



Climate Change Hazards Summary Report for Facility Investment Planning

Olympic National Park February 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 Olympic 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. If not addressed through building design or more efficient temperature control systems, the increased demand for complex air conditioning systems can add stress to building envelopes and can require significant alterations to a structure.

Comparing climate experienced during the past 10–30 years relative to the longer 1901–2012 historical range of variability, Monahan and Fisichelli (2014) found two temperature variables showed recent warming at Olympic National Park. These include the minimum temperature of the coldest month and the mean temperature of the wettest month, indicating winters are warming at the park. Gonzalez et al. (2018) analyzed annual warming trends (as opposed to the seasonal analysis of Monahan and Fisichelli 2014) but did not find statistically significant warming, evaluating data over the periods 1895-2010 and 1950-2010.

Future projected temperatures indicate warming at Olympic National Park. Gonzalez et al. (2018) project a range of end-of-century warming rates from 2.9 °F (+/- 1.1) to 7.6 °F per century (+/- 1.8), 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). Regional climate change

projections indicate warming in all seasons, but are especially pronounced in the summer (McCaffery and Jenkins 2018).

Analyses of data from the broader western U.S. (including Olympic National Park) 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

Altered precipitation patterns, increased extreme precipitation, 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. 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.

No historical trend in annual total precipitation was found for Olympic National Park by Gonzalez et al. (2018) over the period 1895-2010 and 1950-2010 (analysis at whole park scale). Projections of future change in annual total precipitation for the park range from +4% (+/- 5% standard deviation) to +7% (+/- 5%) at the end of the century (compared to the period 1971-2000), depending on greenhouse gas emission scenario. Seasonal projections of precipitation change were not available at the park scale, but broader regional analysis point to wetter winters (+3% mid-century, +8% end-of-century, averaged over all greenhouse gas emission scenarios), and drier summers (-8.5% mid-century, -13% end-of-century, averaged over all greenhouse gas emission scenarios, Littell 2011).

Warming is expected to result in a shift of precipitation form from snow to rain, reductions in snowpack, and earlier snowmelt in the park, some of which have already been observed (McCaffery and Jenkins 2018). Across Washington state April 1st snow water equivalent (a measure of water in snowpack) is projected to decline by 37-44% by the 2040s, and 53-65% by the 2080s, with higher reductions on the Olympic Peninsula depending on greenhouse gas emissions scenario (Elsner et al. 2010). Rainfall is expected to be the dominant form of precipitation across the majority of Washington by the end of the 21st century (Elsner et al. 2010, Frankson et al. 2017), although a transition from snow to rain is unlikely to occur at the park's highest elevations.

The glaciers of Olympic National Park are an important component of the hydrology of the park and grow and shrink in response to snowfall and snowmelt. As such they are sensitive indicators of regional and global climate. As the climate warms rapid loss of glacial ice has been documented at Olympic National Park, especially as precipitation that used to fall as snow, feeding the glaciers, is now

transitioning to rain (McCaffery and Jenkins 2018). Based on comparison of aerial photos from the 1970s to 2009, researchers detected a 34% loss of glacial surface area and a loss of 82 of 266 glaciers present in the park in thirty years (Riedel et al. 2015). The volume of glacial ice in the park is also decreasing. The same study found a 15% decline in glacial volume in the 22 years from 1987 to 2009.

Extreme precipitation events are projected to increase on the western side of the Olympic Peninsula (Salathé et al. 2010, Littell 2011), and this projection is supported by broader modeling across western Washington (including the southwestern Olympics) (Salathé et al. 2010). Current and future warming is expected to drive decreases in snowpack, earlier spring snowmelt, and more precipitation falling as rain instead of snow (McCaffery and Jenkins 2018).

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).

As the climate changes, future drought impacts may be severe. Based on a tree ring analysis of forests in the nearby North Cascades, Harley et al. (2020) found the 2015 drought was unprecedented in the context of the past 400 years, and droughts are projected to be more likely within this century as climates warm (Diffenbaugh et al. 2015). Statewide, the 2015 drought necessitated \$7 million of relief funds to be used for backup emergency water supplies in Washington (May et al. 2018). 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-drive temperatures increases are expected to deepen droughts in this region, particularly in areas with snowpack. Declining snowpack and earlier runoff timing is expected to amplify summer drought conditions, increasing vulnerability to typical droughts caused by inter-annual precipitation variability (Mantua et al. 2010, Vose et al. 2016, May et al. 2018).

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.

Water deficit, a measure related to wildfire risk that characterizes the water demand of plants, is expected to increase on the Olympic Peninsula as a result of the interaction between future warming and precipitation changes. Summer potential evapotranspiration (one component of water balance, closely related to tree stress) is projected to increase in the summer, with the largest increases in low elevation forests in the northeastern part of the peninsula (Halofsky et al. 2011).

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). High tree density and ladder fuels resulting from fire exclusion will exacerbate climate-driven increases in area burned and severity of burns (Raymond et al. 2014).

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 km², 20 sq. mi.) up to three times across the forests of the western U.S. by 2050 (Barbero et al. 2015).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Sea level rise and coastal storm surge

Global sea level is rising and will continue to increase (Tebaldi et al. 2012), with local variability. Higher relative sea level causes accelerated coastal erosion, landward migration of shorelines, and saltwater intrusion and changes in groundwater, and amplifies flooding caused by higher storm surges (Field et al. 2007). Sea level rise poses considerable risks to infrastructure, lighthouses, forts, and other historic structures. Sea level rise visualization tools are available such as the [NPS Sea Level Rise Viewer](#) and for parks with exposure or vulnerability assessment by asset through the [Climate Vulnerabilities Map](#).

Caffrey et al. (2018) projects sea level rise around Washington's Olympic Peninsula and in the San Juan Islands, affecting Ebey's Landing National Historical Reserve, Olympic National Park, and San Juan Island Historical Park, reaching a maximum 1.5 ft (0.46 m, RCP8.5) by 2100. According to this report "This region is subject to tectonic shifts and continuing land movement due to isostatic rebound, further complicating sea level projections. Long-term tide gauge records at Neah Bay, Washington (gauge 9443090), and Tofino, British Columbia, Canada (gauge 822-116), show relative sea levels currently decreasing while tide gauges in Port Angeles, Washington (gauge 9444090), Victoria, Canada (gauge 822-101), and Seattle, Washington (gauge 9447130), show it to be increasing." Sea level projections indicate rising sea level in this region throughout this century, but further investigation of localized changes in land movement are needed (Caffrey et al. 2018).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Lake and reservoir water level change

Olympic National Park has two large low-elevation lakes (Crescent and Ozette). Water levels of these lakes may be impacted by changes in precipitation, which may result in low lake levels during dry periods due to diminished inputs and increased evaporation, or high water levels due to intense storms or consistent precipitation over a prolonged period. We were unable to find studies examining future projections of change for these lakes.

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.

Increases in winter precipitation, changes in precipitation form (i.e., rain rather than snow at transitional elevations) and intensity, and changes in the timing of peak streamflow (especially in transient watersheds) will increase the frequency and magnitude of flood events in many of the Olympic Peninsula rivers (Halofsky et al. 2011, McCaffery and Jenkins 2018). Higher snowlines will also increase the effective basin area, and combined with increased intensity storms and the loss of snow cover will increase the rate and volume of water delivered to river channels, increasing mass wasting, debris flows, channel migration, erosion and scour (Benda and Dunne 1997). Increased damage is anticipated for roads within, or downslope of, transitional or snow-dominated areas because of an increasing proportion of precipitation falling as rain and increased storm intensity (Halofsky et al. 2011).

Modeling of the Queets River in Olympic National Park (USGS gage near Clearwater, WA) indicates a 7% 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 Queets 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 ~25% to ~70%, comparing the periods 1980-2009 to 2070-2099 (high emissions scenario, Van Dusen et al. 2020). Mantua et al. (2010) projects flood frequency for many rivers on the Olympic Peninsula will increase, with the greatest increases in historically transient watersheds such as the Elwha.

Rain-on-snow events in the Olympics are likely to also increase flooding, although generalities are complicated by the changing elevation of the freezing line, existing snowpack, and interannual variability in the magnitude of precipitation (McCabe et al. 2007). 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.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Pest infestation

Increased temperatures and CO₂, changes in precipitation, and disturbance due to extreme climate events can increase the survival, spread, growth, and establishment of pests (IPCC 2014). Facilities may be impacted indirectly through forest insect pest invasions exacerbated by climate change 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). Mountain pine beetle outbreaks at higher elevations in the Olympics is expected to increase under moderate warming (Littell 2011,

McCaffery and Jenkins 2018). Exotic balsam wooly adelgid can infest Pacific silver fir and subalpine fir in the park. With long-term warming it is likely balsam wooly adelgid will expand within the subalpine fir ecotypes, potentially cause greater mortality in trees than is currently experienced (Halofsky et al. 2011). Pest-related tree mortality can also increase erosion and landslides.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Invasive species

Increased temperatures and CO₂, 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*), may invade burned areas, displace natives, and alter fuel and fire regime properties (e.g., increase fire frequency) (Brooks et al. 2004). Prior to dam removal, cheatgrass was present on the berms adjacent to the Glines Canyon dam and on the canyon walls (Riskin 2013, McCaffery and Jenkins 2018). Washington may become more climatically suitable for cheatgrass as the climate changes and increased atmospheric CO₂ levels may increase cheatgrass productivity and biomass (Ziska et al. 2005).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

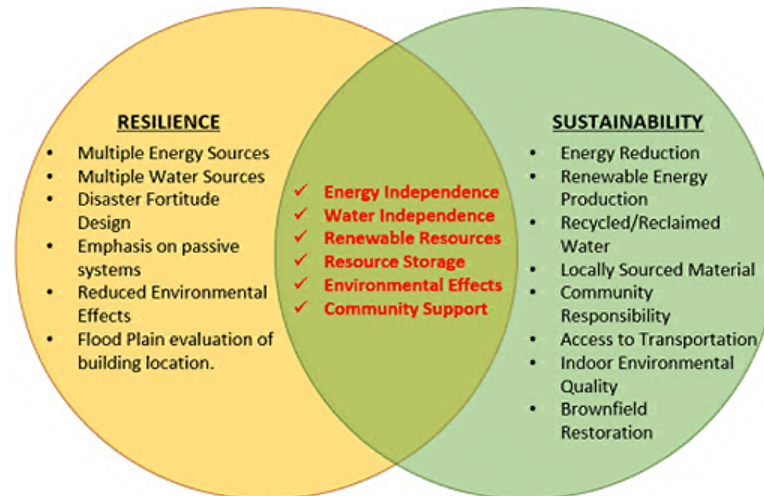
Step 2: Consider adaptation and resiliency strategies

- 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 based on climate-induced changes in hydrology related to road repair, damage to facilities in a floodplain, trail repair, or a water system project is provided below. This information was derived from Halofsky et al. (2011) and Raymond et al. (2014).
- You will need to develop park specific answers 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;** i.e., resilience strategies should be specific to your project type and the relevant climate change hazard.

- The NPS Climate Change Response Program (CCRP) and Sustainable Operations and Maintenance Branch (SOMB) are available to help evaluate climate change hazards and resiliency strategies for your specific projects. Requests should be sent to the NPS [GFIP Hazards and Risk Assistance email account](#); a member of the team will reply with support.

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 Olympic National Park road repair, damage to facilities in a floodplain, trail repair, or a water system project

Several climate change related hazards have been identified that may affect projects in Olympic National Park, including hotter average days, more extreme heat days, increased drought frequency and intensity, altered precipitation and flooding patterns, increased wildfire, sea level rise, and increased tree pests and invasive species abundance or distribution. The primary hazard affecting this project is related to climate change-induced alterations in hydrology. Possible adaptation strategies are provided below.

Vulnerability: Higher peak flows leading to increased road damage at stream crossings

- Replace existing or damaged culverts with higher capacity culverts
- Increase road maintenance including culvert cleaning, armoring outlets and ditches and installing water bars and drivable dips
- Prioritize structure replacement in high-risk (mixed-rain-and-snow) watersheds
- Reroute roads out of floodplains
- Decommission roads with high risk and low access

Vulnerability: Higher peak flows leading to increased damage and disrupted access to facilities and cultural and historical resources

- Restore natural function of the floodplain allowing waterways to migrate
- Remove or modify infrastructure allowing channels to migrate within the floodplain
- Consider increased use of engineered logjams to redirect flows
- Stabilize banks near resources with vegetation

Vulnerability: Higher peak flows and flood frequency may increase damage to trails and bridges, requiring more maintenance, replacements, or closures

- Upgrade trail bridges with stronger rot-resistant materials
- Relocate bridges to locations with stronger parent material if possible
- Reroute trails above waterways with highest flood risk
- Consider increasing the height of bridges above waterways
- Collaborate with hydrologists to consider future peak flows in design of new trails and trail bridges
- Abandon damaged trails with low use and high flood risk
- Reroute trails in locations that eliminate the need for trail bridges

Vulnerability: Decreased water and potable water availability with reduced snowpack, lower summer precipitation, and increased demand in the dry season

- Increase water conservation by installing waterless urinals and low-flow, solar, and composting toilets
- Institute gray water recycling
- Reduce campground capacity or close facilities when water is not available
- Investigate alternative water sources (e.g., ground water)
- Consider constructing new wells, cisterns, and reservoirs
- Increase water storage with artificial storage infrastructure (e.g., water towers)

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.
- Appendix 2 below, which provides a map to visualize how climate is changing for the park.
- 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 **Olympic 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 Judgment' 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 ☒ Potential Hazard ☐ Not Applicable ☐	<ul style="list-style-type: none">• Inadequate HVAC• Road surface degradation• Lack of water due to increased water for irrigation• Increased humidity• Danger to staff	<ul style="list-style-type: none">• National Climate Assessment• State climate summary	<ul style="list-style-type: none">• National Climatic Data Center• DAYMet gridded climate data• National park historical and projected climate change

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 ☐</p> <p>Potential Hazard ☒</p> <p>Not Applicable ☐</p>	<ul style="list-style-type: none"> Limited water supply for cooling, landscaping, structural fire suppression, other equipment Increased competition for available water and water rights conflicts Crack/heave damage in drier soils Increased vulnerability to wildfire (below) 	<ul style="list-style-type: none"> Drought Monitor National Integrated Drought Information Center National Climate Assessment State climate summary 	<ul style="list-style-type: none"> Drought Monitor National Integrated Drought Information Center
Increased wildfire frequency, intensity, magnitude, and duration	<p>Known Hazard ☐</p> <p>Potential Hazard ☒</p> <p>Not Applicable ☐</p>	<ul style="list-style-type: none"> Damage to facilities and contents Smoke damage Air quality dangerous to staff and visitors Increased runoff Increased erosion Damage to water treatment plants 	<ul style="list-style-type: none"> Barbero et al. 2015 International Journal of Wildland Fire 	<ul style="list-style-type: none"> NIFC International Wildland-Urban Interface Code

Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Altered precipitation patterns, increased extreme precipitation, and changing humidity	<p>Known Hazard ☒</p> <p>Potential Hazard ☐</p> <p>Not Applicable ☐</p>	<ul style="list-style-type: none"> • Local flooding • Mold growth • Wood decay • Drought • Fire • Groundwater change • Surface erosion • Floods (see below) • Water damage to structures from driven rain • Unstable saturated soils 	<ul style="list-style-type: none"> • National Climate Assessment • State climate summary 	<ul style="list-style-type: none"> • National Climatic Data Center • DAYMet gridded climate data • National Park historical and projected climate change • Evaluations are mostly at regional scales
Riverine flood/flash flood	<p>Known Hazard ☐</p> <p>Potential Hazard ☒</p> <p>Not Applicable ☐</p>	<ul style="list-style-type: none"> • Damage or destruction of infrastructure • Stream channel migration • Stream bank erosion/extreme erosion • Safety • Water quality diminished • Damage to water source and delivery infrastructure • Changing requirements for culvert flow capacity 	<ul style="list-style-type: none"> • FEMA Flood map service 	<ul style="list-style-type: none"> • FEMA Map Service Center • Floodplain maps for HUD projects • Van Dusen et al. 2020 (for select parks) • May require a special flood study

Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Sea level change and coastal storm surge	<p>Known Hazard ☒</p> <p>Potential Hazard ☐</p> <p>Not Applicable ☐</p>	<ul style="list-style-type: none"> • Rising sea and lake levels • Rising water – wind driven (e.g. hurricane, nor'easter) • Saltwater intrusion • Vegetation damage 	<ul style="list-style-type: none"> • NOAA SLR viewer • NOAA - Great Lakes Environmental Research Laboratory 	<ul style="list-style-type: none"> • IRMA – Coastal reports • NPS SLR viewer • Specific Hazard Assessment: Coastal Storm Surge with Climate Change Effects (requires VPN connection) • SLR reports • Great Lakes Dashboard Project
Lake and reservoir level change	<p>Known Hazard ☐</p> <p>Potential Hazard ☒</p> <p>Not Applicable ☐</p>			
Hurricanes and tornadoes	<p>Known Hazard ☐</p> <p>Potential Hazard ☐</p> <p>Not Applicable ☒</p>	<ul style="list-style-type: none"> • Building destruction • Flying debris • Storm surge • Tree fall <p>(see other categories for associated intense rainfall and floods)</p>		<ul style="list-style-type: none"> • Wind speed data – from local codes • International Building Code • FEMA Map Service Center

Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Pest infestation	Known Hazard ☐ Potential Hazard ☒ Not Applicable ☐	<ul style="list-style-type: none"> • Historic/facility fabric loss • Vegetation loss • Disease vectors may increase • Termites and other woodboring pests expanding range with warming and increased humidity 	<ul style="list-style-type: none"> • USFS Forest Health Advisory System 	<ul style="list-style-type: none"> • NPS Pest and Invasive Species Management Contacts • Fisichelli et al. forest pests • USFS maps
Invasive species	Known Hazard ☐ Potential Hazard ☒ Not Applicable ☐	<ul style="list-style-type: none"> • Aquatic mussels – water intakes clogged • Vegetation (kudzu, vines) – damage buildings, kill trees, obstruct waterways 	<ul style="list-style-type: none"> • National Invasive Species Council 	<ul style="list-style-type: none"> • NPS Pest and Invasive Species Management Contacts • Early Detection and Distribution Mapping System (current distribution) • Early Detection and Distribution Mapping System (projected distribution)

Appendix 2. What Will the Park Climate Feel Like in 60 Years?

The map below is intended to help visualize how the present-day climate in the region of **Olympic National Park** is projected to change as a result of climate change (Fitzpatrick and Dunn 2019). Under a high greenhouse gas emission scenario, Sequim, Washington's climate in 2080 may feel like today's climate near Seattle, Washington. The typical summer in Seattle, Washington is 6.6°F (3.7°C) warmer and 18.8% drier than summer in Sequim, Washington. The red line shows the average of the 27 climate models; the black lines show the 27 individual projections assuming continued high emissions, providing a sense of the plausible range of future climates. The size of a red circle gives a sense of how good of a match that location is, with smaller circles indicating better matches; all circles (red or purple) denote cities used in the analysis. The analysis is based on twelve climate metrics, including minimum and

maximum temperature and precipitation by season (spring, summer, fall, winter). More details are available in the reference cited above and the website <https://fitzlab.shinyapps.io/cityapp/>.



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.