



# **Climate Change Hazards Summary Report for Facility Investment Planning**

## **Mount Rainier National Park January 2021**

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## Introduction

Parks are required to complete a PARK Project Narrative Template for each proposed Great American Outdoors Act Facility Investment Plan (GFIP) project for Legacy Restoration Funding in fiscal years 2023-2025. Information provided in this report is intended to help parks consider climate change related hazards when addressing Question 16 of the narrative template.

*Specifically: What risks or hazards (current and projected, e.g. effects of climate change) are likely to affect this project? If applicable, what adaptation strategies and/or resiliency measures have been identified for scenarios that pose high risks to project assets?*

### Step 1: Review summary information for known or potential hazards identified for Mount Rainier National Park

- Review the list of potential hazards below and decide whether or not they apply to your specific GFIP project. NPS Climate Change Response Program (CCRP) staff attempted to identify potential hazards for the park; however, park staff and project planners have more information about hazards that are likely to be applicable to a specific project.
- The hazards below were selected from a longer list included in Appendix 1, which also indicates CCRP's 'best professional judgement' about the relevance of the hazard for this park. Note both lists serve as a "coarse filter" screening tool to help identify potential climate-related hazards for facility and asset planning.

#### Hotter average days and more very hot days

Extreme temperatures can increase weathering of structures, threaten park staff and visitor safety, and increase stresses for HVAC systems. Demand for complex air conditioning systems can add stress to building envelopes and often requires significant alterations to a structure.

Historical temperature trends at Mount Rainier based on an analysis of a long term weather station at Longmire found a robust warming trend of annual average daily maximum temperatures and a cooling trend for annual average daily minimum temperatures (1895-2011) (Hoffman et al. 2014). Comparing climate experienced recently (past 10–30 years) relative to the 1901–2012 historical range of variability, Monahan and Fisichelli (2014) found that MORA has experienced extreme warm conditions (exceeding 95% of the historical range of conditions) during the driest quarter of the year and the warmest quarter of the year. The minimum coldest month of the year also appeared to warm, although the changes were not statistically significant (Monahan and Fisichelli 2014).

Future projected temperatures indicate warming at MORA. Gonzalez et al. (2018) project a range of warming from 3.1 °F per century (+/- 1.3) to 8.3 °F per century (+/- 2), based on a low to high greenhouse gas emissions scenario, respectively. At the regional scale, modelling under a high emissions scenario projects 35 to 45 fewer days with a minimum temperature < 32 °F between the periods 1980-2000 and 2041-2070 (Kunkel et al. 2013).

Analyses of data from the broader western U.S. (including MORA) detected statistically significant increased winter temperatures (Barnett et al. 2008, Bonfils et al. 2008), decreased snowpack (Barnett et al. 2008, Pierce et al. 2008), decreased ratio of snow to rain (Pierce et al. 2008), and earlier spring streamflow (Barnett et al. 2008) from 1950 to 1999 (Gonzalez 2013).

*Park staff assessment – relevant to GFIP Project:*

- ☐ Yes
- ☐ No

### Increased drought frequency, intensity, magnitude, and duration

Changing drought conditions (frequency, severity, duration) can challenge a variety of infrastructure and operations (Department of Homeland Security 2015) in the NPS (e.g., water supply and wastewater systems), impair water quality (Mosley 2015), affect soil heaves and shrinkages (Fernandes et al. 2015), and will enhance other related risks such as wildfire (Halofsky et al. 2020). The 2015 drought necessitated \$7 million of relief funds to be used for backup emergency water supplies in Washington (May et al. 2018).

As the climate changes future drought impacts may be severe. Conditions resembling historical droughts (Xiao et al. 2016), including the recent 2015 event, are projected to be more likely within this century as climates warm (Diffenbaugh et al. 2015). These threats are likely to impact the park by coinciding with increased park visitation (Fisichelli et al. 2015).

Droughts occur in the Pacific Northwest when warm or dry winters reduce snowpack or when hot, dry summers reduce soil moisture and streamflow (Dalton et al. 2013, Dello and Dalton 2015). A record warm 2015 winter led to historically low snowpack in much of the Northwestern mountains as winter precipitation fell as rain instead of snow, resulting in drought, water scarcity, and wildfire throughout the region (Mote et al. 2016, May et al. 2018). Climate change-driven temperatures increases are expected to deepen droughts in this region, particularly in areas with snowpack. Declining snowpack is expected to amplify summer drought conditions, increasing vulnerability to typical droughts caused by inter-annual precipitation variability (Vose et al. 2016, May et al. 2018).

Streams in MORA are critical water sources that serve park infrastructure needs including drinking water supply for park visitors. As exemplified by the 2015 water year, drought in MORA is a current reality. In 2015 MORA experienced above normal winter and spring air temperatures, record low snowpack, and extremely warm June temperatures, resulting in a hydrologic drought (Crausbay et al. 2017). These conditions stressed water supplies in MORA given the availability of surface water to support several water intakes approached critically low levels.

Glaciers found in MORA provide storage and the slow release of cool waters during summer. Measurements of MORA glaciers have shown substantial decreases in recent decades consistent with, but not formally attributed to, human climate change (Gonzalez 2013). Sisson et al. (2011) showed that Mount Rainier lost 14% of its glacial ice and perennial snow during the 37 year period from 2007 to 1970.

*Park staff assessment – relevant to GFIP Project:*

- ☐ Yes
- ☐ No

### Increased wildfire frequency, intensity, magnitude, and duration

Wildfire is a natural part of many forest, woodland, and grassland ecosystems. Excessive fire, however, can damage ecosystems, kill people, and damage infrastructure. Climate change is intensifying the heat that drives wildfire (Jolly et al. 2015) and altering the distribution and density of vegetation that comprises the fuel for wildfires (Gonzalez et al. 2010). These effects combine with the unnatural buildup of coarse woody debris and understory trees from decades of suppression of all fires, even natural ones (Agee and Skinner 2005). The effects of climate change on wildfire vary across landscapes. For areas where projected climate change increases fire risk, buildings, cultural landscapes, or other infrastructure located under or near tree canopies or dense grasslands are vulnerable to burning and destruction.

In the western U.S., analyses of causal factors have found that human-caused climate change has doubled the area burned by wildfire since 1984 above natural levels, mainly through drying of vegetation (Abatzoglou and Williams 2016). Under the highest greenhouse gas emissions scenario, projected climate change could increase the frequency of large fires (>50 km<sup>2</sup>, 20 sq. mi.) up to three times across the forests of the western U.S. by 2050 (Barbero et al. 2015).

Wildfires during the drier summer months of the Pacific Northwest are of particular concern (Frankson et al. 2017). The wildfire season of 2015 was the most destructive in Washington's history, with over 1 million acres burned, more than 6 times the average (Frankson et al. 2017). Snowpack in the mountains provides an important source of water during the drier summer months. Drier summers, along with warmer temperatures and earlier melting of the snowpack, increases the frequency and extent of wildfires (Frankson et al. 2017).

*Park staff assessment – relevant to GFIP Project:*

- ☐ Yes
- ☐ No

### Altered precipitation patterns and changing humidity

Changing precipitation and humidity conditions can result in local flooding, encourage mold growth, wood decay, increase fire risk, and intensify drought conditions, depending on the pattern of change.

Historical analysis of precipitation show no trend over the period 1895-2011 for the Longmire station in MORA (Hoffman et al. 2014). However, snow trends for MORA demonstrate robust declines in snow water equivalent, while snow depth does not show a clear trend over the period 1940-2011 (Hoffman et al. 2014). Projected warming will raise the elevation of the snow line in the mountains of Washington state. This will increase the proportion of precipitation falling as rain instead of snow, leading to less snow accumulation during the winter. Rainfall is expected to be the dominant form of precipitation across the majority of Washington by the end of the 21st century (Frankson et al. 2017), although a transition from snow to rain is unlikely to occur at the park's highest elevations. Increasing spring temperatures will also result in earlier melting of the snowpack, with snowpack projected to decline by up to 70% by the end of the 21st century (Frankson et al. 2017). This will decrease water availability during the already dry summer months and increase the risk of spring flooding due to earlier peak flows (Frankson et al. 2017). Projected increases in heavy rainfall events for Washington state by mid-century could further increase flood risk (Frankson et al. 2017).

*Park staff assessment – relevant to GFIP Project:*

- ☐ Yes
- ☐ No

### Increased extreme precipitation

Extreme precipitation events present a variety of threats to infrastructure and operations including flooding of sites, sewage backup, accelerated decay of masonry, overcoming drainage systems, road wash out, cracks in building infrastructure, destabilization of buildings and pipes, erosion of supporting ground around structures, among many other effects.

Model projections for southwest Washington state indicate extreme precipitation events will likely increase in the future (Mote et al. 2013). Heavier rains could also increase the likelihood of avalanches, and Lazar and Williams (2008) predicted the onset of wet avalanche activity is likely to begin earlier in the season, based on a climate change assessment of Aspen Mountain, Colorado. Furthermore, the intensity of extreme precipitation events increase with increasing temperatures (Easterling et al. 2017).

*Park staff assessment – relevant to GFIP Project:*

- ☐ Yes
- ☐ No

### Riverine flood/Flash Flood

Extreme precipitation events and the risk of flooding are expected to regionally intensify with a changing climate (Dethier et al. 2020, Tabari 2020). Floods threaten infrastructure and operations through a variety of mechanisms, including inundation of structures, enhanced erosional forces, road wash out, structural collapse from force of floodwaters, sewage backup, and damage to utilities, generators, and electrical systems. Post-flooding effects include increased rot, fungal/insect attack, mold and mildew, and physical deterioration of wood, brick and stone building materials.

Beason et al. (2011) described changing flood dynamics at MORA in the following text, published in *Park Science*. “Devastating floods at Mount Rainier National Park, Washington, have increased in frequency in the last decade and have led to tens of millions of dollars’ worth of damage to park infrastructure. Major rivers at Mount Rainier are fed by glaciers and are aggrading, or filling in with sediment, at rates of up to 1.8 m (6 ft) per decade whereas historically they were aggrading at 7–13 cm (3–5 in) per decade. As a consequence of regional climate warming, all of the 25 glaciers in the park are retreating and thinning; as glaciers retreat, unconsolidated and unstable sediment is exposed and mobilized into rivers, which causes aggradation downstream. This tremendous increase in aggradation is filling in stream channels and enlarging floodplains, which leads to more frequent catastrophic shifts (avulsions) in the location of river channels. Avulsions tend to destroy park infrastructure and disturb riparian forest habitat. Future climate warming scenarios published by the University of Washington’s Climate Impacts Group anticipate increased year-round temperatures with no significant change in yearly precipitation. These factors favor glacial retreat, decreased snowpack, increased debris flows, and a much larger variation in the occurrence and magnitude of regional flooding.”

Modeling of the Nisqually River in MORA (USGS gage near National, WA) indicates a 39% increase in median 100 year flood magnitude (1% exceedance flow) for the period 2040-2069, compared to the historical period 1951-1979 (Van Dusen et al. 2020). Flood risk for the Nisqually River is non-stationary, both increasing through time and becoming more variable (Van Dusen et al. 2020). For example, the risk of exceeding this site’s stationary 1% seasonal exceedance probability flow in a 20-year project life increases from ~23% to ~88%, comparing the periods 1980-2009 to 2070-2099 (high emissions scenario, Van Dusen et al. 2020).

Atmospheric rivers can also contribute to extreme precipitation events and flooding, particularly along the west coast of the United States. Espinoza et al. (2018) found a pronounced increase in atmospheric river conditions under a high greenhouse gas emissions scenario, resulting in longer, wider atmospheric rivers. Flooding at MORA associated with atmospheric rivers in 2005 and 2006 caused ten debris flows in two days, causing so much damage that the park was closed to the public for six months (<https://media.thenewstribune.com/static/pages/rainier/>).

*Park staff assessment – relevant to GFIP Project:*

- ☐ Yes
- ☐ No

## **Pest infestation**

Increased temperatures and CO<sub>2</sub>, changes in precipitation, and disturbance due to extreme climate events can increase the survival, spread, growth, and establishment of pests (IPCC 2014). Rooting and burrowing mammals and termites have the potential to cause direct damage to power, water, transportation, and building facilities (Vissicelli 2018). Facilities may be impacted indirectly through

other mechanisms exacerbated by climate change such as forest insect pest invasions or fluctuating ground water levels leading to increased tree mortality, hazard trees, and treefall.

Across western North America climate change has caused bark beetle outbreaks leading to the most extensive tree mortality in the last 125 years (Raffa et al. 2015). Although mountain pine beetle is native to MORA, rising temperatures could lead high elevation habitats of the park to become more suitable for the beetle, which could, in turn, increase tree mortality (Logan and Powell 2001, Hoffman et al. 2014).

*Park staff assessment – relevant to GFIP Project:*

- ☐ Yes
- ☐ No

## Invasive species

Increased temperatures and CO<sub>2</sub>, changes in precipitation, and disturbance due to extreme climate events can increase the survival, spread, growth, and establishment of invasive species (IPCC 2014). Weeds and aquatic mussels have the potential to cause direct damage to power, water, transportation, and building facilities (Vissicelli 2018). Non-native species that may not currently impact facilities may become harmful due to changes in local climates (NRC 2002, IPCC 2014).

Non-native plant species, such as cheatgrass (*Bromus tectorum*, present in the park; Rochefort 2010), may invade burned areas, displace natives, and alter fuel and fire regime properties (e.g., increase fire frequency) (Brooks et al. 2004).

*Park staff assessment – relevant to GFIP Project:*

- ☐ Yes
- ☐ No

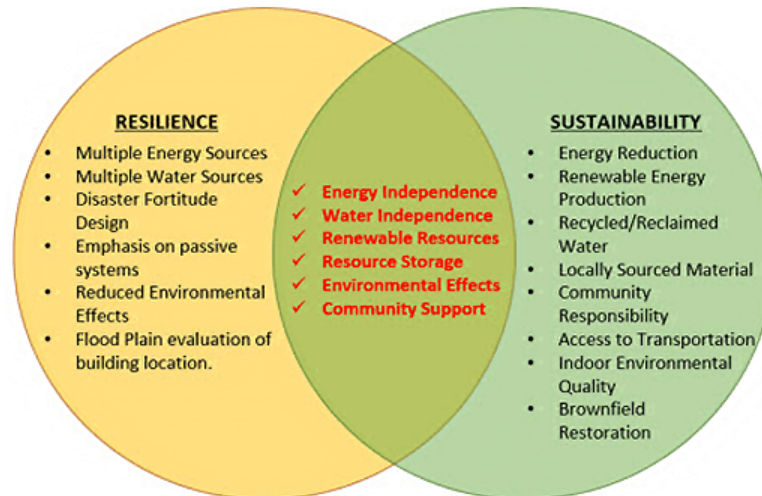
## Step 2: Consider adaptation and resiliency strategies

- Review definitions of resiliency and adaptation strategies.
- Identify adaptation strategies that will help park resources respond to the hazards identified in Step 1.

Question 16 requires a screening for climate hazards followed by a review of adaptation and resiliency strategies that would be put in place to respond to these hazards. For the purposes of this report and investment planning, resilience is a property of a system or asset and generally refers to the ability of the system or asset to maintain its intended purpose following a temporary disturbance.

Adaptation strategies, in the context of built infrastructure, refers to the intentional management decision to identify, prepare for, and respond to observed or expected sustained changes in hazards, including climate change, to adjust to a sustained change in conditions.

It is important to note that resilient park operations can be supported through the use of green infrastructure such as sustainable landscaping, as well as sustainable energy, water, and building envelope solutions. The figure below illustrates this relationship.



Lists of adaptation strategies for different types of infrastructure projects in response to different hazards can be found here: [Incorporating Climate Change Adaptation in Infrastructure Planning and Design](#) (see Chapter 4, Tables 25-34). If used, these adaptation strategies will need to be modified for proposed park projects.

Buildings and assets within national parks may include cultural resources (e.g., historic and pre-historic buildings and structures). The adaptation and resiliency options for cultural resources often overlap with those defined for facilities; however, NPS has detailed specific strategies when dealing with cultural resources and climate change in national parks. ([Cultural Resources Climate Change Strategy](#)). “Climate change poses an especially acute problem for managing cultural resources because they are unique and irreplaceable — once lost, they are lost forever.” ([NPS Policy Memorandum 14-02](#)).

**Step 3: Develop an answer to Question 16 for your specific project and location, as well as strategies to address each hazard**

- An example response to Question 16 is provided below. THIS IS A GENERIC EXAMPLE FROM ANOTHER PARK.
- You will need to modify the answers below based on the hazards identified in Step 1 and the adaptation strategies identified in Step 2 for your park and project. The park response should be as project-specific as possible.

*Question 16: What risks or hazards (current and projected, e.g. effects of climate change) are likely to affect this project? If applicable, what adaptation strategies and/or resiliency measures have been identified for scenarios that pose high risks to project assets?*

**Example from Grand Teton National Park: Building assets, water development, or road construction**

Several climate change hazards have been identified that may affect projects in GRTE, including hotter average days, more extreme heat days, increased drought frequency and intensity, altered precipitation and flooding patterns, increased wildfire, and increased invasive species abundance or distribution. Some example adaptation and resiliency strategies for the expected hazards are described below:

- Hotter average days and more extreme heat days will increase demand and requirements for appropriately sized air conditioning systems unless accommodated by changes in building design or systems.
- Energy demand increases should be offset by conservation measures and renewable energy implementation where possible.
- Extreme heat can stress the building envelope and may require significant humidity control alterations for structures.
- Increased and more intense wildfires will require more planning in the wildland-urban interface, either by relocating park assets, using fire-resistant building materials, reducing fuels near structures, or all of these measures.
- Increased drought and faster runoff can reduce the amount of water available for park use. New water sources might need to be identified and water conservation measures prioritized.
- Heavy rains during the spring thaw can cause rapid melting of the snowpack resulting in severe flooding. Road construction may require relocation, as well as larger culverts and other flood control measures to accommodate heavy runoff.
- Buildings, infrastructure, and roads in existing flood zones may need additional mitigation.
- The potential for increased invasive species should be mitigated. Measures include mitigation during construction (e.g., using weed-free gravel and cleaning construction equipment) and increased weed treatment post construction.
- Termites are likely to arrive in GRTE by mid-century. Early detection monitoring and eradication, if possible, will help protect historic structures and other buildings.

## Step 4: Seek additional assistance if desired

- Additional resources for answering question 16 and related questions can be found in:
  - Appendix 1 below, which includes a full hazards checklist, providing additional links for supporting information related to each hazard.
  - The [GFIP Guidance and Logistics](#) folder under the [Resources to Assess Risks and Hazards](#) [tab](#) includes:
    - An Excel workbook labeled [T75 Parks GFIP NRSS Supporting Materials](#) that provides links to information for natural resources to be considered during project design and construction.
    - A [FAQs – Assessing Risks and Hazards](#) document that provides detailed guidance for answering Question 16.

- A [Natural Hazard Assessment Webinar](#) recording that provides key information, definitions, and guidance for understanding natural hazards and related resources.
- The NPS Climate Change Response Program (CCRP) and Sustainable Operations and Maintenance Branch (SOMB) are also available for assistance in evaluation of climate change hazards and resiliency strategies as they relate to specific projects. Questions can be sent to the NPS [GFIP Hazards and Risk Assistance email account](#) and a member of that team will reply with support.

## Appendix 1: The Climate-Related Hazard Checklist

This appendix provides an initial evaluation of climate hazards for **Mount Rainier National Park** according to the hazard ratings identified below. The information used to identify hazards in the checklist is mostly from regional assessments. Park and project specific information was generally not available when assessing these hazards. NPS Climate Change Response Program (CCRP) staff made an initial attempt to identify potential hazards for the park broadly (see 'Best Professional Judgement' column); however, park staff and project planners have more information about hazards that are likely to be applicable to a specific project.

### Explanation of Hazard Ratings

**Known hazard:** Conditions that cause the hazard are well documented in the area where the park occurs. If applicable to the project site, these hazards should always be addressed in the project plan.

**Potential hazard:** Conditions that cause or underlie the hazard are known to occur nearby or are likely to occur based on studies with conditions similar to the park. If applicable to the project site, these hazards should be considered for inclusion in the project plan.

**Not applicable:** No evidence *was identified* showing this hazard is relevant to the park. Note this is a coarse filter evaluation; local knowledge of a hazard(s) should be used, when available.

**Table 1. Climate-related Hazards Checklist**

| Potential Climate Hazard                   | Best Professional Judgment                                                                                                                        | Examples of risk or secondary hazard                                                                                                                                                                                            | Sources of General Non-site specific Data                                                       | Sources for Site Specific Data                                                                                                                                                                                                            |
|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hotter average days and more very hot days | Known Hazard<br><input checked="" type="checkbox"/><br>Potential Hazard<br><input type="checkbox"/><br>Not Applicable<br><input type="checkbox"/> | <ul style="list-style-type: none"> <li>• Inadequate HVAC</li> <li>• Road surface degradation</li> <li>• Lack of water due to increased water for irrigation</li> <li>• Increased humidity</li> <li>• Danger to staff</li> </ul> | <ul style="list-style-type: none"> <li>• <a href="#">National Climate Assessment</a></li> </ul> | <ul style="list-style-type: none"> <li>• <a href="#">National Climatic Data Center</a></li> <li>• <a href="#">DAYMet gridded climate data</a></li> <li>• <a href="#">National park historical and projected climate change</a></li> </ul> |

| Potential Climate Hazard                                         | Best Professional Judgment                                                                                                                                          | Examples of risk or secondary hazard                                                                                                                                                                                                                                                                                        | Sources of General Non-site specific Data                                                                                                                                                                      | Sources for Site Specific Data                                                                                                                                                                                                      |
|------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Increased drought frequency, intensity, magnitude, and duration  | <p>Known Hazard<br/><input type="checkbox"/></p> <p>Potential Hazard<br/><input checked="" type="checkbox"/></p> <p>Not Applicable<br/><input type="checkbox"/></p> | <ul style="list-style-type: none"> <li>Limited water supply for cooling, landscaping, structural fire suppression, other equipment</li> <li>Increased competition for available water and water rights conflicts</li> <li>Crack/heave damage in drier soils</li> <li>Increased vulnerability to wildfire (below)</li> </ul> | <ul style="list-style-type: none"> <li><a href="#">Drought Monitor</a></li> <li><a href="#">National Integrated Drought Information Center</a></li> <li><a href="#">National Climate Assessment</a></li> </ul> | <ul style="list-style-type: none"> <li><a href="#">Drought Monitor</a></li> <li><a href="#">National Integrated Drought Information Center</a></li> </ul>                                                                           |
| Increased wildfire frequency, intensity, magnitude, and duration | <p>Known Hazard<br/><input type="checkbox"/></p> <p>Potential Hazard<br/><input checked="" type="checkbox"/></p> <p>Not Applicable<br/><input type="checkbox"/></p> | <ul style="list-style-type: none"> <li>Damage to facilities and contents</li> <li>Smoke damage</li> <li>Air quality dangerous to staff and visitors</li> <li>Increased runoff</li> <li>Increased erosion</li> <li>Damage to water treatment plants</li> </ul>                                                               | <ul style="list-style-type: none"> <li><a href="#">Barbero et al. 2015 International Journal of Wildland Fire</a></li> </ul>                                                                                   | <ul style="list-style-type: none"> <li><a href="#">NIFC</a></li> <li><a href="#">International Wildland-Urban Interface Code</a></li> </ul>                                                                                         |
| Altered precipitation patterns and changing humidity             | <p>Known Hazard<br/><input checked="" type="checkbox"/></p> <p>Potential Hazard<br/><input type="checkbox"/></p> <p>Not Applicable<br/><input type="checkbox"/></p> | <ul style="list-style-type: none"> <li>Local flooding</li> <li>Mold growth</li> <li>Wood decay</li> <li>Drought</li> <li>Fire</li> <li>Groundwater change</li> </ul>                                                                                                                                                        | <ul style="list-style-type: none"> <li><a href="#">National Climate Assessment</a></li> </ul>                                                                                                                  | <ul style="list-style-type: none"> <li><a href="#">National Climatic Data Center</a></li> <li><a href="#">DAYMet gridded climate data</a></li> <li><a href="#">National Park historical and projected climate change</a></li> </ul> |

| Potential Climate Hazard                      | Best Professional Judgment                                                                                                                                | Examples of risk or secondary hazard                                                                                                                                                                                                                                                                                                                          | Sources of General Non-site specific Data                                                                                                                           | Sources for Site Specific Data                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Increased extreme precipitation               | Known Hazard<br><input type="checkbox"/><br><br>Potential Hazard<br><input checked="" type="checkbox"/><br><br>Not Applicable<br><input type="checkbox"/> | <ul style="list-style-type: none"> <li>• Surface erosion</li> <li>• Floods (see below)</li> <li>• Water damage to structures from driven rain</li> <li>• Unstable saturated soils</li> </ul>                                                                                                                                                                  | <ul style="list-style-type: none"> <li>• <a href="#">National Climate Assessment</a></li> </ul>                                                                     | <ul style="list-style-type: none"> <li>• Evaluations are mostly at regional scales</li> </ul>                                                                                                                                                                                                                                                                         |
| Riverine flood/flash flood                    | Known Hazard<br><input checked="" type="checkbox"/><br><br>Potential Hazard<br><input type="checkbox"/><br><br>Not Applicable<br><input type="checkbox"/> | <ul style="list-style-type: none"> <li>• Damage or destruction of infrastructure</li> <li>• Stream channel migration</li> <li>• Stream bank erosion/extreme erosion</li> <li>• Safety</li> <li>• Water quality diminished</li> <li>• Damage to water source and delivery infrastructure</li> <li>• Changing requirements for culvert flow capacity</li> </ul> | <ul style="list-style-type: none"> <li>• <a href="#">FEMA Flood map service</a></li> </ul>                                                                          | <ul style="list-style-type: none"> <li>• <a href="#">FEMA Map Service Center</a></li> <li>• <a href="#">Floodplain maps for HUD projects</a></li> <li>• <a href="#">Van Dusen et al. 2020</a> (for select parks)</li> <li>• May require a special flood study</li> </ul>                                                                                              |
| Sea/lake level change and coastal storm surge | Known Hazard<br><input type="checkbox"/><br><br>Potential Hazard<br><input type="checkbox"/><br><br>Not Applicable<br><input checked="" type="checkbox"/> | <ul style="list-style-type: none"> <li>• Rising sea and lake levels</li> <li>• Rising water – wind driven (e.g. hurricane, nor’easter)</li> <li>• Saltwater intrusion</li> <li>• Vegetation damage</li> </ul>                                                                                                                                                 | <ul style="list-style-type: none"> <li>• <a href="#">NOAA SLR viewer</a></li> <li>• <a href="#">NOAA - Great Lakes Environmental Research Laboratory</a></li> </ul> | <ul style="list-style-type: none"> <li>• <a href="#">IRMA – Coastal reports</a></li> <li>• NPS <a href="#">SLR viewer</a></li> <li>• <a href="#">Specific Hazard Assessment: Coastal Storm Surge with Climate Change Effects</a> (requires VPN connection)</li> <li>• <a href="#">SLR reports</a></li> <li>• <a href="#">Great Lakes Dashboard Project</a></li> </ul> |

| Potential Climate Hazard | Best Professional Judgment                                                                                                                        | Examples of risk or secondary hazard                                                                                                                                                                                                                    | Sources of General Non-site specific Data                                                             | Sources for Site Specific Data                                                                                                                                                                                                                 |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hurricanes and tornados  | Known Hazard<br><input type="checkbox"/><br>Potential Hazard<br><input type="checkbox"/><br>Not Applicable<br><input checked="" type="checkbox"/> | <ul style="list-style-type: none"> <li>• Building destruction</li> <li>• Flying debris</li> <li>• Storm surge</li> <li>• Tree fall</li> </ul> (see other categories for associated intense rainfall and floods)                                         |                                                                                                       | <ul style="list-style-type: none"> <li>• Wind speed data – from local codes</li> <li>• International Building Code</li> <li>• <a href="#">FEMA Map Service Center</a></li> </ul>                                                               |
| Pest infestation         | Known Hazard<br><input type="checkbox"/><br>Potential Hazard<br><input checked="" type="checkbox"/><br>Not Applicable<br><input type="checkbox"/> | <ul style="list-style-type: none"> <li>• Historic/facility fabric loss</li> <li>• Vegetation loss</li> <li>• Disease vectors may increase</li> <li>• Termites and other woodboring pests expanding range with warming and increased humidity</li> </ul> | <ul style="list-style-type: none"> <li>• <a href="#">USFS Forest Health Program</a></li> </ul>        | <ul style="list-style-type: none"> <li>• Integrated Pest Management</li> <li>• <a href="#">Fisichelli et al. forest pests</a></li> <li>• <a href="#">USFS maps</a></li> </ul>                                                                  |
| Invasive species         | Known Hazard<br><input type="checkbox"/><br>Potential Hazard<br><input checked="" type="checkbox"/><br>Not Applicable<br><input type="checkbox"/> | <ul style="list-style-type: none"> <li>• Aquatic mussels – water intakes clogged</li> <li>• Vegetation (kudzu, vines) – damage buildings, kill trees, obstruct waterways</li> </ul>                                                                     | <ul style="list-style-type: none"> <li>• <a href="#">National Invasive Species Council</a></li> </ul> | <ul style="list-style-type: none"> <li>• <a href="#">Early Detection and Distribution Mapping System</a> (current distribution)</li> <li>• <a href="#">Early Detection and Distribution Mapping System</a> (projected distribution)</li> </ul> |

## References

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## Disclaimer

### Report Purpose and Scope:

Parks identified for Legacy Restoration Funding in fiscal years 2023-2025 are required to develop a Great American Outdoors Act Facility Investment Plan (GFIP). The intended use of this series of park-specific reports is to help parks address Question 16 of the narrative template: *What risks or hazards (current and projected, e.g. effects of climate change) are likely to affect this project? If applicable, what adaptation strategies and/or resiliency measures have been identified for scenarios that pose high risks to project assets?*

Each report compiled and summarized published information on a suite of climate change hazards. Each report included an analysis of each hazard, for which the report author assigned a 'hazard rating' as follows:

**Known hazard:** Conditions that cause the hazard are well documented in the area where the park occurs. If applicable to the project site, these hazards should always be addressed in the project plan.

**Potential hazard:** Conditions that cause or underlie the hazard are known to occur nearby or are likely to occur based on studies with conditions similar to the park. If applicable to the project site, these hazards should be considered for inclusion in the project plan.

**Not applicable:** No evidence was identified showing this hazard is relevant to the park. Note this is a coarse filter evaluation; local knowledge of a hazard(s) should be used, when available.

As articulated within the report (in an appendix of the hazard ratings) those ratings constitute the author's 'best professional judgement' about the relevance of the hazard for that park based on the reviewed literature (cited in the narrative text for the hazard & provided in the report bibliography).

The intended use of each report is to inform decisions for facility investment planning related to (i) potential hazards that a suggested facility investment concept would need to appropriately consider and avoid or mitigate and (ii) identifying facilities possibly at greater relative vulnerability due to the identified hazards. The level of information quality in the report was calibrated to those purposes, i.e. to inform development of questions for a facility investment scoping process to further explore.

### Peer Review Process:

Each report was based on a template, which heavily relied on boilerplate text for the non-park specific elements. The boilerplate text underwent multiple rounds of informal peer review by assorted CCRP staff, including members of the Climate Science and Adaptation Team, the Communications Team, the Regional Climate Change Liaisons, and the Climate Change Liaison to Facilities and Planning. Each report was peer-reviewed by a member of CCRP to check interpretation, consistency in hazard ratings, improve narrative coherence, and flag priority additions/modifications. In situations where revisions were required, the peer reviewer then re-reviewed the final revised report to assure adequate resolution of the identified issues.