10. BUDGET EXPOSURE TO INCREASED COSTS AND LOST REVENUE DUE TO CLIMATE CHANGE

The climate crisis poses a serious threat to the United States economy and human welfare, with a narrowing timeframe to make strategic investments to avoid the most catastrophic impacts. Acute effects such as extreme weather events, changing precipitation patterns, impacts to air quality and water quality, disruptions to supply chains, and changes to food production and supply can result in cascading impacts disrupting services.[1] Chronic physical risks from climate change also adds risks to deteriorating infrastructure, land-use changes, and populations.[2] Without action, climate change threatens the Nation's economy, national security, essential services, and the Nation's fiscal health. The Fourth National Climate Assessment (NCA4)[3] notes that:

> *Climate change is transforming where and how we live and presents growing challenges to human health and quality of life, the economy, and the natural systems that support us. Risks posed by climate variability and change vary by region and sector and by the vulnerability of people experiencing impacts.*

To help address threats that climate change poses to the economy, the President signed Executive Order 14030, "Climate-Related Financial Risk" on May 20, 2021. Section 6(b) of Executive Order 14030 directs "[t]he Director of OMB and the Chair of the Council of Economic Advisers, in consultation with the Director of the National Economic Council, the National Climate Advisor, and the heads of other agencies as appropriate, [to] develop and publish annually, within the President's Budget, an assessment of the Federal Government's climate risk exposure." This chapter meets the requirements of this section of the Executive Order.

This assessment is complementary to the analysis directed by Section 6(a) of Executive Order 14030, "[T]he Director of OMB, in consultation with the Secretary of the Treasury, the Chair of the Council of Economic Advisers, the Director of the National Economic Council, and the National Climate Advisor, shall identify the primary sources of Federal climate-related financial risk exposure and develop methodologies to quantify climate risk within the economic assumptions and the long-term budget projections of the President's Budget." The work directed by Section 6(a) takes a broad, macroeconomic view of the impact of climate risk on economic assumptions used within the President's Budget, which includes gross domestic product (GDP) and the debt based on long-term budget projections. The 6(a) analysis assesses how climate change indirectly affects Federal revenues and outlays through macroeconomic channels, whereas the analysis under Section 6(b) primarily focuses on the direct impact of climate on Federal expenditures through illustrative examples. Therefore, together the analysis of Section 6(a) and Section 6(b) show the multi-faceted impact of climate change on the Federal Budget.

This chapter is divided into two sections: 1) a review of test cases of assessments of the Federal Budget's exposure to climate risk, using the limited climate risk financial tools that are currently available; and 2) an outline of a common framework for agencies to assess the budget exposure to climate risk of federally administered programs, federally owned assets, operations, and mission. This year's chapter includes three assessments of the Federal Budget's exposure: an updated analysis on flood risk to selected Federal facilities; a summary of the work completed under Section 5(c) of Executive Order 14030 on the climate risks to Federal lending with an analysis on the exposure of the single-family housing portfolio of the Federal Government; and a new assessment on the impact of increasing temperatures due to climate change on the Low Income Home Energy Assistance Program (LIHEAP). These test cases rely on today's limited climate financial tools and as a result, can underestimate risk. Therefore, the results are intended to illustrate, but not represent, a comprehensive estimate of projected impacts. They are presented here to document methodologies to date, including the limitations of current tools, so to inform the development of the next generation of robust climate financial risk methods and tools. The section on the framework of future assessments is structured as follows: 1) current approaches used by Federal agencies for assessing climate risk; 2) climate data and modeling that is currently available to agencies; 3) a proposed common framework to assess climate-related financial risk and necessary technical inputs; and 4) a discussion of next

[1] Jay, A., D.R. Reidmiller, C.W. Avery, D. Barrie, B.J. DeAngelo, A. Dave, M. Dzaugis, M. Kolian, K.L.M. Lewis, K. Reeves, and D. Winner, 2018: Overview. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 33–71. doi: 10.7930/NCA4.2018.CH1

[2] Clarke, L., L. Nichols, R. Vallario, M. Hejazi, J. Horing, A.C. Janetos, K. Mach, M. Mastrandrea, M. Orr, B.L. Preston, P. Reed, R.D. Sands, and D.D. White, 2018: Sector Interactions, Multiple Stressors, and Complex Systems. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 638–668. doi: 10.7930/NCA4.2018.CH17

[3] Jay, A., D.R. Reidmiller, C.W. Avery, D. Barrie, B.J. DeAngelo, A. Dave, M. Dzaugis, M. Kolian, K.L.M. Lewis, K. Reeves, and D. Winner, 2018: Overview. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 33–71. doi: 10.7930/NCA4.2018.CH1

Table 10–1. PRELIMINARY SUMMARY OF QUANTIFIED FEDERAL CLIMATE RISK EXPOSURE PROJECTED CHANGE IN ANNUAL EXPENDITURES OF ASSESSED PROGRAMS

(In billions of 2021 dollars[1])

Assessment Topic	Mid-Century			Late-Century		
	Central Measure[3]	Low	High	Central Measure[3]	Low	High
Crop Insurance[2]	N/A	N/A	N/A	1.3	0.3	2.2
Coastal Disasters	15.3	4.6	34.0	51.8	22.9	98.5
Healthcare	1.0	0.2	1.9	11.9	0.9	22.9
Wildland Fire Supression	1.7	0.9	2.4	3.9	1.6	10.0
Total for Assessments[4]	**18.0**	**5.7**	**38.3**	**68.8**	**25.7**	**133.6**

N/A = Not Available

[1] The summary table of the assessments within the 2023 President's Budget used 2020 dollars, hence the values in this table, which are in 2021 dollars, are slightly higher due to inflation.

[2] The crop insurance analysis was only conducted for late century.

[3] The median of all wildland fire suppression simulations is used in the "Central Measure" column, so outliers in the "Higher" scenario are not overemphasized in the results. All other topics use the mean as the central measure.

[4] Multiple Federal financial risks are not included in this table due to the nascent ability to quantify future expenditures in this field.

steps to further develop the common framework to improve climate financial risk tools.

Update on the Federal Budget Exposure to Climate Risk

In an effort to better understand the risks that climate change poses to the Federal Budget, the Office of Management and Budget (OMB) continues to work across the Federal Government to further the assessment of climate-related financial risks. In the 2023 President's Budget, OMB published an assessment[4] that included six types of climate risks and projected a $26 billion to $134 billion (2021 dollars) increase in Federal costs, shown in Table 10-1. This is likely an underestimation of impacts due to the limitations of today's climate financial risk tools. The analyses in the 2023 President's Budget demonstrated the feasibility of conducting quantitative assessment of climate risk in the Federal Budget.

This chapter provides several updates to the Federal Budget's exposure to climate risk. The goal of the three analyses conducted this year is to advance our collective understanding of the current capabilities and limitations of available modeling tools and data, in order to generate a more representative assessment of the true cost of climate change in the Federal Budget. Through a series of illustrative analytical test cases, Federal researchers and modelers identified informative trends and identified data and modeling gaps that will inform improvements in climate financial risk modeling tools and provide a more accurate and representative estimate of the cost of climate risks for the Federal Budget in coming years. Through additional refinement of analytical tools and continued research, policy officials will be equipped with the knowledge to make more informed decisions about investing resources more efficiently to mitigate climate risk. The analysis on flood risk to Federal facilities now provides an estimate of the loss for a select set of Federal facilities and incorporates forward-looking climate scenarios for flooding. The evaluation of the Federal single-family housing lending portfolio, provides insights on the current risk climate change may bring to the portfolio, while also underscoring the need for improved analytical tools to assess climate related financial risk. Lastly, LIHEAP—a Federal program that assists low-income households with heating and cooling costs—is added to the assessment of Federal fiscal climate risks.

Quantified fiscal impacts of climate change provided for the new test cases are illustrative and not suitable for decision-making due to the limitations of today's tools that are unable to provide accurate and robust projections of exposure and loss. The presented quantitative results are not official Government estimates. Rather, these results provide transparency and underscore the lack of data and modeling currently available through the Federal Government to accurately assess climate related financial risk.

Findings from the three test cases —i.e., not cost estimates, not intended for decision-making—include:

- *Federal single-family housing portfolio*: After conducting a test case exercise that analyzes past, present, and future climate risks to the Federal single-family housing portfolio, the conclusion of the agencies' analysis indicated that current climate financial risk tools underestimate climate risk. This analysis concluded that five climate hazards (hurricanes, coastal flooding, riverine flooding, wildfires, and tornadoes) examined, riverine flooding is anticipated to cause half of the annual losses of unpaid principal balances across the Department of Agriculture (USDA), the Department of Veterans Affairs (VA), and the Department of Housing and Urban Development's (HUD) single-family housing portfolio. However, when applying a proprietary climate risk model, utilized by one of the largest housing lenders in the Nation, to Federal lending data to test the model the researchers found that the model did not consider future climate projections, and therefore underestimated climate risks.

[4] Office of Management and Budget (2022). Climate Risk Exposure: An Assessment of the Federal Government's Financial Risks to Climate Change.

- *Replacement Cost of Federal Facilities Impacted by Sea Level Rise*: The researchers found that there is currently no public or private sector climate data available to accurately estimate the cost implications of sea level rise on Federal facilities. In an illustrative analysis using public data, noting among the multiple data limitations—including: 1) that the data used was not intended to identify site-specific risks; and 2) does not take into account the value of the services provided, the annual replacement value effected from sea level rise is projected between $72 million and $127 million for mid-century and between $449 million and $1.786 billion by the end of the century, not counting transition costs – an underestimation of climate risk due to data limitations. For example, following Hurricane Katrina, in only one year, $38 million was needed to repair more than 83 Federal facilities damaged from the hurricane.[5] This shows that better data and modeling is needed to evaluate the true cost of climate change to Federal facilities (see Table 10-3).
- *Heating and Cooling Assistance*: The 20-year average for heating degree days is projected to decline by up to 30 percent by the end of the century, while the average number of cooling degrees days in estimated to increase by 65 percent. These changes may impact energy demand for heating and cooling, and in turn, LIHEAP funding. In addition to changes in the trends of cooling degree days and heating degree days, extreme weather events induced by climate change will continue to impact the needs of cooling and heating assistance, as the frequency, duration, and intensity of extreme weather events are projected to change over time.

The analyses presented in this chapter are expected to be revised in future years as new climate and financial risk modeling capabilities are incorporated and data quality and availability are improved. The results of these assessments should be viewed as tests cases, not definitive or comprehensive results. The preparation of these illustrative test cases highlights where further research is needed to address data gaps and methodological limitations, which are discussed further in the section titled "Establishing a Common Framework for Evaluating Climate-Related Financial Risks".

Exploratory Analyses on Federal Lending Portfolio of Single-Family Housing

Executive Order 14030, Section 5(c) directs the Secretary of Agriculture, the Secretary of Housing and Urban Development, and the Secretary of Veterans Affairs, "to consider approaches to better integrate climate-related financial risk into underwriting standards, loan terms and conditions, and asset management and servicing procedures, as related to their Federal lending policies and programs". OMB established the 5c Task Force under the Federal Credit Policy Council, with HUD, USDA, and VA (lending agencies) to conduct initial analyses and to create a replicable framework for assessing climate risk in Federal lending programs. This analysis marks the first time that the Federal Government has undertaken the task of broadly examining how climate-related financial risks could impact Federal lending across multiple agencies and evaluating the limitations of current tools used to calculate those risks.

The 5c Task Force determined that the first step to considering new approaches for integrating climate related financial risk in various lending programs is to understand the nature and extent of risks to the single-family guaranteed housing programs at each Federal agency. These programs include:

- USDA's Rural Development (RD) Single Family Housing Guaranteed Loan Program (SFHG);
- HUD's Federal Housing Administration (FHA) single-family insurance program;
- HUD's Government National Mortgage Association (Ginnie Mae) Mortgage-Backed Security (MBS) guarantee program; and
- VA's Loan Guaranty program (VA).

The Federal lending programs for single-family housing had a cumulative outstanding exposure of $2.1 trillion as of 2021, and Ginnie Mae had a similar exposure in outstanding guaranteed MBS.

In order to gain a better understanding of the cost of climate change to the Federal lending portfolio, as well as the limitations of today's climate financial risk tools, OMB and the lending agencies conducted three exploratory analyses to evaluate retrospective, current, and future climate risk. In the prospective test case, OMB and the lending agencies applied a proprietary climate risk model utilized by one of the Nation's largest housing lenders to Federal lending data in order to determine if the results would accurately value the risk that climate change poses to the Federal lending portfolio. Leveraging the existing proprietary tool, OMB's test case failed to measure substantive climate risk which is likely a gross underestimation due to the significant limitations of this climate financial risk tool. These three exploratory test cases indicate that both public and private sector models, when applied to Federal data, vastly undervalue the true cost that climate change poses to lending agencies. This finding suggests that proprietary climate models are underestimating the cost of climate change to lenders in the private housing market. Although these exploratory analyses have several shortcomings, which are summarized below, these test cases demonstrate that new tools must be developed to gauge past, present, and potential future risk to the single-family guaranteed housing programs. OMB and the lending agencies are eager to work with the private sector to develop these tools in line with detailed recommendations at the bottom of this section.

[5] Congressional Research Service. (2007). General Services Administration Federal Facilities Affected by Hurricane Katrina. *https://crsreports.congress.gov/product/pdf/RS/RS22281/14*

Risk Assessment

Retrospective Risk: To examine past risk, the lending agencies executed a retrospective analysis using a sample of 18 disasters that resulted in Presidentially Declared Major Disaster Areas. The agencies analyzed single-family housing borrowers and portfolio behavior for one year after these 18 extreme weather events from 2017 through 2021. This retrospective analysis demonstrated that disaster-affected areas' 90-day delinquency (DQ3) rates increase after disasters when compared to non-disaster areas, including an increase by 1.6 percentage points[6] for RD, an increase by 2.4 percentage points for VA, and an increase by 2.5 percentage points for FHA. That is, the 90-day delinquency rate for Federal mortgages was 1.6 to 2.5 percentage points higher. It was determined that using 90-day delinquency as a measure of past risk underestimates systemic portfolio-wide risk and costs to the Federal Government. Leveraging a 90-day delinquency as a measure of past risk fails to account for the role that disaster loss mitigation programs, private and Federal insurances, and Federal assistance dollars play in protecting against default, effectively shift portfolio hazard risk onto State and Federal entities. Furthermore, using the default metric in isolation was shown to ignore other systemic risks to the portfolio, such as the impact of climate risk poses to insurance carriers. This is exemplified by the 2022 bankruptcy of eight companies in Louisiana following Hurricane Ida, affecting tens of thousands of customers and forcing the State to scramble to find coverage.[7]

Current Risk: To examine current risk, the agencies developed a novel, expected annual loss (EAL) calculation using portions of the Federal Emergency Management Agency (FEMA) National Risk Index (NRI) database, as well as their own self-reported unpaid principal balance (UPB) estimates. Calculations for each agency were tabulated for five select hazards: hurricanes, coastal flooding, riverine flooding, wildfires, and tornadoes. Across all three agencies, riverine flooding posed the highest risk with UPB-EALs ranging from $160 million for RD, to $1.1 billion for VA, and $1.7 billion for FHA, which represented at least half of total UPB-EAL for each agency, indicating riverine flooding are anticipated to cause half of the expected annual losses of unpaid principal balances. Concurrently, Ginnie Mae, which guarantees MBS that utilizes the other agencies' loans as underlying collateral, calculated similar UPB-EALs for the respective portfolios. Compared to the total volume of each agency's portfolio, the sum of UPB-EALs for the five hazards mentioned above was approximately a quarter of a percent of total UPB (0.27 percent for VA and FHA, 0.23 percent for RD, and 0.27 percent for Ginnie Mae), which underestimates climate financial risk due to modeling limitations. These results do not take into account that each program has unique coverage and policy requirements that will mitigate the Federal Government's financial loss exposure. The test case indicates the limitations of this methodology. In order to garner the most accurate current risk projections, it was determined that it would be critical to augment NRI analysis with a climate risk analytical tool that accounts for higher precision on current and near time future risk and includes additional climate modeling augmented by expanded climate hazard categories.

Future Risk: With regard to future risk, the agencies conducted preliminary and partial prospective analysis on the impact of climate events to a simulated Federal housing portfolio over the next 30 years. The agencies used a sample of publicly available Ginnie Mae data, which represented approximately 72 percent of the total FHA/VA/RD portfolio. This initial analysis uses a proprietary model common in the private sector and already available to the 5c Task Force through an existing contract with one of the lending agencies. The agencies used this model to estimate losses to each agency under two assumptions of future economic conditions (a 50th percentile baseline scenario and a 96th percentile severe adverse scenario) and then compared losses in these scenarios with and without climate shocks occurring. The proprietary model projects the expected loss in the lending agencies' mortgage portfolios that could occur for different scenarios of world events, economic trends, and some climate impacts. Federal researchers found that the model showed little risk – a vast underestimation considering a recent study published in Nature found that "residential properties exposed to flood risk are overvalued by $121 billion–$237 billion, depending on the discount rate."[8] The Federal analysis is considered preliminary and partial due to limitations in the analytical methods available. For example, the researchers found that current tools could not incorporate an adequate range of potential natural disasters, including wildfires and winter storm events, that are becoming more frequent from climate change, nor does the model incorporate a range of warming scenarios based on the best science and the most up to date climate models. Additional limitations include, but are not limited to:

- The proprietary model only includes climate shocks that are based on historical data, rather than future climate information obtained from global climate models. While this does provide a starting point for a prospective analysis on the Federal housing portfolio, future analysis should incorporate warming scenarios based on the best available science.
- The projected climate shocks are based on the FEMA-designated natural disasters for riverine and coastal floods, hurricanes, typhoons, and tornadoes, rather than global climate modeling. The magnitude of the impact of other natural disasters that are not

[6] A percentage point measures the difference between two percentages. For example, the difference between 5.5 percent and four percent is 1.5 percentage point. In this text, the percentage point is the change in the 90-day delinquency rates.

[7] Finch, M. (2022, Aug. 5). "Eighth Louisana homeowners insurer goes under, stranding 10,300 policyholders." *https://www.nola.com/news/business/eighth-louisiana-homeowners-insurer-goes-under-stranding-10-300-policyholders/article_74eca3b8-1502-11ed-bfc8-8f4127db48fe.html*

[8] Gourevitch, J.D., Kousky, C., Liao, Y., Nolte, C., Pollack, A.B., Porter, J.R., and Weill, J.A.. (2023) Unpriced climate risk and the potential consequences of overvaluation in US housing markets. Nature Climate Change. *https://doi.org/10.1038/s41558-023-01594-8*

accounted for in this model, such as wildfires and winter storm events, which are becoming more frequent from climate change, and earthquakes, is unknown and strongly warrants further analysis.

- The analysis only makes projections for current portfolio exposure, and the analysis does not model the addition of new mortgages to agency portfolios over the 30-year period.
- The modeling is agnostic to the varying insurance structures by program, which guarantee different amounts of losses through claims to lenders/issuers, and ignores that insurance and Federal and State disaster relief are effectively shifting portfolio hazard risk onto State and Federal entities. The analysis was conducted at the State level due to data limitations.
- Each program has unique coverage and policy requirements, which may change the overall Federal Government exposure to the respective portfolios.

The agencies' efforts to analyze the climate-related financial risks of the Federal housing portfolio has highlighted the lack of available modeling suitable for prospective analyses and the need for additional data and modeling resources to understand the future climate risk to Federal mortgage programs. The conclusion of this analysis is that current tools underestimate climate risk to the portfolio and that new tools need to be developed to gauge past, present, and potential future risk to the single-family guaranteed housing programs. In the next phase of the 5C workstream, the Task Force will define the new tools that are needed to identify, assess, and respond to the risk climate change poses to the portfolios. The Task Force is planning to engage the National Oceanic and Atmospheric Administration (NOAA) and Department of Energy (DOE) National Laboratories climate modeling experts in tool design and development, leverage the latest in climate modeling capabilities, and is eager to engage stakeholders including climate-related data and analytics providers, non-profit organizations, and academia.

To refine and expand this analysis, the 5c Task Force recommends the following key next steps:

- building expertise and learning within the interagency through a Climate Data Working Group that relies on the latest climate and hazard models and defining appropriate data sources for current and future climate risk analysis as well as relevant data sets for consideration;
- developing or procuring the necessary skills and resources in order to improve quantitative capabilities in a rapidly evolving landscape;
- determining an appropriate cadence for repeating and refining the analyses, based on the availability of budget resources and workload requirements;
- sharing lessons learned on risk analysis with other programs within the agencies, and more broadly with other Federal lending and guarantee programs;
- engaging with NOAA, the DOE National Laboratories, and private sector stakeholders through conversations on current practices and challenges posed by climate change in the financial and housing sectors;
- analyzing options suggested by academics, industry groups, and other stakeholders to managing increasing risks from climate change;
- expanding the pool of assets to be analyzed by working with Government-sponsored enterprises and appropriate agencies on identifying a pool of federally-owned or subsidized housing assets to conduct rigorous analysis of current and future climate risk; and,
- coordinating across agencies to identify programs, funding, and procedures to disclose and manage climate risk reduction for the housing pool.

Update on the Flood Risk to Federal Civilian Facilities

Federal facilities face a number of climate change-related hazards, including increased flood risks, extreme weather events, and fire. For example, flooding damage from heavy downpours is projected to increase in various regions across the Nation.[9] Sea-level rise is also expanding the coastal floodplain, causing increased frequency and magnitude of coastal flooding and compounding damages from storm surges. This increase has led to record numbers of events that cause over $1 billion in damages.[10]

OMB, the U.S. Geological Survey (USGS), and NOAA used the Federal Real Property Profile Management System (FRPP MS)[11], a public dataset to assess the flood risks of federally-owned buildings and structures. The FRPP MS public dataset is an inventory system; it was not designed nor intended to be used for flood analysis or any other complex analysis requiring precision. For that reason, there are numerous caveats to the use of the data which are documented in the white paper *Federal Budget's Climate Risk Exposure: A Preliminary Assessment and Proposed Framework for Future Assessments*.[12] These caveats underscore the limitations of the projections shared within this section. Given the current data and modeling available, the following es-

[9] AECOM, 2013. The Impact of Climate Change and Population Growth on the National Flood Insurance Program through 2100. Prepared for the Federal Emergency Management Agency.

[10] National Oceanic and Atmospheric Administration, National Centers for Environmental Information. (2023, Jan. 10). U.S. Billion Dollar Weather and Climate Disasters. *https://www.ncdc.noaa.gov/billions/*.

[11] General Services Administration. (n.d.). Federal Real Property Profile Management System (FRPP MS). *https://www.gsa.gov/policy-regulations/policy/real-property-policy/asset-management/federal-real-property-profile-management-system-frpp-ms*

[12] Office of Management and Budget. (2023). Federal Budget's Climate Risk Exposure: A Preliminary Assessment and Proposed Framework for Future Assessments.

Table 10–2. TEST CASE NUMERIC RESULTS: PROJECTED ANNUAL REPLACEMENT VALUE EFFECTED BY FLOODING
(In million of dollars)

	100-Year Flood Event (1% Annual Chance)			500-Year Flood Event (0.2% Annual Chance)		
	Year 2022	Year 2052	Change: 2022 To 2052	Year 2022	Year 2052	Change: 2022 To 2052
Low (Exploratory; Not For Decision-Making Purposes)	$84	$94	$10	$23	$24	$2
Midpoint (Exploratory; Not For Decision-Making Purposes)	$171	$195	$25	$46	$49	$3
High (Exploratory; Not For Decision-Making Purposes)	$258	$297	$39	$70	$74	$5

Note: Analysis is an illustrative example of the process for developing projections, rather than an official Government estimate of the projected losses. These projections are not for decision-making purposes. Estimated replacement value effected is not a financial loss to the Federal Government.

timates have significant limitations, and the projected losses and exposure should be interpreted as preliminary and partial and not for decision making purposes. We can currently state with confidence that Federal facilities are exposed to flood risk. The numeric estimates in the tables of this section are for illustrative purposes only and are not for decision-making purposes, given we currently lack the data required to make robust exposure and loss projections.

To conduct this analysis, USGS overlaid the location of federally-owned facilities with flood hazard maps provided by First Street Foundation's Flood Model for 2022 and the mid-21st century.[13] The flood hazard maps generated by the First Street Foundation's Flood Model show the locations for both the projected one percent annual probability of flooding and 0.2 percent probability of flooding with projected flood depths. These flood hazard maps differ from those used in the flood risk assessment for Federal facilities within the 2023 President's Budget, which assessed current exposure and did not examine future climate risk. Additionally, while the assessment from the 2023 President's Budget examined the impact of Sea Level Rise (SLR), using the data underlying the NOAA Sea Level Rise Viewer[14] to determine at what level of SLR Federal facilities would experience inundation, for this year's assessment, NOAA provided projections of the risk of flooding based on recently published Federal projections of SLR.[15] These projections are provided for the years 2050 and 2100 and two SLR scenarios (Intermediate and Intermediate-High), representing potential circumstances where significant risk management and adaptation actions are necessary to avoid adverse impacts. This advances the analysis provided in last year's assessment by using the latest Federal projections for SLR for specific future time periods and identifying specific scenarios for SLR.

Table 10-2 shows the projected annual estimated replacement value effected for approximately 40 percent of Federal buildings from flooding. This table provides projected annual estimated replacement value effects for flood events that have the same annual chance of occurring in 2022 and 2052, which accordingly means that in 2052 an event with equivalent annual chance of occurring is expected to cause more flooding than in 2022. The estimated replacement value effects for a 100-year flood event are projected to increase between $10 million to $39 million annually by 2052, albeit there is immense uncertainty due to limitations of the climate financial risk models, hence the projections are not for decision-making. For a 500-year flood event, the effects are projected to increase $2 million to $5 million annually. The overall

[13] The flood hazard maps, which are for a "low" warming scenario thirty years into the future, are from a proprietary modeling.

[14] National Oceanic and Atmospheric Administration. Office of Coastal Management. (2022). Sea Level Rise Viewer. Retrieved from Digital Coast: *https://coast.noaa.gov/digitalcoast/tools/slr.html*

[15] Sweet, W.V., B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak, 2022: Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Waer Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. *https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nostechrpt01-global-regional-SLR-scenarios-US.pdf*

Table 10–3. TEST CASE NUMERIC RESULTS: ANNUAL PROJECTED REPLACEMENT VALUE EFFECTED BY SEA LEVEL RISE
(In million of dollars)

Scenario	Year	Projected Estimated Replacement Value
Intermediate (Exploratory; Not for Decision-Making Purposes)	2050	$72
	2100	$449
Intermediate High (Exploratory; Not for Decision-Making Purposes)	2050	$127
	2100	$1,786

Note: Analysis is an illustrative example of the process for developing projections, rather than an official Government estimate of the projected losses. These projections are not for decision-making purposes. Estimated replacement value effected is not a financial loss to the Federal Government.

projected estimated replacement value effect is smaller for a 500-year flood event relative to the projected effect under the 100-year flood event since the lower probability of the 500-year flood event (0.2 percent) more than offsets the greater severity and area covered of the 500-year flood relative to the 100-year flood. The estimated replacement value effect from SLR is projected between $72 million and $127 million for mid-century and between $449 million and $1.786 billion by the end of the century (see Table 10-3), albeit there is immense uncertainty due to limitations of the climate financial risk models – hence the projections are not for decision-making and are a gross underestimate of the cost. For example, following Hurricane Katrina, in only one year, $38 million was needed to repair more than 83 damaged Federal facilities. This shows that better data and modeling is needed to evaluate the true cost of climate change to Federal facilities.[16]

While this year's assessment on the flood risks to Federal facilities has made notable improvements relative to last year's assessment, there are still significant caveats to the analysis. The extent of future changes in flood risk has not been estimated across the full Federal inventory of real property. For instance, assets that were not assessed include national security-sensitive facilities and real property exempt due to the Freedom of Information Act (FOIA), which leaves approximately 40 percent of the real property in the Federal portfolio for the analysis within this assessment. Given that the FRPP MS public dataset is not intended to be used for analysis of site-specific risks and that climate science continues to evolve, there is a significant level of uncertainty in the projected flood risk and estimates. Additionally, it is noted that SLR is only one factor involved in coastal flooding, and these projections do not take into account the value of the services provided that would be impacted by flooding and SLR. As the data and science improve, future assessments will reevaluate available methods and accordingly may have substantial changes in projected exposure and estimates relative to this year's assessment.

Projected Impacts on Higher Temperatures on LIHEAP

The NCA4 examines the impacts of extreme heat on human health.[17] Extreme heat is tied to higher risks for multiple illnesses and death, especially for vulnerable populations, such as older adults, children, and pregnant women.[18] Heat-related illnesses include cardiovascular and respiratory complications[19], electrolyte imbalance, kidney stones[20], and premature birth.[21] Although cold-related deaths are projected to decline due to climate change, heat-related deaths are expected to increase.[22] These projected impacts highlight the importance of Federal programs that help mitigate the risks of temperature-related illnesses and deaths, such as LIHEAP.[23] LIHEAP provides households with financial assistance to offset energy costs. LIHEAP benefits target households with low incomes, particularly those that have a high home energy burden (percentage of income that goes to heating and cooling bills).

Chart 10-1 highlights how heating degree days and cooling degree days have changed over the last century for the continental United States.[24] Degree days are measures of how cold or warm a location is. A degree day compares the mean (the average of the high and low) outdoor temperatures recorded for a location to a standard temperature, usually 65 degrees Fahrenheit. The more extreme the outside temperature, the higher the number of degree days. A high number of degree days generally results in higher levels of energy use for space heating or cooling.[25] Heating degree days are equal to the annual sum of the greater of: 1) 65 degrees Fahrenheit minus the daily average temperature; or 2) zero. Cooling degree days are equal to the annual sum of the greater of: 1) the daily average temperature minus 65 degrees Fahrenheit; or 2) zero. When examining the 20-year moving averages for cooling degree days and heating degree days for the years 1915 versus 2022[26], cooling degree days have already increased in the United States by 20 percent, while heating degree days have decreased 12 percent.

[16] Congressional Research Service. (2007). General Servies Administration Federal Facilities Affected by Hurricane Katrina. *https://crsreports.congress.gov/product/pdf/RS/RS22281/14*

[17] Ebi, K.L., J.M. Balbus, G. Luber, A. Bole, A. Crimmins, G. Glass, S. Saha, M.M. Shimamoto, J. Trtanj, and J.L. White-Newsome, 2018: Human Health. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 539–571. doi: 10.7930/NCA4.2018.CH14

[18] Sarofim, M. C., S. Saha, M. D. Hawkins, D. M. Mills, J. Hess, R. Horton, P. Kinney, J. Schwartz, and A. St. Juliana, 2016: Ch. 2: Temperature-related death and illness. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment., U.S. Global Change Research Program, Washington, DC, 43–68. doi:10.7930/J0MG7MDX.

[19] Gronlund, C. J., A. Zanobetti, G. A. Wellenius, J. D. Schwartz, and M. S. O'Neill, 2016: Vulnerability to renal, heat and respiratory hospitalizations during extreme heat among U.S. elderly. Climatic Change, 136 (3), 631–645. doi:10.1007/s10584-016-1638-9.

[20] Ross, M. E., A. M. Vicedo-Cabrera, R. E. Kopp, L. Song, D. S. Goldfarb, J. Pulido, S. Warner, S. L. Furth, and G. E. Tasian, 2018: Assessment of the combination of temperature and relative humidity on kidney stone presentations. Environmental Research, 162, 97–105. doi:10.1016/j.envres.2017.12.020.

[21] Ha, S., D. Liu, Y. Zhu, S. S. Kim, S. Sherman, and P. Mendola, 2017: Ambient temperature and early delivery of singleton pregnancies. Environmental Health Perspectives, 125, 453–459. doi:10.1289/EHP97.

[22] Sarofim, M. C., S. Saha, M. D. Hawkins, D. M. Mills, J. Hess, R. Horton, P. Kinney, J. Schwartz, and A. St. Juliana, 2016: Ch. 2: Temperature-related death and illness. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment., U.S. Global Change Research Program, Washington, DC, 43–68. doi:10.7930/J0MG7MDX.

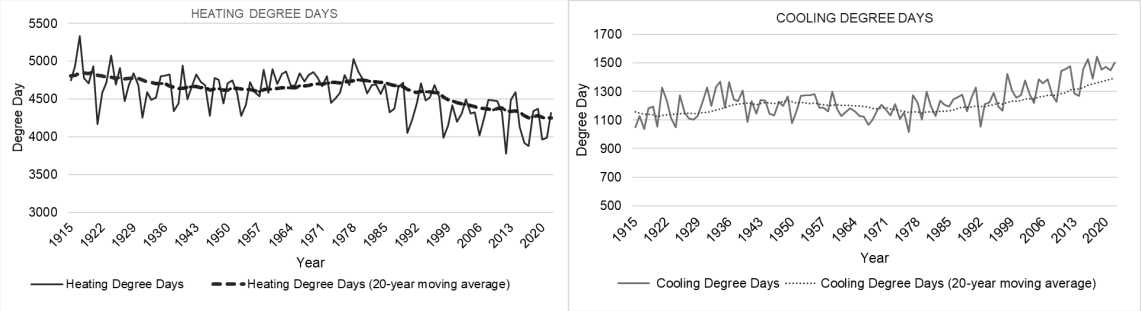
[23] 42 U.S.C. 8621 et seq.

[24] National Centers for Environmental Information, National Oceanic Atmospheric Administration, 2022. Climate at a Glance National Time Series. *https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/national/time-series/*

[25] Energy Information Administration. (n.d.). Units and calculators explained: Degrees days. *https://www.eia.gov/energyexplained/units-and-calculators/degree-days.php*

[26] The years included in the moving averages are (1896-1915) for 1915 and (2003-2022) for 2022.

Chart 10-1. Heating Degree Days and Cooling Degree Days for the Continental United States, 1915 – 2022[a]



[a] Heating degree days are equal to the annual sum of the greater of 1) 65 degrees Fahrenheit minus the daily average temperature or 2) zero. Cooling degree days are equal to the annual sum of the greater of 1) the daily average temperature minus 65 degrees Fahrenheit or 2) zero.

Source: National Centers for Environmental Information, National Oceanic Atmospheric Administration, 2022.

The increase of cooling degree days and decrease of heating degree days are projected to continue under different warming scenarios, also referred to as Representative Concentration Pathways (RCPs),[27] as shown in Chart 10-2. Under the RCP 4.5 emissions scenario, the 20-year average for heating days is projected to decline by 13 percent between 2039[28] and 2099[29], while number of cooling degree days increases by 20 percent for the same time period. For the RCP 8.5 emissions scenario, heating degree days are projected to decline by 30 percent, while cooling degree days are projected to increase by 65 percent. These trends may impact energy demand for heating and cooling, and in turn, the needs of LIHEAP. In addition to changes in the trends of cooling degree days and heating degree days, extreme weather events induced by climate change will continue to impact the needs of cooling and heating assistance, as the frequency, duration, and intensity of extreme weather events are projected to change over time.

In order to develop expenditure projections of LIHEAP that could be used for decision-making, there are several areas of research that need further development:

1. Underpin all perils risk with the most up to date climate modeling relying on expertise from NOAA, the National Labs, and industry experts.

2. Incorporate modeling on the costs of natural gas and other residential energy sources used for residential heating, and the transition to electrification.

3. Integrate LIHEAP grantees' design decisions into modelling.

4. Incorporate assumptions regarding population growth and interstate migration.

5. Analyze electrical grid stability to understand the ability of the current framework of utility distribution to handle increased demand for cooling.

While other aspects of the modeling could be developed, these items are essential to developing informative projections.

The Need for Action

The United States and the rest of the world has a narrow moment to pursue actions to avoid the most catastrophic impacts of the climate crisis. By reducing greenhouse gas (GHG) pollution from 2005 levels by 50 to 52 percent in 2030 and reaching net-zero emissions economy-wide by no later than 2050, we can do our part to avoid the worst and irreversible impacts of climate change.[30] The Administration, in partnership with the Congress' historic action under the Inflation Reduction Act of 2022 (Public Law 117-169) and the Infrastructure Investment and Jobs Act (Public Law 117-58), is taking a whole-of-Government approach to reduce emissions in every sector of the economy; increase resilience to the impacts of climate change; protect public health; conserve our lands, waters, and biodiversity; deliver environmental justice; and spur good paying union jobs and economic growth, especially through innovation, commercializa-

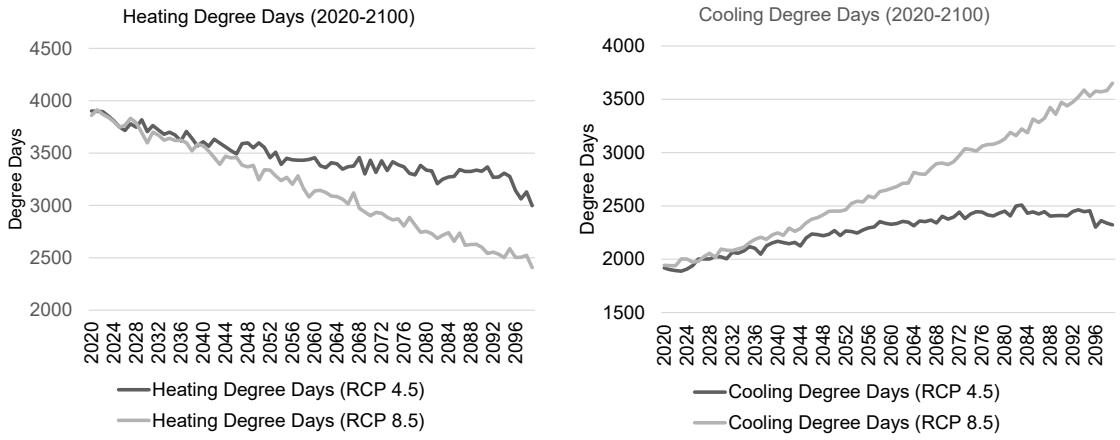
[27] RCPs are widely used in the climate research community to describe different climate futures and are based on the volume of greenhouse gases emitted. RCPs form the foundation for the majority of recent climate-related modeling efforts.

[28] 20 year average uses the years 2020-2039.

[29] 20 year average uses the years 2070-2099.

[30] *White House Fact Sheet: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies*. April 22, 2021.

Chart 10-2. PROJECTED Heating Degree Days and Cooling Degree Days for the Continental United States, 2020– 2100[a]



[a] Heating degree days are equal to the annual sum of the greater of 1) 65 degrees Fahrenheit minus the daily average temperature or 2) zero. Cooling degree days are equal to the annual sum of the greater of 1) the daily average temperature minus 65 degrees Fahrenheit or 2) zero.
Source: Coupled Model Intercomparison Project 5 (CMIP5), author's calculations

tion, and deployment of clean energy technologies and infrastructure. With that approach is a need to advance consistent, clear, intelligible, comparable, and accurate disclosure of climate-related financial risk, while taking near-term actions to reduce exposure to those risks.

The Inflation Reduction Act of 2022 is the single largest investment in climate and energy in history, delivering $370 billion in investments to tackle the climate crisis and strengthen American energy security. This law will increase U.S. clean energy deployment of solar, wind, battery storage, and more, creating good-paying jobs for American workers. A variety of rebates and tax incentives will help families save money on energy costs, including support for making home energy efficiency upgrades, installing new electric appliances or rooftop solar panels, and purchasing new or used electric vehicles. This law also provides grants, loans, and other programs to support cleaner industrial facilities, ports, and heavy-duty vehicles; community-led climate and environmental justice projects; and climate-smart agriculture and forestry. The savings, jobs, and other benefits provided by this legislation will provide tangible benefits to diverse communities across the Nation. These investments are more than paid for through this legislation, which reduces the deficit.

Additionally, the Infrastructure Investment and Jobs Act provides unprecedented levels of resources for upgrading the power grid, improving public transit and investing in zero-emission transit and school buses, installing a nationwide EV charging network, cleaning up legacy pollution, replacing lead pipes, and delivering clean water. This legislation also aims to strengthen the Nation's resilience and save taxpayer money, helping communities safeguard against extreme weather events, catastrophic wildfires, and other climate-related disasters—which last year caused more than $150 billion in damages from the biggest 20 weather and climate disasters alone.[31]

The 2024 Budget highlights several near-term budgetary needs that will both help reduce the Federal Government's long-term fiscal exposure to climate-related financial risk and reduce future climate risks for all Americans. In total, the Budget invests $52.2 billion in discretionary funding to tackle the climate crisis. This includes more than $15 billion to advance clean energy innovation and support emissions mitigation, and further U.S. competitiveness through innovative technologies that accelerate the transition to a net-zero emissions economy. $24 billion within the Budget is provided to strengthen climate resilience and adaptation efforts across the Federal Government. Investments to increase the resilience of ecosystems and communities to wildfires, flooding, and drought and better incorporate climate impacts into predisaster planning and infrastructure development ensure that the Nation is rebuilding smarter and safer for the future. OMB utilized the results of the FY23 Federal Budget Exposure to Climate Risk presented in Table 10-1 to sharpen our understanding of where the largest costs of climate change are to the Federal Budget. Based on the findings that crop insurance, coastal flooding, health insurance, and wildfires are expected to substantially increase the annual spending of the Government, the Budget proposes to reduce three out of four of those climate risks and in turn reduce the cost of climate change

[31] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2023). *https://www.ncei.noaa.gov/access/billions/*, DOI: *10.25921/stkw-7w73*

in the long-term. For example, the 2024 Budget includes: a new mandatory proposal to provide incentives to farmers through their crop insurance to plant cover crops to make their fields more resilient to climate change[32]; a discretionary request to provide long-term pay increases to wildland firefighters so we are better able to respond to and decrease climate risks; over $1.9 billion for the Corps of Engineers to address coastal and inland flood risks; $175 million for flood mitigation grants through FEMA; and a commitment to work with the Congress to determine the coastal areas most at risk of climate change where investments should be prioritized. In addition, the Budget also provides more than $500 million for FEMA's flood hazard mapping program, which will support the implementation of the Federal Flood Risk Management Standard, as well as continued modeling and data acquisition for current and future flood conditions.

The Administration has not only taken bold action to confront the financial risks created by the climate crisis, but turned it into an opportunity to advance environmental justice. Severe harms from climate change fall disproportionally upon socially vulnerable populations, and racial and ethnic minority communities are particularly vulnerable to climate impacts. The Budget supports communities that have been left behind by targeting investments to ensure that 40 percent of the benefits from tackling the climate crisis are directed toward addressing the disproportionately high cumulative impacts on disadvantaged communities. For instance, the Budget provides $160 million for the Demonstration of Industrial Decarbonization Technologies, which is a competitive solicitation managed by DOE to support the creation of at least two large-scale industrial decarbonization projects directly benefitting disadvantaged communities.

In summary, climate risk data shows us that if we fail to invest in climate change, we are failing at our responsibility to properly manage funding on behalf of tax payers. Near-term Federal investments to both mitigate GHG emissions and adapt to future climate scenarios can help reduce future financial burdens, but will rely on both congressional appropriations and Federal implementation to reduce those risks. Investments in climate adaptation can significantly reduce future risk exposure. Higher upfront climate adaptation costs will save taxpayers and the Federal Government in the long-term. On the other hand, business-as-usual investments could further exacerbate future climate risks. Additionally, more work is needed to identify and quantify the Federal Budget's exposure to climate change fiscal risk. For this reason, the Budget establishes a Climate-Related Risk Technical Support Center at the Department of the Treasury. The Center would develop, conduct, and integrate assessments on the Federal Government's climate-related risk exposure and facilitate climate risk data sharing across the Government and with the private sector. Better understanding and analysis is important for taking steps to mitigate the broad and urgent financial crises the Federal Government could face.

Establishing a Common Framework for Evaluating Climate-Related Financial Risks

The assessments from the 2023 President's Budget and this year provide policymakers and stakeholders a framework for the potential monetary impacts of climate change on Federal assets and programs and can inform action that reduces the Federal Government's exposure to climate-related financial risks taking into account the current limitations on Federal data and tools.

In order to meet the requirements of Section 6(b) of Executive Order 14030, "Climate-Related Financial Risks," in future years, we need a consistent and repeatable methodology to enable year-over-year comparisons, inform action to reduce climate-related financial risk to the Federal Budget, and improve understanding of the effect of actions agencies are taking to reduce these risks. To address this challenge, the White House established the Assessments of Federal Financial Climate Risk Interagency Working Group (AFFCR), which is led by OMB. The AFFCR is working on establishing a generalized framework for how the assessments of climate-related financial risk can be conducted and identifying and coordinating climate risk data across the Federal Government. This section of the chapter is organized into the following sections: 1) summary descriptions of the current approaches used by Federal agencies to assess climate-related risk to assets and programs; 2) a description of currently available climate data and information products necessary to conduct climate-related financial risk assessments; 3) an outline of proposed common framework for use across the Federal Government to assess climate-related financial risk and necessary technical inputs; and 4) a description of next steps the AFFCR is taking to further develop the common framework and technical capabilities necessary for future annual assessments of climate-related financial risk for the Federal Budget.

Current Approaches for Assessing Climate-Related Risks

Here we present two ongoing activities across the Federal Government to assess climate risk to assets, programs, or other activities within the Government. While these approaches do not necessarily seek to quantify financial risks, the methodological approaches inform and can be incorporated into the proposed common framework for climate-related financial risks.

Assessments Required for Agency Climate Adaptation and Resilience Plans: Many agencies within the Federal Government have developed quantitative measures to assess climate vulnerabilities; however, most agencies have not developed monetized estimates of climate-related financial risks.[33] Within and outside of the Federal Government, the quantification of climate-related financial risk is a burgeoning area of research and there has

[32] Department of Agriculture, Climate Hubs. (n.d.). "Cover Cropping to Improve Climate Resilience." *https://www.climatehubs.usda.gov/hubs/northeast/topic/cover-cropping-improve-climate-resilience*

[33] Gade, J.T., P.M. Seman, A.O. Pinson, A.K. Jordan, J.R. Arnold, B.A. Thames, P.S. O'Brien, C.A. Hiemstra, P.M. Loechl, K.D. White, and E.E. Ritchie. (2020). Department of Defense Climate Assessment Tool. Army Corps of Engineers: Washington DC.

not been previous Federal guidance quantifying climate-related financial risks. In response to Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad" and Executive Order 14030, agencies created Climate Adaptation Plans (CAPs) "to evaluate the most significant climate-related risks and vulnerabilities for agency operations and missions, and identify action to manage those risks and vulnerabilities."[34] For example, USDA and the Department of Health and Human Services (HHS) outline the vulnerabilities and climate adaptation planning for their programs, such as decreased agricultural productivity driven by climate change impacting the demand for USDA programs and expanding "existing climate change-related public health and biomedical research activities" overseen by HHS.[35, 36] As part of the CAPs, agencies also assessed the climate vulnerabilities to real property and have the development of quantitative metrics of climate vulnerabilities as part of their adaptation and resilience planning. The General Services Administration (GSA) is currently integrating environmental and climate justice factors to inform decisions related to real property. As part of GSA's climate adaptation planning, the agency also intends to quantitatively assess climate-related financial risk, and projects completion of this action by the end of 2026.[37] At many agencies, the offices responsible for developing the CAP are not necessarily connected to the offices responsible for long-term budget planning (e.g., the Office of the Chief Financial Officer (OCFO)), although some agencies—including GSA—have assigned climate risk disclosure responsibilities to the OCFO explicitly built into their CAP.[38]

Agency-Specific Qualitative Assessment Tools and Methods: In response to Executive Order 14008 and Executive Order 14057, "Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability", agencies have developed qualitative tools and assessments that assist the agencies in determining their climate vulnerabilities. These tools and assessments typically either provide highly detailed analyses for individual projects or are broad screening tools. The scope of most assessments undertaken to-date have included physical risk to assets (e.g., buildings and infrastructure).

Two examples of these tools include the Department of Defense (DOD) and Department of Homeland Security's (DHS) screening tools to assess exposure to climate-related risks for their assets and facilities. The DOD Climate Assessment Tool (DCAT) allows DOD personnel to identify the vulnerability—defined as exposure, sensitivity, and adaptive capacity—of installations. The tool makes use of both historical extreme events and climate change projections to determine the vulnerability of an asset and whether the vulnerability of the asset warrants further climate-related studies.[39] Similarly, DHS developed a qualitative questionnaire-based vulnerability assessment tool to assign vulnerability scores to agency assets.

While these tools are essential for climate adaptation and resilience planning, the tools are not designed to demonstrate the Federal Budget's exposure to climate change. In other words, while the tools assess climate risks to assets (e.g., whether a mission-critical asset is vulnerable to sea level rise), the tools do not monetize the climate risk of the agency. Further work is needed to develop this analytical capability.

Available Federal Data and Modeling – Climate Data

Federal agencies maintain a range of scientific data products that provide climate change projections for various analytical purposes and agency- or program-specific management decisions.[40] For non-Sea Level Rise projections, these products largely present statistically downscaled projections of Coupled-Model Intercomparison Project Phase 5 (CMIP5) climate model simulations.[41] Downscaling is a set of methods that translate large-scale Global Climate Models (GCMs) data into a finer spatial resolution that can be used for specific decision or management contexts.[42] The NCA4 provided a series of statistically downscaled scenario products covering the period through 2100 for the purpose of developing NCA4, and have been since used in Federal climate projection data products.[43] As noted below, GCM output, whether downscaled or not, does not provide information related to many hazards of interest, including flood, wildfire, sea

[34] Council of Environmental Quality—Office of the Chief Sustainability Officer. (n.d.). Climate Resilient Infrastructure and Operations. *https://www.sustainability.gov/federalsustainabilityplan/resilience.html*

[35] Department of Agriculture. (2021). Action Plan for Climate Adaptation and Resilience. *https://www.sustainability.gov/pdfs/usda-2021-cap.pdf*

[36] Department of Health and Human Services. (2022). 2021 Climate Action Plan. *https://www.sustainability.gov/pdfs/hhs-2021-cap.pdf*

[37] General Services Administration. (2022). GSA Climate Change Risk Management Plan: 2022 Progress Report. *https://www.sustainability.gov/pdfs/gsa-2022-cap.pdf*

[38] General Services Administration. (2022). Climate Change Risk Management Plan. *https://www.sustainability.gov/pdfs/gsa-2021-cap.pdf*

[39] Department of Defense. (n.d.) DOD Climate Assessment Tool. *https://media.defense.gov/2021/Apr/05/2002614579/-1/-1/0/DOD-CLIMATE-ASSESSMENT-TOOL.PDF*

[40] Examples include NASA Earth Exchange Downscaled Climate Projections (NEX-DCP30), DOI USBR Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections (Maurer, E. P., L. Brekke, T. Pruitt, and P. B. Duffy (2007), 'Fine-resolution climate projections enhance regional climate change impact studies', Eos Trans. AGU, 88(47), 504.), US Forest Service National Forest Climate Change Maps, USACE's Climate Hydrology Assessment Tool, DOT FWHA's Climate Data Processing Tool (based on DOI USBR downscaled CMIP5 projections).

[41] Taylor, K. E., R. J. Stouffer, and G. A. Meehl, 2012: An overview of CMIP5 and the experiment design. Bulletin of the American Meteorological Society, 93 (4), 485–498. doi:10.1175/BAMS-D-11-00094.1

[42] Climate Adaptation Science Centers-U.S. Geological Survey. (2021). "Data Spotlight: Downscaled Climate Projections to Inform Climate Research in the South-Central U.S. Region." *https://www.usgs.gov/news/data-spotlight-downscaled-climate-projections-inform-climate-research-south-central-us-region*

[43] Avery, C.W., D.R. Reidmiller, M. Kolian, K.E. Kunkel, D. Herring, R. Sherman, W.V. Sweet, K. Tipton, and C. Weaver, 2018: Data Tools and Scenario Products. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1413–1430. doi: 10.7930/NCA4.2018.AP3

level rise, tornadoes, or hurricanes. To assess risks related to these hazards, specialized hazard-specific models, driven by climate model output, are used.

Developing tools that support agencies' efforts to identify appropriate downscaled climate projections and the selection of climate scenarios relevant to an agency or program's specific vulnerabilities, risk profile, or planning timescale of interest remains an ongoing effort. The Consolidated Appropriations Act, 2022 (Public Law 117-103) directs the Office of Science and Technology Policy (OSTP) to develop guidance on the use of climate information and scenarios in Federal agency adaptation planning. This direction was repeated in the Consolidated Appropriations Act, 2023 (Public Law 117-328). The guidance will facilitate future updates to Federal Climate Adaptation Plans, consistent with Executive Order 14057, "Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability"; agencies should use these tools in identifying appropriate climate projections and resources for assessing climate-related financial risk to the Federal Budget. This forthcoming guidance should be considered when identifying appropriate climate projections for assessing climate-related financial risk to the Federal Budget. One recent tool, developed largely based on the NCA4 downscaled climate projections for screening level assessment, is the Climate Mapping for Adaptation and Resilience (CMRA) Assessment Tool.[44] CMRA was released in September 2022, as a joint effort among NOAA, the Department of the Interior (DOI), and the White House. In addition to showing past and current climate risk exposure, the tool presents statistically downscaled projections of climate variables from NCA4.[45] The scenarios are based on the RCP scenarios 4.5 and 8.5. The projections are provided for three epochs: Early Century (2015-2044), Mid Century (2035-2064), and Late Century (2070-2099).[46] Projections of climate variables in CMRA include:

- temperature projections, such as annual days above 95 degrees, average minimum temperature, and average maximum temperature;
- precipitation projections, such as average annual precipitation and annual number of days with measurable precipitation; and
- coastal inundation projections based on the results of the NOAA 2022 *Technical Report of Sea Level Rise*.[47]

Other currently available downscaled climate resources and tools from Federal agencies and partner organizations include, but are not limited to, the following examples:

- *U.S. Climate Resilience Toolkit* and *Climate Explorer*
- NOAA's *Sea Level Rise Viewer*
- *2022 Sea Level Rise Technical Report*[48]
- *Climate Risk and Resilience Portal (ClimRR)*
- *Climate and Hazard Mitigation Planning (CHaMP) Tool*
- *NASA's Sea Level Change Tool*
- *NASA's NEX-GDDP-CMIP6*

Other natural hazard exposure resources are provided below, although the projected hazard exposure may not be based on downscaled global climate models:

- *Drought.gov*
- *Heat.gov*
- *FEMA's National Risk Index*

In the fall of 2023, the Fifth National Climate Assessment (NCA5) will be released and projections used in the assembly of NCA5 can be used to update Federal climate data and decision-making tools. NCA5 will use downscaled datasets for the continental U.S. that is based on CMIP6. These updated tools should be used in future climate-related financial risk assessments, including for the 2025 President's Budget.

Available Federal Data and Modeling – Facility & Program Data

Agency data on assets and outlays are essential to conducting these analyses. For example, the Federal Real Property Profile Management System (FRPP MS) contains

[44] Climate Mapping for Resilience and Adaptation. *https://resilience.climate.gov/*

[45] Department of Commerce, National Oceanic and Atmospheric Administration. "Biden Administration launches portal to help communities assess exposure to climate hazards" (September 8, 2022) *https://www.noaa.gov/news-release/biden-administration-launches-portal-to-help-communities-assess-exposure-to-climate-hazards*

[46] Avery, C.W., D.R. Reidmiller, M. Kolian, K.E. Kunkel, D. Herring, R. Sherman, W.V. Sweet, K. Tipton, and C. Weaver, 2018: Data Tools and Scenario Products. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1413–1430. doi: 10.7930/NCA4.2018.AP3

[47] Sweet, W.V., B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak, 2022: Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. *https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nostechrpt01-global-regional-SLR-scenarios-US.pdf*

[48] Sweet, W.V., B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak, 2022: Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. *https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nostechrpt01-global-regional*

data of all Federal civilian real property owned, leased, or controlled by the Federal Government, with the exception of real property withheld for national security reason—for example, no DOD installations are included—or withheld due to a FOIA exemption.[49] The data is collected annually and provides an inventory snapshot of the real property held by the Federal Government. The FRPP MS includes data on the location of the asset, a score of the asset's condition, and replacement value.[50] While this data does provide a starting point for conducting analyses on the climate risks to Federal facilities, this data product was not established to screen federally-owned real property for physical risks. For example, accuracy of longitude and latitude are not guaranteed, as seen in the updated assessment on the flood risk to Federal Facilities. Future assessments on Federal real property may evaluate alternatives to the FRPP MS.

With respect to Federal programs, agencies maintain records of the outlays spent on individual programs, generally by fiscal year. Historical outlay data may or may not be required for projecting outlays under various climate scenarios. For example, the 2022 analysis on wildland fire suppression outlays did require historical outlays for the modeling, while the modeling for crop insurance premiums did not.[51] However, regardless of whether the historical outlays are used within the modeling directly, this data provides important context for whether or not the projected outlays are in an explicable range. In addition to the data outlined above, agency data other than expenditures and revenue may be used when conducting the analysis, such as acres burned by wildland fire published by the National Interagency Fire Center.[52]

In addition to the analysis presented earlier in this chapter, there are few sources of information on modeling the Federal Budget's exposure to climate risk. The 2022 white paper produced by OMB outlines how assessments were conducted for six programmatic areas: premium subsidies for the Federal Crop Insurance Program, Federal emergency relief for coastal disasters, Federal healthcare spending, Federal wildland fire suppression, Federal facilities' exposure to flood risk, and the National Flood Insurance Program.[53] Additionally, DOD assessed the flood risk to DOD installations, which will be included in an update to DODI 4165.70 Real Property Management.[54] While not specific to net outlays of the Federal Government, the Environmental Protection Agency's Framework for Evaluating Damages and Impacts (FrEDI) was released in 2021 and synthesizes the research of dozens of climate change studies conducted under the Climate Change Impacts and Risk Analysis (CIRA) project, which quantifies the economic damages in the U.S. by sector.[55] Economic damages by sector will not necessarily align with outlays or revenue losses of the Federal Government; however, FrEDI could be used for topics where there is compelling evidence that sectoral damages are correlated with Federal Government spending or revenues.

Proposed Common Framework to Assess Climate-Related Financial Risk for the Federal Budget

The assessment of the Federal Budget's exposure to climate change is comprised of analyses on federally-owned assets and specific Federal programs. In future years, the cost of changes in mission and operations could be further explored. These components will be assessed using a common structure and set of assumptions. The assessment will examine the impact of the physical risks of climate change. The physical risks are the direct result of the changes in climate on the current environment, such as increased frequency and intensity of natural disasters on infrastructure.[56] The other form of risk from climate change is transition risks, which are not examined in this assessment, although this is a potential area for further research.[57]

Generally, the Federal Budget's exposure to climate risk is measured as the projected change in real dollars of net outlays of the Federal Budget caused by climate change. By focusing on net outlays, this narrows the scope of what is examined relative to other economic analyses on the physical impacts of climate change. The literature on the Federal Budget exposure to climate change is limited, while there is a rich literature on the impacts of climate change on a wide variety of economic sectors. Unfortunately, there are only select programs where assuming the program's outlays will be proportional to economic losses of a particular sector is appropriate.

The Assessments of Federal Financial Climate Risks (AFFRC) Interagency Working Group is developing an overarching framework for assessing the climate-related financial risks to physical assets, programs, agency mission, or operations of the Federal Government. A common set of technical assumptions and climate data resources and climate scenarios will underpin these assessments. These common assumptions for future assessments could include common climate scenario options and time periods for assessing risks.

Physical Asset Risk: Climate change presents a significant risk to the Federal portfolio of physical assets

[49] U.S. General Services Administration. (n.d.). Federal Real Property Profile Management System (FRPP MS). *https://www.gsa.gov/policy-regulations/policy/real-property-policy/asset-management/federal-real-property-profile-management-system-frpp-ms*

[50] Ibid.

[51] Office of Management and Budget. Climate Risk Exposure: An Assessment of the Federal Government's Financial Risk to Climate Change. (April 2022) *https://www.whitehouse.gov/wp-content/uploads/2022/04/OMB_Climate_Risk_Exposure_2022.pdf*

[52] National Interagency Fire Center. (n.d.) Statistics. *https://www.nifc.gov/fire-information/statistics*

[53] Office of Management and Budget. Climate Risk Exposure: An Assessment of the Federal Government's Financial Risk to Climate Change. (April 2022) *https://www.whitehouse.gov/wp-content/uploads/2022/04/OMB_Climate_Risk_Exposure_2022.pdf*

[54] Department of Defense. (2022). DTM 20222-03 "Flood Hazard Area Management for DoD Installations" released 7 June 2022.

[55] Environmental Protection Agency. Technical Documentation on the Framework for Evaluating Damages and Impacts (FrEDI). (2021) U.S. Environmental Protection Agency, EPA 430-R-21-004. *https://www.epa.gov/cira/fredi*

[56] Financial Stability Oversight Council. Report on Climate-related Risks. (2021). *https://home.treasury.gov/system/files/261/FSOC-Climate-Report.pdf*

[57] Ibid.

(buildings, infrastructure, and other fixed capital), given the Federal Government is financially responsible for any damages from natural disasters that occur to its own assets. This also includes assets that are climate-sensitive, such as dams, irrigation infrastructure, and flood levees, that also present risks where they may under-perform (i.e., service reduction) due to a changing climate. Using an expected value approach to developing projections of annual losses to the Federal portfolio of physical assets requires three key pieces of information to formulate a dollar value of losses:

1. Exposure: Improving the estimated exposure of Federal assets requires accurate and transparent accounting of Federal real property, whether the information is held within the FRPP MS or another dataset held by individual agencies.

2. Frequency and intensity of climate-related events: The availability of widely accessible models for the frequency of climate-related events varies by the type of event and geography. For example, while the projected annual frequency of days over 100 degrees Fahrenheit under different climate scenarios is accessible from the downscaled data of NCA4, there are not easily available projections for the frequency of hurricanes under different climate scenarios.

3. Modeling of Losses: In many cases exposure to a climate stressor will not result in a complete loss of the physical asset, therefore, a model that translates the exposure and sensitivity of the asset and frequency, duration, and intensity of climate events to losses is needed. Options are currently limited in modeling of losses that could easily be applied, and this is an area in significant need of further research.

Expenditures of Federal Programs: The physical impacts of climate change on Federal programs can vary depending on the structure of the program. Certain programs experience greater outlays as a result of climate change. For example, this includes programs that respond to the physical risks of climate change, such as wildland fire suppression, Stafford Act Programs, and other Federal programs pertaining to emergency management. There are also programs that experience increased outlays, but the mission of the program is broader than responding to climate-related events. This includes Federal health care programs, which was described in last year's assessment. The NCA4 discusses the broad range of health impacts that are associated with climate change.[58] Given that in 2021, Medicare spending composed 21 percent ($900.8 billion) of total National Healthcare Expenditures and Medicaid composed $734.0 billion (17 percent)[59], there is sufficient evidence to assume that a significant portion of the increase in national health expenditures as a result of climate change would be absorbed by Federal healthcare spending.[60, 61] For credit programs, climate change may increase default risk of direct loans from the Federal Government and loans guaranteed by the Federal Government. Borrowers being unable to sufficiently recover financially from climate-related events could result in higher rates of delinquency and default. Some Federal programs may experience decreased revenue caused by climate change, particularly given that climate change can cause disruptions to trade and may cause economic losses to a wide range of industrial sectors.[62] Ongoing work responding to Section 6(a) in Executive Order 14030 will quantify the macro-economic costs of climate change and could be used in concert with other tools, to inform revenue projections. Lastly, some programs may have their efficacy impacted by climate change, but not experience higher outlays or decreased revenues; instead, the program may experience a fall in performance metrics, such as members of the public served. Below we provide three possible methods for projecting expenditures of Federal programs.

1. Comprehensive Modeling of Physical Damages and Expenditures: For certain programs, a comprehensive modeling structure may be considered, which would build on the common framework used across agencies. This would not only provide the Federal Budget exposure, but non-monetary outcomes of climate change as well. For example, the analysis on wildland fire suppression in the 2022 white paper provided projections of acres burned by wildland fire, in addition to the projections of outlays for wildland fire suppression from the Forest Service and DOI. Developing comprehensive modeling requires substantial investment by the Federal Government for an individual program since the modeling of the program mechanics are unlikely to translate to other

[58] Ebi, K.L., J.M. Balbus, G. Luber, A. Bole, A. Crimmins, G. Glass, S. Saha, M.M. Shimamoto, J. Trtanj, and J.L. White-Newsome, 2018: Human Health. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 539–571. doi: 10.7930/NCA4.2018.CH14

[59] Centers for Medicare & Medicaid Services. NHE Fact Sheet. (2022) *https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NHE-Fact-Sheet* accessed on February 8, 2023.

[60] EPA. 2017. Multi-model framework for quantitative sectoral impacts analysis: A technical report for the Fourth National Climate Assessment. U.S. Environmental Protection Agency, EPA 430-R-17-001. *https://www.epa.gov/cira/multi-model-framework-quantitative-sectoral-impacts-analysis*

[61] Tamma Carleton, Amir Jina, Michael Delgado, Michael Greenstone, Trevor Houser, Solomon Hsiang, Andrew Hultgren, Robert E Kopp, Kelly E McCusker, Ishan Nath, James Rising, Ashwin Rode, Hee Kwon Seo, Arvid Viaene, Jiacan Yuan, Alice Tianbo Zhang, Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits, The Quarterly Journal of Economics, Volume 137, Issue 4, November 2022, Pages 2037–2105, *https://doi.org/10.1093/qje/qjac020*

[62] Smith, J.B., M. Muth, A. Alpert, J.L. Buizer, J. Cook, A. Dave, J. Furlow, K. Preston, P. Schultz, and L. Vaughan, 2018: Climate Effects on U.S. International Interests. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 604–637. doi: 10.7930/NCA4.2018.CH16

Federal programs. For these models, the modeling will generally have three stages.

- Climate projections: Agencies will utilize guidance provided by the AFFCR on the selection and use of appropriate climate projections and associated variables to ensure consistency throughout the assessment.
- Physical damages of climate change: Agencies develop a model, if needed, that translates the climate projections into the physical impact of interest (e.g., acres burned by wildland fire, health impacts from poorer air quality, damage to infrastructure, buildings loss).
- Federal financial damage of climate change: Agencies develop a model that estimates the cost to the Federal Government based on the physical damages projected in the previous stage.

2. Modeling Expenditures Directly from Climate Variables: Given the resource intensity of developing comprehensive modeling for individual Federal programs, a more streamlined framework involves establishing a relationship between historical climate variables and outlays, then utilizing the relationship to develop projections of outlays under different climate change scenarios. Additionally, where there is a demonstrated relationship between program expenditures and climate variables, agencies could explore the possibility of using the correlation among Federal outlays of different programs to investigate whether the relationship between climate variables and the outlays of one Federal program can also be used to explain other programs. Method development would need to address suitable approaches for characterizing non-linear relationships between changes in climate variables and program expenditures.

3. Modeling Expenditures as a Proportion of Economic Damages: Where the outlays or losses of the Federal Program are assumed to be proportional to the sectoral damages projected in FrEDI. While this method would require the least amount of additional modeling, further research would need to be conducted to ensure that assuming outlays increase proportionally with economic damages to a particular sector included within FrEDI is reasonable.

Given the wide-diversity of Federal programs, there is no "one size fits all" approach, when developing projections of expenditure changes for individual programs, however the approaches discussed here would provide a common framework to build agency-or program-specific analyses. The AFFCR is exploring modeling approach options, including developing capability for comprehensive modeling of physical damages and expenditures, an approach to model expenditures directly from climate variables, and modeling expenditures as a proportion of economic damages.

Mission and Operational Risk: Mission and operational risk could both explicitly impact the outlays of the agency and impact performance, but rather cause the performance of the agency to decline given funding constraints. The risk to operations brought on by climate change is diverse. Impacts to mission and operations may include:

- disruptions in continuity of operation, including disruptions caused within supply chains of federally procured goods and services;
- loss of assets not owned by the Federal Government but of which the Federal Government has a vested interest in maintenance; and
- reduced ability to meet mission and functional performance. For example, climate-related risks to NASA's critical launch facilities or current technologies to assist in agricultural conservation decreasing in effectiveness due to climate change.

At this time the AFFCR is not actively establishing a framework for quantifying mission and operations risks; however, as data collection continues and research in this area may grow, the AFFCR will explore the feasibility of creating a framework for quantifying the impacts on operations and mission risk in the future.

Continued Work to Develop the Common Framework and Methodology for Future Assessments

The assessment included in this chapter presents advances in incorporating forward-looking projections of climate change and multiple approaches to estimate how changes in climate variables and natural hazards (e.g., flooding) relate to potential future risk to Federal assets and programs. This work has built on the continued growth of accessible climate information (e.g., NCA4 statistically downscaled projections, CMRA, flooding projections from Federal and external providers), and further work remains to link projections in changes to physical variables to Federal Budget decision contexts. To support future assessments, the AFFCR is working in several areas: 1) continuing to develop the common framework, provide technical guidance, and examples of implementation across a range of Federal assets and programs; 2) identifying necessary and emerging climate data and information resources, including projections of extreme weather events where information is currently unavailable (e.g., projecting physical impacts of tropical cyclones); and 3) increasing capacity and training of Federal agencies to conduct climate-related financial risk assessments.