Climate Resilience Evaluation and Awareness Tool Exercise Report

CITY OF PORTSMOUTH, NEW HAMPSHIRE

June 29, 2015

EXECUTIVE SUMMARY

The City of Portsmouth, New Hampshire provides drinking water, wastewater, and stormwater services to residents and local businesses. The utility provides drinking water to about 8,000 customers in the communities of Portsmouth, Greenland, Rye, Newcastle and Newington, and large commercial, industrial and recreational customers. A surface water reservoir and wells are the primary drinking water sources and the City operates an advanced water treatment plant. The City operates two wastewater treatment facilities, twenty wastewater pump stations and recently completed the construction phase of its long-term control plan for combined sewer overflows.

From November 2014 to May 2015, the City of Portsmouth engaged in a series of webinars and an in-person meeting to conduct a climate risk assessment using the U.S. Environmental Protection Agency's (EPA) Climate Resilience Evaluation and Awareness Tool (CREAT). The risk assessment considered drought impacts on their drinking water supply and coastal storm surge on their wastewater pump stations. The City used two different climate change scenarios to assess threats; drier future conditions for a drought threat on water supply ('hot and dry' projection) and wetter future conditions for a coastal storm surge threat on its wastewater pump stations ('central' projection). See **Table 1** for CREAT-provided climate data. With the implementation of adaptive measures, the City of Portsmouth found they could reduce all potential consequences of future coastal storm surge events to the pump stations from 'Very High' to 'Low', and from 'High' to 'Low' for drought impacts to the water supply.

Table 1: CREAT-Provided Data and projections for the City of Portsmouth

CLIMATE VARIABLE	HISTORICAL VALUES	CREAT 2060 PROJECTED VALUES (HOT AND DRY PROJECTION)	CREAT 2060 PROJECTED VALUES (CENTRAL MODEL PROJECTION)
Average Annual Temperature	46.63 degrees Fahrenheit	52.36 degrees Fahrenheit	51.39 degrees Fahrenheit
Total Annual Precipitation	46.79 inches	46.22 inches	50.12 inches
100-Year Storm	7.36 inches	8.08 inches	8.53 inches
Sea Level Rise	N/A	30 to 36 inches	30 to 36 inches

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BACKGROUND

The City of Portsmouth, New Hampshire provides drinking water, wastewater and stormwater services to residents and local businesses. The utility provides drinking water to about 8,000 customers in the communities of Portsmouth, Greenland, Rye, Newcastle and Newington, with some large industrial water users. About 60% of production is commercial or industrial customers, including the decommissioned Pease Airbase (now an office park), two power plants, two gypsum factories, a pharmaceutical company, golf courses and breweries.

Average potable water production from both groundwater and surface water sources is about 3.5 to 6.5 million gallons per day (MGD), with a maximum of 8 MGD. The Bellamy Reservoir is the main surface water source and has 900 million gallons of storage, with a safe yield of 3.5 to 5 MGD. The Madbury Water Treatment Plant (WTP) treats water from the Bellamy Reservoir, and was recently upgraded and is LEED certified (Silver rating). The utility has 9 groundwater wells, with three of the wells at the Madbury WTP. The remaining wells are in and around Portsmouth including the Haven Well near the Pease Airport that is affected by perfluorochemicals (PFC) contamination from previous activities at the Pease Airbase. There have been past detections of contaminants at the Haven Well and this latest contamination episode has necessitated the closing of the well, most likely permanently. There are some concerns that the PFCs could contaminate several neighboring wells, affecting the long-term availability of those supplies.

The City of Portsmouth treats wastewater for about 6,300 customers in the communities of Portsmouth, Newcastle, Greenland and Rye. Average wastewater treatment from two wastewater treatment facilities (WWTF), the Pierce Island WWTF (4.8 MGD) and the Pease WWTF (1.2 MGD), is a total of 6 MGD. The Pierce Island WWTF has upgrades in design to expand capacity to 6.1 MGD and improve treatment to comply with a federal consent order. The Pease WWTF will soon require an upgrade as well, so the City is evaluating alternative designs and purposes for both facilities in the future. The City has also recently completed construction of controls for its combined sewer overflow (CSO) long-term control plan (LTCP) and is in a post-construction monitoring phase.

The City of Portsmouth has a number of ongoing planning efforts to increase overall sustainability, including a green infrastructure program and the Coastal Resilience Initiative to reduce the impacts of extreme flooding, and to increase the resilience of infrastructure to coastal flooding and sea level rise. In May 2015, the City has received the New Hampshire Department of Environmental Services' (NHDES) "Source Water Sustainability" award for a variety of water conservation measures being implemented, including New Hampshire's first customer rebate program that provides incentives for customers to install more water-efficient appliances. Through a research partnership with the University of New Hampshire, a vulnerability assessment was completed in 2013 for the City that identified vulnerabilities from different climate change scenarios and sea level rise elevations[1]. The City of Portsmouth is planning for a 1.0 to 1.7 foot rise in sea level by the year 2050 and as much as 6.3 feet by 2100.

Flooding from coastal storm surge, sea level rise, and short-term drought are the primary climate-related concerns to the City. While the Pierce Island WWTF is above the 500-year flood elevation, multiple wastewater pumping stations are at

[1] *2013 Climate Change Vulnerability Assessment and Adaptation Plan,* available at: http://www.planportsmouth.com/cri/CRI-Report.pdf

risk now from coastal flooding. The two WWTFs are not at a direct risk to flooding impacts due to their high elevations, however the access road to the Pierce Island WWTF floods on king tides and storm surges, which may be more frequent and worse in the future with sea-level rise, preventing access to the WWTF during those periods.

Locations of the pump stations that were assessed are shown in **Figure 1** below.

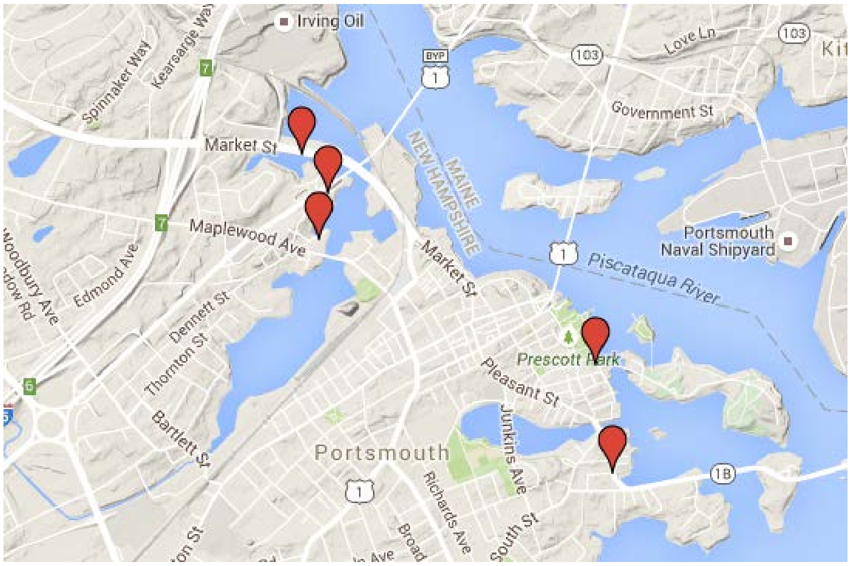

Figure 1**. Locations of wastewater pumping stations that were assessed with CREAT.**

Water supply is also a concern to the City, considering projected temperature increases and changes to precipitation patterns. While the drought of record occurred during the 1960s, the City of Portsmouth has recently experienced dry conditions. In 2001-2002, the City experienced a hot and dry period with little groundwater recharge and during summer 2014, Portsmouth experienced a period of intense heat and reduced precipitation for approximately six to eight weeks. Demand approached the maximum capacity of the Madbury WTP (8 MGD), however the City did not need to implement demand reduction measures. A short-term drought is expected to only affect surface water (about 60% of supply), but a longer-term drought (exceeding one year) would also affect groundwater (about 40% of supply). Reservoir levels tend to increase quickly after a moderate rain event (2 inches), but groundwater recharges much more slowly. The City announced voluntary water restrictions on May 27, 2015 because of below-normal rainfall, below-normal stream flows, high demand and the loss of the Haven Well due to contamination.

ASSESSMENT

Exercise Process

From November 2014 to May 2015, City of Portsmouth participated in a series of calls, webinars and one in-person event to guide them through a climate change risk assessment process. To better understand the vulnerabilities of their drinking water and wastewater infrastructure and operations, the City of Portsmouth assessed potential climate change impacts using the U.S. Environmental Protection Agency's (EPA) Climate Resilience Evaluation and Awareness Tool (CREAT)[2]. The assessment brought together individuals from various departments within the City of Portsmouth and EPA Regional offices to think critically about potential climate impacts, priority assets and possible adaptation options **(Appendix A)**.

CREAT Analysis and Results

CREAT provides climate data within a risk assessment framework to help utilities understand climate change assess risks and evaluate adaptation. Leveraging the available information, several potential impacts of a changing climate were discussed including: flooding due to coastal storm surge, flooding due to increased precipitation, and drought. For assessment purposes, the City of Portsmouth elected to focus on their critical assets. Specifically, they considered the potential impacts of flooding due to coastal storm surge on their wastewater pump stations (Leslie Drive, Marcy Street, Marsh Lane, Mechanic Street, and Northwest Street pump stations) and a three-year period of drought with below-average rainfall on their water supply, similar to conditions experienced during 1962 to 1964.

The Mechanic Street pump station is a critical asset (serving 80% of the entire service area) and is most vulnerable to flooding in its current location. All flow to the Pierce Island WWTF flows through this pump station, and there are concerns that with more intense flooding events the electrical panels would be inundated, requiring the pump station to be temporarily taken off-line. The Pierce Island WWTF cannot operate until pumping capabilities could be re-established at Mechanic Street. This would cause raw sewage to be discharged to surface waters until services are restored. There are conceptual plans to relocate the pump station to a nearby property at a higher elevation. CREAT analyses could be used to support permitting and funding processes and potentially apply for hazard mitigation funding to recover some of the costs of relocation.

Within CREAT, users can consider climate scenarios of projected changes in climate to assess consequences to their assets from climate-related threats. The three projected climate scenarios available in CREAT capture the range in potential future conditions at any given location within the US based on Global Climate Model (GCM) results. While all models project warming, the projected changes in precipitation vary, with some projecting wetter conditions and others projecting drier conditions. The City of Portsmouth included two CREAT-provided projected climate scenarios in their assessment; 'hot and dry' scenario for the drought threat and the 'central' scenario for the coastal storm surges threat. The data sources for these scenarios are listed in **Table 2**.

[2] EPA Climate Resilience Evaluation and Awareness Tool, available at: http://water.epa.gov/infrastructure/watersecurity/climate/creat.cfm

Table 2. City of Portsmouth Data Sources (2060 time period)

SCENARIO	DATA
Hot and dry projected climate scenario	Hot and dry scenario in CREAT (Meteorological Institute of the University of Bonn (Germany), Meteorological Research Institute of the Korea Meteorological Administration (KMA), and Model and Data Group (Germany/Korea))
Central projected climate scenario	Central scenario in CREAT (Max Plank Institute of Meteorology (Germany))
	Sea level rise – 30 inches

The 2060 time period was selected to align with the City's 2013 Plan. In the hot and dry scenario, the total annual precipitation is projected to be 46.22 inches (1.22% decrease) for 2060. In the central model projection, the total annual precipitation is projected to be 50.12 inches (7.12% increase), and the 100-year storm is 8.53 inches of rain in a 24-hour period (15.81% increase) for 2060. The sea level rise projection of 2.5 to 3.0 feet and a storm surge height of 6.8 feet was taken from the City's 2013 Plan. For more information on the City of Portsmouth climate data, see **Appendix B**.

In general, risk assessments facilitate an evaluation of potential threats or hazards in terms of the likelihood of their occurrence and the anticipated consequences should they occur. Based on the likelihood that the coastal storm surge threat will be realized sometime within the next 50 years, the City of Portsmouth elected to use the conditional likelihood setting within their CREAT analysis. This setting enabled them to consider the threat as occurring and to focus on assessing how effective potential adaptation options would be at reducing consequences. The risk assessment framework in CREAT guides users through baseline and resilience analyses to gauge the potential future vulnerability of utility assets with and without adaptation options. The baseline analysis includes current or existing actions only, while the resilience analysis includes additional potential adaptive actions.

To assess the level of consequences, CREAT provides a consequence matrix of five categories that capture the range of impacts a utility may experience. These include and were weighted as follows: utility business impacts (10%), utility equipment impacts (30%), source and receiving water impacts (30%), environmental impacts (10%) and community/public health impacts (20%) The full consequence matrix, descriptions and weights are provided in **Appendix C**. Within each of these categories, the City of Portsmouth assessed consequences on a four-point qualitative scale from Low to Very High. CREAT combines these assessments into an overall consequence rating for each analysis.

Within their risk analysis, the City of Portsmouth considered the potential consequences of projected coastal storm surge and drought conditions to their infrastructure and operations. For the assessment of each of these potential threats, the City of Portsmouth then considered how potential adaptive measures would help to lower consequences. Many potential adaptive measures were considered for the drought threat, including developing new groundwater sources, and implementing actions to better manage water sources, including watershed management, improving water quality and supply-demand models, updating drought contingency plans, conducting weather forecast monitoring, establishing adaptive rates, conducting supply risk management, and monitoring surface water quality.

For the flooding and coastal storm surge threat, the City may relocate the Mechanic Street Pump Station to a location 2 to 4 feet higher in elevation. Actions to harden all other assessed pump stations from flooding events are also being considered, including constructing temporary flood barriers, building hydrologic barriers, and developing a flood risk management plan.

Given the capabilities of the selected potential adaptive measures, the City of Portsmouth was able to lower all potential consequences from 'Very High' to 'Low' for the coastal storm surge assessments, and from 'High' to 'Low' for the drought assessment. See **Table 3** and **Table 4** for example baseline and resilience assessment results. Baseline results illustrate the consequences the utility would expect to experience if the threat occurred, considering the utility's current capabilities. Resilience results reflect new levels of consequences if the same threat occurred, but considering additional capabilities of potential adaptation options that could reduce consequences. For detail on level definitions, see **Appendix C**.

Table 3. City of Portsmouth Baseline and Resilience Analysis Results for the Water Supply/Drought Assessment (2060 time period)

ANALYSIS	Utility Business Impacts	Utility Equipment Damage	Source/ Receiving Water Impacts	Environmental Impacts	Community/ Public Health Impacts
Baseline – Hot and dry model projection	HIGH	LOW	HIGH	LOW	VERY HIGH
Resilience – Hot and dry model projection	LOW	LOW	LOW	LOW	LOW

Table 4. City of Portsmouth Baseline and Resilience Analysis Results for the Mechanic Street Pump Station/Coastal Storm Surge Assessment (2060 time period)

ANALYSIS	Utility Business Impacts	Utility Equipment Damage	Source/ Receiving Water Impacts	Environmental Impacts	Community/ Public Health Impacts
Baseline – Central model projection	HIGH	VERY HIGH	HIGH	MEDIUM	HIGH
Resilience – Central model projection	LOW	LOW	LOW	LOW	LOW

Assessment were completed on the other wastewater pump stations (Leslie Drive, Marcy Street, Marsh Lane, and Northwest Street), and indicated that a very high level of consequences is expected for all pump stations if threatened by coastal storm surge. The threat was defined for all five pump stations as 2.5 to 3.0 feet of sea level rise and a 6.8-foot storm surge as shown in Table 1, which is estimated to have a flood stage of 3.44 feet above grade.

NEXT STEPS

Based on the results of their analysis, the City of Portsmouth is considering developing new groundwater sources, and implementing actions to better manage existing water sources to increase their resilience to potential drought conditions.

The City plans to address the impacts from coastal storm surges to each pump station individually, depending on the elevations and characteristics of each station. For example, the City of Portsmouth may relocate the Mechanic Street Pump Station to a location 2 to 4 feet higher in elevation, whereas the City may focus on hardening all other assessed pump stations from flooding events.

CREAT analyses can continue to be refined as new data is obtained from ongoing research partnerships, and as the City continues to implement its sustainability initiatives.

APPENDIX A: EXERCISE PARTICIPANTS

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APPENDIX B: CLIMATE DATA

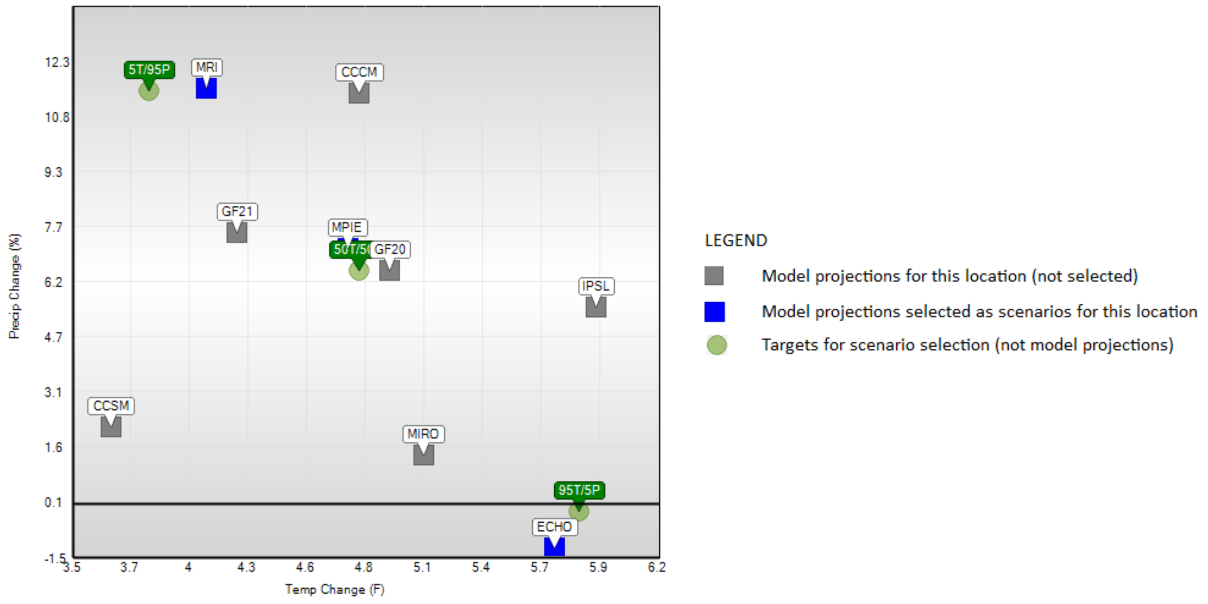
Climate Model Selection for the City of Portsmouth

The scatter plot of model run results below provides a visual of how the CREAT-provided scenarios were selected. Each point represents the projected changes in average annual temperature and total annual precipitation in 2060 for the ½ degree cell containing Portsmouth, New Hampshire. For each scenario, the selected model was used to generate monthly changes in average conditions as well as the changes in intense precipitation event magnitudes on annual and seasonal bases.

Model projections for changes in average annual conditions for the 2060 time period were considered to evaluate the distribution of possible future conditions and to select three models that best describe the range of projections. This selection was based on finding the specific model that projected a change in conditions nearest to three statistical targets, each indicative of certain projected changes. The three scenarios provided in CREAT are:

- **Hot and dry model projection** – model nearest the 5th percentile of precipitation and 95th percentile of temperature projections (larger increase in temperature with lower total precipitation)
- **Central model projection** – model nearest the 50th percentile of both precipitation and temperature projections (central condition, among models, for temperature and total precipitation)
- **Warm and wet model projection** – model nearest the 95th percentile of precipitation and 5th percentile of temperature projections (smaller increase in temperature with larger total precipitation)

The terms dry and wet are used here relative to the range of total precipitation projected for this location in the 2060 time period. For example, dry does not always indicate a reduction in total precipitation relative to current conditions; dry simply indicates projected total precipitation on the lower end of distribution of projected precipitation. A horizontal line on the plot indicates no projected change in precipitation (i.e., 0%) to help distinguish those models projecting increases in annual total precipitation from those projecting decreases.



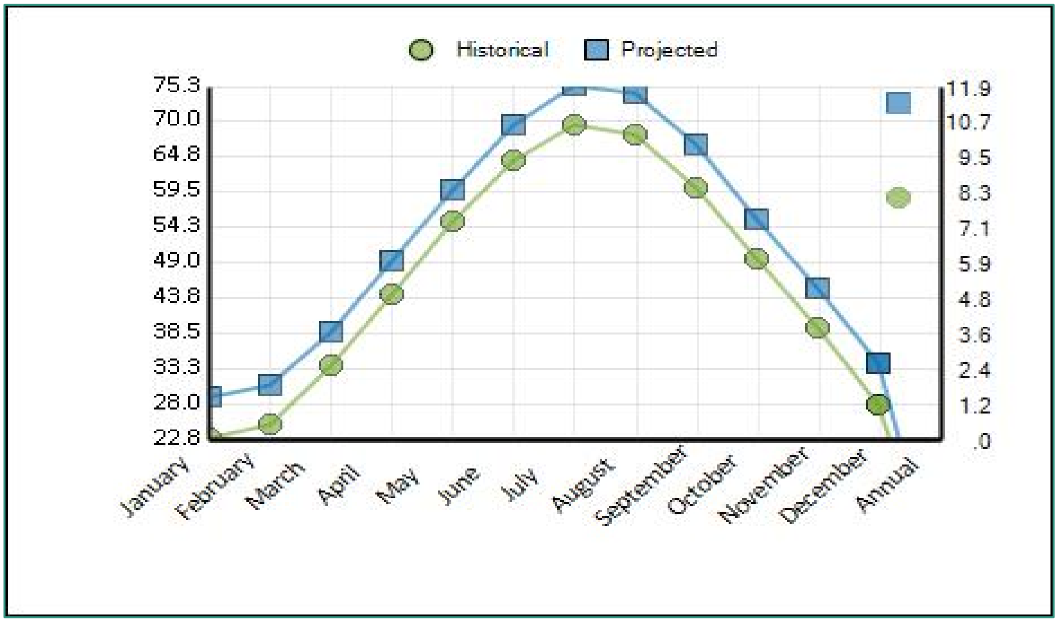
Hot and Dry Model Projection: Projected Climate Conditions for the Year 2060 in Portsmouth, New Hampshire

AVERAGE TEMPERATURE DATA (°F)		TOTAL PRECIPITATION DATA (INCHES)	
Annual	52.36	ANNUAL	46.22
JAN	29.19	JAN	3.79
FEB	30.97	FEB	3.61
MAR	38.89	MAR	4.48
APR	49.23	APR	4.77
MAY	59.94	MAY	3.76
JUN	69.58	JUN	3.59
JUL	75.27	JUL	3.44
AUG	74.14	AUG	3.36
SEP	66.52	SEP	3.37
OCT	55.45	OCT	3.64
NOV	45.10	NOV	4.22
DEC	34.05	DEC	4.20

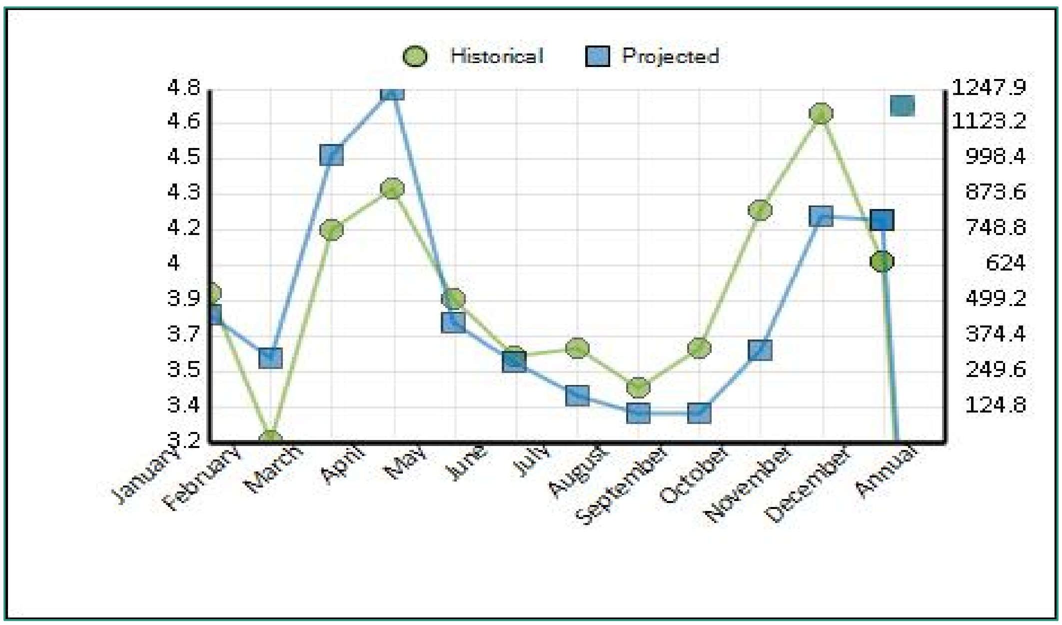
Total Precipitation (inches) During 24-Hour Event

RETURN INTERVAL	ANNUAL	WINTER (DJF)	SPRING (MAM)	SUMMER (JJA)	FALL (SON)
5-YEAR	3.92	2.41	2.50	2.58	3.06
10-YEAR	4.75	2.89	3.15	3.15	3.84
15-YEAR	5.27	3.15	3.63	3.54	4.36
30-YEAR	6.19	3.59	4.46	4.15	5.32
50-YEAR	6.92	3.94	5.15	4.67	6.10
100-YEAR	8.08	4.36	6.22	5.36	7.39

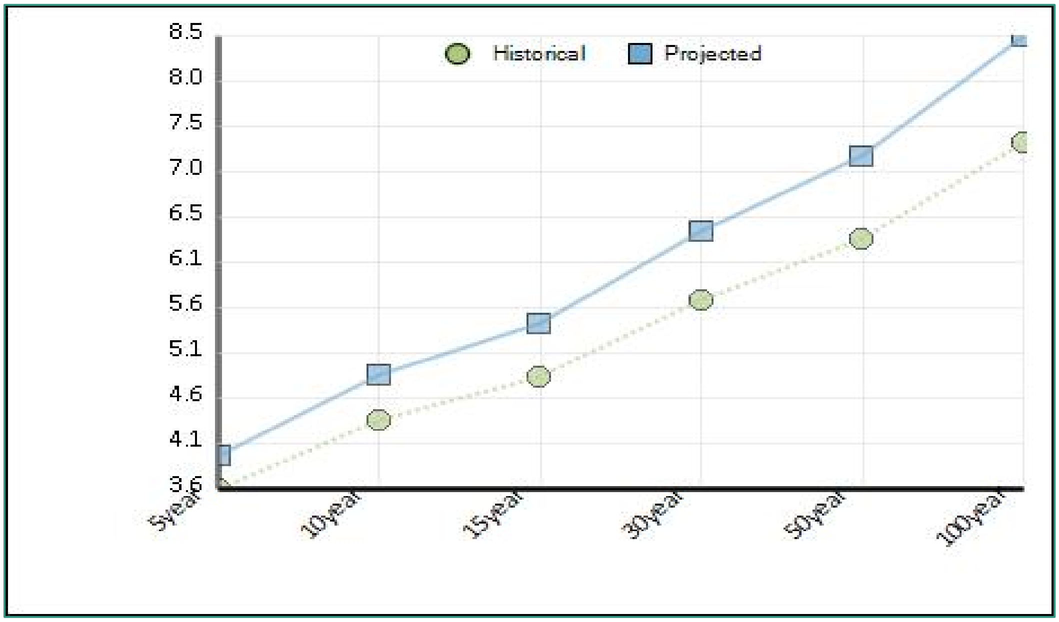
Average Temperature



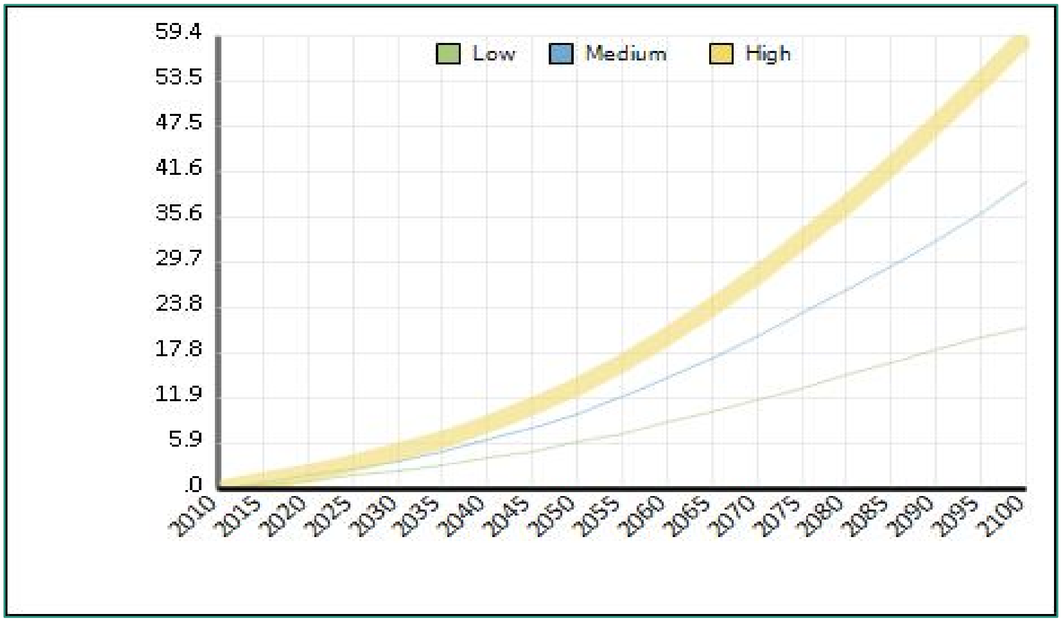
Total Precipitation



24-h Event Precipitation



Sea Level Rise



APPENDIX C: CONSEQUENCE CATEGORIES AND LEVEL DESCRIPTIONS

Title	Utility Business Impacts	Utility Equipment Damage	Source/ Receiving Water Impacts	Environmental Impacts	Community Public Health Impacts
Description	Revenue or operating income loss evaluated in terms of magnitude and recurrence of service interruptions	Costs of replacing the service equivalent provided by a utility or piece of equipment evaluated in terms of magnitude of damage (minimal, minor, significant, complete loss) and financial impacts (flexible cost scale, "$x," can be customized by each user)	Degradation or loss of source water or receiving water quality and/or quantity, evaluated in terms of recurrence (minimal, temporary, seasonal or episodic, long-term)	Evaluated in terms of environmental damage or loss (aside from source water or other assets) and compliance with environmental regulations (minimal, short term, persistent/permit violations significant impact and/or regulatory enforcement and actions)	Evaluated in terms of duration (short- or long-term) and extent (minimal, minor, localized, or widespread)
Very High	Long-term and/or significant loss of expected revenue or operating income	Complete loss of asset; replacement costs of $x++	Long-term compromise of source water quality and/or quantity	Significant environmental damage — may incur regulatory action	Long-term and/or widespread public health impacts
High	Seasonal or episodic — but minor — compromise of expected revenue or operating income	Significant damage to equipment; costs estimated at <$x+	Seasonal or episodic compromise of source water quality and/or quantity	Persistent environmental damage — may incur regulatory action	Short-term and localized public health impacts
Medium	Minor and short-term reductions in expected revenue or operating income	Minor damage to equipment; costs estimated at <$x	Temporary impact on source water quality and/or quantity	Short-term environmental damage, compliance can be quickly restored	Minor public health impacts
Low	Minimal potential for any attributable loss of revenue or operating income	Minimal damage to equipment	No more than minimal changes to source water quality and/or quantity	No impact or environmental damage	No impact on public health
Weight	20	20	20	20	20

EPA