



Best Practices & Key Considerations for Enhancing Federal Facility Security and Resilience to Climate-Related Hazards

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Message from the Executive Director

Protecting Federal employees and private citizens who work within and visit U.S. Government-owned or leased facilities from all hazards is a complex and challenging responsibility. Comprising 56 Federal departments and agencies, the Interagency Security Committee's (ISC) primary mission is to accomplish this goal through providing guidelines, security standards, and best practices for nonmilitary Federal facilities in the United States. To ensure continued personnel safety, mission performance, and secure buildings, the ISC must consider necessary preparations for the impacts of climate change. As stated in Executive Order E.O. 13653, *Preparing the United States for the Impacts of Climate Change*, November 2013, federal departments and agencies have prepared Agency Adaptation Plans that evaluate the most significant climate change related risks to, and vulnerabilities in, actions that agencies will take to manage these risks and vulnerabilities.

As Acting Executive Director of the ISC, I am pleased to introduce, *Best Practices & Key Considerations for Enhancing Federal Facility Security and Resilience to Climate-Related Hazards*. This document was developed to identify threats posed by climate change to Federal assets, missions, operations, and workforce, and provide guidance and security planning considerations for agencies housed in nonmilitary Federal facilities. The main purpose of this document is to identify short and long-term strategies to enhance physical security and resilience against climate-related threats.

The authorities that have been used for the purpose of this document are Executive Orders (E.O.) 12977, 13653, and 13693. E.O. 13693 requires all Federal departments and agencies evaluate risks and vulnerabilities posed by climate change, manage the effects, and create adaptation plans documented in their annual Strategic Sustainability Performance Plan (SSPP). Consistent with E.O. 12977 (October 19, 1995), *Best Practices & Key Considerations for Enhancing Federal Facility Security and Resilience to Climate-Related Hazards* should be applied to all buildings and facilities in the United States occupied by Federal employees for nonmilitary activities. These include existing owned; to be purchased or leased facilities; stand-alone facilities; Federal campuses; individual facilities on Federal campuses; and special-use facilities.

Climate change will affect critical infrastructure, personnel, missions, and facilities in the near and distant future. Taking climate change into consideration is a fundamental goal of this document and will serve to proactively safeguard nonmilitary facilities and operations nationwide.



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Acting Executive Director
Interagency Security Committee

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1 Background

The Interagency Security Committee (ISC) was formed by Executive Order (E.O.) 12977 which was signed by President Bill Clinton in 1995 following the Oklahoma City bombing. This devastating event prompted the White House to establish a permanent body to address continuing physical security and building protection needs for nonmilitary Federal facilities. Today, the ISC is chaired by the Department of Homeland Security (DHS) Assistant Secretary for Infrastructure Protection and consists of a permanent body with representatives from 56 Federal agencies and departments.

E.O. 13693, *Planning for Federal Sustainability in the Next Decade*, was signed on March 19, 2015. This latest E.O. extends and enhances the goals initially established in E.O. 13514 and requires all Federal departments and agencies to prepare for impacts of climate change by identifying and addressing projected impacts of climate change on mission critical water, energy, communication, and transportation demands and considering those impacts in operational preparedness planning. It is the policy of the United States that agencies increase efficiency and improve their environmental performance.

A number of Federal coordination efforts have been undertaken to provide strategies and mitigating factors to assist agencies in preparing for a changing climate. In response to concerns raised by its membership, the ISC established the Climate Change Working Group (ISCCCWG). The ISCCCWG was tasked with developing a document that agencies housed in nonmilitary Federal facilities could reference to identify physical security considerations in a changing climate.

2 Applicability and Scope

This document is issued pursuant to the authority granted to the ISC in E.O. 12977. The E.O. directs the ISC to “take such actions as may be necessary to enhance the quality and effectiveness of security and protection of Federal facilities.” The purpose of this document is to provide guidance and security planning and climate impact considerations for agencies housed in nonmilitary Federal facilities. This document outlines climate-induced hazards by U.S. region, potential impacts to Federal infrastructure and operations, preventive measures, mitigation options, potential facility security operation impacts, Federal facility case studies, and cross-government coordination best practices.

E.O. 13693 provides Federal Executive departments and agencies with clarifying instructions. This document revokes and supersedes the *Instructions for Implementing Executive Order 13423* issued by the Council on Environmental Quality (CEQ) on March 29, 2007. CEQ and other agencies have also issued various implementing instructions and guidance regarding E.O. 13514. The following instructions remain in effect: Sustainable Locations for Federal Facilities of September 15, 2011; Sustainable Practices for Designed Landscapes of October 31, 2011, as supplemented on October 22, 2014; Federal Greenhouse Gas Accounting and Reporting Guidance [Revision 1] of June 4, 2012; and Federal Agency Implementation of Water Efficiency and Management Provisions of Executive Order 13514 of July 10, 2013.

This document is intended to be a best practices guide that agencies may consult when considering the potential impacts of climate change on Federal facilities. It is a compilation of open-source information, internal ISC member agencies’ best practices, and Federal standards and guidance. As such, it was produced by the ISCCCWG to streamline existing guidance to facilitate Federal agencies’ access to climate change information as it relates to Federal facility security. The

information and best practices contained herein are not meant to limit or supersede any internal agency policies.

This guidance is designed to be applicable to all buildings and facilities in the United States occupied by Federal employees. These include existing buildings, new construction, or major modernizations; facilities owned, or being purchased, or leased; stand-alone facilities; Federal campuses; where appropriate, individual facilities on Federal campuses; and special-use facilities.

The authority for Federal departments and agencies to provide security for their facilities and employees is cited in various sections of the United States Code (USC) and the Code of Federal Regulations (CFR). In accordance with their respective authority, each department or agency obtains the funds to provide security at its facilities. It is beyond the scope of this document to cite individual department and agency authorities. For more information regarding authorities, the reader should contact his/her agency's Office of General Counsel.

3 Introduction

Climate change is already impacting Federal facilities, communities, and the environment throughout the United States (U.S.) and the world. In response, the ISCCCWG was tasked to provide climate preparedness and resilience-related guidance and security planning considerations for agencies housed in nonmilitary Federal facilities.

Agencies are actively taking steps to manage climate impacts to Federal agency missions, programs, and operations to ensure that resources are invested wisely and Federal services remain effective for the American people. Agencies have developed and continue to refine climate adaptation plans to identify their vulnerabilities and prioritize activities that reduce climate risks and impacts. As agencies continue to understand how climate risks are likely to affect the strategic landscape, agencies can more effectively manage these risks to Federal assets and overall national security.

Many potential risks exist, ranging from rising sea levels, to power interruptions, wildfires, regional flooding, droughts, or the impacts of severe storms; each risk should be of concern to the persons responsible for the security of Federal facilities and personnel. The Department of Defense (DoD) and DHS consider climate change to be a “threat multiplier.” Although climate change occurs gradually over time, impacts can already be seen, and those impacts are projected to worsen over time (National Climate Assessment [NCA], 2014). Actions to mitigate climate impacts must be a component of preparedness and adaptation planning. Planning will reduce costs over the long-term and will streamline the process of climate change adaptation.

This document provides agencies with best practices and key considerations that reinforce strong partnerships, enhance security coordination, and provide accessible information and tools to help decision makers develop strategies to prepare for a changing climate. These efforts will assist in reducing extreme weather impacts and other climate risks that affect Federal facilities' security operations and building integrity. This document opens with an orientation of projected climate-related impacts, categorized by geographic region of the United States. Once the threats of climate change have been outlined, potential impacts on the security of Federal infrastructure, programs, facilities, as well as concerns for employees will be discussed.

Section 11 includes a list of resources and links that may be useful in developing or reviewing climate change preparedness plans. These websites are constantly evolving and being updated as lessons are learned. The inclusion of certain references does not imply endorsement of any

documents, products, or approaches. Other resources may be equally helpful and should be considered in creating or revising existing plans and procedures.

4 Frequency and Intensity of Climate-Related Hazards

Warming of the climate system is unequivocal and since the 1950s many of the observed changes are unprecedented. The atmosphere and oceans have warmed, amounts of snow and ice have diminished, and sea level has risen (Intergovernmental Panel on Climate Change [IPCC] 2013). Worldwide, these observed changes in conditions have been accompanied by cumulative trends in extreme heat and heavy precipitation events (Melillo et al. 2014).

Across the country, changes are noticeable; in some areas summer temperatures are being experienced for longer duration, while winter temperatures are shorter and extreme weather events are more frequent and intense. Some cities are experiencing more frequent and severe flooding, while in other regions more frequent wildfires are occurring (Melillo et al. 2014). The impacts of climate change are occurring now.

Global climate is projected to change over this century and beyond, based on various emission scenarios. These emission scenarios will be explained in the next sub-section. Another 0.5°F increase in temperature is expected over the next few decades even if all emissions from human activities ceased (Melillo et al. 2014). Continued emission of greenhouse gases will cause the average global temperature to rise and will cause changes in all components of the climate system (IPCC 2013).

Although this section will help identify climate-related hazards of concern, more localized information will be required to conduct accurate vulnerability assessments of nonmilitary Federal facilities. Sources of such additional information include: the 2014 National Climate Assessment (NCA), Regional Integrated Science Assessments (RISAs), State Climate Offices, and Climate Science Centers. Section 10, “Cross-government Coordination and Assistance,” includes supplementary sources of information and potential partnerships.

This section of this document identifies climate-related hazards and projected effects in each region; Section 5 explains the impacts to infrastructure, missions, facilities, and personnel, of various climate-induced hazards by each region. Measures to alleviate and mitigate these impacts are discussed in Sections 6 and 7.

Unless otherwise noted, information described in *Section 4: Frequency and Intensity of Climate-Related Hazards* is derived from the Third National Climate Assessment.¹

4.1 Emission Scenarios

As projections of climate change depend heavily upon future human activity, climate models are run under multiple scenarios that include plausible projections of what might happen under a given set of assumptions. These scenarios describe possible futures through 2100 in terms of population, energy sources, technology, and greenhouse gas emissions. This report uses the 2000 Special Report on Emission Scenarios (SRES) developed by the IPCC. These climate model projections can

¹ Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: *Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

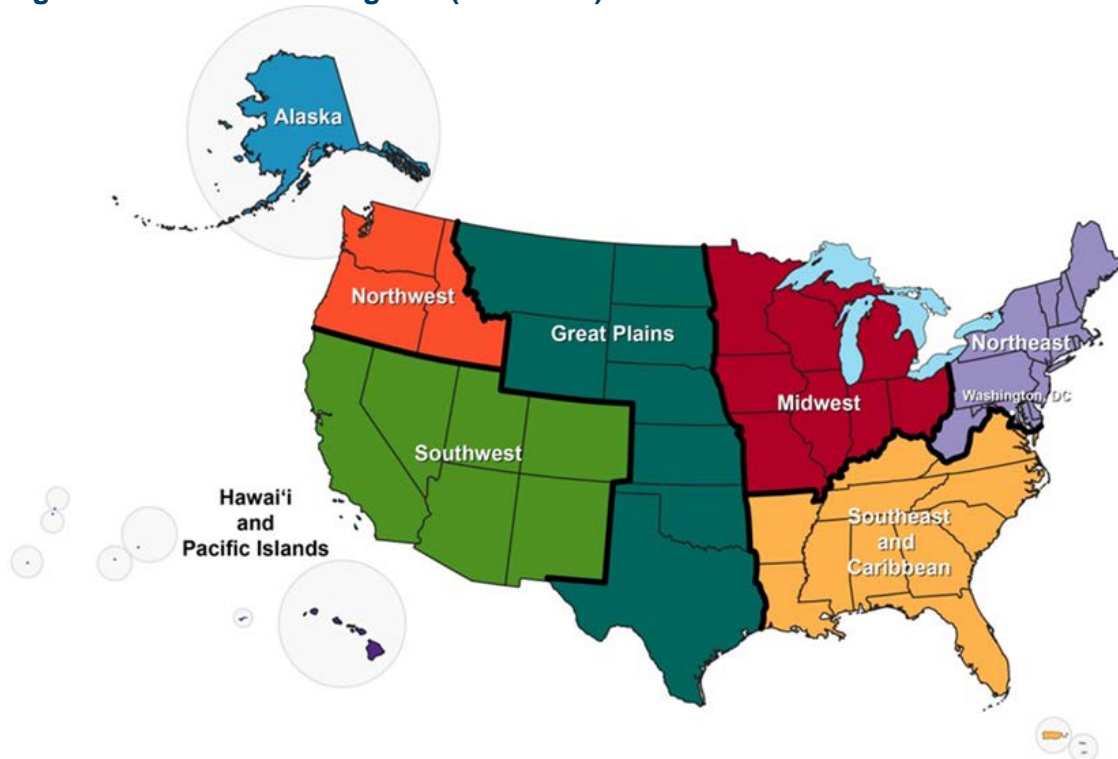
be utilized to estimate global parameters to develop expectations and potential preparation scenarios at any given timescale.

Over the next few decades, there will continue to be uncertainty in projecting global and regional climate-related changes due to scientific limitations in our ability to model and fully understand the Earth's climate system. Though natural variability will continue to occur, most of the difference between present and future climates will be determined by choices that society makes today and over the next few decades. These choices are grouped into scenarios. The further out in time models project, the greater the influence of human choices on the magnitude of future change (Melillo et al. 2014).

4.2 U.S. Regions

Across the U.S. climate changes will vary, as will their impacts to Federal missions, programs, buildings, and personnel. This sub-section summarizes the historic changes and future projections of the most relevant climate-related hazards in eight U.S. regions: Northeast, Southeast and Caribbean, Midwest, Great Plains, Southwest, Northwest, Alaska, and Hawaii and Pacific Islands. This information is explained in more detail in the DHS Climate Adaptation Plan (DHS CAP) and is based on the U.S. Global Change Research Program's Regional Climate Trends and Scenarios for each region.

Figure 1: U.S. Climate Regions (DHS 2014)



4.2.1 Northeast Region

Heat waves, increases in temperatures, sea level rise, intense storm events, increases in precipitation, coastal flooding, and river flooding will present a growing challenge to the Northeast. Already, Northeast Region annual average temperatures have risen by nearly 2°F from 1895 to 2011 (Kunkel et al. 2013a). If emissions continue to increase, a projected warming of 4.5°F to 10°F

is likely by the 2080s (Kunkel et al. 2013a). Additionally, the intensity, frequency, and length of heat waves are expected to increase (Melillo et al. 2014).

The Northeast has experienced approximately one foot of sea level rise since 1900 (Melillo et al. 2014). Philadelphia, PA has seen a 1.2-foot rise over the last 100 years (National Ocean Service [NOS] 2013). This rate exceeds the global average of approximately eight inches and is attributed to land subsidence (Church et al. 2010), with possible contributions from changes in ocean circulation (Sallenger et al. 2012). Even without land subsidence and added ocean circulation factors, global sea levels are predicted to rise one to four feet by 2100 (Parris et al. 2014). This will augment the potential for coastal flooding.

Hurricanes and other extreme weather events are of concern to the Northeastern U.S. Category 4 and 5 hurricanes occurring in the North Atlantic have increased in strength and number since 1980 and are projected to continue this trend through late in this century (Melillo et al. 2014). Northeast precipitation has increased by 0.4 inches per decade, or more than ten percent, for a total increase of approximately five inches between 1895 and 2011 (Kunkel et al. 2013a).

The Northeast is the leading U.S. region for a surge in extreme precipitation events. This region experienced a 71 percent increase in the heaviest one percent of daily rain events between 1958 and 2012 (Groisman et al. 2013). Heavy downpours are projected to be more frequent, increasing the potential for floods and threatening infrastructure.

4.2.2 Southeast and Caribbean Region

The Southeast and Caribbean are vulnerable to sea level rise, increasing temperatures, wildfires, extreme precipitation events, droughts, and hurricanes. Due to the variable topography of this region, from the Appalachian Mountains to the alluvial plains, the geographic distribution of these impacts and vulnerabilities is uneven.

Sea level rise will affect the Southeast and Caribbean. While the global sea level rise over the last 100 years averaged approximately eight inches, with an accelerating rate through the end of this century, low-lying cities are particularly at risk. Southeastern cities of particular concern include New Orleans, Miami, Tampa, Charleston, and Virginia Beach (Strauss et al. 2012).

Over the next 100 years, temperatures are expected to rise across the Southeastern U.S. and Caribbean (Puerto Rico Climate Change Council [PRCCC] 2013). Miami, Atlanta, New Orleans, and Tampa have had increases in the number of days over 95°F (Sheridan et al. 2009). This will equate to a significant increase in the number of hot days (days 95°F or above) and decreases in the number of freezing events, such as ice storms. Similarly, the Caribbean experienced an increase in the number of days above 90°F (PRCCC 2013). Metropolitan areas including Atlanta, Miami, New Orleans and Tampa have already seen increases in the number of hot days per year, during which the number of deaths is higher than average (Sheridan et al. 2009). Finally, interior states in the Southeast are projected to be warmer than the surrounding coastal states by 1°F to 2°F (Melillo et al. 2014).

The continental southeastern U.S. leads the nation in number of wildfires, averaging 45,000 fires per year, and this number is growing (Gramley 2005). Fire frequency, intensity, and size have increased along with a common fire initiator: lightning. This region of the U.S. leads the country with the most lightning strikes (Ashley and Gilson 2009).

The Southeast is located in a zone between projected drier conditions to the Southwest and wetter conditions to the north and northeast (Kunkel et al. 2013b). In the Caribbean, most models show future decreases in precipitation (PRCCC 2013). Over the last century, more extreme precipitation

events have been observed than in previous years and are expected to become more frequent over the next 100 years (Melillo et al. 2014).

This region has already experienced extensive droughts, such as the 2007 drought in Atlanta, GA that brought about water conflicts among three states (Kunkel et al. 2013b) (Melillo et al. 2014). The Southeast's available net water supply is expected to decline with a greater decline in the western states within the region (Sun et al. 2013). Droughts have been called "one of the most frequent climate-related hazards in the Caribbean" and are projected to be a growing problem in the future as a result of growing temperatures (Farrell et al. 2010).

The number of Category 4 and 5 hurricanes in the Atlantic basin have increased in strength and number. Model projections suggest that "warming will cause tropical storms to be fewer in number globally, but stronger in force, with more Category 4 and 5 storms" (Knutson et al. 2010). Under some emission scenarios, hurricane wind speeds may exceed existing building design standards (Mudd et al. 2013).

4.2.3 Midwest Region

In the Midwest, rising temperatures, increased heat waves, and heavy precipitation pose a particular threat. The rate of warming in the Midwest is steadily increasing. The annual average temperature from 1900 to 2010 rose by more than 1.5°F and is continuing to accelerate (Kunkel et al. 2013c). By 2100, warming in the Midwest is projected to be 5.6°F to 8.5°F warmer than between 1979 and 2000, depending on the emissions scenario (Pryor et al. 2013a).

Heat waves have been more numerous over the last 60 years (Luber and McGeehin 2008). Air quality in this region is also a concern. Longer summers, more frequent hot days and heat waves, and higher humidity have led to an increase in the number of cooling degree days and an increase in energy requirements for cooling (Melillo et al. 2014).

During the last 100 years, extreme rainfall events have increased in number and are expected to become more frequent and intense across the entire region (Melillo et al. 2014). In the Midwestern states, the ten rainiest days of the year may contribute up to 40 percent of the total yearly precipitation, which equates to very intense rainfall events for this region (Pryor et al. 2009a). Over the last century, annual precipitation rose by as much as 20 percent in some areas of the Midwest and the heaviest of rainfalls has intensified (Pryor et al. 2009a) (Pryor et al. 2009b). These heavier rainfalls may increase erosion for the region as well. Annual precipitation is expected to increase in the northern Midwest more so than in the southern area of the region (Kunkel et al. 2013c).

Snowfall in this region is variable; however, in spring, water from the melting snowpack has the potential to combine with heavy rain events which can cause widespread and catastrophic flooding (Peterson et al. 2013). Historically, lake-effect snowfall has increased (Kristovich 2009); however fewer years with high snowfall have been occurring (Kunkel et al. 2009). Projections and impacts of snowfall may be difficult; however the impact of combined climate-related hazards, like snowmelt and heavy rainfall, can be significant.

4.2.4 Great Plains Region

The Great Plains is an ever-changing and diverse region with dynamic weather. In this region, temperatures can range from -70°F in Montana to 121°F in North Dakota and Kansas (National Climatic Data Center [NCDC] 2012). Climate-related hazards of concern include rising temperatures, heavy precipitation events, winter storms, droughts, floods, sea level rise, and storm surge from extreme weather events.

Currently, there is an average of seven days per year when the maximum temperatures reach more than 100°F in the southern Plains and about 95°F in the northern Plains (Kunkel et al. 2013d). Even under a scenario of substantially reduced emissions, "...days over 100°F are projected to double in the north and quadruple in the south by mid-century" (Kunkel et al. 2013d). North Dakota leads the continental U.S. with the fastest increase in annual temperatures over the last 130 years (Kunkel et al. 2013d).

While summer and fall precipitation is expected to remain stable, winter and spring precipitation in the northern Great Plains is projected to increase (Melillo et al. 2014). Heavy rain and snow events, as well as more frequent and intense droughts are expected to be more common with the overall trend of a drier south and wetter north by 2070 (Melillo et al. 2014). Droughts may become more common in the central and southern areas of the Great Plains due to decreased precipitation. More days are projected to have heavy precipitation, especially in the northern Great Plains, whereas Texas and Oklahoma are projected to see longer dry spells (Melillo et al. 2014). Heavy rains lead to increased flooding, runoff, stormwater, erosion, and reduced water quality, as well as the potential of spring meltwater from snowpack to cause devastating floods, such as those common around the Red River (Melillo et al. 2014).

Sea level rise is a concern to the south, along the Gulf coast of Texas. Tropical storms or hurricanes bring storm surge events and increased sea levels would exacerbate the potential for flooding. Again, the number and intensity of Category 4 and 5 hurricanes in the Atlantic basin, including the Gulf of Mexico, have increased. Currently, the Texas coast sees three tropical storms or hurricanes every four years (Roth 2010).

4.2.5 Southwest Region

From the High Sierras to Death Valley in the Mojave Desert, the Southwest includes the driest and hottest areas of the U.S. This region is subject to climate-related hazards including increasing temperatures, more heat waves, decreasing precipitation, more droughts, more frequent flooding, wildfires, and rising sea levels.

Temperatures in the Southwest have been higher from 2001 to 2010 than in the previous century (Hoerling et al. 2013). Annual average temperatures are projected to rise by 2.5°F to 5.5°F by 2041 to 2070 and by 3.5°F to 9.5°F by 2070 to 2099, depending on the scenario (Kunkel et al. 2013e). Extensive heat waves in the Southwest are already occurring, such as the 2006 California heat wave that lasted ten days (Ostro et al. 2009). Heat waves are expected to increase in frequency, intensity, and duration, and become more humid (Melillo et al. 2014).

From 1991 to 2012, average annual precipitation has decreased in most of Arizona and southeastern California, and increased in other areas of California and parts of northwestern Nevada and Utah (Peterson et al. 2013). Southwest precipitation projections are variable. Winter and spring precipitation will likely be reduced by 2100 in the southern areas of the region (Melillo et al. 2014).

Droughts in the Southwest are projected to increase in frequency, intensity, and duration (Cayan et al. 2013). Warmer and drier conditions led to a 650 percent increase in burned area in western mid-level conifer forests between 1970 and 2003 (Westerling et al. 2006). Future wildfires are expected to be more frequent and larger due to increased warming and drought conditions, with a projection of twice the burned area in the Rockies and 74 percent more in California by 2100 (Westerling et al. 2011). Effects like bark beetle outbreaks causing trees to die, tree death from increased temperatures, policies to extinguish every fire leaving an over-accumulation of wood, and droughts make the Southwest more vulnerable to fire (Melillo et al. 2014).

Sea level rise is already occurring; California's coast has lost 6.7 to 7.9 inches in the last 100 years (National Research Council [NRC] 2012). The sea level is predicted to increase at an accelerating rate with a predicted 16 inch rise in the next 50 years (San Francisco Bay Conservation and Development Commission [SFBCDC] 2011). This rise will contribute to extreme high tides, larger storm surges from hurricanes, seawater inundation to freshwater aquifers, and coastal flooding. Inland river flooding is expected to occur in winter as a result of increased atmospheric moisture flowing over mountains.

4.2.6 Northwest Region

The Northwest is the region with the most glaciers and greatest glacial area in the contiguous U.S. (Portland State University [PSU] 2009). It also has widespread coniferous forests and the Great Basin Desert. As a result of climate change, the northwestern U.S. is predicted to be subject to warmer temperatures, drier summers, more wildfires, and rising sea levels.

In the Northwest, temperatures have increased 1.3°F from 1895 to 2011 and are predicted to increase by 3.3°F to 9.7°F by 2100, compared with the average between 1970 and 1999 (Kunkel et al. 2013f) (Melillo et al. 2014). Snowpack has decreased by 20 percent since 1950 (Mote 2006) (Pierce et al. 2008). Changes in annual precipitation are not certain, however, models agree that summer precipitation will decrease by ten to 30 percent (Melillo et al. 2014). Drier summers equate to less streamflow west of the Cascades (Bumbaco and Mote 2010) and more wildfires occurring with warmer temperatures (Littell et al. 2010). More days with greater rainfall are projected, with the number of days having more than one inch of precipitation increasing by 13 percent for 2041 to 2070, compared with 1971 to 2000 (Kunkel et al. 2013f).

Wildfire is a concern in northwestern coniferous forests. Since the 1970s, warmer and drier conditions have increased the scope and frequency of wildfires and future projections suggest the same trend (Melillo et al. 2014). Two million acres, four times as much as the 1916 to 2007 average, are estimated to be burned annually on average by the 2080s (Melillo et al. 2014).

Sea level rise is expected to occur along the Northwest coastline, but effects may not be seen before 2100 due to natural variations and tectonic uprising. El Niño conditions increase regional sea level by "4[four]-12 inches for periods of many months," (NRC 2012) (Zervas 2001). Streamflow changes are also uncertain.

4.2.7 Alaska

Alaska is warming faster than any other state in the U.S. and its glaciers are melting. Climate changes such as warmer temperatures, less sea ice, permafrost thawing, wildfires, and greater precipitation will pose continued threats to Alaska in future years.

Compared to other U.S. states, Alaska has warmed more than twice as much in the last 60 years (Steward et al. 2013). Annual temperatures have increased by 3°F and are projected to rise by 2°F to 4°F by 2050 and by 2100, increase by 10°F to 12°F in the north, 8°F to 10°F in the interior, and 6°F to 8°F in the rest of the state (Melillo et al. 2014).

Sea ice in the arctic has been reduced by about 50 percent since 1979 (Malowski et al. 2012) (Stroeve et al. 2012) and is predicted to approach a 100 percent reduction in the summers of the 2030s (Stroeve et al. 2007) (Wang and Overland 2009) (Wang and Overland 2012). Permafrost is present under 80 percent of Alaska's lands and is already thawing, with an increase of 4°F to 5°F at 65 foot depth by the arctic coast since the late 1970s (Osterkamp and Romanovsky 1999) (Romanovsky et al. 2012). Permafrost is projected to continue to thaw with near-surface permafrost melting entirely by 2100 (Jafarov et al. 2012).

Wildfires have increased in number, with more large fires over the last ten years than ever previously recorded (Kasischke 2010). Places in Alaska that had never seen extensive fires are starting to succumb to wildfires, such as the Alaskan tundra in 2007 (Hu et al. 2010) (Mack et al. 2011).

Annual precipitation is projected to increase by approximately 15 to 30 percent by 2100 (Melillo et al. 2014). Evaporation rates increase as temperatures rise, therefore, overall reductions in water availability are predicted (Hinzman 2005).

4.2.8 Hawaii and the U.S. Affiliated Pacific Islands

Hawaii and the U.S. Affiliated Pacific Islands consist of over 2,000 islands with remote archipelagos that are vulnerable to severe storms. These islands will be subject to growing temperatures, possible changes in precipitation, and rising sea levels.

In this region, annual temperatures have been increasing; in Hawaii and the central North Pacific, annual temperatures are projected to increase by 1.5°F to 3.5°F by 2055, from averages recorded between 1971 and 2000 (Christensen et al. 2007) (Meehl et al. 2007). Temperatures in the western North Pacific are expected to increase by 1.9°F to 2.6°F and those in the South Pacific are projected to increase by 1.9°F to 2.5°F, depending on the model scenario (Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation [CSIRO] 2011).

Historical precipitation trends are variable across this region. Hawaii has become progressively drier for nearly the last century (Melillo et al. 2014). In the western North Pacific, the eastern islands experienced a 15 percent decrease in precipitation, whereas the western islands saw a slight increase (Ganachaud 2011). Future projections are not very confident; however predictions range from up to a five percent increase for Hawaii, to a ten percent decrease in the Northwestern Hawaiian Islands by 2100 (Melillo et al. 2014). Hawaii's wet season is projected to decrease by five to ten percent, increasing the dry season by five percent by 2100 (Timm and Diaz 2009).

Due to the vast quantity of coastline, this region is especially vulnerable to sea level rise. The sea level has risen nearly eight inches since 1900 (Church and White 2011) and is projected to rise an additional eight inches by 2100, consistent with global predictions (Melillo et al. 2014). Regional variations may cause regional sea levels to rise higher than the global average, such as during high tides, El Niño Southern Oscillation (ENSO) events, storms, and other ocean circulation changes.

5 Climate-Related Hazard Impacts

Climate-related hazards may increase in both frequency and intensity, adversely impacting nonmilitary Federal facilities, personnel, missions and programs. Climate-related hazards, including sea level rise, increased temperatures, more frequent heat waves, more intense droughts, increased number and intensity of hurricanes, severe storms, greater precipitation, and more wildfires, all have the potential to threaten the security of personnel, facilities, and infrastructure.

Historically, Federal facilities have been affected significantly by climate-related hazards. Hurricane Katrina caused significant infrastructure damage to 83 Federal facilities in Louisiana, Mississippi, and Alabama, requiring \$38 million in repairs. Nearly 2,600 Federal employees from 26 agencies were displaced. A year after Katrina made landfall, five Federal buildings had still not reopened (Smith 2006).

Events like hurricanes, winter storms, and wildfires and other climate-related events threaten critical infrastructure, including power, water, communications, and transportation. All functions of

infrastructure have some degree of dependency on electricity, and therefore power restoration is a “top priority” following disasters (DHS 2014).

Climate change may magnify impacts of events beyond their primary effects. This co-occurrence can also be referred to as the “cascading effects” of climate-related hazards. For example, extreme heat and diminished precipitation interact to stress electricity production and distribution more than these hazards would alone; heavy precipitation and warmer water temperatures interact to reduce fresh water supply; and sea-level rise and storm surge interact to increase coastal flooding. Consequently, it is beneficial to consider threats and impacts in an integrated way.

5.1 Primary Effects of Climate-Related Hazards on Critical Infrastructure

Climate-related hazards pose a direct risk to infrastructure, facilities, and personnel. This subsection addresses hazards directly affecting the security of infrastructure.

Sea level rise poses a major threat to coastal infrastructure, including roads, airports, port facilities, rail lines, and energy infrastructure. These systems can be inundated with saline water which corrodes electrical equipment and pipes, can flood and become water damaged, or may have foundations eroded by invading coastal waves. Offshore oil and natural gas platforms, vital to providing energy fuel generation, are also at risk of damage from rising sea levels. Sea level rise increases the frequency and area of the current 100-year coastal flood zone,² furthering the flood threat to coastal infrastructure. Flooding destroys transportation infrastructure, inhibits operations, disrupts power delivery to vital security systems, and puts personnel at risk. While sea level rise causes immediate flooding concerns, it can be exacerbated by a number of combined hazards.

In every U.S. region, temperatures are predicted to increase. This temperature increase, along with increases in heatwaves, can lead to equipment overheating and reduced functionality. Increased temperatures demand equipment cooling, decrease efficiency of power generation, and reduce generation capacity on hotter days. Transmission losses could also occur and/or increase with temperatures, with the potential to cause brownouts or blackouts during heat waves. Increasing air and water temperatures reduces the efficiency of thermoelectric power generation and transmission, regardless of fuel source, and could reduce available generation capacity in summer by 4.4 to 16 percent by 2060, compared to late in the 20th century (Zamuda et al. 2013). The optimal temperature for power plants to operate becomes significantly less than the ambient air temperature, causing difficulties exacerbated by combining stresses. Cooling water temperatures are also affected. For example, a unit at American Electric Power’s D.C. Cook Nuclear Plant shut down due to increased temperatures, as the containment building temperature reached over 120°F and the cooling water temperature was too hot to utilize (Zamuda et al. 2013). Other combining stresses will be detailed later, as in the case of brownouts and blackouts. These stresses also create security risks as power is a vital component in security systems. Hotter temperatures and heatwaves also are a potential health risk to essential personnel.

Droughts can result in lower water levels in municipal and private supplies. Droughts pose a threat to water supplies needed for infrastructure operation, such as equipment cooling for energy generation and can lower river water levels enough to inhibit water transport. Lower water levels mean “lower vessel drafts on navigable rivers and associated lock and dam pools” (Melillo et al. 2014). This may be enough to block river passage for certain vessels carrying necessary cargo, such

² The area with a 1 percent or more chance of experiencing a coastal flood in a given year (Melillo et al. 2014).

as oil tankers. Cargo delivery may be impossible during droughts and can halt operations for some facilities.

Hurricanes can directly destroy infrastructure through damage due to winds or flooding from heavy rainfall or storm surge. Storm surge alone results in greater potential flooding in addition to heavy precipitation associated with these severe storms. Almost all transportation systems are disrupted by flooding: subways, tunnels, roads, bridges, and railways. The National Oceanic and Atmospheric Administration (NOAA) reports that “72 percent of ports, 27 percent of major roads, and nine percent of rail lines within the Gulf Coast region are at or below 4 ft. elevation,” (NOAA 2014). North Atlantic hurricanes are a high risk to transportation infrastructure. High winds, 74 miles per hour or greater, prohibit airplane travel, as well as most transport operations. Offshore oil and natural gas platforms and delivery infrastructure are also vulnerable to hurricanes and ensuing damaging winds. Energy infrastructure can be damaged from high winds and flooding. Power lines can be damaged or destroyed, and energy substations can flood. Power to pump fuel and operate traffic lights can be interrupted, thus impeding road travel. Communication infrastructure may also be disrupted. The combination of these effects contributes to an overwhelming security risk to infrastructure, including Federal facilities.

In addition to precipitation during hurricanes, heavy precipitation can inhibit water quality and lead to riverine flooding, therefore impacting transportation infrastructure, especially rail lines that often follow riverbeds. Rail transportation lines deliver coal to power plants, which in 2011 produced 42 percent of U.S. electricity (Melillo et al. 2014). Flooding from intense precipitation can erode railroads and roadbeds, cause swift currents across roadways to form, and make travel difficult for vital personnel. Road damage and roads blocked by downed trees and other debris can inhibit operations and heighten security concerns.

Wildfires threaten water, transportation, communications, and power infrastructure. Direct harm to infrastructure through damaged transmission grids and other infrastructure facilities can occur. Smoke from burning wildfires can decrease visibility, resulting in road and airport closures, as well as heightening security risks. Wildfires clear trees and brush, exposing slopes to erosion and landslides (Melillo et al. 2014). Wildfires also threaten personnel safety and vital resource security.

5.2 Cascading Effects of Climate-Related Hazards on Critical Infrastructure

Climate impacts on critical infrastructure can magnify multiple hazards occurring together in a cascading fashion. These co-occurrences serve to amplify effects of a single climate change hazard and are major concerns to infrastructure. Cascading effects include those that threaten water quality and supplies, interrupt the electric supply, affect the capacity of the electric supply, and cause wildfire damage. Each effect stems from primary hazards previously discussed, however those hazards interact together to form adverse conditions and magnify security risk. Cascading climate-related hazards result in thawing permafrost, coastal flooding and erosion, power brownouts and blackouts, decreased water availability and quality, inland and riverine flooding, and increased wildfires.

Hurricane Sandy demonstrated how hazards impact the functionality of critical infrastructure due to the cascading effects from the loss of lifeline systems such as power and water. Below are some examples of those cascading effects:

- Transportation – Operations at the Port of New York/New Jersey were impacted by the loss of power and debris. Many of the in tunnels and rail systems in New York and New Jersey were closed for an extended period of time due to flooding and water damage.
- Healthcare and Public Health – Some hospitals lost primary and backup power and had to evacuate patients and ultimately close for an extended period of time.
- Energy – Localized fuel shortages were caused by a combination of power outages and damage to the truck racks at fuel terminals. These disruptions were exacerbated by road closures and personnel shortages. Many service stations ran out of fuel and shortages led to rationing by local jurisdictions.
- Water / Wastewater – Many water and wastewater treatment systems were impacted due to the loss of power at pumping stations and extensive flooding at many wastewater treatment plants. This led to the loss of potable water in many jurisdictions.

Permafrost is thawing as a result of rising temperatures, fewer freezing events, longer summers, and warmer winters. The culmination of these climatic events results in thawing land that has been frozen for thousands of years. As permafrost thaws, methane, a potent greenhouse gas, is released. Permafrost thawing also results in land subsidence, as ice has a greater volume than water. As the frozen ground thaws, land subsides and can result in a loss of foundation structural integrity of buildings, uneven roadways, damage to railways and airports, and damage to power lines. Uneven ground sinking also “will likely disrupt community water supplies and sewage systems” (Alessa et al. 2008) (Jones et al. 2009) (White et al. 2007). These disturbances to transportation, power, and water infrastructure systems can have adverse effects elsewhere and result in security threats.

Coastal flooding and erosion can result from permafrost thawing, sea level rise, intense precipitation, extreme storm surge, and reduced sea ice. As permafrost thaws, the once solid, frozen coastal bluffs become weaker and more vulnerable to erosion from battering waves. Erosion by sea level rise is aggravated by high tides and approaching storms. Storms lead to more coastal erosion from larger waves as coasts are more exposed due to reductions in sea ice. Higher sea levels will cause longer high tide periods, increased erosion, and flooding potential. Coastal flooding and the resulting wave-driven erosion can wash away land under roads, railways, and power lines. In areas without permafrost, coastal flooding and erosion can be intensified by the combination of high tides, sea level rise, intense precipitation and storm surge from severe storms and hurricanes. Storm surge from these storms and hurricanes can raise local sea levels and has the potential to exacerbate high tides.

Projections on local sea level rise are provided by the National Oceanic Service (NOS 2013). Flooding and erosion pose a risk to harbor operations, low-lying airports, and coastal structures including energy facilities, refineries, pipelines, and transmission and distribution networks (Department of Energy [DOE] 2013). Roads, ports, cities, railways, airports, oil and gas facilities, and water supplies situated at low elevations are vulnerable to the impacts of sea level rise. Coastal cities are particularly at risk.

Power interruptions and outages, including brownouts and blackouts, are liabilities to power infrastructure. “Vulnerability is further increased as key infrastructure, including electricity for... air conditioning, is more likely to fail precisely when it is most needed- when demand exceeds supply,” (Melillo et al. 2014). Demand for more cooling increases with higher temperatures, higher humidity, longer summers, and more frequent heat waves. These conditions, and the potential decreased efficiency in energy transmission, capacity, and generation, may add excessive stress on power infrastructure (Melillo et al. 2014). Higher temperatures and more heat waves contribute to these stressors and can result in power brownouts and blackouts. Since higher temperatures are predicted in every region across the U.S., these stressors may occur across the Nation. As

temperatures rise, power plants have increased cooling needs. Electricity is required to obtain, purify, and pump cooling water (Melillo et al. 2014), further stressing the power network and water resources. If the supply of water is not sufficient to cool the power plant, then brownouts and blackouts may occur (DOE 2013).

Water infrastructure and supplies, including those used by power infrastructure, will also be stressed by climate change effects. Water quality is degraded by increased stormwater from urbanization, flooding from increased rainfall and extreme storms, and flooding from melting snowpack. Increased stormwater can affect the capacity of treatment plants, enables the potential for additional untreated water entering water reservoirs and degrading water quality. “The U.S. Environmental Protection Agency (EPA) estimates there are more than 800 billion gallons of untreated combined sewage released into the nation’s waters annually” (McLellan et al. 2007).

Increased demand, sea level rise, droughts, higher temperatures, decreased rainfall, and wildfires all contribute to a decrease in available freshwater supplies. Supply and demand of water varies with climate, land use, and population (PRCCC 2013) (Ingram 2013). Increased water demand and use decreases supply, rising seawater results in saltwater intrusion into freshwater supplies, and decreased rainfall decreases the recharge rate of supplies (Melillo et al. 2014). Higher temperatures mean not only increased evaporation, but increased usage of water, such as for crop irrigation, consumer use, electricity generation, or even in response to wildfires. Droughts also contribute to a lower volume of water in rivers which means less electricity generated by hydropower systems (DOE 2013), further stressing power infrastructure. Wildfires also increase with many of these same conditions. Each condition amplifies the effect on critical water supply availability.

Inland and riverine flooding occurs as a result of intense and increased precipitation events, sea level rise, changes in snowmelt, and rising temperatures. Increased inland flooding can occur during intense precipitation events as stormwater drainage systems are overwhelmed and unable to empty into the ocean due to sea level changes (Bloetscher et al. 2011). Drainage problems are currently occurring during high tides, intense precipitation events, and during storm surges (Melillo et al. 2014). Riverine flooding may increase with more frequent and intense precipitation events across a river basin or a combination of snowpack melt with intense rainfall events. Snowpack melting increases with growing temperatures, furthering the riverine flooding risk. Resulting flooding has the potential to interrupt power supplies, disrupt building operations, and inhibit transport.

Wildfires are exacerbated by increased droughts, insect outbreaks, tree diseases, seasonal dry periods, problems with fire suppression tactics, rising temperatures, warmer winters, and increases in pollutants (Melillo et al. 2014). All of these elements increase tree death rates and contribute to available woody fuels to feed fires, and can occur simultaneously. Insects, increased pollutants, and diseases kill trees and fire suppression tactics hinder natural burning processes that allow an over-accumulation of woody fuels (Melillo et al. 2014). More trees die as insect outbreaks spread (Raffa et al. 2008) and droughts are more prevalent (Van Mantgem et al. 2009) (Breshears et al. 2005). Water stress also plays a huge role as wildfires are more common due to increased tree death caused by droughts and increased temperatures. Wildfires are a threat to infrastructure, as the total burn area in the continental U.S. has almost doubled since 2000, compared to averages from 1960 to 1999 (Melillo et al. 2014). In California, exposure of some power lines to wildfires is projected to increase by 40 percent by 2100 (California Energy Commission [CEC] 2012). Wildfires contribute to a number of security risks and can result in interruptions or complete destruction of infrastructure.

5.3 Impacts on Lifeline Functions and Interdependencies

As noted in the National Infrastructure Protection Plan (NIPP) report on strengthening regional resilience: Effective risk management requires an understanding of criticality as well as the associated interdependencies of infrastructure (NIPP 2013). The NIPP identifies certain lifeline functions that are essential to the operation of most critical infrastructure sectors. These lifeline functions include communications, energy, transportation, and water (NIPP 2013). Federal agencies should identify essential functions and resources that impact Federal facilities throughout the regions. The identification of these lifeline functions can support preparedness planning and capability development (NIPP 2013). Depending on the region, event, or stakeholder, other functions may also be considered critical lifelines (NIAC 2013). Climate-related hazards have the potential to weaken infrastructure and exploit vulnerabilities in ways that may be difficult to foresee. Moreover, due to the interconnected nature of all sixteen critical infrastructure sectors, there are likely to be cascading effects on all sectors as a result of the disruption or destruction of one or more lifeline function (NCA 2014).

It has become clear that “stronger sector interdependencies may trigger cascading events that interrupt critical services, impede emergency response, and threaten public safety in unexpected ways” (NIAC 2013). Dependent and interdependent operations among critical sectors were highlighted by recent disasters, such as Hurricane Sandy. It is expected that growing interdependencies will be further exacerbated by stronger and more frequent weather events. As discussed previously in this document, Federal facilities were not left untouched by catastrophic weather events. Not only have Federal operations been disrupted due to the direct effects of these incidents, Federal facilities and their occupants are heavily dependent on lifeline functions.

5.3.1 Energy Functions

The energy functions provide a good example of the interconnection between and within infrastructure systems. For instance, almost 90 percent of electrical energy in the U.S. is produced by thermo-electric power plants, which require the use of water for cooling processes (NCA 2014). The U.S. Geological Survey (USGS) reports that thermo-electric power constitutes 40 percent of all freshwater withdrawals (Zamuda et al. 2014). The capacity to support thermal plant cooling has already been diminished in certain areas affected by climate change whereby increasing temperatures have contributed to a decreased supply in surface water. For example, higher water temperatures in the southern U.S. affect the efficiency of electric generation and cooling processes (NCA 2014). Dominion Resources’ Millstone Nuclear Power Station in Connecticut shut down one reactor for two weeks in August 2012 because the temperature of the intake cooling water, withdrawn from the Long Island Sound, was too high for the reactor (Zamuda et al. 2013). Higher stream temperatures and longer “low flow” periods due to anticipated climate changes may cause water withdrawals to be unreliable for electric power plant cooling (NCA 2014). Approximately 25 percent (250,000 MW) of electricity in the U.S. is generated in counties projected to be at high or moderate water supply sustainability risk in 2030 (Zamuda et al. 2014).

Higher temperatures can result in reduced carrying capacity and decreased transmission efficiency in electricity lines. Increased demand for electricity for cooling is expected in every U.S. region as a result of higher average temperatures and extraordinary temperature extremes. Rising electricity demand, paired with reduced water availability for power plant cooling may lead to black outs and brown outs (NCA 2014). In 2011, consecutive days of triple-digit heat and record drought in Texas resulted in the Electric Reliability Council of Texas declaring power emergencies due to a large number of unplanned power plant outages (Zamuda et al. 2013). Disruptions in energy services will lead to disruptions in other infrastructure sectors that depend on affected systems (NCA 2014). In addition, many components of U.S. energy supplies such as coal, oil, and electricity must move

from one region of the country to another. Consequently, extreme climate events affecting energy infrastructure in one area can lead to supply concerns elsewhere (NCA 2014; Zamuda et al. 2013). Case in point, in 2011 an 11-minute power system disruption compounded into outages leaving 1.5 million San Diego residents without power for 12 hours. This lengthy outage disrupted pumps and water service, culminating in a sewage leak near surrounding beaches totaling 1.9 million gallons of untreated wastewater (NCA 2014).

5.3.2 Transportation Functions

As discussed in the 2014 National Climate Assessment, there are four critical impacts of climate change on the transportation sector: 1. Sector reliability and capacity are diminished; 2. Coastal areas are at risk of temporary and permanent flooding of infrastructure; 3. Transportation is disrupted by extreme weather events which are only likely to increase over time; and 4. The total costs of climate change to transportation systems and users continue to increase but could be reduced through climate change adaptation measures (NCA 2014).

For example, during Hurricane Sandy the cascading effects of electricity restoration delays were evident when the transportation sector experienced significant flooding due to a lack of backup generator power to pumping mechanisms (NIAC 2013). Owners and operators had initially believed the backup generators could produce sufficient power to meet their pumping needs. However, as power restoration was not completed quickly, smaller power generation capacity and unanticipated fuel supply shortages resulted in insufficient power to deal with flooding from the storm therefore disrupting and damaging portions of the transportation sector. Another example of climate impacts is that of extreme or severe temperatures on transportation infrastructure. Expansion joints found in bridges and highways are put under more stress than for which they were originally designed, rail tracks are strained and buckling could increase, and aircraft performance and airport lift-off procedures will require more limits (NCA 2014).

Climate change mitigation and adaptation strategies could improve the resilience of the transportation sector. Effective land-use planning could reduce the risks to infrastructure and costs of disruption and damage "...by avoiding new development in flood-prone areas, conserving open space to enhance drainage, and relocating or abandoning structures or roads that have experienced repeated flooding" (NCA 2014). Some state and local governments have produced vulnerability assessments to determine the likelihood and severity of impacts to transportation assets (NCA 2014). Understanding risks and vulnerabilities allows for proper mitigation and adaptation. For instance, after conducting assessments, New York City opted to elevate rail ventilation grates to decrease the risk of flooding (NCA 2014). The National Climate Assessment also suggests effective asset management and regular maintenance of infrastructure to increase resilience to climate change.

5.3.3 Communications Functions

Like the other functions, communications is vulnerable to the effects of climate change and reveals the interconnectedness and interdependencies of all sectors, but particularly the lifeline functions. The derecho thunderstorm system that moved across the United States in June 2012 demonstrated extreme weather impacts on communications systems. More than 150 utility poles and 900 fiber cables were downed by winds reaching 91 mph in places. Cell phone towers also experienced disruptions and backup generator failures made four 911 call center locations inoperable for three days in northern Virginia. Utility companies realized the need to evaluate infrastructure vulnerabilities and the effectiveness of internal programs and procedures to increase system reliability during climate-related events (NIAC 2013). The 2013 NIAC report also suggests co-locating key officials from lifeline functions and public agencies in emergency operations centers

during climate incidents. During Hurricane Sandy this proved to be a valuable way to better coordinate repairs and accelerate restoration of services, particularly in the energy and communications functions (NIAC 2013).

5.3.4 Water/Wastewater Functions

Over time, climate change will test the nation's water and wastewater sector infrastructure. For instance, floodwaters can overrun wastewater treatment plants, as seen during Hurricane Irene in 2012. Seventeen municipal wastewater treatment plants in Vermont were breached by floodwaters resulting in hazardous waste release. The cost to clean up the hazardous materials across the state was estimated at \$1.75 million (NCA 2014). Moreover, as a result of such heavy rain events, the incidence of waterborne disease increases (NCA 2014). Additionally, aging drainage infrastructure which is sometimes insufficient during heavy storms will likely be worsened as climate change impacts become more evident. As mentioned previously, surface water supplies are decreasing as temperatures continue to rise due to the effects of climate change. This may exacerbate problems in areas with limited water supply and necessitate extensive planning measures to ensure continued provisions (NCA 2014). The National Climate Assessment recommends both structural (i.e., infrastructure upgrades, renovations, etc.) and non-structural (i.e., procedural changes, policy implementation, capacity-building initiatives, etc.) adaptation approaches to climate change for water infrastructure. Incorporating climate change as a factor could improve infrastructure planning particularly through "...new design standards and in asset management and rehabilitation of critical and aging facilities, emphasizing flexibility, redundancy, and resiliency" (NCA 2014).

5.4 Facilities

Facilities are vulnerable to wildfires, flooding and storm surge, and other effects of climate change which can be a major impact to facilities. Wildfires can propagate by consuming available fuel, including vegetation and combustible materials. In an approaching wildfire, facility components that are combustible can be ignited by embers, firebrands, flames, radiant energy, and convective energy. Burning embers and firebrands, carried on air currents, can travel significant distances in advance of a wildfire and land on a facility, igniting exterior materials, or enter the facility through an opening, igniting interior materials. Radiant energy from combustion of nearby materials and convective energy, in the form of hot gases can be sufficient to ignite facility components, even if the components are not on the exterior of the facility. Wildfires can also deform or melt facility components that do not initially ignite. In addition, wildfires frequently destroy power lines and create fluctuations, including power surges and power outages. Both destroyed power lines and fluctuations may damage building equipment (Federal Emergency Management Agency [FEMA] P-754).

The climate change impact of flooding has the potential to cause severe damage. However, some flood-prone buildings exposed to floodwaters that are not fast moving, or that may be relatively shallow, may not result in structural damage. Simple inundation and saturation of a building can result in significant and costly nonstructural damage, including long-term health complications associated with mold (FEMA P-754). Furnaces, air handlers, and ductwork that have been submerged and are not thoroughly cleaned can circulate mold and accumulated sediment throughout the facility, causing respiratory problems (FEMA P-424). Floodwaters are often contaminated with chemicals, petroleum products, or sewage. Under such circumstances, recovery generally involves removal of nonstructural materials and finishes. Even when buildings are not subject to water damage per se, floods can produce large quantities of debris and sediment that can damage a site and be expensive to remove (FEMA P-543).

Heavy downpours are currently an issue nationally, and have been over the last three to five decades, with the largest increases occurring in the Midwest and Northeast. Increases in extreme precipitation are projected for all U.S. regions. Nearly five million people in the U.S. live within four feet of the local high-tide level (also known as mean higher high water). In the next several decades, storm surges and high tides could combine with sea level rise and land subsidence to further increase flooding in many of these regions (NCA 2014).

Telecommunications and data centers are key utilities that facilitate the functioning and connectivity of the Nation's economy. Disruptions in the ability to communicate or access information severely inhibit governments, companies, and citizens, and in periods of disaster or extreme events, this inability to communicate puts national and human security and business value at risk. A data center serving 128 New Orleans public schools was located on the fourth floor of an administrative building when Hurricane Katrina landed in 2005. The hurricane blew the air conditioning system off the roof, allowing rain ingress. When power was restored, there was no air-conditioning, and the rainwater and heat corroded contacts on switches. Other gear overheated and failed. Repairs to the data center cost in excess of \$3 million and took several months. Some key factors to consider are:

- Plan for both a changing climate baseline and for climate extremes. Successfully addressing climate risk requires careful attention to subtle impacts (e.g., the cumulative impact of sequences of warmer than average days on wired telecommunications) as well as to the effects of extreme storms.
- Build awareness of climate risks before disasters strike. Working with stakeholders to build consensus and collect the information each offers is to effectively build resilience.³

The intensity, frequency, and duration of North Atlantic hurricanes, as well as the frequency of the strongest (Category 4 and 5) hurricanes, have all increased since the early 1980s. Hurricane intensity and rainfall are projected to increase as the climate continues to warm. Hurricanes can cause both flood and high wind damage. Facilities damaged by high winds often suffer damage to multiple components – roof covering, wall panels, and rooftop equipment can be blown away. Roof covering damage is the most common type of wind damage (FEMA P-424). Exterior glazing (window) damage is also very common. Exterior wall covering, soffit, and large door damage is common during hurricanes. Structural damage (e.g., roof deck blow-off, blow-off or collapse of the roof structure, collapse of exterior bearing walls, or collapse of the entire building or major portions thereof) occasionally occurs during hurricanes.

5.5 Human Health

The 2014 NCA found that “Climate change threatens human health and well-being in many ways, including impacts from increased extreme weather events, wildfire, decreased air quality, and illnesses transmitted by food, water, and diseases carriers such as mosquitoes and ticks.” As a result of these impacts, several secondary human health effects of climate-related hazards include greater incidence of respiratory and cardiovascular disease, injuries and premature deaths resulting from extreme weather events, changes in the occurrence and geographical dispersal of foodborne or waterborne illnesses and other infectious diseases, and dangers to mental health or emotional security (Melillo et al. 2014).

³ Climate Risks Study for Telecommunications and Data Center Services

The negative effects of heat on human cardiovascular, cerebral, and respiratory systems are well established. Higher temperatures and greenhouse gases contribute to the formation of harmful air pollutants. Many health threats may result from heat rising: heat-related deaths and illnesses due to heat waves and higher temperatures, degraded drinking water supply quality due to algal blooms, interrupted cooling power supply due to blackouts or brownouts, increases in allergies due to increased pollen from longer summers, and degraded air quality, possible migration, and death due to wildfires (Melillo et al. 2014).

These public health impacts may increase the occupational hazards for security personnel and create new threats for health providers and facilities. Security personnel and other employees working outside may be at a greater risk to heat stressors and exhaustion, respiratory disease, and injuries related to extreme weather events. During extreme heat events, employees working outside may need to work shorter shifts, participate in work/rest cycles, or be provided with additional protections. The Occupational Safety and Health Administration (OSHA) produced a heat index guide to assist employers with ensuring workers are protected from heat-related hazards.⁴ The guide suggests “more frequent breaks, adequate water supplies, physical monitoring, and acclimatization” to avoid heat-related illnesses (OSHA 2015).

Many U.S. regions are projected to see increases in temperature and/or heat wave occurrences. The increased heat can be exacerbated by effects such as the urban heat island effect, in which temperatures tend to be higher in cities compared to surrounding areas, even at night. Increased heat combines with other effects to increase ozone levels near the ground, forming smog. This degrades the air quality and “the combination of heat stress and poor air quality posts a major health risk to personnel,” (Melillo et al. 2014). The Midwest has seen increases in major heat waves and over 20 million people in this region experience air that fails to meet national ambient air quality standards (Pryor and Barthelmie 2013). In the Southwest, heat stress is the leading weather-related cause of death since 1986 (National Weather Service [NWS] 2012), with the highest rates in Arizona (Brown et al. 2013). On the Gulf Coast, waterborne diseases are a threat as well as bacterial infection from shellfish ingestion due to algal blooms (Martinez-Urtaza et al 2010). The Southwest is projected to see increases in wildfires, putting personnel at risk to health effects from smoke inhalation, burns from fires, and death.

Climate change also poses risks to medical facilities. Climate-related hazards may not only physically damage medical facilities, but may also increase their patient workload. To address the risk to health facilities, the recently-published *Primary Protection: Enhancing Health Care Resilience for a Changing Climate*⁵ provides case studies and best practices by health systems leaders to enhance health facility resilience in the face of climate change impacts.

5.6 Occupational Health

A number of worker populations, both indoors and outdoors, may be particularly vulnerable to threats from climate change, including emergency responders, security personnel, health care workers, fire fighters, utility workers, transportation workers, and others. Climate change impacts can exacerbate existing health and safety conditions, and new unanticipated hazards may emerge. Workers may be exposed to climate-related conditions that the general public can elect to avoid, and health impacts may present in workers whose jobs are most affected by climate change impacts, including wild land firefighters and others. For worker populations such as utility personnel, transportation workers, National Guardsmen who are called up to assist in times of need, and those

⁴ The OSHA Heat Index is available at: https://www.osha.gov/SLTC/heatillness/heat_index/index.html.

⁵This guide can be found at: <http://toolkit.climate.gov/image/662>.

who live in inadequate environmental conditions or have other social and economic constraints, the health effects of climate change may be additive from exposures both at work and at home.

Impacts to workers can include the direct effects of climate change-associated occupational hazards such as increased ambient temperatures and extreme weather events. Additionally, indirect climate change associated occupational hazards are likely to occur from vector-borne diseases, air pollution, and mold buildup from building flooding. The OSHA Heat Index is a simple tool and a useful guide for employers making decisions about protecting workers in hot weather. It does not account for certain conditions that contribute additional risk, such as physical exertion. Workers need to measure intake of liquids, as staying hydrated is vital in hot work conditions. Heat-related considerations include worker acclimatization, emergency planning and response, training to recognize heat-illnesses, and supplies like rest areas and ensuring adequate water (OSHA 2015). This makes it particularly important to reduce work rates, reschedule work, or enforce work/rest schedules.

5.7 Land Use and Land Cover Change

Federal facility landscaping, national parks and other Federal land will be impacted by climate change. Landscape destruction may have adverse effects on stormwater and flood-prevention infrastructure. Fast-moving floodwaters and waves also can uproot plants and trees. Site improvements such as swales and stormwater basins may be eroded, filled with sediments, or clogged by debris (FEMA P-543). The Department of Interior (DOI), United States Department of Agriculture (USDA) Forest Service, and National Park Service are addressing climate change through multiple programs to help land managers respond to these impacts. The Climate Resilience Toolkit is a resource that shows Climate Science Centers' (CSC), Regional Integrated Sciences and Assessments' (RISA), and the Landscape Conservation Cooperative's (LCC) regions via map form. Below are some programs that are available:

- DOI has formed a Climate Change Response Council that will coordinate the agencies response to the impacts of climate change within and among our bureaus. It will also work to improve the sharing and communication of climate- change impact science. [DOI has also established Regional CSCs](#). Serving Alaska, the Northeast, the Southeast, the Southwest, the Midwest, the West, Northwest, and Pacific regions, these centers will synthesize existing climate change impact data and management strategies, help resource managers put them into action on the ground, and engage the public through education initiatives. Within these eight regions, LCC will engage Interior and other and Federal agencies, local and state partners, and the public to craft practical, landscape-level strategies for managing climate change impacts on natural landscapes⁶.
- NOAA's RISA program supports research teams that help expand and build the nation's capacity to prepare for and adapt to climate variability and change. Central to the RISA approach are commitments to process, partnership, and trust building. RISA teams work with public and private user communities to:
 - advance understanding of context and risk;
 - support knowledge to action networks;
 - innovate services, products and tools to enhance the use of science in decision making; and

⁶ More information is available at <http://www.doi.gov/whatwedo/climate/index.cfm>.

- advance science policy⁷.

5.7.1 Protected National Areas

Protected national areas include national parks, national wildlife refuges, Federal wilderness areas, national recreation areas, national monuments and other specially designated Federal lands and waters. Protected national areas will experience climate impacts consistent with impacts to other lands and waters described the previous sections. Protected national areas, which are managed primarily by DOI agencies, the USDA Forest Service and NOAA, are served by the same types of climate change programs described in the previous section.

The following describe a few special considerations for national protected areas:

- Visitor Safety and Health
 - Extreme weather events and other impacts of climate change will affect the visitor experience at many national protected areas. Some events, including flash floods, extreme temperatures and wildfires, could impact visitor safety and health.
- Habitat Impacts
 - Fish, wildlife and plant habitats are being impacted by climate change – a trend that is projected to increase this century. Impacts include shifting habitats, spread of invasive species and changes in habitat water availability. The National Fish, Wildlife, and Plants Climate Adaptation Strategy⁸ describes a national approach for addressing many habitat issues.
 - Sea-level rise caused by climate change is expected to have significant impacts on coastal national protected areas, which could cause major disruptions to visitor services, emergency services, and infrastructure such as roads, bridges, and buildings. Coastal storm systems will exacerbate sea-level rise impacts to national protected areas.

6 Preventive Measures

The mitigation of risk to Federal facilities from natural hazards and climate impacts is addressed in facility siting and construction through laws, zoning, building codes, and the North American Reliability Corporation's (NERC) Critical Infrastructure Protection (CIP) standards for electric infrastructure. Hazard avoidance, such as not building in a known flood plain, is the most effective way of mitigating hazard risks. Consequently, Federal facilities should take appropriate and deliberate steps to reduce climate risks and enhance resilience through climate adaptation planning. This section reviews preventive measures to increase the resilience of Federal facilities.

6.1 Emergency Preparedness Plans

As part of emergency preparedness planning, facility design professionals, facility managers, and building operations managers must consider the near-, mid-, and long-term impacts of climate change to facility and mission operations. Consideration must be given to adaptation and resilience

⁷More information is available at:

<http://cpo.noaa.gov/ClimatePrograms/ClimateandSocietalInteractions/RISAProgram/AboutRISA.aspx>

⁸More information is available at: <http://www.wildlifeadaptationstrategy.gov/Sea-level Rise>

planning, including impacts of stormwater and potential flooding, heat, wind, facility siting, transportation access, and other planning factors. Structural impacts (including roofs, walls, access ways, etc.) and non-structural systems (including utilities, electro-mechanical systems, communications, supply chain management, etc.) should be considered in preparedness plans. Impacts to natural infrastructure (forests, wetlands, floodplains, etc.) should be considered as they play a major role in protecting communities from the impacts of climate change and extreme weather events. Finally, organizational considerations (including supply chain, staff accommodation and protection, etc.) should be included in planning. Facility risk and vulnerability assessments must consider the direct and indirect impacts of climate change, adjusted for localized threats, as part of a robust preparedness plan. Refer to Section 7 for more information on vulnerability assessments and risk mitigation. Facilities should have emergency operations plans and checklists in place for response to disasters (FEMA P-765). As part of the planning process, facilities should perform a comprehensive vulnerability assessment including an evaluation that addresses the loss of utilities (electrical power, water, sewer, and communication) (FEMA P-765).

Additional information on conducting vulnerability assessments can be found in Federal Continuity Directive (FCD) 1 and FCD 2.

6.2 Physical Security Resources

Mitigating physical security loss during a climate-related hazard is crucial to minimize the impact on physical security elements. Loss of a camera system or guard house can degrade security at a Federal facility and may even prevent it from re-opening in a timely manner after a natural disaster.

Steps can be taken to lessen the chances of a physical security loss delaying re-opening of a facility. The most important part in this process is pre-incident planning. Building managers, engineers and physical security specialists should complete a walkthrough of their facility and look for vulnerabilities - not only from an adversarial aspect - but from a disaster point-of-view. Refer to Section 7 for more information on vulnerability assessments and risk mitigation.

In response to the potential effects of climate change, Federal buildings should have redundant systems to the greatest extent possible. For instance, camera systems should have overlapping coverage, Digital Video Recorder (DVR) systems with extra capability, doors with electronic access and key access, etc. This can be expensive, but increases the odds of security systems being functional post-disaster.

Nearly every agency has guidance on developing plans for disasters. DHS Management Directive Volume 9000 “Emergency Preparedness and Response” and FEMA’s “Plan and Prepare” website are two excellent resources for disaster planning before, during and after the event.

6.3 Continuity Plan & Emergency Operations Plan

Continuity of Operations (COOP) is defined as an effort within individual organizations to ensure they can continue to perform essential functions during a wide range of emergencies, including localized acts of nature, accidents, and technological or attack-related emergencies. A continuity plan is defined as a plan that details how an individual organization will ensure it can continue to perform its essential functions during a wide range of emergencies.⁹ Critical to developing a comprehensive continuity plan is the establishment of planning and procedural objectives and

⁹ Federal Continuity Directive 1- Federal Executive Branch National Continuity Program and Requirements, October 2012

requirements and use of metrics to ensure that an essential function continues during continuity operations, given the criticality and priority of the essential function.

The position planning guides (PPGs) and standard operating procedures (SOPs) should cover the processes and procedures needed to maintain the mission essential functions of an organization after it has experienced a disaster. However, the continuity plan must cover the four phases of continuity: preparedness, activation, operations, and reconstitution. The SOP should include a plan on how the organization will operate within the ten elements of continuity. The continuity plans should reference a risk assessment of the primary and alternate operating facility (COOP site). The climate-related hazards identified in this document should be considered in a risk assessment for the primary and alternate facilities. The alternate facility should be far enough from the primary facility that it is not affected by the same disaster. The mitigation measures followed for these types of natural hazards must provide an acceptable level of safety for the facility and the personnel.

For more detailed information, refer to Federal Continuity Directive 1, Federal Executive Branch National Continuity Program and Requirements, which provides Federally-mandated continuity requirements, guidance, and direction in developing continuity plans and programs.

6.4 Response Strategies

In addition to the direction and requirements found in FCD-1, the following recommendations are provided to address a climate-related natural disaster that could potentially shut down a building for an extended period of time, it is recommended that an emergency operations plan should provide checklists and/or guidance to ensure physical security is reestablished before occupation. The information within an emergency operations plan should take into account how to restore physical security and building operations. Specifically, it is recommended to include information on:

- Documents
- Entry Control
- Electronic Countermeasures
- Communications
- Recovery Security

Documents: A critical component for physical security is the documentation and securing of operational processes and procedures. Security officers at Federal facilities are given written orders that detail their duties and response to various situations. These orders also include special instructions, new threats to look for, people to identify, etc. The Protective Security Officer's (PSOs) written orders are cumulative and thus difficult to replace. In the face of an impending disaster, security officers should refer to standard operating processes and procedures, and ensure their safekeeping through all phases of the event.

The documents also include security designs, operating manuals, access codes, alarm codes, passwords, etc. Any documents that are required to reestablish the physical security of a building should be included and kept secure for reopening.

Entry Control: Does the system still work? There must be a mechanism for testing and repair as necessary. It is recommended that there should be multiple contractors listed in the continuity plan for rapid repair of damaged systems. Is the facility ready to employ key locks in case the electronic access system cannot be repaired in a timely manner? Minor issues should also be planned for and addressed in the continuity plan. Issues may include: checking the mirrors for vehicle security screening at security posts and verifying that entryway lighting is operational.

Electronic Countermeasures: The Intrusion Detection System (IDS) and Closed Circuit Television (CCTV) systems have to be tested to determine the extent of damage. During the testing, phone lines used solely for IDS should be included. The Uninterrupted Power Supply (UPS) and Uninterrupted Battery Source (UBS) must also be verified, as they are part of the IDS and CCTV systems. It will take time to properly check all aspects of electronic security, but the importance of a fully-functioning system is imperative.

Communications: It is recommended that agency emergency operations plan address all communications needs, such as: encryption, line monitoring, shared networks, wireless, cellular, mobile radio, loss of communication, call signs, brevity codes, and routine maintenance actions. All forms of communications should be checked to ensure proper operation.

Recovery Security: If a Federal facility is closed down for any length of time, the emergency operations plan provides an excellent resource for recovering security in the aftermath of a disaster. Does relocation of the security officer make sense? A flood at a building might force relocation to another site for a few weeks, but the other site might already have security officers. Emergency operations plans should address where the security officer will deploy, dependent on certain situations.

Federal facilities should prepare for having extra security on site during recovery operations. The extra security should have temporary orders with concise direction on how to handle breaches of security and protocols during system repairs and how testing is being accomplished.

Disaster recovery plans are more likely to be effective if agencies and building security managers implement pre-disaster physical security programs. Agencies should establish a balance between post- and pre-disaster planning. No matter how detailed the disaster recovery plan, those responsible for physical security must develop a comprehensive disaster prevention/mitigation plan to protect people and property

7 Climate Change Vulnerability Assessments and Risk Mitigation Options for Consideration

The mitigation of risk to Federal facilities from climate-related events and other natural hazards varies depending on the location, site, mission, and associated factors. Climate change impacts increase the vulnerability and risk to existing Federal facilities, missions, and personnel. Accordingly, sites should take appropriate steps to reduce and prepare for potential hazards. Given the expected service duration of facilities undergoing design and construction now, it is essential that designers, architects, and decision-makers consider the known and projected impacts of climate change as part of resilience planning. Regional and localized climate impacts specific to facility siting and projected operations will help inform building in resilience as part of an overarching mitigation strategy. For existing structures, strategies can be implemented to mitigate hazard impacts after a facility is located, designed, and constructed to lessen climate-related vulnerabilities.

This best practice guide can serve as baseline information to consider when developing a site specific vulnerability assessment. This section reviews processes for conducting a vulnerability assessment and provides examples of potential mitigation options to increase the resilience of Federal facilities.

7.1 Vulnerability Assessments

Performing a site vulnerability assessment is crucial to understanding the risks posed by climate change and a necessary first step toward enhancing resilience. The assessment acts as an enabling mechanism, empowering security professionals and facility managers to evaluate the degree to which their site's systems, infrastructure, and operations are susceptible to potentially damaging impacts of a changing climate. The goal of this section is to enable site security professionals and facility managers to conduct their own assessments that consider probabilities and consequences of impacts. To achieve this goal, this section provides a basic vulnerability assessment framework that sites can utilize to launch their vulnerability assessment process, as well as suggested breakdown of physical security risk sectors to consider. By evaluating each sector through the framework, sites will be able to identify and evaluate potential threats.

7.1.1 Factors of Security to Include in Climate Change Vulnerability Assessments

Climate change is a threat multiplier, thus every aspect of a site's physical security must be examined carefully during a vulnerability assessment. Prior to evaluating vulnerability, site systems, components, infrastructure, and operations that could potentially be impacted by climate change must be identified and categorized. This structure will provide an organized framework to ensure all facets of physical security are included in the site vulnerability assessment.

The categorical framework selected for use in this guidance is adapted from *The Risk Management Process for Federal Facilities: An Interagency Security Committee Standard*. This ISC standard was issued in August 2013 as guidance for risk evaluation protocols for Federal facilities. In Appendix B of the ISC Standard, the document outlines security measures in six distinct security criteria that must be used to develop a customized level of protection for the site. Brief descriptions of the security criteria are:

1. **Site:** Includes the site perimeter, site topography, climate history, access, exterior areas/assets, and parking;
2. **Structure:** Includes structural hardening, barriers(natural/man-made), facade, windows, and building systems;
3. **Facility Entrances:** Includes pedestrian entrances and exits, loading docks, as well as other openings to the building envelope;
4. **Interior:** Includes space planning and security of specific interior spaces;
5. **Security Systems:** Including IDS, access control, and CCTV systems;
6. **Security Operations and Administration:** This final sector includes planning, guard force operations, management, communication systems (analog/digital), and decision making, as well as mail handling/receiving.

While this categorization of security measures is advised, the ISC recognizes the need for sites to tailor vulnerability assessments to the characteristics and missions specific to the site, including the potential impacts of climate change. Regardless of the structure, it is imperative that every aspect of site security is included in the analysis.

7.1.2 Climate Change Vulnerability Assessment Framework

A vulnerability assessment is a process of identification, quantification, and prioritization of potential vulnerabilities to enhance risk management practices. For the purpose of this publication, an assessment can be further defined as a site self-evaluation method that produces a comprehensive understanding of the degree to which climate change stressors may impact infrastructure, operations, and the mission of a particular facility. The final product can then be used

as a guide in site planning efforts for mitigating threats while also enhancing resilience, adaptation, and preparedness. Climate change vulnerability assessments can incorporate a vast array of tools and resources, such as the use of advanced models, quantitative analyses, scientific literature, and qualitative evaluations. The types and complexity of analyses performed are left to the discretion of the site, though more comprehensive tools will yield more accurate results in terms of the final product.

Figure 2: Vulnerability Assessment Process (Glick et al. 2011)



A standard framework used by many Federal agencies for determining vulnerability is shown in Figure 2, and has been used by some of the vulnerability assessments listed in the references at the end of this section. The diagram shows a simplified three-phase process resulting in the identification of vulnerabilities. The definitions of the terms in Figure 2 are:

- *Exposure*: The change in future climate conditions to which the site will be subjected or exposed.
- *Sensitivity*: The degree to which key elements (site systems, infrastructure, or operations) can be impacted by relevant climate metrics (i.e. temperature, flooding, etc.). Sensitivity defines the relationship between some systems or components of interest and climate or weather variables.
- *Potential Impact*: The range of possible damaging consequences, including primary or second-order impacts.
- *Adaptive Capacity*: The capability of the site's systems, infrastructure, or operations to adapt to or be resilient in the face of changing climate threats. It is the extent to which the site can make adjustments to reduce deleterious impacts as possible.
- *Vulnerability*: The susceptibility of the site to climate-related hazards, ranked in a prioritized list.

The process shown in Figure 2 begins by determining the site's *Exposure* to climate-related hazards. The goal is for site personnel to be as informed about probable climate changes in their region as possible so that security management practices are built upon sufficiently accurate data. Exposure is determined by conducting research and performing modeling studies to determine the expected range of climate conditions that the site will likely be subjected to in the future. These conditions include measures such as changes in projected average temperature, number of days requiring use of Heating, Ventilation, and Air Conditioning (HVAC), expected precipitation, frequency of potentially damaging storms, and electrical power (primary/secondary). If modeling studies are not feasible, a study that thoroughly consults peer-reviewed scientific literature assessing the climate of the site's vicinity is acceptable. The quantity and type of research required for determining exposure is subjective to the site's needs and mission.

Once research is complete, the range of potential future climate threats will be known. This knowledge will enable the evaluation of how sensitive site equipment might be to increased exposure to intensified climate-related hazards. The *Sensitivity* step in Figure 2 is meant to determine the degree of vulnerability of the site's security measures. For example, climate research may point to increased future exposure to elevated precipitation rates. This means the site will see an increased likelihood for flooding, which could mean that some of the site's security access points at lower elevations could be damaged or temporarily forced out of service. In summation, security access points at low elevations show sensitivity to increased precipitation amounts. Each potential sensitivity to a climate hazard must be qualified and/or quantified using a system that ranks the sensitivities from insensitive, which means the security measure is more resilient, to more sensitive, meaning that the measure is vulnerable. The site can develop its own system for determining the relative sensitivity of each system, component, or operation, but ranking each potential sensitivity is important for the final evaluation.

The next step in the process is to determine the *Potential Impact* to the previously identified climate-related hazards associated with the site. The combination of Exposure and Sensitivity points to possible events that could be damaging or disruptive to site security systems, or security or mission operations. This is a step beyond Sensitivity, as the ranges of potential disruption or damage must be defined. Potential Impacts should be evaluated in terms of costs, likelihood of occurrence, and most importantly by the potential to compromise the site's security and mission objectives. Costly impacts with a high probability of occurrence and a high security or mission impact are the greatest danger, while less costly impacts with a low likelihood of occurrence are less of a threat. The development of an impact-defining quantification system is left completely at the discretion of the site. Table 1 provides an example of how a final summary of Potential Impacts might be broken down, though the system used should ultimately be tailored toward the site's specific security needs.

A similar approach is needed to evaluate the *Adaptive Capacity* of the relevant site systems, infrastructure, and operations. A system or component with a weak capability to adapt to a climate hazard and a high sensitivity to stressors should be prioritized for improvements well above a system with a high adaptive capacity and a lower sensitivity. An example of Adaptive Capacity can be explored while considering security camera surveillance systems. These systems have a stronger capability to maintain operation if connected to an emergency backup power source, so that security operations can be maintained in the event of a loss of external power during a storm. The Adaptive Capacity of security systems, infrastructure and operations must be determined by the site using a clear ranking system. This could be as simple as a low/medium/high capacity rating, a number system (one-being low adaptive capacity, ten being high, etc.) or any other approach that the site finds most useful. As previously mentioned, Table 1 provides examples of how the summary of this information might be described.

Table 1: Example of a (Hypothetical) Physical Security Vulnerability Assessment

Sector	System	Component / Operation	Climate Variable(s) Influencing Component/ Operation	Projected Change in Climate Variable(s)	Potential Impacts	Expected Impact	Adaptive Capacity (Low/ Med/ High)	Vulnerability (Low/ Med/ High)
Security Systems	Surveillance & Monitoring	Cameras	Extreme storms, elevated average temperatures, heat stress, drought, etc.	Higher frequency and intensity of hurricanes expected in region. Average annual temperatures expected to rise by 2°F by 2040, and 4°F by 2080.	System dependent on off-site electricity and no source of back up electricity for CCTV cameras is available on site. Electrical grid is susceptible to extreme storm events destroying infrastructure, such as power lines. Also vulnerable to brownouts due to high electricity demand or weak electricity output during periods of high temperatures (power plants must reduce output).	Higher frequency of power outages could impair surveillance system operation.	Medium	Medium
Security Operations & Administration	Guard Force	Operations	Extreme storms, flooding, higher average annual temperatures, greater number of high heat days/heat waves, etc.	Higher frequency and intensity of hurricanes expected in region. Flooding frequency will increase, especially in areas of low elevation. Average annual temperatures expected to rise by 2°F by 2040, and 4°F by 2080. Number of days with temperatures >90°F will increase from 29 in 2014 to 43 by 2040.	Storms and flooding could make commutes to and from the facility more hazardous, or force site evacuations in extreme circumstances. Higher average annual temperatures and increased number of high heat days increases heat stress to guard force. High heat also reduces air quality, which also is detrimental to the health of the guard force and other employees.	Guard force availability disrupted more frequently due to commute and health issues.	High	Low

The next step in the vulnerability assessment process is to evaluate the points at which Adaptive Capacities meet Potential Impacts to produce a prioritized list of site security Vulnerabilities. Very simply put, the point at which potential problems with higher impact probabilities intersect with systems with a low capability to handle stress is the beginning of the prioritized vulnerabilities list. Low impact threats with low damage or security/mission compromise potential should be placed near the bottom. The site will need to have a clear system for qualifying or quantifying why certain climate threats are prioritized above others. For example, if the site is located in an area susceptible to infrequent but high cost climate-related events, this threat will need to be assessed against those of much greater frequencies but lower costs of damage. A cost-benefit analysis and/or a decision tree might be useful in determining which threats are prioritized above others.

Once the final priority rankings are established for all potential vulnerabilities, the site's vulnerability assessment is ready for integration into ongoing site operations and overall management planning. Site security and facility managers can begin to adjust practices and budgets to compensate for the most glaring weaknesses. It is important to note that scientific understanding of climate is ever-changing, thus vulnerability assessments should be seen as an ongoing or iterative process that requires continuous re-evaluation.

For additional helpful resources on vulnerability assessments, please reference Section 11.1.

7.2 Mitigation Options for Consideration

A proactive approach to climate change is ideal, including the consideration of potential mitigation methods during ongoing planning and operating processes. The following strategies are some examples that can be implemented after a facility is located, designed, and constructed to lessen vulnerability to climate-related hazards including wildfires, flooding, sea level rise, hurricanes, tornadoes, blizzards, and extreme storm events.

Wildfires:

- Remove vegetation, such as trees, brush, and grasses, to create firebreaks immediately adjacent to buildings and other structures to create defensible space (FEMA P-754).
- Aside from creating a defensible space, installing a Class A rated roof is the most critical element in reducing a building's vulnerability to wildfire. Install a noncombustible roof covering such as clay and concrete tile, slate, fiber-cement tiles, and metal shingles and panels (FEMA P-754).
- Install metal flashing and fire-resistant underlayment below flashing in areas on the roof that may accumulate debris. Areas that commonly accumulate debris are roof valleys, roof edges, intersections with exterior walls, and penetrations in the roof covering, such as chimneys, through-roof vents, and skylights (FEMA P-754).
- Install gutters constructed with noncombustible material such as aluminum, galvanized steel, or copper. Install leaf guards to provide a cover over gutter openings and help resist debris from accumulating in the gutter (FEMA P-754).
- To prevent hot gases and embers from entering the building through gaps, seal gaps around wall penetrations or, if possible, remove above-ground exterior wall penetrations, relocate the utility entry to an underground location, and seal the gaps in the wall (FEMA P-754).

- Install temporary or permanent metal shutters, including roll-down window covers (FEMA P-754).
- Protect exterior-mounted equipment (such as air conditioners) with enclosures constructed of fire-resistant or noncombustible materials (FEMA P-754).
- Electronic building equipment that is sensitive to power surges can be protected by properly grounding equipment and installing devices rated to provide surge protection (FEMA P-754).
- Provide a backup power supply for electronics (FEMA P-754).

Flooding and sea level rise:

- Relocate utility installations below grade to properly elevated floors or platforms (FEMA P-543).
- Elevate components of utility systems including electric transformers, communications switch boxes, water heaters, air conditioning compressors, furnaces, boilers, and heat pumps in-place on platforms (FEMA P-543).
- Fuel tanks can be elevated or anchored. If anchored below the design flood elevation (DFE), tank inlets, vents, fill pipes, and openings should be elevated above the DFE, or fitted with covers designed to prevent the inflow of floodwaters or outflow of the contents of the tanks (FEMA P-543).
- If utility components cannot be elevated, it may be feasible to construct watertight enclosures, or enclosures with watertight seals that require human intervention to install when flooding is predicted (FEMA P-543).
- Control panels, gas meters, and electrical panels can be elevated, even if the equipment they service cannot be protected (FEMA P-543).
- Where areas within an existing facility are flood-prone, separation of control panels and electrical feeders will facilitate shutdown before floodwaters arrive, and help protect workers during cleanup (FEMA P-543).
- Current fluctuations and service interruptions are common in areas affected by flooding. Equipment and sensitive electrical components can be protected by installing surge protection and uninterruptible power supplies (FEMA P-543).
- Pre-wired portable generator connections allow for quick, failure-free connection and disconnection of the generators when needed for continued functionality (FEMA P-543).
- Relocate the uses that require plumbing to elevated floors and remove the fixtures that are below the DFE to provide protection and prevent contamination with floodwater. Wellheads can also be sealed with watertight casings or protected within sealed enclosures (FEMA P-543).
- Wastewater system components become sources of contamination during floods. Rising floodwaters may force untreated sewage to backup through toilets, to prevent this specially designed back-flow devices can be installed (FEMA P-543).
- Permanently relocate high-value or sensitive functions that are often found on the ground floor of critical facilities (e.g., offices, records, libraries, and computer laboratories) to higher floors or elevated additions (FEMA P-543).
- Planned actions to move high-value contents from the lower floors to higher floors when a flood warning is issued (FEMA P-543).

- Install separate electric circuits and ground fault interrupter circuit breakers in areas that will flood (FEMA P-543).

Floodplain Management:

E.O. 11988 requires Federal agencies to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities" for the following actions:

- Acquiring, managing, and disposing of Federal lands and facilities;
- Providing Federally-undertaken, -financed, or -assisted construction and improvements;
- Conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing activities.

Hurricanes and other extreme storm events, in addition to the flooding recommendations above:

- Place rooftop equipment in penthouses rather than exposed on the roof to lessen wind damage (FEMA P-543).
- Provide emergency power.
- Conduct diligent periodic inspections and special inspections after storms. Ensure diligent maintenance and prompt repairs.

In order to provide building integrity during hurricanes and other extreme storm events, upgrades should be made to withstand a higher wind velocity:

- Secure metal siding (FEMA P-804).
- Strengthen vents and soffits (FEMA P-804).
- Secure roofs (such as metal, built-up and single-ply, composition shingle) (FEMA P-804).
- Brace gable end roof framing and strengthen vertical framing (FEMA P-804).
- Brace trusses (FEMA P-804).
- Install roof hurricane straps.
- Reinforce exterior wall coverings (FEMA P-804).
- Reinforce doors or replace with impact-resistant doors (FEMA P-804).
- Reinforce and install impact-resistant covering or replace garage doors with impact-resistant doors (FEMA P-804).
- Install impact-resistant windows or window protection (such as shutter systems) (FEMA P-804).
- Remove dead trees or trees with voids in their trunks (FEMA P-804).
- Retrofit exterior equipment (FEMA P-804).

In response to increased stress on the power system caused by rising temperatures (and consequent demand for cooling) and reduced water availability:

- Strengthen and coordinate emergency response plans.
- Add back-up power supply (such as generators) for grid interruptions.
- Improve building energy efficiency and cooling efficiencies.
- Set higher ambient temperatures in buildings.
- Improve water use efficiency.
- Allow flexible work schedules and telework policies to transfer energy use to off-peak hours.

8 Impacts to the Federal Security Officer

Climate-related hazards can affect Federal facilities and should increase the awareness of the Federal security officer in several areas. The security officer should engage in scenario planning and vulnerability assessment for any additional set of stressors and events. The security officer should consider decision-making, communication, sustenance and safety as major concerns. Mitigating these issues before disaster strikes is prudent. Training and better direction is needed to prepare officers for increased security response and notification requirements for weather-related problems. Property and security managers should be aware of impacts to security officers and take steps to alleviate problems before they occur. Some areas to observe are the security officer knowledge level, training, equipment, and communication devices.

8.1 Facility Security Officer Knowledge Level

Federal security officers are well trained in many areas relating to security (e.g., first aid, crowd control, handling disorderly persons, etc.) However, there are some examples of specialized areas that fall outside of their core training. Addressing climate-related issues is an area where they may (or may not) receive basic training.

Climate-related hazards will bring more frequent occurrences of extreme weather events. Therefore, Federal security officers should have a close working relationship with emergency managers, facility managers, environmental offices and others to integrate respective responsibilities for enhancing climate adaptation principles and resilience.

8.2 Security Officer Training

Training programs should be developed to enhance security officer knowledge in the areas of disaster response, weather response, emergency preparedness plans, and climate adaptation principles. Other areas that might require further training are mechanical systems, countermeasures, and notification. The training can be made part of their initial hire and subsequent annual training.

Federal security officers would also need to be incorporated into the facilities emergency preparedness plan with a greater role, as well as participating in the vulnerability assessment phase of climate adaptation planning to the extent practical. Property and security managers must consider effects on a facility security officer when developing emergency preparedness plans.

8.3 Property/Security Manager Considerations

This sub-section applies to any event/emergency situation. During disasters, security officers, facility managers, and emergency management officials will experience stress as part of their duties. Potentially, stress may impede their performance of critical duties, or the event itself may limit their ability to report to work. As such, managers should plan for contingency security posts, adjust access points, as needed, and consider adjusting security requirements. Clear communication is essential at this time.

To minimize unclear direction from a number of potential sources, there should be clear lines of authority and accountability that is planned for and practiced pre-event.

Consider contract agreements (to the extent they apply) and their impact on immediate response operations. Security officers may be required to work extended shifts and replacements may not be able to travel to or access the site. Property and security managers should review existing contracts to ensure that contingency clauses are in place.

To support security officers expected to remain on station for extended periods, consider accommodations for food, water, emergency power, communications, and other essential amenities. Establish a chain-of-command and points of contact along with telephone (landline and radio/cell phone) numbers. For radio communications it would include call signs/frequencies. Also, consider required personal protective equipment and pre-event training requirements. These considerations and more should be spelled out in writing in the occupant emergency plan and other written security plans. Specific information relating directly to the Federal security officer should be added to the post orders.

8.4 Training and Contract Requirements

Security officers are usually the first witnesses and responders when disaster strikes a Federal facility. Ensuring that they are properly trained to activate or deactivate key systems or deploy critical assistive technologies can reduce the impact of events and minimize overall costs to the government.

For example, if security officers know how to secure valuable equipment, such as x-ray machines and magnetometers, they will be able to shut down equipment more quickly than if a technician is required. Similarly, training security officers on facility pumping systems, air handling equipment, and emergency lighting can minimize impacts and improve responsiveness.

Early notification of an impending or occurring disaster is essential. Organizations should have robust notification systems in place and practiced pre-event. Security officers must have access to a detailed notification list, including local response teams and decision-makers. Security officers may be assigned to begin phone tree notifications in order to shorten notification time while managers are involved with other response actions. Every situation is different and it is important that agencies work closely with building managers to develop a thorough plan and define the role of facility security officers in case of an emergency. The ability to react quickly using proven response procedures can reduce the impact in a worst-case scenario.

Securing Federal facilities and making them safe for employees and visitors during and after a disaster is a significant responsibility for property and security managers. Planning and brain-

storming potential problems and their mitigation are key. OSHA has a reference (OSHA 3335-10N2007) titled “*Preparing and Protecting Security Personnel in Emergencies*” that has a wealth of information about hazardous material response and other items.

9 Case Studies for U.S. Federal Facilities

This section outlines specific instances where Federal facilities were forced to confront climate-related hazards and the effects of natural disasters. As evidenced by these examples, Federal facilities vary in preparedness level and degree to which industry best practices have been implemented.

Federal Courthouse and Post Office, Galveston TX:

During Hurricane Ike, the Federal Courthouse and Post Office (U.S. Postal Service) facility, located in Galveston, TX suffered flood and minor wind damage. Although the facility was damaged, it also demonstrates the value of best practices. Floodwater inundated the basement, which caused major damage to mechanical equipment and the main electrical switchgear room. Although flooding damaged the switchgear in the basement, the emergency generator was appropriately housed in a wind-resistant and windborne-debris-resistant building elevated above the floodwater level and remained functional. Therefore, it was possible to reconfigure power to portable equipment used to dry the interior of the building. Minor rooftop equipment damage was observed but was minimized by supplementary anchor straps, recommended in FEMA guidance that secured rooftop equipment. In addition, roof tiles were hooked to prevent wind damage.

Federal Triangle Buildings, Washington, DC:

In June 2006, a storm event dropped 7.01 inches of rain in 24 hours in the Washington, DC metropolitan area. The heavy rainfall caused significant flood damage to buildings located in the Federal Triangle, including the Department of Justice and Internal Revenue Service buildings. The DC Water and Sewer Authority system for street drainage is designed for a 15-year storm event or about 5.5 inches in 24 hours. The damaged buildings were able to handle the stormwater run-off until infrastructure in the adjacent streets failed to accommodate the stormwater and overflows started to occur. This failure resulted in an extreme and rapid rise in floodwaters, resulting in the backup of stormwater into the buildings and subsequent disruption of electrical service needed to support pumping, causing additional flooding and further failure of interior building systems.

Estimates suggest that the Internal Revenue Service building flooded with approximately six million gallons of water and the Department of Justice building flooded with approximately three and a half million gallons of water. The Internal Revenue Service building had water penetration at the perimeter moats; excessive pressure built up from flood water and caused a number of window assemblies to fail. The Department of Justice did not have water penetrate through the moats, but a 15-inch stormwater sewer main failed in the basement. In addition, both buildings had secondary flooding through electrical service duct banks, abandoned duct banks, and miscellaneous pipe penetrations.

When water started to enter both buildings, the electrical rooms located on the lower levels, as well as emergency power equipment, were flooded and failed. After primary power and

emergency power failure, the storm water pumps could no longer operate and the buildings quickly filled with water.

USACE Administration Building, Galveston TX:

During Hurricane Ike, the United States Army Corps of Engineers (USACE) Administration Building located in Galveston, TX suffered minor leakage and wind damage. Although the building was not damaged by flooding, floodwater surrounded the building. Some minor leakage occurred at a few windows. Additionally, some fan cowlings and louvers at condensers were blown off, and some of the Lightning Protection System (LPS) conductors detached from the roof membrane. While the building suffered only minor damage, it remained inoperable due to the disruption to municipal power and water supply. The gas supply was shut down prior to the storm by the gas supplier. The facility was without power until a portable generator was supplied by FEMA. Additionally, the building was without potable water for two days and was reoccupied four days later.

83 Federal Buildings Including 4 Courthouses, LA, MS, AL:

Hurricane Katrina made landfall on August 25th, 2005 and caused severe, widespread damage to Federal facilities throughout the region. Across Louisiana, Alabama, and Mississippi, 83 Federal facilities including four courthouses shut down due to structural damage and loss of supporting critical infrastructure (Smith 2006). Levee failures contributed to flooding 80 percent of New Orleans, LA as a consequence of vulnerabilities and weather factors including low land elevation, storm surge, heavy precipitation, and levee base erosion (NOAA 2015). As a result of the hurricane's destruction and subsequent debris, major roadways and transportation infrastructure were impassible and 95 percent of U.S. Gulf oil production was disrupted (Office of Fossil Energy [OFE] 2015). Loss of power disabled communications infrastructure, including 911 dispatch systems, and halted operations at water pumping stations and fuel distributors. Due to a lack of law enforcement presence in the days following the hurricane, the Federal Bureau of Investigation (FBI) formed the Law Enforcement Coordination Center. This center was a uniform command structure that allowed law enforcement agencies operating in New Orleans to coordinate together. The vast devastation called for massive evacuations, including abandoning compromised healthcare facilities. A rooftop evacuation of the Louisiana State University Hospital was undertaken by FEMA Emergency Response Team. As many as 2,600 Federal employees representing all major Federal agencies were relocated as a result of Hurricane Katrina (Smith 2006).

The White House released a document in 2006, *The Federal Response to Hurricane Katrina: Lessons Learned*, containing recommended considerations that could enable improved preparedness at Federal facilities. This document advances readiness through many actions, including developing coordination and building operational plans, procedures, and policies to ensure effective law enforcement response during a natural disaster. These plans should be adopted at the facility level and can be applied to prepare for future climate impacts, hurricanes, and other severe weather events.

10 Cross-Government Coordination and Resources

Multiple Federal and national organizations provide climate change information to inform climate resilience planning regionally and locally (listed below). These organizations provide

useful resources to better understand local climate change risks. In addition, many states and a growing number of localities have climate change plans and programs that may inform Federal facilities' climate resilience planning.

Approximately half the states in the U.S. have a climate adaptation plan or are in the process of developing a plan. These plans typically include information about the climate-related hazards that pose the greatest threat to the state's infrastructure, people, and resources. Several states have also developed tools to provide even more localized data. For example, in California, Cal-Adapt, a web-based climate adaptation planning tool, provides easily accessible climate change data to inform adaptation planning. Local programs such as the Santa Fe Basin Climate Change Study focus on developing knowledge of local climate impacts, other programs focus on planning for future changes. Federal facility managers are encouraged to coordinate with state, regional, and local climate change programs, and to integrate adaptation and resilience planning with their local counterparts.

Climate Science Centers

Funded by DOI, CSCs provide scientific information, tools, and techniques that land, water, wildlife, cultural resource managers and others can apply to anticipate, monitor, and adapt to climate change impacts. The information and tools provided by the CSCs will be guided by the cross-sector needs of agencies and communities in the region. There are eight centers, one for each climate region.

NOAA Regional Climate Centers (RCC)

Regional Climate Centers are a Federal-state cooperative effort. The six centers that comprise the RCC Program are engaged in the production and delivery of climate data, information, and knowledge for decision makers and other users at the local, state, regional, and national levels. The RCCs support NOAA's efforts to provide operational climate services while leveraging improvements in technology and collaborations with partners to expand quality data dissemination capabilities.

Regional Integrated Science Assessments

NOAA has established 11 RISAs to support research that addresses complex climate sensitive issues of concern to decision-makers and policy planners at a regional level. The RISA research team members are primarily based at universities, though some of the team members are based at government research facilities, non-profit organizations or private sector entities. RISA teams work closely with NOAA's Federal, state, and local partners, and many have strong connections with other Federal initiatives such as the DOI's CSCs.

American Association of State Climatologists (AASC) State Climate Offices

The mission of the State Climate Offices and NOAA RCCs is to effectively provide the nation with high-quality, timely, and relevant climate services. The RCCs are responsible for the collection of regionally-observed climate data and the application of these data to help frame regional problems and issues. The RCCs also serve end users in those states lacking a state climate office. The AASC State Climate Office has the best understanding of the climate of its state, and the ability and knowledge to provide climate data and information to inform policies, planning, and decision-making.

GSA Regional Emergency Coordinators and DHS/Federal Protective Service (FPS) Megacenters

General Services Administration (GSA) building managers are notified of emergency events from DHS/FPS. Four regional call centers, known as the Megacenters, continuously monitor events in government facilities. In the event of an emergency, over 1,000 entities can be notified expediently, drawing from a Notification Matrix (GSA 2007). This matrix, with prior input from individual agencies, holds personnel contact information for different anticipated situations. Primarily, these Megacenters monitor intrusion alerts and fire alarm notifications in specific buildings, however they have the capacity to monitor other situations that may affect homeland security.

Currently, there is no direct communication between city agencies and the Megacenters. The Washington, D.C. Water and Sewer Authority, that manages the street drainage, storm water, and sewer system does not have the ability to directly communicate with the Megacenters (GSA 2007).

GSA has Regional Emergency Coordinators who are primary points of contact with the DHS/FPS Megacenters. GSA may obtain notifications of emergency incidents from local emergency management agencies (GSA 2007). Federal facilities should ensure that they have mechanisms in place to receive notifications and information from the appropriate agencies for timely notice of potential hazards, including notification from city, county or regional emergency management officials. Federal facilities should review their hazard response plans and ensure that necessary information is reported per established protocols quickly and efficiently.¹⁰

11 General Climate Change and Related Resources

- **20 Good Ideas for Promoting Climate Resilience**
The 20 ideas contained in this document represent a collection of planning, funding, regulatory, and investment efforts already taking place in different U.S. states and localities to prepare for and reduce the risks of climate change. These ideas offer insights and lessons for all communities to learn from and build upon in developing their own responses to a changing climate.
- **Adapting to Urban Heat: A Tool Kit for Local Governments**
This document, commissioned for the Georgetown Climate Center (GCC) and developed in 2012 by Sara P. Hoverter, provides a decision-making framework for local governments to reduce the effects of increased heat on their communities and citizens.
- **Climate Change and Occupational Safety and Health - Climate Change: A Risk for Workers.**
Discusses health risks, and how climate change is an occupational issue.
- **Climate Data Initiative**
Provides data related to climate change that can help inform and prepare America's communities, businesses, and citizens.
- **Climate Resilience Toolkit**

¹⁰ GSA Flood Mitigation and Prevention of Federal Triangle Report (2007)

Provides resources and a framework for understanding and addressing the climate issues that impact people and their communities.

- **DHS: 2014 Quadrennial Homeland Security Review (QHSR)**
The 2014 QHSR identifies the trends related to climate change as a major area of homeland security risk. It cites climate-driven disasters as a major threat to the Nation.
- **EcoAdapt: Climate Adaptation Knowledge Exchange (CAKE)**
Managed by EcoAdapt, a non-profit organization, and offers a virtual library of guidebooks, adaptation plans and case studies, including a map search feature. The site also hosts a directory of organizations and climate change professionals, and climate change tools.
- **EPA Climate Change Indicators**
The EPA has compiled a set of 26 indicators tracking signs of climate change. The data is compiled from government agencies, academic institutions, and other organizations, and references are provided to the original data sources. Most of these indicators focus on the U.S., but some include global trends to provide context or a basis for comparison.
- **E.O. 11988: Floodplain Management**
Requires Federal agencies to avoid, to the greatest extent possible, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practical alternative. This E.O. was amended by E.O. 13690 (see below).
- **E.O. 13653: Preparing the United States for the Impacts of Climate Change**
Requires Federal agencies to promote: 1. engagement and strong partnerships and information sharing at all levels of government; 2. decision-making based on risk analysis and tools; 3. adaptive learning whereby past experience informs future actions and modifications; 4. preparedness planning.
- **E.O. 13690: Federal Flood Risk Management Standard**
Builds upon the principles outlined in E.O. 11988 by establishing a Federal Flood Risk Management Standard (FFRMS) and a Process for Further Soliciting and Considering Stakeholder Input. The Standard represents a flexible framework to increase resilience against flooding and help preserve the natural values of floodplains. Incorporating this Standard will ensure that Executive Branch departments and agencies expand management from the current base flood level to a higher vertical elevation and corresponding horizontal floodplain to address current and future flood risk and ensure that projects funded with taxpayer dollars last as long as intended.¹¹
- **E.O. 13693: Planning for Federal Sustainability in the Next Decade**
Requires all Federal departments and agencies prepare for impacts of climate change by identifying and addressing projected impacts of climate change on mission critical water, energy, communication, and transportation demands and considering those climate impacts in operational preparedness planning.
- **Federal Continuity Directive 1**
Provides direction to the Executive Branch for developing continuity plans and programs. Continuity planning facilitates the performance of Executive Branch essential functions

¹¹ FEMA has established guidelines for implementing this E.O. which can be accessed at <https://www.fema.gov/media-library/assets/documents/110377> and <http://www.fema.gov/federal-flood-risk-management-standard-ffrms>.

during all-hazards emergencies or other situations that may disrupt normal operations. The ultimate goal of continuity in the Executive Branch is the continuation of National Essential Functions (NEFs).

- **Georgetown Climate Center – Adaptation Clearinghouse**
Features a directory of resources and groups to help with adaptation planning.
- **Institute for Sustainable Communities – Promising Practices in Adaptation & Resilience**
Provides case studies and advice for adaptation planning, including a large list of resources for local planners.
- **Intergovernmental Panel on Climate Change - Fifth Assessment Report (AR5)**
AR5 provides a clear and up to date view of the current state of scientific knowledge relevant to climate change. It consists of three working group reports and a Synthesis Report (SYR).
- **National Climate Assessment 2014**
The NCA summarizes the impacts of climate change on the United States, now and in the future. A team of more than 300 experts guided by a 60-member Federal Advisory Committee produced the report, which was extensively reviewed by the public and experts, including Federal agencies and a panel of the National Academy of Sciences.
- **National Park Service: Using Scenarios to Explore Climate Change: A Handbook for Practitioners**
This handbook from National Park Service’s Climate Change Response Program describes the five-step process for developing multivariate climate change scenarios. Detailed instructions are provided on how to accomplish each step of the five-step scenario building process. Appendices include a hypothetical scenario exercise that demonstrates how to implement the process, some early examples of how climate change scenarios are being used to inform planning and decision making, and advice on designing and facilitating scenario workshops.
- **NCAR Climate Data Guide**
The Climate Data Guide is a website devoted to the ins and outs of obtaining and analyzing various existing climatic data sets. Developed by The National Center for Atmospheric Research (NCAR), it is envisioned as a focal point for users to find not only data, but also expert user guidance, commentary, and questions and advice on appropriate data applications.
- **NOAA Earth System Research Laboratory, Physical Sciences Division**
This group provides integrated expertise in weather and climate physical observations, modeling, analysis and applications. The site features many interesting ways to access and display data, including an interactive plotting and analysis feature.
- **NOAA NCDC**
The NCDC is the world's largest archive of weather data. The center offers access to data, maps and publications as well as services such as data resource consultations. This website is also a gateway to accessing many NOAA data sub-sites, some of which are listed below.
- **NOAA NCDC - Monitoring**
The NCDC monitoring section provides records of variations in various aspects of climate, including drought, wildfire, storms, snow and ice, etc.
- **NOAA NCDC - U.S. Climate Normals**

The average value of a meteorological element over 30 years is defined as a climatological normal. The normal climate can be used as a base to which current conditions are compared. Every ten years, the NCDC computes new 30-year climate normals for selected temperature and precipitation elements. The 1981-2010 Normals were released on July 1, 2011.

- **NOAA NOS Sea Level Map**
NOS partnered with The Center for Operational Oceanographic Products and Services as a culmination of efforts to provide maps of land lost by projected sea level rise.
- **North American Regional Climate Change Assessment Program (NARCCAP)**
NARCCAP is an international program that will serve the climate scenario needs of both the U.S. and Canada. They are systematically investigating the uncertainties in regional scale projections of future climate and producing high resolution climate change scenarios using multiple regional climate models (RCM) and multiple global model responses to future emissions scenarios.
- **NYCPCC: Climate Risk Information**
This document from the 2009 New York City Panel on Climate Change (NYCPCC) provides climate change projections for New York City and identifies potential risks to the city's critical infrastructure posed by climate change.
- **Preparing for Climate Impacts: Lessons Learned from the Front Lines**
Shares some of the lessons learned from its adaptation work in recent years and include a number of short case studies highlighting successful efforts and barriers to change.
- **RAWS USA Climate Data Archive**
There are nearly 2,200 interagency Remote Automated Weather Stations (RAWS) strategically located throughout the U.S. These stations provide weather data that assist land management agencies with a variety of projects such as monitoring air quality, rating fire danger, and providing information for research applications. The RAWS archive (still in development) provides access to some of that data.
- **Sustainable and Climate Resilient Healthcare Facilities Initiative**
A guide to assist health care providers, design professionals, policymakers, and others with roles and responsibilities in assuring the continuity of quality health and human care before, during, and after extreme weather events.
- **Sustainable DC: Heat Related Climate Adaptation Planning**
This is a plan that was developed in an effort launched by Mayor Vincent C. Gray for Washington, D.C. on September 16, 2013 and includes challenges and solutions to impacts of climate change.
- **University of Washington: Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments**
Guidebook, written by the University of Washington's Center for Science in the Earth System (Climate Impacts Group) and the Joint Institute for the Study of the Atmosphere and Ocean, designed to help local, regional and state governments prepare for climate change, from assessing vulnerability and risk through implementation.
- **U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather**
This report from the U.S. Department of Energy examines current and potential future impacts of climate trends on the U.S. energy sector.
- **USFS: ForWarn**
ForWarn is a joint effort from the United States Forest Service (USFS), National Air and

Space Administration (NASA), USGS, and Oak Ridge National Laboratory (ORNL) to provide a satellite-based forest disturbance monitoring system for the conterminous U.S. It delivers new forest change products every eight days and provides tools for attributing abnormalities to insects, disease, wildfire, storms, human development or unusual weather. Archived data provide disturbance tracking across all lands since 2000.

- **USFS: Template for Assessing Climate Change Impacts and Management Options (TACCIMO)**

TACCIMO is a web-based tool developed by the USDA Forest Service to assist land managers and planners with evaluation of climate change science implications for sustainable natural resource management. TACCIMO provides users with an interactive resource that efficiently delivers climate change science needed to assess, manage, and monitor forest resources under a changing climate.

- **United States Global Change Research Program (USGCRP) Federal Adaptation Resources Library**

A collection of resources by and for Federal agencies intended to support the planning and implementation of measures to adapt to climate change.

- **Using the Heat Index: A Guide for Employers**

Discusses concerns for employers who oversee outdoor workers exposed to hot and humid conditions that are at risk of heat-related illness.

11.1 Vulnerability Assessment Resources

The following documents are invaluable resources that should be consulted prior to initiating any climate change vulnerability assessment. Published by and for Federal agencies, these are informative guides or examples for how a proper assessment should be conducted. While the focus of many of these documents does not directly address physical security concerns, interpreting the approach and results through the lens of security would still be tremendously valuable.

- **DOE – Idaho National Laboratory (INL): Climate Change Vulnerability Assessment for Idaho National Laboratory**

In October of 2014, INL completed a comprehensive climate change vulnerability assessment using the framework discussed in Section 7.2. Consulting this document would be beneficial to those who wish to perform a similar study.

- **DOE: U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather**

This publication was produced by the U.S. DOE to document the myriad susceptibilities to climate change impacts that are present in the energy sector. This could be useful for those interested in researching the energy security of their facilities and for assessing potential weaknesses in off-site energy supplies.

- **National Wildlife Federation (NWF): Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment**

A publication of the NWF, this document offers detailed advice on how to structure and complete a climate change vulnerability assessment. Key components of this guide include assisting users in identifying vulnerability, understanding why certain resources or systems are vulnerable, and advice for prioritization of susceptibilities. It should be noted that this document has a heavy focus on wildlife and natural resources, so security

professionals should read their approach and results within the lens of physical security challenges.

- **United States Department of Agriculture: Adapting to Climate Change at Olympic National Forest and Olympic National Park**

This case study was a science-based sensitivity assessment of management activities, constraints, and adaptation workshops that focused on the Olympic National Forest and the Park. This study provides an example that other national forests, parks, or other similar types of Federal facilities might evaluate their susceptibility to the impacts of climate change.

- **USDA: Responding to Climate Change in National Forests: A Guidebook for Developing Adaptation Options**

This publication is meant to act as a guide for those seeking to evaluate adaptation options. The authors used a science-based approach to develop tools that were used to evaluate climate threats, identify key resource issues, and develop improved management options to reduce the deleterious effects of climate change. Another useful example to follow for those seeking to perform their own vulnerability assessment.

- **USFS & National Park Service: The North Cascadia Adaptation Partnership: A Science-Management Collaboration for Responding to Climate Change**

USFS and the National Park Service launched the North Cascadia Adaptation Partnership in 2010 to increase climate change awareness, assess vulnerability, and develop science-based strategies to enhance adaptation. This publication describes the approach, process, and results of their analysis, and is a useful example for those who wish to perform similar evaluations at their own facilities.

- **University of Washington: Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments**

Designed to support local, regional, and state governments prepare for climate change by describing a comprehensive procedure for enhancing climate change preparedness. The guide assists in identifying vulnerabilities, prioritizing weaknesses, assessing threats, developing a climate preparedness plan, and measuring resilience.

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Appendix A: Example of Preventive Measures for Climate-Related Hazards

The following example is designed to serve as a chart of preventive measure considerations for the specified potential climate change impacts. This chart is meant to assist agencies with identifying climate-related hazards that may impact Federal facilities in the regional, state, and local areas. Considerations may vary by region/facility. Suggested mitigation options can be found in Section 7.2 of this document.

Climate-Related Hazards/ Potential Impacts	Preventive Measures	Northeast	Southeast and Caribbean	Midwest	Great Plains	Southwest	Northwest	Alaska	Hawaii and Pacific Islands
Temperature Anomaly									
Frost Free Season									
Polar and Sea Ice									
Precipitation Change									
Sea Level Rise									
Hurricanes and Severe Weather Events									
Wildfires									

List of Abbreviations/Acronyms/Initializations

TERM	DEFINITION
AASC	American Association of State Climatologists
AR5	5 th Assessment Report (from the Intergovernmental Panel on Climate Change)
CAKE	Climate Adaptation Knowledge Exchange
CAP	Climate Action Plan
CCTV	Closed-Circuit Television
CEC	California Energy Commission
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CIP	Critical Infrastructure Protection
COOP	Continuity of Operations
CSC	Climate Science Center
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
DFE	Design Flood Elevation
DHS	Department of Homeland Security
DoD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DVR	Digital Video Recorder
ENSO	El Niño Southern Oscillation
EO	Executive Order
EPA	Environmental Protection Agency
FBI	Federal Bureau of Investigation
FCD	Federal Continuity Directive
FEMA	Federal Emergency Management Agency
FPS	Federal Protective Service
GCC	Georgetown Climate Center
GSA	General Services Administration
HVAC	Heating, Ventilation, and Air Conditioning
IDS	Intrusion Detection System
INL	Idaho National Laboratory
IPCC	Intergovernmental Panel on Climate Change
ISC	Interagency Security Committee
ISCCCWG	Interagency Security Committee Climate Change Working Group
LCC	Landscape Conservation Cooperative

LPS	Lightning Protection System
NARCCAP	North American Regional Climate Change Assessment Program
NASA	National Air and Space Administration
NCA	National Climate Assessment
NCAR	National Center for Atmospheric Research
NCDC	National Climate Data Center
NCEP	National Center for Environmental Prediction
NEF	National Essential Function
NERC	North American Reliability Corporation
NHC	National Hurricane Center
NIAC	National Infrastructure Advisory Council
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NRC	National Research Council
NSC	National Security Council
NWF	National Wildlife Federation
NWS	National Weather Service
NYCPC	New York City Panel on Climate Change
OFE	Office of Fossil Energy
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Health and Safety Administration
PPG	Position Planning Guide
PRCCC	Puerto Rico Climate Change Council
PSO	Protective Security Officer
PSU	Portland State University
QHRS	Quadrennial Homeland Security Review
RAWS	Remote Automated Weather Station
RCC	Regional Climate Center
RCM	Regional Climate Model
RISA	Regional Integrated Sciences and Assessments
SFBCDC	San Francisco Bay Conservation and Development Commission
SOP	Standard Operating Procedures
SRES	Special Report on Emission Scenarios
SYR	Synthesis Report
TACCIMO	Template for Assessing Climate Change Impacts and Management Options
UBS	Uninterrupted Battery Supply
UPS	Uninterrupted Power Supply

USACE	United States Army Corps of Engineers
USC	United States Code
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGCRP	United States Global Change Research Program
USGS	United States Geological Survey

Glossary of Terms

TERM	DEFINITION
Adaptation	Adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects.
Adaptive Capacity	The capability of the site’s systems, infrastructure, or operations to adapt to changing threats. In other words, it is the extent to which opportunities exist for adjustments to be made to reduce deleterious impacts of these threats.
Building	An enclosed structure (above or below grade).
Cascading Effects	Effects that compound the effect of climate change. These effects work together to worsen the initial effect and result in a dramatic change to the overall system.
Continuity of Operations	Defined as an effort within individual organizations to ensure they can continue to perform their essential functions during a wide range of emergencies, including localized acts of nature, accidents, and technological or attack-related emergencies.
Continuity Plan	Defined as a plan that details how an individual organization will ensure it can continue to perform its essential functions during a wide range of emergencies.
Critical Infrastructure	Necessary elements in order to continue operations.
Exposure	A measure of the environmental factors that site systems, equipment or operations are likely to experience.
Facility	Space built or established to serve a particular purpose. The facility is inclusive of a building or suite and associated support infrastructure (e.g., parking or utilities) and land.
Fracture-Critical	Refers to when centralized infrastructure, including power grids and hospitals, are larger and more complex, they are dependent upon massive amounts of ongoing maintenance and may be entirely incapacitated by the failure of a single element.
Land Subsidence	May occur when large amounts of groundwater have been withdrawn from certain types of rocks, such as fine-grained sediments. A gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials, including ice and groundwater.
Mitigation	An intervention to reduce the causes of changes in climate, such as through reducing emissions of greenhouse gases to the atmosphere.

Potential Impact	The range of all possible outcomes resulting from changes in the environment.
Primary Effects	Effects that can be directly attributed to climate change.
Resilience	The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.
Security Organization	The government agency or an internal agency component responsible for physical security for the specific facility.
Sensitivity	The qualification of how and to what degree that key components are vulnerable to environmental conditions.
Special-use facility	An entire facility or space within a facility itself that contains environments, equipment, or data normally not housed in typical office, storage, or public access facilities. Examples of special-use facilities include, but are not limited to, high-security laboratories, hospitals, aircraft and spacecraft hangars, or unique storage facilities designed specifically for such things as chemicals and explosives.
Storm Surge	As hurricanes propagate forward, their winds push water forward as well; as they approach land, this water level is higher than the usual sea level and can contribute to a greater flooding risk. Hurricanes also have a low pressure center, which draws water upward, increasing localized sea levels.
Urban Heat Island Effect	Urban areas have higher temperatures than surrounding areas due to a lack of vegetation and a large percentage of surface area as concrete and asphalt, which absorbs solar radiation and heats the ground surface.
Vulnerability	The propensity to be drastically affected by threats present in an environment.
Vulnerability Assessment	The process of identification, quantification, and prioritization of potential vulnerabilities to enhance risk management practices.