



Climate Change Hazards Summary Report for Facility Investment Planning

San Juan National Historic Site February 2021

Prepared By
NPS Climate Change Response Program
NPS Sustainable Operations and Maintenance Branch

Executive Summary

The following climate change related hazards could impact GAOA projects at SAJU and may need to be considered in preparing project narratives. Under a changing climate, hurricane intensity and precipitation are projected to increase (USGCRP 2017). Hurricanes can cause tremendous wind associated damage by ripping off roofs, blowing out windows, and tearing shutters from buildings. Hurricanes can also produce damaging tornados. Annual average precipitation is expected to decrease, but more sporadic extreme events could bring waves of pests as breeding conditions change including mosquitoes, scorpions, centipedes, flying cockroaches, and tarantulas.

Puerto Rico is already facing growing drought and water shortage, and projections are that with a changing climate, annual average precipitation will decrease slightly by less than 1% (RCP2.6) or far more dramatically by as much as 26.6% (RCP 8.5) by the end of the century (Gonzalez et al. 2018). Drought conditions primarily affect water and wastewater related infrastructure projects, but can also impact transportation projects. Due to the moderating influence of the ocean, temperatures at SAJU are fairly stable. Increases in temperature due to climate change won't change this stability.

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?

Summary information for known or potential hazards

Hotter average days and more very hot days

Due to the moderating influence of the ocean, temperatures at SAJU are fairly stable. Increases in temperature due to climate change won't change this stability. At SAJU, temperature can be used to predict visitation patterns with 76% accuracy, with peak heat coincident with peak visitation in the summer (Fischelli et al. 2015). By the end of the century, low greenhouse gas scenarios (RCP 2.6) project an annual mean temperature increase of 1° C, and scenarios of higher atmospheric concentrations of greenhouse gas (RCP 8.5) project an increase in annual mean temperature of 3° C (Gonzalez et al. 2018).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Altered precipitation patterns, decreased precipitation and water shortages

Puerto Rico is already facing growing drought and water shortage, and projections are that with a changing climate, annual average precipitation will decrease slightly by less than 1% (RCP2.6) or far more dramatically by as much as 26.6% (RCP 8.5) by the end of the century (Gonzalez et al. 2018).

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).

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. SAJU is projected to experience 0.12 m more sea level rise by 2030 (RCP 2.6), and up to 0.64 m (RCP 8.5) by 2100 (Caffrey et al. 2018). Parts of SAJU, like Castillo San Felipe del Morro are highly fortified and elevated far above sea level, and low lying infrastructure like Paseo del Morro are constructed from cement and resistant to damage from storms. Other sections of the coast are extremely rocky and resist damage from high waves. Low lying areas with unconsolidated sandy soils could be subject to erosion from storms.

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

Hurricanes and tornadoes

Hurricanes are projected to increase in intensity and precipitation in the Caribbean (USGCRP 2017). Storm surge can cause flooding and road wash outs. Hurricanes threaten structures via damage from wind, wind-blown rain and debris; their large temperature swings stress buildings through sudden thermal expansion and can crack pipes.

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

Pest infestation

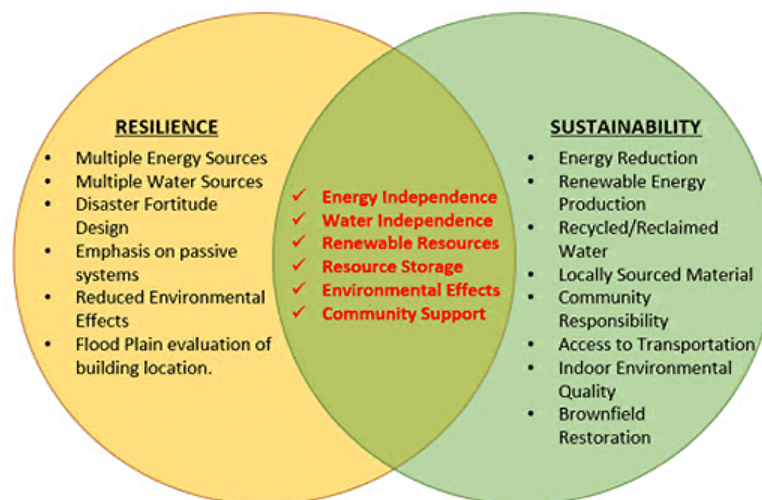
Increased temperatures and CO₂, changes in precipitation, and disturbance due to extreme climate events can increase the survival, spread, growth, and establishment of pests (IPCC 2014). Mosquitoes, scorpions, centipedes, flying cockroaches, and tarantulas can all be found in Puerto Rico. While annual average precipitation is expected to decrease, more sporadic extreme events could bring waves of pests as breeding conditions change.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Adaptation and resiliency strategies

- Historic structures have resilient design features. If buildings are well maintained, they may have a better chance of surviving a major storm.
- Storms are expected to happen; all damages cannot be anticipated or mitigated in advance; and post-storm recovery is a critical opportunity to learn and adapt to climate change.
- Resilient park operations can be supported with 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. The NPS [Coastal Adaptation Strategies Handbook](#) (Beavers et al., 2016) provides guidance for policy, planning, cultural resources, and facility adaptation in the coastal zone.

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](#)).

Example answers to Question 16 from other parks

Two example responses to Question 16 are provided below. You can view other examples here: [Example responses to Q16 on hazards Organized by Park](#). *You will need to develop park specific answers based on the hazards and the adaptation strategies identified above 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 Minute Man National Historic Park: Restoring historic structures

Several climate change hazards may affect building-related projects at MIMA, including hotter average days, more extreme heat days, increased hurricane impacts from wind and flooding, altered precipitation patterns, and increased extreme precipitation. 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 higher capacity air conditioning systems unless accommodated through modified building designs or other systems.
- Extreme heat and humidity can stress the building envelope and will require significant humidity control alterations for structures.
- Changes in building design or post-flooding dehumidification systems, in coordination with the NPS Historic Architecture, Conservation and Engineering Center or Historic Preservation Training Center, to avoid any increase in energy use.
- Hurricane force wind and wind-blown rain as well as damage from wind-blown debris or treefall will require wind resistant fortification of the structure. Addressing hazardous trees and retrofitting roof structures to be more wind resistant may also be required.
- Flooding from increased hurricane events, increased extreme precipitation, or in conjunction with altered precipitation patterns may require modifications to building infrastructure location and landscape drainage systems.
- Post-flooding effects may include increased rot, mold and mildew, and physical deterioration of wood, brick and stone building materials. Adaptation actions will include identifying appropriate dehumidification and air handling systems and coordinating with the NPS Historic Preservation Training Center regarding alternatives and maintenance for historic structures.

Example from San Francisco Maritime National Historic Park: pier repair, historic building restoration, road repair, or water system project

Several climate change hazards may affect a (pier repair, historic building restoration, road repair, or water system) project at San Francisco Maritime National Historical Park, including sea level rise, storm surge, more frequent storms, San Francisco Bay flooding, increased street stormwater runoff, hotter temperatures, and increased insect pests. Possible adaptation and resiliency strategies include:

- Adoption of sea-level rise adaptation measures developed by Golden Gate National Recreation Area in a plan for Crissy Field that covers an area up to the western boundary of San Francisco Maritime National Historical Park.
- Natural shoreline features along Aquatic Park Beach to handle some inundation from sea level rise.
- Vegetated catch basins for urban street stormwater runoff.
- Drainage systems and culverts that could handle greater water flows.
- Relocation of any infrastructure from an area where a hazard cannot be avoided.
- Water conservation measures to reduce water use during droughts.
- Strengthening structures to prevent damage from extreme storms or treefall.
- Changes in building design or building systems to maintain appropriate temperatures and humidity without increasing energy use, which would increase greenhouse gas emissions and exacerbate climate change. Energy conservation and renewable energy systems to prevent any increase in fossil fuel energy use.
- Early detection and removal of termites or other pests or hazards.

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

The following checklist is an expert-opinion based screening tool that illustrates the hazards that were considered in the development of this report. Knowledge of how climate change will unfold is developing rapidly and new hazards may become evident in the future.

Potential Hazard	Best Professional Judgment	Potential Risk or Secondary Hazard
Air Temperature: Hotter Average Days and More Very Hot Days	Known Hazard ☒ Potential Hazard ☐ Not applicable ☐	• Inadequate HVAC • Road surface degradation • Lack of water due to increased water for irrigation • Increased humidity • Danger to staff and visitors
Melting Permafrost/ Declining Sea and Lake Ice	Known Hazard ☐ Potential Hazard ☐ Not applicable ☒	• Road and building foundations unstable • Landslides and unstable hillsides • Shoreline erosion
Drought: Increased Frequency, Intensity, Magnitude, and Duration	Known Hazard ☒ Potential Hazard ☐ Not applicable ☐	• Limited water supply for cooling, landscaping, other equipment • Increased competition for available water and water rights conflicts • Crack/heave damage in drier soils • Increased vulnerability to wildfire (below)
Wildfire:	Known Hazard	• Damage to facilities and contents

Increased Frequency, Intensity, Magnitude, and Duration	☐ Potential Hazard ☐ Not applicable ☒	• Smoke damage • Air quality dangerous to staff and visitors • Increased runoff • Increased erosion • Damage to water treatment plants
Precipitation: Altered Patterns and Changing Humidity	Known Hazard ☒ Potential Hazard ☐ Not applicable ☐	• Local flooding • Mold growth • Wood decay • Drought • Fire • Groundwater change
Precipitation: Increased Extreme Events	Known Hazard ☒ Potential Hazard ☐ Not applicable ☐	• Surface erosion • Floods (see below) • Water damage to structures from driven rain • Unstable saturated soils
Riverine Flood/ Flash Flood	Known Hazard ☐ Potential Hazard ☐ Not applicable ☒	• 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
Sea Level Change and Coastal Storm Surge	Known Hazard ☐ Potential Hazard ☒ Not applicable ☐	• Rising sea and lake levels • Rising water – wind driven (e.g., hurricane, nor'easter) • Saltwater intrusion • Vegetation damage • Need to elevate or relocate coastal facilities
Hurricanes, Tornados, and Other High Wind Events	Known Hazard ☒ Potential Hazard ☐ Not applicable ☐	• Building destruction • Flying debris • Storm Surge • Tree fall (see other categories for associated intense rainfall, floods)
Pest Infestation	Known Hazard ☐ Potential Hazard ☒ Not applicable ☐	• Historic fabric and facility damage • Vegetation loss • Disease vectors may increase. • Termites and other woodboring pests are expanding range with warming and increased humidity.
Invasive Species	Known Hazard ☐	• Vegetation (e.g., kudzu, vines, Brazilian pepper) can damage buildings,

	Potential Hazard ☒ Not applicable ☐	kill trees, obstruct waterways. • Marine and aquatic invasive species
Subsurface Hazards Cave/Karst (Sinkholes)	Known Hazard ☒ Potential Hazard ☐ Not applicable ☐	• Surface collapse • Contamination • May affect freshwater availability, drainage, and drought potential • Abandoned Mineral Lands (AML) features
Shrink/ Swell Soils	Known Hazard ☐ Potential Hazard ☐ Not applicable ☒	• Damage to structure • “Heaving” of ground beneath structure • Increased landslide susceptibility
Landslide/ Rockfall/ Avalanche	Known Hazard ☐ Potential Hazard ☐ Not applicable ☒	• Rockfall • Mud or debris slides or flows onto structures • Mud or debris slides or flows from under structures • Snow avalanche
Tsunami	Known Hazard ☒	• Coastal area inundation associated with earthquakes or undersea landslides

	Potential Hazard ☐ Not applicable ☐	• May be triggered by mass wasting events
Volcanic Eruption	Known Hazard ☐ Potential Hazard ☐ Not applicable ☒	• Lava Flows • Fire • Toxic gas releases • Ash
Hydrothermal Activity (e.g., Geysers)	Known Hazard ☐ Potential Hazard ☐ Not applicable ☒	• Toxic gas release • Explosion • Boiling water • Steam • Surface collapse into void
Earthquake	Known Hazard ☒ Potential Hazard ☐ Not applicable ☐	• Falling objects • Collapsing structures • Inoperability of major building systems e.g. power, sewer, water • Liquefaction; loss of strength to foundations, silt deposition, standing water • Trigger to other hazards e.g. landslides, debris flows

References

- Caffrey, M. A., R. L. Beavers, and C. H. Hoffman. 2018. Sea level rise and storm surge projections for the National Park Service. Natural Resource Report NPS/NRSS/NRR—2018/1648. National Park Service, Fort Collins, Colorado.
- Department of Homeland Security (2015). Drought Impacts to Critical Infrastructure. Office of Cyber and Infrastructure Analysis. April 23, 2015. Hyperlink
- Fernandez, M., Denis, A., Fabre, R. & Lataste, J.F. (2015). In situ study of the shrinkage-swelling of a clay soil over several cycles of drought-rewetting. *Eng. Geol.* 192, 63-75.
- Fisichelli, N. A., G. W. Schuurman, W. B. Monahan, and P. S. Ziesler. 2015. Protected Area Tourism in a Changing Climate: Will Visitation at US National Parks Warm Up or Overheat? *PLOS ONE* 10:e0128226.
- Gonzalez, P., F. Wang, M. Notaro, D. J. Vimont, and J. W. Williams. 2018. Disproportionate magnitude of climate change in United States national parks. *Environmental Research Letters* 13:104001.
- Halofsky, J.E., Peterson, D.L. & Harvey, B.J. Changing wildfire, changing forests: the effects of climate change on fire regimes and vegetation in the Pacific Northwest, USA. *fire ecol* 16, 4 (2020). <https://doi.org/10.1186/s42408-019-0062-8>
- IPCC. 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf.
- Mosley, L. M. (2015). Drought impacts on the water quality of freshwater systems; review and integration. *Earth-Science Reviews*, 140, 203-214.
- Tebaldi, C., B. H. Strauss, and C. E. Zervas. 2012. Modelling sea level rise impacts on storm surges along US coasts. *Environmental Research Letters* 7.
- USGCRP. 2017. Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 470 pp., doi: 10.7930/J0J964J6.