongoing forest restoration measures aimed at protecting community resources.
- Identify the City's critical infrastructure that needs to have redundant back up power.
- Incorporate redundant back up power needs for Utilities' operations into master planning efforts.
- Incorporate future infrastructure needs into utility rate design.
- Support evidence-based, ongoing assessment of the organization's vulnerability and risk to changes in local climate.
- Provide the resources necessary to evaluate and implement the organization's sustainability performance, including vulnerability and risk reduction efforts.
- Research a performance management system to evaluate the organization's resiliency and sustainability as outlined in the Municipal Sustainability Plan.
- Identify, document and evaluate performance measures that support the City'sresiliency.
- Core Team to meet with representatives of upcoming projects and programming to discuss considerations of operational impacts to increase temperature, decrease precipitation, increase storm magnitude.

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Appendices

Emergency Services System – Sensitivity Analysis Results

Temperature 5-8 °F Increase; Precipitation 5% Decrease		
Non climate factors that currently affect the Emergency Services System		
Non climate factors that currently affect the Emergency Services System	• The state of the economy: homelessness, drug use, depression, etc. • Public safety • Age and health of the population the emergency management system serves • Population shifts/migration • Funding for the operation and maintenance of the emergency management system including available Federal and State funding to assist smaller communities to better prepare for weather • Policy development	
Who or what could be impacted	**How do weather and / or climate currently affect this system**	**Description of Potential Climate Change Impact**
Police and fire services		
Personnel safety	Decrease in safe working conditions	Increase of hazards and impediments to personnel
Response times	Increase in response times	Increase in response times
Wildland resources	Increase fire risk and frequency of fire related events	Increase in the demand on resources able to respond to wildfire events
Communication infrastructure	Increase demand and reduced access	Decrease of reliability of communication infrastructure
Forest dwellers	Increase in migration of homeless to forest areas	Increase in length of stay of forest dwellers

Forest services	Increase in fire risk	Increase in the demand for Woods Watch Patrol
Call volume	Increase in nature and number of calls	Increase in mutual aid calls
EMS		
Elderly and populations vulnerable to respiratory illness	Increase in respiratory related health emergencies	Increase in heat related emergencies
Mental health	Negative mental health consequences	Increase in acute stress, PTSD, and substance abuse
Motorists	Increased motor vehicle crashes	Increase in weather-related transportation injuries
Disaster Response		
Search and rescue operations	Increase calls due to rapid changes in severe weather	Increase in demand for specialized equipment and training for search and rescue operations
HAZMAT	Increase risk of accidents with hazardous materials	Increase of risk of hazardous material spills on interstates and railroad
Basic goods and services	Increase demand for emergency food, water and shelter	Reduce in access to emergency food, water and shelter
Outlying communities	Reduce access to urban centers	Increase in demand for goods and public services from outlying communities
City and County personnel	Increase demand for City and County services	Limited ability for municipal personnel to commute to work
Public Works		
Snow operations	Increase snow loads	Reduce of accessibility of roads and highways
City facilities	Reduce accessibility of critical City facilities to employees and public	Reduce of accessibility of public facilities
Fiscal resources	Increase stress on fiscal resource	Increase in demand and limited resources for services and repairs
Fleet services	Increase demand for fleet services	Increase in frequency and demand for fleet services

Emergency Services System – Adaptive Capacity Assessment Results

What Does the Emergency Services System Currently Have That Will Help it to Adapt?	What Does the Emergency Services System Need in Order to Adapt?
• A robust emergency management system • Coconino County Multi-Jurisdictional Hazard Mitigation Plan • Coconino County Emergency Operations Plan • County/City Emergency Operations Center • Volunteer Organizations Active in Disaster • Emergency Declaration process that allows for the coordination and assistance between City-County-State -Federal government agencies such as FEMA • Arizona Counties Mutual Aid Compact coordinated through the Arizona Department of Emergency Management • Robust and organized Woods Watch Program (citizen volunteer and training program) • Gated entrances to I-40 interchanges in Flagstaff area • Public safety signage on State highways to alert drivers to road conditions and weather concerns • The National Flood Insurance Program • Public Safety partnerships for mutual aid response • Community Emergency Response Team • Social services programming throughout the community • Educated community • Communication plans including the 800 MH emergency radio system	• Funding for a larger emergency management system- study and implementation • Continued allocation of secure funding for emergency management operations • Update Coconino County Multi-Jurisdictional Hazard Mitigation Plan to include preparedness and prevention measures that address projected variability in climate • Update Coconino County Emergency Operations Plan to include preparedness and prevention measures that address projected variability in climate • Increase coordination of resource needs and citizen welfare through City/County Emergency Operations Center • Constant information sharing with all stakeholders to assess the situation status on a regular basis • Provide continuous updates to the State EOC to evaluate needed resources for the community to assist with recovery efforts • Continue joint training with City/County staff in preparation for climactic and weather related events such as drought • Adopt additional interagency cooperation and mutual aid compacts between emergency response agencies • Plan for future public safety providers to absorb additional requirements to mitigate impacts with climate changes • Public safety signage on State highways to alert drivers to road conditions and weather concerns • The National Flood Insurance Program • Public Safety partnerships for mutual aid response • Community Emergency Response Team • Social services programming throughout the community • Educated community • Communication plans including the 800 MH emergency radio system

Emergency Services System – Vulnerability and Risk Ranking Results

		Sensitivity Ranking	Adaptive Capacity Ranking	Vulnerability Ranking	Risk Ranking
System	**Key Planning Area**	**Exposure + Potential Impacts + Non Climate Factors**	**What Does This System Currently Have That Will Help it to Adapt**	**Sensitivity + Adaptive Capacity**	**Critical Function + Citizens Affected + Life Threatening + Estimated Cost + Probability**
EMERGENCY SERVICES					
Police and Fire Services		System will be **greatly** affected by the impacts	System will be **somewhat** able to adapt or adjust to the impacts	**Medium-High Vulnerability**	**Medium Risk**
EMS		System will be **greatly** affected by the impacts	System will be **somewhat** able to adapt or adjust to the impacts	**Medium-High Vulnerability**	**Medium Risk**
Disaster Response		System will be **greatly** affected by the impacts	System will be **minimally** able to adapt or adjust to the impacts	**High Vulnerability**	**Medium Risk**
Public Works		System will be **greatly** affected by the impacts	System will be **minimally** able to adapt or adjust to the impacts	**High Vulnerability**	**High Risk**

Temperature 5-8 °F Increase; Precipitation 5% Decrease		
Non climate factors that currently affect the Energy System		
Non climate factors that currently affect the Energy System	• Population shifts/increase growth rate • Policy development/energy codes and land use • Adequacy of energy infrastructure • Cost of energy • Types of energy available • Competition for energy needs • Public safety – terrorism threats • Energy grid capacity • Local economy • Technology	
Who or what could be impacted	**How do weather and / or climate currently affect this system**	**Description of Potential Climate Change Impact**
All public facilities	Warmer temperatures can increase the demand to cool public buildings	Increase of use at public facilities. Increased energy costs.
Energy suppliers	Higher temperatures and increase demand for water can reduce the efficiency of production in thermal power plants	Reduce in operating efficiency at regional thermal power plants
Energy cost	Energy costs can increase due to increase demand for resources	Increase in energy costs for utility rate payers, increase demand for renewable energy and energy conservation

Energy security	Utility lines can be damaged by high winds, snow loads, fallen trees, etc.	Increase in duration of power outages
Residents	Warmer temperatures increase the use of air conditioning	Increase in demand and duration for residential cooling and heating
Businesses	Warmer temperatures increase the use of air conditioning	Increase in energy demand and cost for businesses
Tourism	Energy delivery interruptions due to weather can impact businesses that rely on climate/weather (winter and summer)	Increase in energy demand and costs for summer based tourism industries
Groundwater	Less rain results in increase use of groundwater wells to meet potable water demand	Increase in the City's energy demand and cost to produce water
Surface water	Erosion increases sedimentation of Lake Mary	Increase in the City's energy demand and cost to treat water
Critical public resources (Hospitals, Fire/Police, City Hall, Water Plants, etc.	Weather related power outages can impact emergency and critical operations	Increase in power outages and increase need for back-up generators
City fiscal resources	Weather related events and impacts to energy delivery/security increase stress on fiscal resources	Increase in demand for services and repairs subject already limited resources

Energy System – Adaptive Capacity Assessment Results

What Does the Energy System Currently Have That Will Help it to Adapt?	What Does the Energy System Need in Order to Adapt?
• Local APS on site in Flagstaff • Trends toward diversification of energy portfolios • APS Smart Grid • APS Community Power Project • UniSource and APS DSM programming • NAU Sky Dome – shelters in place • Back up generators at critical City facilities • Rainwater harvesting efforts • Energy costs incorporated into water rates for delivery and production • Energy efficiency and renewable energy resolution – Municipal Sustainability Plan • Ability to modify building codes • Conservation mindset exists within the community • City's residential energy efficiency programming • Coconino County Emergency Operations Plan • County/City Emergency Operations Center	• Shelters equipped with AC for heat related emergencies • Mobile cooling stations/ fan distribution • Neighbor check-in system • Additional back up generators • Additional funding to support increased energy costs • Allocated funding to support energy efficient technologies and optimal performance within City operations • Additional funding to support production of renewable energy at City facilities • Modify building energy codes to address increase costs for heating and cooling • Streamline permitting process for energy efficient and renewable energy projects • Adequate supply of local food, water and ice • Increased capacity at wastewater and water treatment plants at times of limited power supply • Funding to support and offset performance based energy saving measures within all sectors of the community • Funding to support behavioral change efforts to meet energy reduction targets

Energy System – Vulnerability and Risk Ranking Results

		Sensitivity Ranking	Adaptive Capacity Ranking	Vulnerability Ranking	Risk Ranking
System	**Key Planning Area**	**Exposure + Potential Impacts + Non Climate Factors**	**What Does This System Currently Have That Will Help it to Adapt**	**Sensitivity + Adaptive Capacity**	**Critical Function + Citizens Affected + Life Threatening + Estimated Cost + Probability**
ENERGY					
Energy Assurance and Delivery		System will be **somewhat** affected by the impacts	System will be **somewhat** able to adapt or adjust to the impacts	**Medium-Low Vulnerability**	**Medium Risk**
Energy Demand and Cost		System will be **largely** affected by the impacts	System will be **somewhat** able to adapt or adjust to the impacts	**Medium-High Vulnerability**	**High Risk**

Temperature 5-8 °F Increase; Precipitation 5% Decrease		
Non climate factors that currently affect the Forest Health System		
Non climate factors that currently affect the Forest Health System	• Recreation including hunting, camping, fuel wood gathering and motorized recreation • Commercial interests in forest resources • Endangered species designations • Invasive species establishment • Vast geographic area • Volunteers • Population shifts/migration • Zoning and land development • Biomass utilization • Local, State and Federal funding and policy development • Local economy • Public safety • Awareness of forest management approaches • Human resources available for forest management efforts	
Who or what could be impacted	**How do weather and / or climate currently affect this system**	**Description of Potential Climate Change Impact**
Forest Management		
Soil moisture	Increase risk of wildfire events	Increase in severity and frequency of wildfire events
Recreation	Reduce access to forest areas due to fire risk	Increase in forest closures and decrease in recreational opportunities
Watersheds	Reduce recovery and storage of water	Loss of long term storage of water

Water storage	Reduce stability and increase in washed out tanks	Reduce in storage assets
Quality of municipal water supply	Increase debris flows	Reduce in water quality
Interception of precipitation by forest canopy	Reduced surface moisture and infiltration	Loss of long term storage and recharge rate
Viewshed	Economic loss	Decrease in tourism and home values
Forest dwellers	Increase in migration of homeless from warmer communities to forest areas	Increase in length of stay and impact (trash, fires) of forest dwellers
Wildlife and Vegetation		
Vegetation	Increase stress to disease vulnerable species	Increase in brush based forests, tree mortality
Grazing	Change in the type and quality of flora	Adverse affect to rangeland production, pest control and grazing capacity.
Wildlife	Reduce access to food and shelter/habitat	Increase in human-animal contact. species migration and vector borne illnesses
Public Infrastructure		
Accessibility of municipal water supply	Decrease access to water supply and infrastructure	Decrease of accessibility to water due to damaged water infrastructure
Tourism	Reduce aces to forest users and visitors	Reduce in the number of tourists and conventions
Wildland-urban interface	Increase risk of wildfire and flooding	Increase in frequency and number of threatened structures
Property values	Increase proximity to destroyed forests/flood areas	Decrease in property values
EMS/Fire/Police Personnel	Increase demand for EMS/Fire/Police	Increase in illegal uses of forests
Property crime rates	Increase visitors to area can lead to increase in property crime rates	Decrease in business attraction and retention

Forest Health System – Adaptive Capacity Assessment Results

What Does the Forest Health System Currently Have That Will Help it to Adapt?	What Does the Forest Health System Need in Order to Adapt?
• The City's Forest Management and Wildland Fire personnel, programming and services • Various regulatory agencies (Game & Fish, US Forest Service) ability to control how the forests are used, or not used • Local presence of US Forest Service, National Park Service and AZ Game and Fish • Citizen/volunteer groups to educate and spur action • NAU School of Forestry, Ecological Restoration Institute, Miriam Powell Research Station and NAU Centennial Forest • Quasi-governmental groups including Four Forest Restoration Initiative, Greater Flagstaff Forest Partnership, Grand Canyon Forests Partnership Wildland Fire Advisory Council, Ponderosa Fire Advisory Council to identify and the health needs of the local forests and fuel mitigation efforts to help reduce the risk of wildfire and improve forest health • Robust and organized Woods Watch Program (citizen volunteer and training program) • Public Safety Officers are trained and equipped to conduct transient and Woods Watch patrols • Coordination with other public safety agencies, including DPS, to provide assistance in patrols (thermal imaging fly-overs, etc.) • No camping in City limits ordinance • Successful treatment projects are a resource for increased resiliency to future fire events • History of "bad" fire to help set priorities and develop response plans • General public is informed about fire wise and fire safe practices • Wildland Urban Interface Fire Code	• Expansion of resources and planning communication that connects forest health and fire risk to ecological habitat and water quality • Holistic forest management plans that incorporate projected climate variability • Additional gates on forest service roads to prevent access during closures and appropriate signage • Increase US Forest Service law enforcement activities to monitor legal and illegal activities occurring due to the influx of people in the forest • Continued support and resources allocated to the efforts between the City and forest partnerships • Limit public use of the forests during dry periods and critical fire conditions • Ensure utility companies with lines that traverse the forests are up to standards, reducing fire hazards • Increase funding for prevention activities (ex: FireWise) and Hazard Mitigation/forest management treatments (ex: thinning, debris disposal, and prescribed fire)

Forest Health System – Vulnerability and Risk Ranking Results

		Sensitivity Ranking	Adaptive Capacity Ranking	Vulnerability Ranking	Risk Ranking
System	**Key Planning Area**	**Exposure + Potential Impacts + Non Climate Factors**	**What Does This System Currently Have That Will Help it to Adapt**	**Sensitivity + Adaptive Capacity**	**Critical Function + Citizens Affected + Life Threatening + Estimated Cost + Probability**
FOREST HEALTH					
Forest Management		System will be **greatly** affected by the impacts	System will be **minimally** able to adapt or adjust to the impacts	**High Vulnerability**	**High Risk**
Wildlife and Vegetation		System will be **greatly** affected by the impacts	System will be **minimally** able to adapt or adjust to the impacts	**High Vulnerability**	**Low Risk**
Public Infrastructure		System will be **greatly** affected by the impact	System will be **minimally** able to adapt or adjust to the impacts	**Medium-High Vulnerability**	**High Risk**

Temperature 5-8 °F Increase; Precipitation 5% Decrease		
Non climate factors that currently affect the Public Health System		
Non climate factors that currently affect the Public Health System	• Population shifts/migration • Non-climate related health pandemics • Public safety • Local, regional and national economy • Policy development, affordable healthcare, unfunded mandates • Mental health care demands • State of local social services • Educational system	
Who or what could be impacted	**How do weather and / or climate currently affect this system**	**Description of Potential Climate Change Impact**
Public Health Infrastructure		
Public Health Personnel	Decrease in safe working conditions	Increase in exposure of communicable diseases to public health personnel
Hospitalization rates	Increase in hospitalization rates	Increase of rate and duration of hospitalization
Communication infrastructure	Increase demand and reduced access	Decrease in reliability of communication infrastructure
Disaster response	Increase calls due to rapid changes in severe weather	Increase in demand for specialized equipment and training for search and rescue operations
HAZMAT	Increase risk of accidents with hazardous materials	Increase of risk of hazardous material spills on interstates and railroad
Public health notifications	Weather can impact accessibility of residents to receive public notifications	Reduce in access to public notification systems

Mental health	Weather related crisis can create anxiety among population	Increase in the demand for crisis counselors and mental health providers
Public health funding resources	Increase demand for public health funding after weather related event	Reduce in availability of public health funding due to increase demand to resources
People		
Outsiders moving into Flagstaff	As weather changes elsewhere more people may move to Flagstaff	Increase in health emergencies such as elevation sickness, dehydration, respiratory illness
General population	Exposure of heat and flood related health illnesses	Increase in number of treated respiratory illnesses, infectious disease and heat stress induced illnesses
Motorists	Increased motor vehicle crashes	Increase in weather-related transportation injuries
Outdoor workers	Increase exposure to heat	Increase of susceptibility to dehydration, allergies, infectious disease and heat related illnesses
Residents and businesses in floodplain	Flooding events challenge public safety	Increase in storm and flood related injuries
Children, elderly and people living in poverty	Increase demand for energy and water resources	Increase in heat related exposure of groups disproportionately impacted
Public Services		
Air quality	Increase frequency and type of allergies	Increase in air pollution related health effects
Livestock/pets	Residents may abandoned pets and livestock to seek shelter from disaster	Increase in demand for animal management agencies
Solid waste	Increase waste due to weather related destruction of buildings and infrastructure	Increase in demand for solid waste operations due to increase population and waste
Food security	Decrease in access to outside quality food	Decrease in duration of periods of access to food
Access to goods and services	Demand for emergency food, water and shelter	Reduce in access to emergency food, water and shelter
Water supply	Reduce accessibility of critical water resources	Reduce in access to potable water

Public Health System – Adaptive Capacity Assessment

What Does the Public Health System Currently Have That Will Help it to Adapt?	What Does the Public Health System Need in Order to Adapt?
• Robust 800 MH radio communication system • Coconino County Public Health Services District • Emergency Management Office's preparedness and prevention outreach • Arizona Department of Health Services • Interagency mutual aid MOUs and Agreements • Coconino County Emergency Operations Plan • County/City Emergency Operations Center • Gated entrances to I-40 interchanges in Flagstaff area • Public safety signage on State highways to alert drivers to road conditions and weather concerns • Health care facilities (Fronske, Flagstaff Medical Center, Walk-in clinics, Verde Valley Medical Center) • Emergency Medical Services – Guardian Medical Transport • Coconino County's social media efforts • Fort Tuthill – staging grounds • City HAZMAT teams • Strategic National Stockpile • Coconino County Public Health Stockpile • Redundancy in the City's water system • Emergency Alert System • NAU research facilities	• Social services and local government coordination in public health disaster • Greater capacity at health care facilities • Increase specialization of medical personnel and practices • Funding for planning and implementation of efforts that recognize and address associated health impacts of climate change • Local disaster management action team • Increase supply of local food and basic goods • Increase use and access of social media communication • Specialized radio alert station • Increase individual preparedness • Increase services for mental health care

Public Health System – Vulnerability and Risk Ranking Results

		Sensitivity Ranking	Adaptive Capacity Ranking	Vulnerability Ranking	Risk Ranking
System	**Key Planning Area**	**Exposure + Potential Impacts + Non Climate Factors**	**What Does This System Currently Have That Will Help it to Adapt**	**Sensitivity + Adaptive Capacity**	**Critical Function + Citizens Affected + Life Threatening + Estimated Cost + Probability**
PUBLIC HEALTH					
Public Health Infrastructure		System will be **somewhat** affected by the impacts	System will be **mostly** able to adapt or adjust to the impacts	**Low Vulnerability**	**Medium Risk**
People		System will be **largely** affected by the impacts	System will be **mostly** able to adapt or adjust to the impacts	**Medium-Low Vulnerability**	**Medium Risk**
Public Services		System will be **largely** affected by the impacts	System will be **somewhat** able to adapt or adjust to the impacts	**Medium Vulnerability**	**High Risk**

Temperature 5-8 °F Increase; Precipitation 5% Decrease		
Non climate factors that currently affect the Stormwater System		
Non climate factors that currently affect the Stormwater System	• Continued development leads to larger and faster stormwater runoff • Policy development including zoning and land development guidelines • Health and adequacy of under-sized storm drainage systems • Long term funding • Local economy • Public safety and emergency management operations	
Who or what could be impacted	**How do weather and / or climate currently affect this system**	**Description of Potential Climate Change Impact**
Infrastructure		
Stormdrain infrastructure	Overwhelm stormdrains and detention facilities	Increase in capital costs to manage greater flooding events
Surface water quality	Increase concentrations of pollutants in runoff	Increase in potential for groundwater contamination
Ground stability	Increase in erosion and sedimentation	Increase of under cutting of roads/structures, etc. and sediment in stormdrains
Watersheds	Increase impact to burn areas resulting in flooding	Change to 100 year flood
Utility infrastructure	Increase damage to utility infrastructure	Loss of potable water and utility communication systems
Transportation infrastructure	Damage to roads and railroad	Reduce in access for emergency response and disaster operations

Dams	Increase flooding to areas adjacent to Rio de Flag	Reduce in access to essential services for residents adjacent to Rio de Flag
Fiscal resources	Increase stress on fiscal resources	Increase in demand and limits to resources for services and repairs
Ecosystems	Increase erosion alters habitat	Loss of bio-diversity and decrease in water quality
Buildings		
Flood insurance rates	Increase impact to drainage areas and flood zones	Increase of insurance rates and the number of structures located in flood zones
Residents in flood prone areas	Decrease accessibility to private property	Loss of life
Government operations	Demand for protection and services	Increase in demand for protection of life, infrastructure and property
Public and private property	Damage to public and private property	Increase in loss of property - often not insured

What Does the Stormwater System Currently Have That Will Help it to Adapt?	What Does the Stormwater System Need in Order to Adapt?
• A dedicated funding source • A staff of 5 with different areas of expertise within stormwater management • The ongoing development of a City-Wide Master Drainage Plan • The National Flood Insurance Program and FEMA • The City Streets Section operations allow for response and mitigation of small scale flooding and/or drainage issues • Low Impact Development Ordinance • Draft Rainwater Harvesting Ordinance to increase water conservation efforts and extend the City's potable water supply • Rio de Flag, detention basins, flood plain designations, washes and dry lake beds	• Increased Stormwater Utility fees to cover the cost of protecting existing development from increased flooding • Update Stormwater Management Plan to include preparedness and prevention measures that address projected variability in climate • Additional Low Impact Development projects that will conserve water and improve water quality • An outreach program to educate the citizens how to deal with local flooding and install Low Impact Development systems • Increase and reinforce current drainages to handle capacity flows from storms and snow melt • Construction of additional City reservoirs to assist with storage of drinking water • Forest management treatment in the Dry Lake Hills area to reduce the potential of a catastrophic wildfire in that area and the subsequent large-scale damage from flooding that would be expected to occur following such an event

Stormwater System – Vulnerability and Risk Ranking Results

		Sensitivity Ranking	Adaptive Capacity Ranking	Vulnerability Ranking	Risk Ranking
System	**Key Planning Area**	**Exposure + Potential Impacts + Non Climate Factors**	**What Does This System Currently Have That Will Help it to Adapt**	**Sensitivity + Adaptive Capacity**	**Critical Function + Citizens Affected + Life Threatening + Estimated Cost + Probability**
STORMWATER					
	Infrastructure	System will be **greatly** affected by the impacts	System will be **somewhat** able to adapt or adjust to the impacts	**Medium-High Vulnerability**	**High Risk**
	Buildings	System will be **somewhat** affected by the impacts	System will be **somewhat** able to adapt or adjust to the impacts	**Medium-Low Vulnerability**	**Medium Risk**

Temperature 5-8 °F Increase; Precipitation 5% Decrease		
Non climate factors that currently affect the Transportation System		
Non climate factors that currently affect the Transportation System	• Aging infrastructure • Transportation congestion and public safety incidents • Population – seasonal and permanent • Tourism • Local economy • Flagstaff Metropolitan Planning Organization • Policy – Highway User Revenue Fund	
Who or what could be impacted	**How do weather and / or climate currently affect this system**	**Description of Potential Climate Change Impact**
NAIPTA		
Service Routes: Level of Service Reduction	Reduced access to transit opportunities	Reduce in service levels for public transportation resulting in an increase reliance on private transportation
Service Routes: Delay of Service	Disruption in daily lives - decrease in reliability	Increase in frequency and duration of disruptions in service for public transportation
Public transit riders	Increase use of public transit in adverse weather conditions	Increase in reliance on public transportation
Funding for public transit	Diverting of critical funds to other operations	Decrease in the level of service and response to events

Elderly and populations vulnerable to weather related health problems	Increase in the demand for Para-transit services	Increase in demand on services and weather-related transportation injuries
City and County residents	Increase demand for public transit services	Limit in ability for commuting using alternative means including public transit
Fleet services for public transit	Increase demand for fleet services	Increase in frequency and demand for public transit fleet services
Transportation Infrastructure		
Roads and streets	Increase damage to asphalt and pavement	Reduce in pavement integrity, Increase maintenance costs for asphalt and pavement, increase damage to vehicles
Fiscal resources for transportation maintenance	Locations where drilling/refineries are stationed are currently impacted by weather. Increase in gas prices relates to decrease in driving which in turn relates to decrease in HURF dollars and increase cost of construction materials	Reduce in funding for transportation maintenance and materials for new development
Traffic congestion	Increase motor vehicle traffic constriction	Increase in traffic-related congestion, crashes and injuries
Supply routes/food security	Blocked routes as a result of flooding, wind or snow can hinder supplies including food to reach Flagstaff	Increase in duration of lack of access to supply routes into Flagstaff, resulting in impacts to economy
Bridges and culverts	Increase flooding and impact to waterways	Increase in potential for collapse of bridges and damage to culverts
Construction	Increase for potential project delays	Increase in duration of delays for construction projects and capital improvement projects

City Fleet	Increase demand for fleet services	Increase in frequency and demand for City fleet services
Public Access, BNSF and Airport		
Airport flight operations	Increase in potential flight cancelations and delays	Increase in frequency and duration of flight cancelations and delays
Airport infrastructure	Warmer temperatures combined with higher altitude reduces overall aircraft lift	Increase in need for runway extensions for larger aircraft
BNSF	Disruption in rail traffic	Increase in time needed to transport goods via rail and increase potential for HAZMAT events along rail
Policy shifts	ADOT policy to close I-17 in (small to large) weather events	Reduce in tourism, connectivity, emergency response
Outlying communities	Reduced access to urban areas	Increase in demand for goods and public services from outlying communities
Motorists	Increased motor vehicle crashes	Increase in weather-related transportation injuries
Bicycles	Higher temperatures and less frequent rain result in more bicycle ridership	Increase in need for FUTS and bike infrastructure
Residents	Impacts to commute times to/from work, school and places of economic activity	Increase in commute times and transportation costs for local residents
Evacuation routes	Extreme rain events cause flooding in critical locations	Decrease of accessibility of evacuation routes
Local economy	Reduce access for economic activity due to road closures, and storm operations	Decrease in local economic activity

What Does the Transportation System Currently Have That Will Help it to Adapt?	What Does the Transportation System Need in Order to Adapt?
• Coconino County Multi-Jurisdictional Hazard Mitigation Plan • Coconino County Emergency Operations Plan • County/City Emergency Operations Center • Volunteer Organizations Active in Disaster • Arizona Counties Mutual Aid Compact coordinated through the Arizona Department of Emergency Management • Gated entrances to I-40 interchanges in Flagstaff area • Public safety signage on State highways to alert drivers to road conditions and weather concerns • Northern Arizona Intergovernmental Public Transportation Authority • City Manager's EOC Cabinet • Tactical Interoperability Communication Plan – County and State • City of Flagstaff and Coconino County Public Works Departments • NAU Parking lots/ Little America parking • Access to local road supplies during a portion of the year • Flagstaff Metropolitan Planning Organization • Local contractor community – snow operations • Flagstaff Unified School District bus system • Interagency mutual aid MOU and Agreements • Robust 800 MH radio communication system allows for Public Safety and Public Works to communicate on same frequency • BNSF emergency response plan	• Year-round access to local supplies for asphalt and concrete • Longer runway for larger aircraft • Increase city parking when I-40 is closed • Better instrument landing system • Storage/parking at the airport • Qualified CDL drivers • Long-term funding to support transportation planning, infrastructure and programming that addresses projected variability in climate • Policy to support changes in snow operations that address severe snowfall events

		Sensitivity Ranking	Adaptive Capacity Ranking	Vulnerability Ranking	Risk Ranking
System	**Key Planning Area**	**Exposure + Potential Impacts + Non Climate Factors**	**What Does This System Currently Have That Will Help it to Adapt**	**Sensitivity + Adaptive Capacity**	**Critical Function + Citizens Affected + Life Threatening + Estimated Cost + Probability**
TRANSPORTATION					
NAIPTA - Public Transportation		System will be **minimally** affected by the impacts	System will be **mostly** able to adapt or adjust to the impacts	**Low Vulnerability**	**Low Risk**
Transportation Infrastructure		System will be **largely** affected by the impacts	System will be **minimally** able to adapt or adjust to the impacts	**Medium-High Vulnerability**	**Medium Risk**
Public Access		System will be **somewhat** affected by the impacts	System will be **mostly** able to adapt or adjust to the impacts	**Low Vulnerability**	**Medium Risk**
BNSF		System will be **minimally** affected by the impacts	System will be **mostly** able to adapt or adjust to the impacts	**Low Vulnerability**	**Low Risk**
Airport		System will be **largely** affected by the impacts	System will be **minimally** able to adapt or adjust to the impacts	**Medium-High Vulnerability**	**Low Risk**

Temperature 5-8 °F Increase; Precipitation 5% Decrease		
Non climate factors that currently affect the Water System		
Non climate factors that currently affect the Water System	• Population shifts/increase growth rate • Policy development/water regulation and land use • Adequacy of infrastructure • Contamination and water quality • Cost of energy • Operation costs • Water use types • Competition for water sources • Public safety – terrorism threats • Transportation and evacuation routes • Wastewater treatment plant capacity • Water affordability • Local economy	
Who or what could be impacted	**How do weather and / or climate currently affect this system**	**Description of Potential Climate Change Impact**
Water Treatment Quality		
Water quality	Drought and heavy precipitation events affect the occurrence of algae, erosion and siltation	Increase in insect and algae infestation causing increased water treatment costs, Flagstaff's high water quality may spark growth

Wastewater treatment	Climate can affect water quality levels and the number of system users	Increase in demand for wastewater infrastructure
Water Resources		
Reclaimed water supply adequacy	Climate may affect the supply and increases demand for reclaimed water	Increase in the demand for reclaimed water resources and subsequent reduced recharge rate
Groundwater supply adequacy	In periods of drought, water supply must come from wells, possibly depleting supplies faster and decreasing recharge	Increase in the need for groundwater supply to come from deeper in the aquifer or imported, increase demand for more wells
Surface water supply adequacy	Less snow accumulation results in less run off and higher evaporation rate which affects surface water storage. Lake Mary surface water is dependent on snow fall	Reduction of overall reliance of surface water resources
Local economy	Weather related events can affect local economic activity	More forest closures, reduction in natural resource based-tourism and access to local goods and services
Water rates	Cost to produce, treat and deliver water, affecting all users	Low income and major users will be impacted greatly by increase costs. Users may access water by alternative (legal and not legal) means
Water Infrastructure		
Transportation corridors	Flooding affects transportation infrastructure and evacuation routes	Increased in road closures due to severe flooding events
Water infrastructure	Dry and wet conditions can affect pipes, Accumulation can affect location from where water is delivered	Impact to infrastructure by both drought and severe peak flow events, Increase in the demand and delivery distance of water resources
Stormwater system	Stormwater infrastructure is affected by peak flooding events	Increase in the severity of peak flooding events
Forest health	Watersheds health is affected by the availability and adequacy of water supply	Surface water supply and accessibility to water infrastructure will be impacted by forest health

Water System – Adaptive Capacity Assessment

What Does the Water System Currently Have That Will Help it to Adapt?	What Does the Water System Need in Order to Adapt?
• Revenue based system for cost of delivery and production • The ongoing development of a City-Wide Master Drainage Plan • Current tiered residential rate structure • Impact fees • Utilities Comprehensive Plan • Ability to modify building codes • Conservation mindset exists within the community • Red Gap Ranch • Arizona Department of Environmental Quality requirements • Clean Water Act • Current tracking and redundancy of infrastructure resources • Current rate structure will support and fund improvements • Utility and street overlay bond project • 10 year Capital Improvements Plan • Illicit Discharge Ordinance/ Backflow prevention • City's HAZMAT Team • Secondary storage capacity • Coconino County Multi-Jurisdictional Hazard Mitigation Plan • Energy Efficiency and Renewable Energy Resolution • Regional Plan – water scarcity/capacity assessment • Municipal Sustainability Plan – energy and water policies	• Update Utilities Comprehensive Plan to include preparedness and prevention measures that address projected variability in climate • Secure additional water source • Increase conservation of water resources • More aggressive building codes to support water use/energy use • Develop delivery infrastructure at Red Gap Ranch • Contingency planning for reduced growth rates • Funding to support technological improvements for infrastructure and renewable energy projects that support water production, treatment and delivery • Increase and reinforce current drainages to handle capacity flows from storms and snow melt • Construction of additional City reservoirs to assist with storage of drinking water • 100 year water supply • Funding to plan and implement contamination reduction and security efforts at Lake Mary and water treatment plants • Multi-family/commercial tiered rate structure • Forest management treatment in the Lake Mary watershed to reduce the potential of a catastrophic wildfire in that area and the subsequent loss of water storage capacity

		Sensitivity Ranking	Adaptive Capacity Ranking	Vulnerability Ranking	Risk Ranking
System	**Key Planning Area**	**Exposure + Potential Impacts + Non Climate Factors**	**What Does This System Currently Have That Will Help it to Adapt**	**Sensitivity + Adaptive Capacity**	**Critical Function + Citizens Affected + Life Threatening + Estimated Cost + Probability**
WATER					
	Water Treatment Quality	System will be **greatly** affected by the impacts	System will be **mostly** able to adapt or adjust to the impacts	**Medium Vulnerability**	**High Risk**
	Water Resources	System will be **greatly** affected by the impacts	System will be **minimally** able to adapt or adjust to the impacts	**High Vulnerability**	**High Risk**
	Water Infrastructure	System will be **greatly** affected by the impacts	System will be **minimally** able to adapt or adjust to the impacts	**High Vulnerability**	**High Risk**

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