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Global Changes
USACE GUIDE TO RESILIENCE PRACTICES

1. Purpose. Resilience is the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions. The U.S. Army Corps of Engineers (USACE) recognizes resilience as a fundamental characteristic of its systems and operations. This pamphlet provides a comprehensive record of examples for how USACE practices resilience across the organization to help guide USACE staff as they plan and implement resilience in their daily work.

2. Applicability. This pamphlet applies to all Headquarters U.S. Army Corps of Engineers (HQUSACE) elements, major subordinate commands, districts, laboratories, centers and field operating activities.

3. Distribution Statement. Approved for public release. Distribution is unlimited.

4. References. See Appendix A.

5. Records Management (Record Keeping) Requirements. Records management requirements for all record numbers, associated forms and reports required by this regulation are included in the Army's Records Retention Schedule – Army (RRS-A). Detailed information for all record numbers, forms, and reports associated with this regulation are located in the RRS-A at https://www.arims.army.mil.

6. Background and Overview.

a. The USACE Resilience Initiative began in 2015 with the purpose of mainstreaming resilience thinking, inventorying resilience activities, and developing an enterprise strategy for how USACE addresses resilience. A Resilience Project Delivery Team was formed and prepared the USACE Resilience Initiative Roadmap, identifying specific strategies and actions to undertake (USACE 2017a). Among the Roadmap's actions was preparation of a catalog of USACE resilience activities. This pamphlet supersedes earlier versions of the catalog previously developed.

b. This pamphlet demonstrates USACE's leadership in practicing and exemplifying resilience throughout the organization, within the Department of Defense, and externally.

USACE staff are encouraged to use the information contained here as resources and examples for themselves.

FOR THE COMMANDER:

JOHN P. LLOYD
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Chief of Staff

USACE GUIDE TO RESILIENCE PRACTICES

US Army Corps of Engineers

Cover photographs: Camp Humphreys, South Korea; Walter Washington Convention Center Alternate Care Facility, Washington, D.C.; Portugués Dam, Puerto Rico; Lake Borgne Surge Barrier, Louisiana

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Table of Contents

1.0 Introduction and Background

The U.S. Army Corps of Engineers (USACE) defines resilience as *the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions*. USACE has throughout its history practiced resilience through its diverse and wide-ranging Civil Works and Military Programs missions both at home and abroad. Resilience thinking is a fundamental enabler for USACE systems and operations to continue to provide their authorized services despite changing conditions and disruptions.

The *USACE Guide to Resilience Practices* provides a 'common operating picture' of USACE contributions to resilience. It serves as a benchmark, documenting resilience practices across the organization and at the project, system, and community levels. Section 2 provides background on multiple drivers for increased resilience. Section 3 provides examples of initiatives and practices performed within different USACE mission areas – Civil Works, Military Programs, and Research and Development. Section 4 discusses partnerships and forums that USACE has been a participant. Section 5 inventories common tools and methodologies used by USACE and others.

1.1 USACE Resilience Principles

USACE recognizes four principles of resilience: Prepare, Absorb, Recover, and Adapt; referred to as the *P-A-R-A Principles* (Figure 1.1). Individually, each principle guides actions to improve resilience. Together, the principles demonstrate the life cycle needed to maintain and ensure resilience, establishing a framework for understanding resilience across the organization. Detailed descriptions of each principle are provided in Table 1.1.

Figure 1.1 – USACE Resilience Principles

Table 1.1 – USACE Resilience Principles: Prepare, Absorb, Recover, and Adapt

Principle	Description
Prepare	To prepare is to plan, organize, equip, train, and exercise to build, apply, and sustain the capabilities necessary to prevent, protect against, ameliorate the effects of, respond to, and recover from damages to life, health, property, livelihoods, ecosystems, and national security. This principle includes all elements needed to be ready before, during, and immediately after a disruption or changing condition, and to make any changes deemed necessary. Prepare can include such activities as identifying primary threats; assessing risks; developing short-term, emergency, and long-term plans; training; and taking necessary actions in support of the developed plans.

Principle	Description
	Prepare considers all other principles – what is needed to absorb, recover, and adapt.
Absorb	To absorb means to receive a stress or endure change with minimal damage and without loss of normal functionality. Absorb includes actions needed to effectively 'take the punch,' including the immediate response function. Resilience thinking means to anticipate the disruption or changing condition occurring at some point, so individual components will withstand, resist, absorb, retreat, flood fight, emergency response, etc., so that the overall impact is absorbed in a prepared fashion and facilitates the desired recovery priorities.
Recover	To recover is to return to the previous state of functionality following a disruption or when conditions have changed. This principle includes meeting specific recovery goals, such as community-specific critical re-openings of schools or community centers within hours or days post-disruption and, ideally, to build back in a way that allows for less damage or disruption from similar future events.
Adapt	To adapt is to adjust built, natural, or social systems in anticipation of or in response to a disruption or new condition in a way that leverages beneficial opportunities and/or reduces negative impacts. With increasing uncertainty, interdependence, and risks, all solutions should be adaptable to some extent to be resilient. This includes accepting the current state (i.e. accommodating disruption without changing systems); being able to modify a solution to address the disruption or new condition; or being able to transition to an entirely new solution. This principle includes providing more adaptive capacity at all levels. Ideally, adaption elements are embedded in actions in each of the other resilience principles. Note, returning to a state of functionality may not necessarily lead to 100-percent restoration to pre-disruption conditions, since a community may: (1) be able to recover functionality without all the prior infrastructure; (2) the changed conditions may be semi-permanent, such as for climate change, indicating that the prior conditions cannot be fully restored; and/or (3) the community has adaptation actions prepared, thus, functionality may shift to the new areas.

1.2 Resilience Areas of Application

Resilience is often considered under varying scales and breadths. For example, USACE describes different levels or "spheres" of resilience as its areas of application (Figure 1.2). These three main levels of interdependent scales are Project, System, and Community. Conceptually, a project is comprised of multiple components, a system is composed of multiple projects, and a community is comprised of multiple systems. Resilience is applied differently and has different considerations among each of these areas. Accordingly, the role USACE plays in each of these areas of application varies.

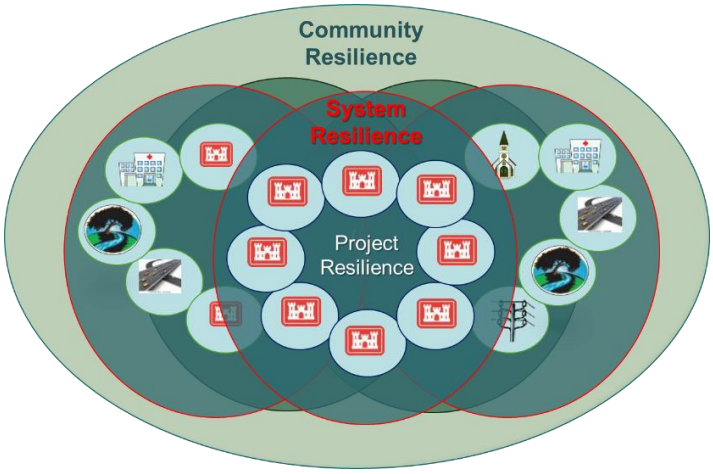

Figure 1.2 – USACE Spheres of Resilience

Table 1.2 – USACE Spheres of Resilience – Project, System, and Community

Sphere	Description
Project Resilience	A project is one component or group of components designed to serve a specific function. Examples of a project are a USACE lock and dam, a hospital, a bridge or a power plant. **Project resilience is the resilience of an individual project, independent of other projects in the vicinity.**
System Resilience	A system is an integrated whole comprised of multiple separable parts that can be defined geographically, technically, and/or politically, and for USACE, typically include natural and built environments (USACE 2015a). **System resilience is the ability of the whole "to withstand a major disruption within acceptable degradation parameters and to recover within an acceptable time and composite costs and risks." (Haimes 2008).**
Community Resilience	A community is a unified group of people who share goals, values or purposes. It generally functions under the authority of a specific governance structure and seeks to strengthen their resilience by working together with numerous partners" (USACE 2017a). A community is made up of many systems. **Community resilience is the manifestation of the resilience of the built, natural, and social systems that make up the community.**

Resilience activities may also be grouped into resilience types to distinguish unique characteristics of what they address. For example, ecosystem resilience relates to natural systems and within USACE typically refers to aquatic ecosystem restoration and environmental fields. Engineering resilience typically refers to resilient planning, standards, and construction techniques. Resilience can also be addressed as targeted initiatives, such as Installation Resilience; Energy Resilience; Infrastructure Systems Resilience; Critical Infrastructure Protection and Resilience; Climate Preparedness and Resilience; and Mission Assurance.

1.3 Resilience-Related Terms and Definitions

In addition to the terms and definitions discussed above, many other terms are also used at USACE when referring to resilience. These are discussed in the table below.

Table 1.3 – Additional USACE Resilience-Related Terms and Definitions

Term	Description
Framework	Frameworks provide a conceptual model and/or an overall construct for analysis. Guiding frameworks include the P-A-R-A Principles and the USACE Spheres of Resilience. Frameworks developed by USACE and others help communities of all sizes and scales better understand their challenges, develop possible solutions, and prioritize anticipated threats, changes, and actions in a structured manner.
Hazard	A hazard is a circumstance that increases the likelihood of danger or peril to life, property, or assets (USACE 2015a). Hazards addressed by USACE typically relate to infrastructure, natural systems, and water resources. Discrete occurrences that cause impacts over a relatively short time are often referred to in a number of ways – adverse event, catastrophic event, disruption, disturbance, emergency, incident, and shock (e.g., hurricane). The terms stress, challenge, and changing condition tend to describe more slowly evolving impacts (e.g., population shifts, climate change, etc.). Danger, risk, and threat can be synonymous with hazard and can be used in either time-horizon context; however, USACE usually refers to risk as an outcome of probability and consequences. In common language, a hazard may also be called a risk.
Indicator	Indicators are parameters for which we can assess magnitudes, extents, and/or trends. For USACE resilience, indicators provide information on the status or condition of resilience. Examples of resilience indicators include the percentage of infrastructure and facilities functioning after a disaster or the percentage of critical facilities functioning after a disaster. Leading indicators are also used to proactively assess the state or condition of a system prior to a potential disruptive event.

Term	Description
Metric	Metrics are qualitative or quantitative measurements or systems of measurements (e.g., index) that can be used to detect and assess changes in performance relative to objectives (USDOI 2015). Resilience often cannot be measured using a single unit metric or standard as it is dependent on many threats and can result in multi-dimensional consequences (Haines 2009). Metrics generally refer to things that we can measure directly, such as temperature or humidity.
Redundancy	Redundancy is the duplication of critical components of a system with the intention of increasing reliability of the system, usually in the case of a backup or fail-safe.
Resilience	USACE defines resilience as the ability to anticipate, prepare for and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions. Many other definitions are used by other organizations. These definitions are mostly similar though they are often tailored for specific applications.
Risk	Risk is a measure of the probability and consequence of uncertain future events and their outcomes. For USACE, risk is woven into every aspect of the P-A-R-A principles. Negative outcomes may be mitigated by decreasing the probability of an undesirable disturbance or reducing the consequence should the disturbance occur.
Robustness	Robustness is the ability of a system to continue to operate correctly across a wide range of operational conditions with minimal damage, alteration, or loss of functionality, and to fail gracefully outside of that range; the wider the range of conditions allowing good performance, the more robust the system.
Sustainability	USACE defines *sustainable solutions* as solutions that balance environmental, economic, and social impacts to meet present needs without sacrificing the ability of future generations to meet their needs. In theory, sustainable solutions are also resilient in that they can withstand disruptions and continue to function. In practice, USACE pursues sustainability in several tangible ways. To comply with federal requirements, the agency is subject to mandates to conserve resources, including energy, water, and other items. USACE also implements other initiatives that help achieve sustainability including asset management, risk-informed decision making, stakeholder collaboration, and other practices.
Tool	A tool in the context of USACE resilience is an analysis methodology or mathematical model used to design a component, calculate risk, or measure a particular function. Tools address specific processes and result in discrete outcomes to support analyses.

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2.0 RESILIENCE DRIVERS

2.1 Introduction

Resilience is not a new concept at USACE although applications have evolved over the years. Among the agency's earliest missions was the construction of military fortifications and the clearing of waterways for defense. National security strongly depended on resilience measures provided by USACE. As an outgrowth of earlier accomplishments and growth of the agency, USACE assumed key roles in ensuring the nation's economic resilience, initially through its navigation mission and later incorporating flood control, hydropower, and other civil works and military missions.

This section discusses recent major drivers that have supported resilience and specific mandates that have required improvements.

2.2 Chronology of Drivers for Increased Resilience

The following is a chronology of major resilience drivers within USACE, beginning with actions following Hurricane Katrina in 2005 and continuing through the present day.

Hurricane Katrina (2005)

Following Hurricane Katrina in 2005, an interagency panel was formed to study failures in the New Orleans and Southeast Louisiana Hurricane Protection System. The panel determined that the "lack of resilience to overtopping significantly increased flooding and resultant losses". The panel emphasized that planning and design methods must also be more systems-based, allowing greater analyses for how structures work alongside other measures to ensure performance of the entire system. This included greater consideration of enhanced natural environments "to deal with the dynamics of climate, demographics, and social and economic well-being". (IPET 2008).

USACE initiated the Actions for Change (AFC) program in 2006, due in part to lessons learned from Hurricane Katrina. The AFC program laid out a comprehensive systems approach intended in part to "review and recommend policies, methods, and technologies to champion adaptive management, responses to dynamic temporal and spatial system changes that introduce uncertainty and reduce resilience…".

In 2007, the AFC program specifically addressed resilience in the context of climate change through the Responses to Climate Change (RCC) program. RCC's goals included better understanding of responses to dynamic temporal and spatial system changes, to increase the agency's ability to manage uncertainties affecting systems and to improve resilience in unforeseen circumstances.

Lessons learned from Hurricane Katrina were applied in the planning and design of the $14 billion Greater New Orleans Hurricane and Storm Damage Risk Reduction System. USACE worked very closely with communities through public meetings, briefings, workshops, and discussions with business leaders. These engagements sought to ensure that residual risk, roles and responsibilities and community resilience needs beyond the system were communicated and

understood. Inundation maps, other risk communication tools and the evaluation of resilience planning played a significant part in the success of this collaborative approach.

Presidential Policy Directive (PPD) No. 8, National Preparedness (2011)

Presidential Policy Directive PPD-8, National Preparedness, issued by the Executive Office of the President (EOP), aims at "strengthening the security and resilience of the United States through systematic preparation for the threats that pose the greatest risk to the security of the Nation, including acts of terrorism, cyber-attacks, pandemics, and catastrophic natural disasters." PPD-8 defines resilience as "the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies." (EOP 2011a).

PPD-8 directs federal departments and agencies to work with whole communities to develop a national preparedness goal and a series of frameworks and plans related to reaching the goal. The Department of Homeland Security (DHS) / Federal Emergency Management Agency (FEMA) was tasked to coordinate this effort, resulting in the following components:

- The National Preparedness Goal was established as "a secure and resilient nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk." The goal identifies 32 core capabilities necessary to prepare for specific types of incidents. Examples of capabilities include operational coordination; threats and hazards identification; infrastructure systems; economic recovery; natural and cultural resources; and community resilience.
- The National Preparedness System outlines an organized process for the nation to move forward with preparedness activities.
- National Planning Frameworks define how agencies work together to best meet the National Preparedness Goal. Frameworks have been developed for each of five preparedness mission areas: National Prevention Framework; National Protection Framework; National Mitigation Framework; National Response Framework; and National Disaster Recovery Framework.
- An annual National Preparedness Report documents the progress made toward achieving the goal.
- Federal Interagency Operations Plans to demonstrate how federal efforts can work together to support state and local plans.
- A comprehensive coordinated effort to build and sustain national preparedness.

Hurricane Sandy (2012)

Following Hurricane Sandy in 2012, USACE prepared together with the National Oceanic and Atmospheric Administration (NOAA) a set of Infrastructure Systems Rebuilding Principles (NOAA and USACE 2013). The primary objective of the principles was to "help rebuild more resilient and sustainable coastal communities that can adapt to and better mitigate the impacts of coastal hazards." USACE subsequently issued a technical guide entitled *Coastal Risk Reduction and Resilience: Using the Full Array of Measures*, outlining how the agency reduces risks and improves resilience through an integrated approach, drawing from an array of coastal measures.

In 2015, USACE released the *North Atlantic Coast Comprehensive Study (NACCS)*, identifying regional opportunities to increase resilience in high risk areas (USACE 2015a). The study built on previous lessons learned and brought to bear the latest scientific information available for state, local and tribal planners. NACCS included a Coastal Risk Management Framework to serve as a common approach for identifying risks and determining coastal management strategies and measures. NACCS also identified nine specific coastal areas warranting further analyses through individual feasibility studies and environmental impact statements.

Executive Order (EO) 13636, Improving Critical Infrastructure Cybersecurity and PPD-21, Critical Infrastructure Security and Resilience (2013)

Executive Order 13636 and PPD-21 set forth national policy to strengthen the security and resilience of critical infrastructure against evolving threats and hazards. Recognizing that critical infrastructure must be secure and able to withstand and rapidly recover from all hazards, EO 13636 and PPD-21 called for an updated and overarching national framework that reflects the increasing role of cybersecurity in securing physical assets.

- PPD-21 advances a national unity of effort to strengthen and maintain secure, functioning, and resilient critical infrastructure – including assets, networks, and systems – that are vital to public confidence and the nation's safety, prosperity and well-being.
- EO 13636 promulgates the integration of physical and cyber security planning and directs the federal government to coordinate with critical infrastructure owners and operators to improve information sharing and collaboratively develop and implement risk-based approaches to cybersecurity.

As an owner and operator of a large portfolio of infrastructure, USACE is actively developing and implementing an integrated physical and cybersecurity risk management framework to address physical and cyber vulnerabilities. (EOP 2013a, 2013b).

U.S. Army Energy Security & Sustainability (ES2) Strategy (2015)

The U.S. Army released a strategic roadmap to future energy security and sustainability called the Energy Security and Sustainability (ES2) Strategy. This document is intended to foster a more adaptable and resilient force, and prepare for a future defined by complexity, uncertainty and rapid change. The strategy outlines five goals: inform decisions, optimize use, assure access, build resilience and drive innovation. The document emphasizes energy and includes recognition of water and land as equally essential resources. (U.S Army 2015a).

Assistant Secretary of the Army Installations, Energy & Environment Strategy 2025 (2015 and 2016)

The Office of the Assistant Secretary of the Army for Installations, Energy and Environment (ASA(IE&E)), released in 2015 its Installations, Energy, and Environment Strategy 2025, which was then updated in 2016. The Strategy specifies the ASA(IE&E)'s vision to "Enhance Army mission effectiveness and resilience in a prudent, efficient, and forward-thinking manner." The Strategy focuses on supporting Army missions by providing the land, facilities, and infrastructure needed by soldiers and families. USACE Military Programs closely aligns with this strategy, recognizing the operational necessity of ensuring the land, water and airspace needed to sustain readiness. (U.S. Army 2015b and 2016).

Three key business drivers are identified in the IE&E Strategy, including: Installations; Energy and Sustainability; and Environment, Safety, and Occupational Health. The targeted outcome of the Energy and Sustainability driver is a "ready and resilient Army, strengthened by secure access to energy, water, and land resources," and among the outcome's five goals is to "assure access" and "build resiliency".

Department of Defense (DoD) Directive 4715.21, Climate Change Adaptation and Resilience (2016)

DoDD 4715.21 requires DoD to be able to adapt to current and future operations to address the impacts of climate change in order to maintain an effective and efficient U.S. military. Mission planning and execution must include identification and assessment of the effects of climate change on the DoD mission; taking those effects into consideration when developing plans and implementing procedures; and anticipating and managing any risks that develop as a result of climate change to build resilience. (DoD 2016).

Guiding Principles for Sustainable Federal Buildings and Associated Instructions (2016)

The Guiding Principles for Sustainable Federal Buildings and Associated Instructions (Guiding Principles) was issued by the White House Council on Environmental Quality (CEQ) in 2016, superseding an earlier set of principles issued in 2008. The Guiding Principles are applicable to both new and existing federal buildings. They seek to: reflect the evolution of sustainable building design, construction, and operating practices; increase the economic and environmental benefits of federal investments in facilities; enhance occupant health, wellness, and productivity; include climate resilience in building design, construction, and operations, and protect Federal facilities investments from the potential impacts of climate change; and provide information on tracking agency green building performance. (CEQ 2016).

EO 13783, Promoting Energy Independence and Economic Growth (2017)

EO 13783 aims to promote clean and safe development of domestic energy resources, including coal, natural gas, nuclear material, flowing water, and other sources. It requires federal agencies to review regulations that may unduly burden the development of these resources beyond the degree necessary to protect the public interest or otherwise comply with the law. (EOP 2017a).

Hurricanes Harvey, Irma, and Maria (2017)

Following Hurricanes Harvey, Irma, and Maria, the Bipartisan Budget Act of 2018 provided $17.4 billion in funding for disaster recovery in six appropriations accounts: Investigations; Construction; Mississippi River and Tributaries; Operation and Maintenance; Flood Control and Coastal Emergencies; and Expenses. Among activities funded in the Investigations account is the South Atlantic Coastal Study (SACS). The SACS is currently being performed and is structured similar to NACCS, which was performed for the north Atlantic coast following Hurricane Sandy. SACS focuses on coastal regions within the jurisdiction of USACE's South Atlantic Division.

EO 13834, Efficient Federal Operations (2018)

EO 13834 aims to focus federal agency energy and environmental efforts on meeting statutory requirements that increase efficiency, optimize performance, eliminate unnecessary use of resources, and protect the environment. The EO instructs agencies to prioritize actions that reduce waste, cut costs, enhance the resilience of Federal infrastructure and operations, and

enable more effective accomplishment of missions. Many of these actions are specified in statutes such as the Energy Policy Act of 2005 (EPAct) and the Energy Independence and Security Act of 2007 (EISA). EO 13834 revokes EO 13693, Planning for Federal Sustainability in the Next Decade, which included specific annual targets for resource conservation. (EOP 2018).

DoD Directive (DoDD) 3020.40 Change 1, Mission Assurance (2018) and Instruction (DoDI) 3020.45, Mission Assurance Construct (2018)

The DoD Mission Assurance (MA) Strategy defines MA as "a process to protect or ensure the continued function and resilience of capabilities and assets - including personnel, equipment, facilities, networks, information and information systems, infrastructure, and supply chains - critical to the performance of DoD Mission-Essential Functions (MEFs) in any operating environment or condition." (DoD 2018a).

The MA Strategy addresses manmade threats as well as naturally occurring hazards and technological failures. MA leverages existing protection and resilience programs, including but not limited to, antiterrorism, physical security, defense critical infrastructure, and information assurance.

DoDD 3020.40 Change 1 was issued in 2018 and assigns responsibilities to meet the goals of refining, integrating, and synchronizing aspects of DoD security, protection, and risk-management programs that directly relate to mission execution as described in the MA Strategy. USACE's MA program resides in the Installation Readiness Division under Military Programs.

DoDI 3020.45 was issued in 2018 and establishes the MA Construct within DoD for identifying, assessing, managing, and monitoring risks to strategic missions. Risks include those to U.S. interests identified in the National Defense Strategy and military risks in the National Military Strategy. (DoD 2018b, DoD 2018c, JCS 2018).

National Defense Authorization Act (NDAA) for Fiscal Year 2018 (2018)

NDAA 2018 establishes requirements for military installations around climate preparedness and energy resilience. This includes reporting to Congress on vulnerabilities to installations resulting from climate change and identifying the most vulnerable installations to each military service based on rising sea tides, increased flooding, drought, desertification, wildfires, thawing permafrost and other categories. These requirements primarily apply to USACE Military Programs activities.

NDAA 2018 also requires DoD to ensure the readiness of the armed forces for their military missions by pursuing energy security and energy resilience. Energy security is defined as having assured access to reliable supplies of energy and the ability to protect and deliver sufficient energy to meet mission essential requirements. Energy resilience is defined as ability to avoid, prepare for, minimize, adapt to, and recover from anticipated and unanticipated energy disruptions in order to ensure energy availability and reliability sufficient to provide for mission assurance and readiness, including task critical assets and other mission essential operations related to readiness, and to execute or rapidly reestablish mission essential requirements. (NDAA 2018).

DoD Instruction (DoDI) 8500.01 Change 1, Cybersecurity (2019)

DoDI 8500.01 requires DoD to implement a multi-tiered risk management process for the cybersecurity of information technologies. Systems must be planned, developed, tested, implemented, evaluated, and operated to ensure operational resilience. This includes limiting access to only authorized users; making security posture visible and understood by mission owners and network operators; and allowing components to reconfigure, optimize, self-defend, and recover with little or no human intervention. (DoD 2019a).

EO 13865, Coordinating National Resilience to Electromagnetic Pulses (EMPs) (2019)

EO 13865 aims to "foster sustainable, efficient, and cost-effective approaches to improving the Nation's resilience to the effects of EMPs." The EO directs DoD to work with relevant agencies and others to improve and develop the ability to rapidly characterize, attribute, and provide warning of EMPs; conduct research and development (R&D) and testing to understand the effects, improve capabilities to model and simulate, and develop technologies to protect DoD systems and infrastructure from the effects of EMPs; review and update existing EMP-related standards; share technical expertise and data regarding EMPs and their potential effects; incorporate attacks that include EMPs as a factor in defense planning scenarios; and defend the Nation from adversarial EMPs through defense and deterrence. (EOP 2019).

AD 2020-08, U.S. Army Installation Policy to Address Threats Caused by Changing Climate and Extreme Weather (2020)

Army Directive 2020-08 requires Army installations with the exception of contingency bases and Civil Works facilities to assess, plan, and adapt to projected impacts of changing climate and extreme weather by adding the results of climate change prediction analysis tools into all facility and infrastructure-related plans, policies, and procedures. In support of AD 2020-08, USACE prepared the Army Climate Resilience Handbook, leveraging its Army Climate Assessment Tool, which provides climate change impact information at the installation, command, and headquarters levels and is specifically developed for use in screening-level assessments. (U.S. Army 2020a, 2020b and 2020c).

Army Installations Strategy: Supporting the Army in Multiple Domains (2020)

The Army Installations Strategy outlines how Army installations are to transform by 2035 into platforms ready for Multi-Domain Operations (MDO) while protecting, supporting, and enabling the Total Army. The Strategy guides Army actions to achieve the following end state: Modern, resilient, sustainable installations, enhancing strategic readiness in a contested MDO battlespace, while providing quality facilities, services, and support to our Soldiers, Families, and Civilians. The Strategy recognizes "the homeland is no longer a sanctuary" and that Army activities in the homeland and on installations are at increasing risk of disruption and attack. Specific strategic outcomes and lines of effort are detailed in the Strategy. (U.S. Army 2020d).

Army Directive (AD) 2020-03, Installation Energy and Water Resilience Policy (2020) and Army Installation Energy and Water Strategic Plan (2020)

Army Directive 2020-03 establishes energy and water resilience requirements for Army installations in support of the 2018 National Defense Strategy and Army Vision. Army installations do not include facilities primarily used by USACE Civil Works. To reduce mission

risk, the Army prioritizes providing resilient energy and water supplies, facilities, and infrastructure that support critical missions. Among the directive's requirements, critical missions must be capable of withstanding an extended utility outage for a minimum duration of 14 days unless otherwise stipulated. AD 2020-03 superseded AD 2017-07 Installation Energy and Water Security Policy (U.S. Army 2017 and 2020e).

The Army Installation Energy and Water Strategic Plan establishes the vision for "Army installation energy and water infrastructure supporting critical missions in the Strategic Support Area is resilient, efficient, and affordable." Three goals are outlined: Resilience – Ensure energy and water for critical missions under all conditions: Efficiency – Optimize energy and water use effectively and sustainably to meet requirements; and Affordability – Manage energy and water cost to enable the Army to refocus investment. Strategic objectives, specific targets, and timelines are provided for each goal. (U.S. Army 2020f).

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3.0 RESILIENCE PRACTICES

3.1 Introduction

The U.S. Army Corps of Engineers (USACE) practices resilience in many ways. Resilience is inherent in much of what the agency does daily through its main mission areas: Civil Works, Military, Environmental, Emergency Management, and Research and Development. There are also many efforts to continually improve on resilience throughout the organization. This section provides just a few examples of how resilience is practiced and pursued in different business lines, Communities of Practice, and various other programs and initiatives throughout the organization.

3.2 USACE Resilience Practices in Civil Works

Civil Works (CW) programs span a range of water resource development activities including flood risk management, navigation, ecosystem restoration, hydropower, water supply, recreation, infrastructure and environmental stewardship, and broad emergency response. All of these activities contribute to the Nation's resilience.

CW programs and initiatives that contribute to resilience include, but are not limited to, the following:

1. Asset Management
2. Beneficial Use of Dredged Material
3. Climate Preparedness & Resilience
4. Critical Infrastructure Protection
5. Dam & Levee Safety Programs
6. Emergency Management
7. Environmental Compliance and Sustainability
8. Environmental Stewardship
9. Floodplain Management Services
10. Hydropower
11. National Flood Risk Management Program
12. Navigation
13. Planning Assistance to States
14. Project Planning
15. Recreation
16. Regulatory
17. Water Supply
18. Water Management

The following pages provide brief descriptions of each of the CW programs and initiatives listed above.

3.2.1 Asset Management

The CW Asset Management effort is an integral part of the USACE Infrastructure Strategy (UIS). Asset Management aligns with ISO 55000 principles and industry best practices, adapted

to the unique multi-mission and public features of CW infrastructure, to develop and deploy a comprehensive systems-based approach to help the Corps better plan, manage, and prioritize infrastructure investments. The goal of this effort is to achieve more relevant, resilient, and reliable performance across the CW portfolio to strengthen the economy, gain national energy independence, improve quality of life, reduce risks and bolster global competitiveness.

Asset Management tools and processes support maintenance management, operational condition assessments, operational risk assessment, and budget prioritization as well as the associated tools and processes applicable to each. It also provides specific approaches necessary to fully integrate across CW functional areas along with project life cycle elements using a system-based approach. These are intended to help optimize the use of limited resources to buy down life cycle performance risk for CW infrastructure by using a risk-based approach to focus strategic investments on the most mission critical infrastructure assets/components that:

- are in the worst condition;
- have the highest likelihood of failing and impacting mission delivery; and
- cause the highest adverse impact to the public and the nation.

USACE is currently in the process of implementing Operations & Maintenance (O&M) 20/20 as its core framework for organizing, prioritizing, and ranking work packages. O&M 20/20 provides CW with a process that is defensible and transparent, allowing decisions to be made across business lines based on relative risk and value.

The use of innovative asset management approaches considers the entire collection of USACE assets across all business lines and identifies which investments achieve the best levels of performance. Applying this life cycle approach across all Civil Works infrastructure systems allows USACE to better prioritize limited funding and make improved investment choices at key decision points throughout the complete life cycle of a project and enable higher return from investment decisions for Civil Works infrastructure.

More information on Asset Management can be found at:
https://operations.erdc.dren.mil/asset.cfm.

3.2.2 Beneficial Use of Dredged Material

USACE dredges more than 200 million cubic yards of sediment annually from the bottom of federally-constructed and maintained navigation channels to maintain safe passage for vessels. The dredged material consists of rock, gravel, sand, silt, clay, and organic matter. Locating suitable placement sites for this large volume of material is a continual challenge and increasingly expensive. USACE is increasingly implementing beneficial use practices for the dredged sediment.

One of the most common beneficial uses for dredged material is as substrate for habitat development. Other beneficial uses include agriculture, horticulture, aquaculture, forestry, strip mine reclamation, solid waste landfill, harbor and port development, and fill for many other types of projects (USACE 2015b). The material has been used to enhance coastal wetlands through marsh creation, wetland nourishment, barrier island restoration, ridge restoration and

other techniques, including regional sediment management practices. These activities can serve to repair damaged marine and coastal ecosystems, and to increase their resilience to future storms.

Overall, about 10-15 percent of dredged material requires special handling, while the remaining 85 percent is available for beneficial use. Of this amount, approximately 30-35 percent is currently used beneficially.

More information on beneficial use of dredged material can be found at https://budm.el.erdc.dren.mil/.

3.2.3 Climate Preparedness & Resilience

The mission of the Climate Preparedness and Resilience Community of Practice (CPR CoP) is to support the overarching USACE Climate Change Adaptation Policy Statement, which states that "mainstreaming climate change adaptation means that it will be considered at every step in the project life cycle for all USACE projects, both existing and planned…to reduce vulnerabilities and enhance the resilience of our water-resource infrastructure." (USACE 2014a and 2014b).

The CPR CoP also addresses other global changes that can impact USACE missions and operations, such as land use/land cover changes, demographic changes, socioeconomic changes, and other complex changes that interact with climate change and must be considered together in a comprehensive systems approach.

Examples of resilience efforts supported by the CPR CoP include the following:

- Policy and technical guidance, including ER 1100-2-8162 and EP 1100-2-1, ensure that USACE missions, operations, programs and projects are resilient to coastal climate change effects, beginning with sea level change. This requires impact evaluations and the development of adaptation measures to account for changing sea levels for every USACE coastal activity as far inland as the extent of the estimated tidal influence. It is applicable to the full range of USACE projects and systems, from simple to complex, from small to very large, and over the full life cycle.

  Note: Though commonly depicted as a slow, linear process, sea level change is actually a series of episodic events that disrupt coastal areas and require constant adjustments. Specific examples of resilience resulting from this policy and guidance include:
  - Beach renourishment projects that adjust nourishment intervals to reflect accelerating rates of sea level change to sustain functional performance.
  - Ecosystem restoration projects for coastal wetlands that include pathways for the migration of wetlands due to changing sea levels to allow for continued provisioning of ecosystem services over the long-term.
  - Coastal navigation projects that consider the effects of changing sea levels and adjust critical features as appropriate to reflect accelerating rates of sea level change to maintain reliability and performance.

- Policy and technical guidance incorporate climate change information in hydrologic analyses considering observed changes over time as well as potential future changes to relevant hydrologic inputs. This includes consideration of abrupt and slowly varying changes in hydrologic processes due to nonstationarity, where the statistical characteristics of hydrologic data series are not constant through time (i.e., the envelope of variability in the past does not represent the future).

- Climate change information synthesized and evaluated during qualitative analyses can inform the decision process related to future without-project conditions, formulation and evaluation of alternative plans, or other decisions related to project planning, engineering, operations and maintenance. These actions reduce vulnerabilities and enhance the resilience of our water resources infrastructure. (USACE 2013, USACE 2019a).

- Support to Department of Army and Department of Defense climate resilience. Department of Defense (DoD) installations have suffered billions of dollars in damages due to extreme weather events, such as coastal and riverine flooding, hurricane damage, severe erosion and permafrost land degradation, wildfire, drought, and temperature extremes. Impacts caused by extreme weather events have caused and will likely continue to cause direct and indirect operational impacts to Army mission activities, health and safety of soldiers and staff, infrastructure, and security. Identifying the degree and timing of these climate risks to the installation mission is the critical first step in incorporating climate resilience in installation plans, including master plans, installation energy and water plans, and integrated natural resource management plans. CPR CoP teams prepared an Army Climate Assessment Tool and accompanying Army Climate Resilience Handbook (U.S. Army 2020b and 2020c) at the direction of the Assistant Secretary of the Army (ASA) for Installations, Energy, and Environment (IE&E). A similar tool has been developed for DoD with release expected in 2021.

More information on the Climate Preparedness and Resilience CoP can be found at: https://www.usace.army.mil/corpsclimate.

3.2.4 Critical Infrastructure Protection

USACE owns and operates a significant amount of critical infrastructure, the failure of which could result in significant loss of life and severe economic impact. USACE has recognized the need to identify, assess, and control risks associated with the secure operation of its CW infrastructure assets.

Critical Infrastructure Protection and Resilience Program

The USACE Critical Infrastructure Protection and Resilience (CIPR) Program leads integrated physical and cyber security risk assessment and prioritization efforts for CW's infrastructure portfolio. The Program seeks to enhance protection capabilities by preventing, deterring or mitigating the effects of manmade incidents and improving preparedness, response, and rapid recovery in the event of a physical or cyber-attack, natural disaster or other emergencies. The Program's security risk assessment framework is fully aligned with national policy defined by

PPD-21, titled “Critical Infrastructure Security and Resilience,” E.O. 13636, titled “Improving Critical Infrastructure Cybersecurity,” and PPD-8, titled “National Preparedness Goal.” (EOP 2011, 2013a, 2013b).

USACE developed the Common Risk Model for Dams (CRM-D) in collaboration with the Institute for Defense Analyses (IDA) and DHS, providing a systematic approach for evaluating physical and cyber security risks across a large portfolio of dams, navigation locks, hydro protects, and similar infrastructure. Risk is calculated for attack scenarios by combining consequence, vulnerability, and threat estimates in a way that accounts for the relationships among these variables. The CRM-D quantifies the benefits of implementing a particular risk mitigation strategy and, consequently, enable return-on-investment analyses for multiple mitigation options. (IDA 2016).

Critical Infrastructure Cybersecurity

The USACE Critical Infrastructure Cybersecurity Mandatory Center of Expertise (MCX) aims to assure that projects and facilities with control systems that are owned and operated by USACE are secured and authorized according to applicable DoD and Army regulations. The Center serves to protect control systems and enable the systems to obtain an Authority to Operate. It maintains state-of-the-art expertise in control systems and cybersecurity solutions and trends and provides design support through supplying and reviewing cybersecurity requirements for new and existing control systems. (USACE 2019b).

Electromagnetic Disturbance

Renewed concern over electromagnetic pulse (EMP) and electromagnetic interference (EMI) has prompted several activities at USACE with respect to the vulnerability of electronic systems. Protection from EMP and EMI is one focus of USACE’s Protective Design MCX (See Section 3.3.7 Protective Design). Standards and guidance from DoD, DHS, and others specific to EMP/EMI protection is available and utilized during planning, design, and operations as needed. This includes Military Standard (MIL-STD) No. 188-125-1 and Military Handbook (MIL-HDBK) No. 423, which define requirements for high-altitude EMP (HEMP) protection and guidance for protecting from HEMP, respectively. A Prospect training course is offered at USACE, focusing on HEMP protection, and new and updated guidance is also being planned and prepared. (DHS NCC 2019, DoD 1998 and 2019b).

More information on the CIPR program can be found in ER 1110-2-1156 Safety of Dams – Policy and Procedures, Chapter 23 Critical Infrastructure Protection and Resilience at: https://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1110-2-1156.pdf

3.2.5 Dam & Levee Safety Programs

Managing and maintaining water infrastructure, including dams and levees, has been a core activity of USACE since the 1800s. The USACE portfolio contains more than 700 dams and around 2,000 levee systems (approximately 15,000 miles of levees) which provide significant benefits to the nation. Traditionally, resilience in dams and levees focused on the infrastructure

itself, including individual technical disciplines (hydrologic, structural, geotechnical, etc.) and design standards through inspections, risk assessments, and program metrics. Examples of such measures include but are not limited to the below.

- Superiority in levees (safe overtopping designs planning for initial overtopping in the least hazardous locations, typically at the downstream end of the system);
- Sharing of inundation mapping for dams with local emergency management agencies and the public as a preparedness measure for use in emergency action plans;
- Redundancy in power supplies for operational components (mechanical and electrical) of dams and levees;
- Use of bypass channels to provide conveyance for flows exceeding design flows;
- Use of designed overtopping sections on dams to provide additional discharge capacity; and
- Use of set-back levees, particularly on the lower Mississippi River, to provide for additional floodplain flow.

After Hurricane Katrina, the dam and levee safety programs received added attention and adopted a more risk-informed approach. Post-Katrina evaluations now place greater focus on the likelihood of the hazards, infrastructure performance against these hazards, and the potential resultant harm caused by the hazards. Additional activities enhancing the resilience of USACE dams and levees include:

- Specific consideration of risk reduction and resilience in selecting risk reduction alternatives for infrastructure;
- Specific consideration of protecting egress routes in floodplains;
- Site specific sponsor engagement and risk communication in communities for dams and levees;
- A focus on improving community awareness of risks, warning/detection systems and evacuation effectiveness in communities;
- Incorporation of human intervention and flood fighting into levee designs;
- Research into allowable overtopping rates and manufactured erosion-resistant materials for levees to identify features that improve resilience to overtopping;
- Research and development of erosion resistant root structures for levee grasses to add resilience to standard designs; and
- Improved scientific and engineering methods for the estimation of extreme storm frequency.

The design standard for high hazard dams is specified in Engineer Regulation (ER) 1110-8-2(FR) Inflow Design Floods for Dams and Reservoirs (USACE 1991). The standard is determined through a risk-informed process that considers the Probable Maximum Flood with freeboard, which provides resilience by having a very low chance of capacity exceedance and considers the variability in the potential consequences of failure.

The allocation of reservoir storage capacity also provides resilience by including inactive capacity for sediment storage; multi-purpose capacity for flood risk management, navigation, water supply, hydropower, and other authorized purposes; and surcharge capacity for passing large floods. (USACE 1997).

Water control plans and water management policies support resilience by providing opportunities for flexible operating rules, variable storage allocation and deviations to manage a range of potential hydrologic conditions (USACE 2016a).

The USACE Risk Management Center (RMC) was established in 2009 to support Civil Works by managing and assessing risks for dams and levee systems across USACE, to support dam and levee safety activities, and to develop policies, methods, tools, and systems to enhance those activities. The RMC serves as a Corps-wide resource for risk-related tools, assessments, knowledge and methods. (USACE 2016b).

More information on these programs can be found at:
http://www.usace.army.mil/Missions/Civil-Works/Dam-Safety-Program/ and
http://www.usace.army.mil/Missions/Civil-Works/Levee-Safety-Program.

3.2.6 Emergency Management

Public Law (PL) 84-99 is the USACE Emergency Management authority specific to natural disaster response. Through PL 84-99, USACE is authorized to undertake activities to include both preparedness measures prior to an event, and emergency measures during and after an event. USACE is involved in disaster preparedness and advance measure activities such as the development of operational plans and procedures, participation in organizational and interagency training and exercises, exchange of technical solutions for uncommon emergency situations, and the repair of eligible Flood/Coastal Storm Risk Management projects post event.

USACE also performs work in emergency preparedness and management under three of five National Planning Frameworks. These include the National Mitigation Framework, the National Response Framework, and the National Disaster Recovery Framework. USACE's specific roles in facilitating state and local communities in implementing resilience actions vary depending on the magnitude of events, the Federal Coordinating Officer, and USACE's capabilities and experience. USACE activities within each of these frameworks is discussed below.

More information on USACE emergency management activities can be found at:
http://www.usace.army.mil/Missions/Emergency-Operations.

National Mitigation Framework

The National Mitigation Framework (NMF) provides context for how the "whole community" works together to foster a culture of preparedness and discusses how mitigation efforts relate to all other parts of national preparedness. As a member of the Mitigation Framework Leadership Group (MitFLG), USACE assists in coordinating policy implementation recommendations across the federal government and with partners in mitigation nationally. Further information on MitFLG can be found in Section 4.2 Resilience Forums.

USACE supports many National Preparedness Goal core capabilities around mitigation, including, but not limited to, Risk and Disaster Resilience Assessment; Community Resilience;

Long-term Vulnerability Reduction; and Threats and Hazards Identification. For example, through the Silver Jackets Program, USACE brings multiple agencies together to collaborate and leverage collective expertise to increase mitigation efforts and reduce flood risk at the state level. Further information on Silver Jackets can be found in Section 3.2.11 National Flood Risk Management Program.

More information on NMF can be found at: https://www.fema.gov/national-mitigation-framework.

National Response Framework

The National Response Framework (NRF) is a guide to how the Nation responds to all types of disasters and emergencies. It describes specific authorities and best practices, including the principles, roles and responsibilities, and coordinating structures for delivering the core capabilities required to respond to incidents varying in severity, and further details about how response efforts integrate with those of the other mission areas. Supplemental Emergency Support Function (ESF) Annexes and Support Annexes were developed to provide a clear understanding of the organization of common government emergency functions.

USACE is designated as the primary agency for ESF #3 – Public Works and Engineering. Duties include assisting the Department of Homeland Security/FEMA by coordinating federal public works and engineering-related support, and providing technical assistance and construction management to prevent, prepare for, respond to, and/or recover from domestic incidents.

USACE is a support agency for ESF #9 – Search and Rescue, while FEMA is assigned as the primary agency. USACE tasks include maintaining a cadre of volunteer Structures Specialists (StS) that can be deployed through a Mission Assignment to augment the FEMA National Urban Search and Rescue (US&R) Response System Incident Support Team (IST). For a non-US&R mission, USACE's StS can also provide "heavy assessment" under ESF#3 for technical purposes.

More information on the NRF and the ESF Annexes can be found at: https://www.fema.gov/media-library-data/1582825590194-2f000855d442fc3c9f18547d1468990d/NRF_FINALApproved_508_2011028v1040.pdf and https://www.fema.gov/media-library-data/20130726-1825-25045-8535/overview_esf___support_annexes_2008.pdf.

National Disaster Recovery Framework

The National Disaster Recovery Framework (NDRF) establishes a common platform and forum for how the whole community builds, sustains, and coordinates delivery of recovery capabilities. NDRF describes principles, processes, and capabilities essential for all communities to more effectively manage and enable recovery following an incident of any size or scale. This Framework defines how the whole community, including emergency managers, community development professionals, recovery practitioners, government agencies, private sector, nongovernmental organization (NGO) leaders, and the public, collaborate and coordinate to

more effectively utilize existing resources to promote resilience and support the recovery of those affected by an incident. Recovery Support Functions (RSF) comprise the coordinating structure for key functional areas of assistance in the NDRF.

USACE is the lead coordinating agency for the Infrastructure Systems RSF and supports all five other RSFs, to include the Community Planning and Capacity Building RSF; the Economic RSF; the Health and Social Services RSF; the Housing RSF; and Natural and Cultural Resources RSF.

More information on the NDRF can be found at: https://www.fema.gov/media-library-data/1466014998123-4bec8550930f774269e0c5968b120ba2/National_Disaster_Recovery_Framework2nd.pdf.

3.2.7 Environmental Compliance and Sustainability

The Environmental Compliance and Sustainability program seeks to make USACE facilities more energy, water, and fuel efficient, while also reducing the agency's footprint on the land by expanding recycling, composting, and use of renewable energy as well as diverting waste from landfills. Promotion of innovative practices reduces greenhouse gas emissions and helps ensure the resilience, safety and well-being of staff, contractors, and facilities. Guided by Executive Orders, Operations Orders, and ER 200-2-3 Environmental Compliance Policies, the program assesses USACE's recreation, navigation, and hydropower facilities annually, and promotes submission of Cost Savings Measures packages to improve the efficiency and resilience of those facilities. (USACE 2010).

Integration of sustainability into the USACE mission and organizational culture is essential in achieving federal sustainability goals as set forth by the White House Office of Management and Budget (OMB) and CEQ. USACE employs a systems-based, continual improvement approach, integrating sustainability into its mission and organizational culture with the ultimate goal of a sustainable and resilient future organization. USACE uses, at all levels of command, a recurring cycle of planning, execution, measurement, performance review, and annual course-correction/redirection that integrates sustainability more deeply into its mission and the organizational culture.

Annual Environmental Compliance Assessments protect USACE natural and cultural resources; act as a preventative for chemical storage dangers, damaging spills, solid and hazardous waste accumulation, improper toxics disposal, underground storage tank issues, and air, water, and wastewater issues; enact real estate lease requirements; and incentivize cost-effective sustainable measures to increase recycling and lower energy and water consumption.

The USACE Environmental Compliance and Sustainability program focuses on achieving energy and water reduction goals by meeting and/or exceeding OMB/CEQ sustainability goals and targets, integrating sustainability into all USACE missions, activities, and actions, and growing sustainability leaders. Energy Audits, CW Sustainable Federal Building Assessments, and Energy Savings Performance Contracts (ESPCs) all promote renewable energy and reuse of resources to increase efficiency and resilience while reducing consumption by USACE facilities.

3.2.8 Environmental Stewardship

The Environmental Stewardship program has responsibilities to monitor land use, protect natural and cultural resources, and promote conservation of habitat on over 400 water resources development projects including 12 million acres of land. One of the primary protection activities under the stewardship program is withstanding thousands of annual encroachments and trespasses that impact the integrity of the natural assets of USACE property. Without a strong commitment to properly marking and maintaining boundary lines, the resilience of USACE land and water holdings would be lost.

Nearly all USACE environmental programs incorporate adaptive management to ensure success throughout the life cycle of the projects or system. For example, Natural Resources Master Plans must be reviewed every five years to determine if changes warrant any updates or revisions, Ecosystem Restoration projects incorporate post-construction monitoring and adaptive management, and USACE activities involving threatened and endangered fish in the Northwest are rooted in adaptive management.

USACE manages over 400 water resources development projects to protect lands and water for recreation and to preserve natural resources. The first line of defense in resilience is to prepare and plan for threats and rapid changes. Over 90 percent of these projects are located within 50 miles of a metropolitan statistical area undergoing rapid expansion and generating increased requests for development on these projects. Additionally, new threats such as gas and oil development, land use requests for pipelines and utilities, and invasive species make proper planning imperative.

USACE Master Plans are designed to provide proper land classification including identifying environmentally sensitive areas, establishing appropriate natural resources objectives according to sound ecosystem principles, and engaging the public and natural resources agencies in long-term development and protection of the natural resources. These documents provide the most important step of resilience for our Natural Resources Management program.

USACE forest management and protection activities can increase the capacity for carbon storage while providing vital ecosystem services such as clean air, clean water, wildlife habitat and recreation. These and other natural resources protections and enhancement also directly support the goals of the National Fish, Wildlife, and Plants Climate Adaptation Strategy. Examples include conserving habitat to support healthy fish, wildlife, and plant populations and ecosystem functions in a changing climate, reducing non-climate stressors to help fish, wildlife, plants, and ecosystems adapt to a changing climate, and enhancing the resilience and productivity of pollinator habitat on USACE lands.

Endangered and Threatened Species

Signed into law in 1973, the Endangered Species Act establishes the policy of Congress that all Federal departments and agencies are to seek to conserve endangered and threatened species and use their authorities in furtherance of the purposes of the Act.

USACE works tirelessly to ensure its actions will not impact endangered species, and where impacts occur, significant efforts are made to mitigate the impacts. USACE has focused heavily on the Columbia and Willamette river systems with respect to adult and juvenile fish passage, as well as avian predation management and salmon survival research and development. Similarly, since 2000, USACE has been working with the U.S. Fish and Wildlife Service on the Missouri River Recovery Project (MRRP) aimed at mitigating losses of aquatic and terrestrial habitat; recovering federally listed species under the Endangered Species Act; and restoring the ecosystem to prevent further declines among other native species.

Invasive Species Management

Disturbances to natural systems often involve the introduction of invasive species, either inadvertently or as a result of natural disasters, such as a fire or drought. To address ongoing threats and impacts and prepare for the future, both the USACE Director of Military Programs and the Director of Civil Works signed a memorandum on Invasive Species Management in USACE on June 24, 2014. The memorandum alerted USACE to the role of the Invasive Species Leadership Team (ISLT) and included the team's Program Management Plan to provide leadership, prevention, early detection and response, management and research of invasive species.

One of the first things the ISLT produced was a communications fact sheet that highlights the seven most problematic invasive species to USACE and provides a link to web resources and educates the audience on how to Prepare, Prevent and Protect, cornerstones of providing resilience.

More information on Environmental Stewardship can be found at: http://www.usace.army.mil/Missions/Environmental.

3.2.9 Floodplain Management Services

USACE often provides services to other organizations through its Floodplain Management Services (FPMS) program. Services may include general technical assistance, general planning guidance, and preparation of guides, pamphlets, and supporting studies. USACE cannot undertake detailed planning, prepare detailed final designs, or undertake construction under the FPMS program.

Services are provided to Native American Tribes and other non-federal public agencies without charge, based on available funding. Services also are offered to other federal agencies and the private sector on a 100-percent cost recovery basis. States, local governments, and Native American Tribes can also voluntarily contribute funds for the purpose of expanding the scope of services requested by these entities.

Under general technical assistance, USACE develops or interprets site-specific data on obstructions to flood flows; flood formation and timing; flood depths or stages; floodwater velocities; and the extent, duration, and frequency of flooding. It also provides information on

natural and cultural floodplain resources before and after the use of floodplain management measures.

Under general planning guidance, USACE provides assistance and guidance in the form of "Special Studies" on all aspects of floodplain management planning, including the possible impacts of off-floodplain land use changes on the physical, socio-economic, and environmental conditions of the floodplain. Special Studies can range from helping a community identify present or future floodplain areas to a broad assessment of the various floodplain management alternatives. Some of the most common types of Special Studies include:

- Floodplain Delineation/Flood Hazard Evaluation Studies
- Dam Break Analysis Studies
- Flood Warning/Preparedness Studies
- Regulatory Floodway Studies
- Comprehensive Floodplain Management Studies
- Urbanization Impact Studies
- Storm Water Management Studies
- Hydrologic, Hydraulic, and Sediment Transport Modeling

The FPMS program also provides guidance and assistance for meeting standards of the National Flood Insurance Program and for conducting workshops and seminars on nonstructural floodplain management measures, such as flood proofing and relocation of structures from the floodplain. Studies are conducted under the program to improve the methods and procedures for mitigating flood damages. Guides and pamphlets also are prepared on flood proofing techniques, floodplain regulation, floodplain occupancy, natural floodplain resources, and other related aspects of floodplain management.

USACE also supports many other initiatives through the FPMS program. These include:

- Interagency Nonstructural Alternatives program – promotes collaborative, small-scale efforts emphasizing nonstructural approaches to manage and reduce specific flood risks, leveraging inputs of multiple partners to achieve benefits that none of the individual partners could achieve alone.
- National Hurricane Program – provides real-time support in hurricane situations and input affecting emergency management, services, evacuation, and actions to enhance preparedness, working closely with FEMA and other emergency management organizations.
- National Nonstructural Committee – provides technical expertise on all aspects of nonstructural flood risk reduction adaptive measures, focusing on reducing the consequences of flooding.
- Systems Approach to Geomorphic Engineering program – works with other agencies and stakeholders to investigate and support coastal resiliency on a landscape scale.

3.2.10 Hydropower

Through its Hydropower Program, USACE is the largest owner/operator of hydroelectric power plants in the United States and one of the largest in the world. Its 75 plants have a total installed

capacity of 20,474 megawatts and produce nearly 70 billion kilowatt-hours of electrical energy a year. This is nearly one-third of the nation's total hydropower output — enough energy to serve about ten million households, or roughly ten cites the size of Seattle, Washington. Over the years Congress has directed USACE to build water resource projects to serve public needs such as flood control, water supply and navigation. Where feasible, hydropower has also been included in these projects.

The Hydropower program contributes to resilience in many ways. It provides renewable electrical energy for the nation. It provides rapid replacement generation when required for the electrical grid operation, including making up for a loss of solar or wind generation. It can also be used for blackstart capability to reestablish an electrical grid during a blackout. Additionally, it can be used for electrical grid voltage regulation.

The Hydroelectric Design Center (HDC) works closely with HQ and Major Subordinate Commands in executing USACE's hydroelectric power plant and pumping plant missions. HDC performs projects of varying sizes, from non-routine maintenance design to major rehabilitation and total plant design. It has extensive expertise in rehabilitation programs, testing of major equipment and systems, failure analysis, seismic design, and power plant control and data acquisition. (USACE 2015c).

More information on Hydropower can be found at: https://www.usace.army.mil/Missions/Civil-Works/hydropower/.

3.2.11 National Flood Risk Management Program

The National Flood Risk Management Program (NFRMP) works across the agency to improve decisions made internally and externally that affect the Nation's flood risk. The program also serves as a vehicle to convene and facilitate dialogue at all levels of government and with other key interested parties to develop a national vision for flood risk management. The principles of resilience, preparing and planning, absorbing and withstanding, recovering, and adapting are intrinsic to the NFRMP.

NFRMP focuses broadly on managing both floodwaters to reduce the probability of flooding and floodplains to manage the consequences of flooding. NFRMP recognizes the concept that flood risk management is a shared responsibility among multiple government agencies at the Federal, state, and local levels, as well as the private sector and private citizens. No single agency has the authorities or resources needed to manage flood risk alone. Because there is not one identified federal agency with the lead responsibility for managing the nation's flood risk, USACE has taken the initiative to facilitate and coordinate efforts across the federal government, and with state and local partners.

By promoting internal and external coordination, NFRMP helps provide a clearer understanding of the programs and resources available throughout the flood risk management life cycle, including response, recovery, and mitigation.

More information on the National Flood Risk Management Program can be found at: http://www.iwr.usace.army.mil/Missions/Flood-Risk-Management/Flood-Risk-Management-Program.

Silver Jackets Program

One way in which NFRMP puts its vision into action is through the Silver Jackets program. Understanding the principle of shared responsibility for flood risk management, state-led Silver Jackets teams facilitate collaborative solutions to specific state-prioritized flood risks. The teams also leverage and optimize resources and improve processes, improve and increase flood risk communication, unify interagency messages, and strengthen relationships to facilitate integrated post-disaster recovery.

Every U.S. state except for Hawaii, as well as the District of Columbia, Puerto Rico, U.S. Virgin Islands and Guam have formed Silver Jackets teams. In each case, the state or territory takes the lead role in setting priorities, with federal members (most commonly, USACE, FEMA, NOAA NWS and USGS) in a supporting or enabling role. Resources to support a team's work typically come from the individual programs of each agency participating on the team, within the constraints of available budgets.

The Silver Jackets program allows for ongoing support to teams by USACE District staff. Support is tailored to meet the individual needs of each state or territory for engagement with partners focused on flood risk (or, in some cases, all hazard) reduction. Team engagement facilitates a common understanding of needs and opportunities, provides a forum for sharing lessons learned and best practices, and builds the relationships needed for whole-community resilience. USACE's FPMS program is sometimes leveraged by Silver Jackets teams whereby state, regional, and local governments and others request USACE assistance (See Section 3.2.9 Floodplain Management Services).

Hundreds of Silver Jackets interagency efforts have been initiated since 2011, covering a variety of activities and spanning all phases of the flood risk management life cycle. Emphasis is placed on integrating partner capabilities to expand the reach and impact of outcomes, such as reducing and better managing flood risk, prompting action, and reducing future expenditures. The interagency efforts' life cycle approach and emphasis on outcomes helps build resilience through coordinated efforts aimed at effecting change on priority flood risk management issues.

More information on the Silver Jackets Program and team activities can be found at: https://silverjackets.nfrmp.us/

3.2.12 Navigation

The USACE navigation mission provides safe, reliable, efficient, effective, and environmentally sustainable waterborne transportation systems for movement of commerce, national security assets, and recreation. The marine transportation system (MTS) includes approximately 25,000 miles of channels, along with structures such as jetties, locks and dams, and bridges.

A disruption to the MTS could affect national security by impacting the economy significantly. It is critical that the MTS increase its resilience so that disturbances, whether natural (e.g., storms, water level variation, visibility, endangered species limitations) or human-induced (e.g., congestion on waterways, encroachment by infrastructure, aging infrastructure, competing use for waterways and water resources), do not adversely affect freight flow across the marine system or its intermodal partners. The navigation focus is on increasing infrastructure reliability and resilience through improved preparations, increased ability to resist damages, reduced recovery times, and adapting to reduce overall impacts from unforeseen disturbances.

The Inland Navigation Design Center (INDC) MCX provides engineering, design, analysis and review services for studies, new locks, new navigation dams, major rehabilitation of existing inland navigation locks and dams, and significant inland navigation lock and dam O&M projects. The INDC leads a coordinated effort to develop, maintain, and strengthen technical competency within the engineering and design community for inland navigation. It provides national leadership for standardization of design, inspection, repair, and renewal of navigation infrastructure; investigate, recommend research and development needs, and implement new technologies as beneficial for life cycle cost reduction. (USACE 2016c).

USACE participates on the U.S. Committee on the Marine Transportation System (CMTS). The CMTS serves as a Federal interagency coordinating committee responsible for assessing the adequacy of the MTS, promoting the integration of the MTS with other modes of transportation and other uses of the marine environment, and coordinating, improving the coordination of, and making recommendations with regard to Federal policies that impact the MTS. More information on CMTS can be found at: http://www.cmts.gov.

The CMTS Resilience Integrated Action Team (R-IAT), co-led by USACE and NOAA, provides knowledge co-production around incorporating the concepts of resilience into MTS operation and management. General descriptions of these actions are provided below:

- Utilizing the input of 12 member agencies, the R-IAT identified present and future hazards and constraints affecting resilience of the MTS and classified these hazards into two categories: environmental (e.g. storm surge, water level extremes, shoaling) and non-environmental (e.g. power disruptions, larger vessels, aging infrastructure). The R-IAT produced a report documenting the involvement and prioritization of Federal agency involvement with these hazards.
- "Infrastructure Resilience" was identified as an initial task area for the R-IAT, with consideration of cross-cutting issues such as water level extremes and long-term change; frequency and severity of storms; extreme temperatures; navigation and channel shoaling, emergency response capabilities, port congestion/larger vessel requirements and regulatory/political/budgetary issues.
- The R-IAT produced a report entitled “Reviewing the 2017 Hurricane Season: Recommendations for a Resilient Path Forward for Federal Agencies.” This report utilized input from member agencies to outline successes, challenges, best practices, and opportunities to improve the resilience of the MTS to future hurricane seasons. (CMTS 2018).

USACE also co-leads other Integrated Action Teams (IATs) formed by CMTS, including the Maritime Data IAT, Future of Navigation IAT, and Maritime Innovative Science and Technology IAT. These IATs occasionally support resilience-related activities, such as developing tools to improve how mariners obtain real-time information about maritime conditions, including hazards, weather and notices.

More information on Navigation can be found at:
http://www.iwr.usace.army.mil/Missions/Navigation/ and
http://www.usace.army.mil/Missions/Civil-Works/Navigation.

3.2.13 Planning Assistance to States

The Planning Assistance to States (PAS) program was authorized by Section 22 of the Water Resources Development Act of 1974 whereby USACE may support water and related land resources activities of non-federal entities, including States, Tribes, and U.S. Territories. Regional coalitions of government entities as well as nonprofit and Tribal organizations working with States, Tribes, or U.S. Territories on State water resource plans may also receive assistance.

USACE may provide support under two types of agreements for the PAS program:

- Comprehensive Water Resource Plan. Typical water resources problems and opportunities include flood risk management, water supply, water conservation, environmental restoration, water quality, hydropower, erosion, navigation, fish and wildlife, cultural resources, and environmental resources.
- Technical Assistance. Assistance includes support of planning efforts related to the management of state water resources, including the provision and integration of hydrologic, economic, or environmental data and analysis in support of the State's water resources management and related land resources development plans identified in the state water plan or other water resources management related state planning documents, such as state hazard mitigation, preparedness, response, and recovery plans and plans associated with changing hydrologic conditions, climate change, long-term sustainability, and resilience.

Prior to commencement of a study, USACE and the non-federal sponsor must sign a cost-share agreement. Activities through the PAS program are cost-shared (50 percent) though study partners may contribute funds in excess of USACE's contribution. Under Comprehensive Water Resource Planning, the non-federal partner may also provide work-in kind. PAS studies and technical assistance are planning level and may not include detailed design or construction. Additional requirements and limitations also apply.

More information on the PAS program may be found at:
https://www.nab.usace.army.mil/technical-services/ and
https://www.usace.army.mil/Missions/Civil-Works/Project-Partnership-Agreements/templates_pas/.

3.2.14 Project Planning

In the resilience cycle of preparing, absorbing, recovering, and adapting, the planning process is key because it develops information that helps determine how best to absorb and recover from disturbance events. Planning for resilience is relevant to all Civil Works missions. It is most commonly associated with the flood and coastal storm risk programs; however, it is also important to the ecosystem restoration, navigation, hydropower, and other water resources missions.

The extent to which project planning incorporates resilience is limited only by a team's ability to define "the resilience of what to what?" In flood systems, it is traditionally viewed as the resilience of the flood system infrastructure to hydraulic loading events. In hydropower and inland navigation major rehabilitation studies, although not explicitly stated this way, it is the consideration of failure probabilities and consequences under a range of operating loads. For ecosystem restoration, it is evaluated as the variation in restoration outcomes when conditions exceed or significantly vary from expected conditions.

Planning is a process of decision-making under uncertainty. The process considers engineering performance, environmental acceptability, economic justification and public safety. USACE flood system planning has used a simplified risk-informed decision-making approach as long as flood frequencies and expected damages have been calculated. The simplified approach has evolved in complexity as a wider range of uncertainties are considered in project evaluations and decision-making.

Prior to the 1980s, USACE used performance design criteria such as the Standard Project Flood (SPF) that focused on avoiding losses and significant disruption of lives and local economies. Uncertainty was managed using freeboard and factors of safety. Since the 1980s, decision-making has been driven by economics with the recommended plan typically being the one that reasonably maximized net economic benefits (this is known as the national economic development (NED) plan). Any resulting residual risk was assumed to be managed through required floodplain management plans. Local sponsors and communities agree to implement these plans as part of their sponsor responsibilities. Local communities also have the opportunity to deviate from the NED plan by accepting more risk at a lower cost or by buying down the risk at a higher cost.

Engineering and construction members of the project delivery team help to inform decisions about the requirements of the measures identified. This includes making sure that all costs and features to assure a complete plan are evaluated, compared, and, finally, recommended. Engineering and construction team members design and build the recommended plan following engineering standards and criteria to assure the system functions as planned. As mentioned in previous sections of this chapter, this planned performance includes resilience features to manage exceedance events for flood risk systems — overtopping sections for dams, levee setbacks, levee superiority, bypass channels to carry exceedence flow — as well as adaptive management plans to address uncertainties in ecosystem restoration performance.

Planned projects also consider and communicate residual risk in the decision-making process. The NED plan can lead to alternatives that are economically viable, but potentially increase risk overall to public safety, economics, and the environment when exceedance occurs. To support community resilience and avoid catastrophic consequences, planning teams work with local sponsors to understand these exceedance scenarios and use them to prepare floodplain management plans and emergency action plans.

More information on Planning can be found at: http://www.usace.army.mil/Missions/Civil-Works/Project-Planning.

3.2.15 Recreation

USACE owned, operated, and maintained dams were constructed to provide the nation with flood control, navigation, and water supply. As a steward of vast amounts of land and water, including more than 400 lake and river projects in 43 states, USACE is also a leading provider of outdoor recreation. USACE manages more than 5,000 developed recreation areas, including more than 90,000 campsites, 30,000 picnic sites, 7,600 trail miles, 880 fishing docks and piers, 3,700 boat ramps, 109,000 marina slips, and associated roads, parking lots, and comfort stations.

USACE parks are major contributors to community resilience. Parks promote social well-being, facilitating recreational opportunities for communities in support of physical and mental health. Parks support local economies, increasing property values, local commerce, and tax revenue. Nearly 30,000 volunteers provide 1.5 million hours of service annually at USACE projects, and the agency receives more than 260 million person-day/night visits per year. USACE facilities are designed to absorb this influx of visitors while providing safe water access and minimizing environmental damage, directly improving community resilience and the resilience of surrounding ecosystems. Parks support environmental sustainability by helping preserve ecological functions and protecting biodiversity. For instance, seven of the top 10 migratory bird flyways in the U.S. cross over USACE-managed waters.

In addition to parks actively managed by USACE, opportunities for public recreation also result from the agency’s other activities, including coastal storm risk management and aquatic ecosystem restoration projects.

More information on Recreation can be found at: http://www.usace.army.mil/Missions/Civil-Works/Recreation.

3.2.16 Regulatory

The USACE Regulatory Program evaluates permit applications for construction activities that occur in the nation's waters, including wetlands. The mission of the program is to protect the nation's aquatic resources, while allowing reasonable development through fair, flexible and balanced permit decisions. Consistent with the program's implementing regulations, USACE is neither a proponent nor opponent of these proposals and must ensure objective evaluation of submitted proposals for compliance with all applicable regulations.

While USACE may not dictate project design considerations or specify resilience criteria for projects that are subject to permitting under its regulatory authorities, in light of climate projections and current science, resilience may have indirect implications for proposed projects and their design. If project proponents are developing proposals based on anticipation of changing conditions, to prepare for or adapt to changing conditions or to withstand, respond to or recover rapidly from disruptions, representatives of the USACE Regulatory Program are available to meet as part of pre-application coordination to discuss such proposals.

While coordinating, USACE provides information on regulatory requirements including notification/application requirements, any required public coordination, evaluation procedures, criteria for decision-making and any consultations that may be required to take into account effects on resources including endangered species and/or historic properties.

USACE has issued nationwide permits for regulated activities, which may enable resilience. Some examples include Nationwide Permit (NWP) 13 for Bank Stabilization, NWP 31 for Maintenance of Existing Flood Control Facilities, NWP 43 for Stormwater Management Facilities, and NWP 45 for Repair of Uplands Damaged by Discrete Events. USACE also enables prompt response and recovery through Emergency Permits per the provisions of 33 CFR 325.2(e)(4) titled "Processing of Applications."

The USACE Regulatory Program continues to evaluate effects of activities over which we have federal control and responsibility. Resilience may be considered on occasion when necessary for certain case-specific projects and each project would be reviewed appropriately within the scope of analysis consistent with USACE implementing regulations.

More information on the Regulatory Program can be found at: http://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits.

3.2.17 Water Supply

National policy concerning USACE's role in water supply has been developed over a number of years and is still being clarified and extended by legislation. This policy recognizes that states and local sponsors have the primary responsibility in the development and management of their water supplies, and that there is a significant but declining federal interest in the long-range management of supplies.

Water supply is an authorized purpose at many USACE reservoir projects, and existing legislation gives USACE authority to use its reservoirs for municipal and industrial (M&I) water supply storage (the Water Supply Act of 1958), for withdrawals of surplus water (Section 6 of the Flood Control Act of 1944), and for agricultural water supply storage in limited circumstances (Section 8 of the Flood Control Act of 1944). About 25 percent of USACE projects are authorized for M&I water supply, irrigation, or both. Thus, USACE may participate/coordinate with states and non-federal sponsors in developing water supplies in connection with water resource improvements for construction, operation, maintenance and modification of federal navigation, flood control, or multipurpose projects when certain conditions for non-Federal participation are met.

Currently, 136 USACE reservoirs have active contracts in 25 states for 9.8 million acre-feet of storage for M&I water supply and 70 million acre-feet of storage for agricultural water supply. USACE is authorized to assist states and local interests in their water supply planning process (such as under Section 22 of the Water Resources Development Act of 1974 - Planning Assistance to States; see Section 3.2.13). Aside from formalized arrangements, USACE can take action to address water supply needs within existing authorities.

3.2.18 Water Management

USACE water management operations have proven relatively robust to observed changes in flow resulting from land-use and land cover changes and observed climate variability. This alone can be viewed as a form of resilience. When combined with a deviation process, USACE has a great deal of flexibility to respond to short-term and long-term needs based on the best available information and science.

Challenges posed to water managers occur in two main areas: (1) balancing the needs across all authorized purposes for the projects and (2) drought. USACE is the steward of water management in the context of flood control and is increasingly being challenged because of increasing demand for its reservoirs to be regulated for the potential impacts of increased drought severity. Balancing the demands for water can be viewed as teetering on the edge of extremes when considering the operation of water resource infrastructure for purposes of flood control and drought mitigation. Many times these goals run counter to one another.

USACE reservoirs are congressionally authorized for specific purposes. They are operated according to water control manuals (WCM), which by policy include reservoir rule curves governing the operations of the various pools/storage and, where appropriate, include drought contingency plans. WCMs contain a provision authorizing the use of temporary deviations from prescribed operations and are intended to address special/unique circumstances including dam safety, flood, environmental and drought issues. Examples of such actions during the California drought include the reservoir operation deviations for Whittier Narrows Dam and Coyote Dam/Lake Mendocino whereby operations were approved to enable local water agencies to maximize runoff capture at these two facilities. This flexibility in other terms has a direct correlation with resilience and sustainability.

Reallocation studies also provide for a means to redistribute storage behind a USACE dam. Approximately 36 percent of reservoir storage in the United States is behind USACE dams. For non-federal entities, having M&I water supply storage in a USACE reservoir can be a key component of their water supply plans. Given that USACE is unlikely to construct new reservoirs in the near future, reallocation studies are seen as viable avenues for reallocating existing storage from another authorized purpose to water supply.

There are at least 13 reallocation studies underway and the number of studies funded each year has increased due to growing recognition of the importance of the USACE water supply mission in assisting communities with meeting rising demands and dealing with drought. As an example, the Willamette River Basin Review is an ongoing study looking at the potential to reallocate up

to 1.1M acre-feet of un-contracted irrigation storage to M&I water supply for the State of Oregon. This basin is projected to be one of the most drought vulnerable watersheds in the future.

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3.3 USACE Resilience Practices in Military Programs

USACE Directorate of Military Programs provides premier engineering, construction, real estate, stability operations, and environmental management products and services for the Army, Air Force, other assigned U.S. Government agencies and foreign governments. Its workforce is spread across the U.S. and in more than 91 foreign countries. In this section, the major mission areas provide examples of resilience and span a multitude of areas and in many cases are already in practice in engineering design and construction principles. Elements of resilience are also included in the energy security, sustainability and climate preparedness emphasis prevalent in today's DoD strategic plans.

Military programs and initiatives that contribute to resilience include, but are not limited to, the following:

1. Control System Cybersecurity
2. Mission Assurance / Defense Critical Infrastructure
3. Environmental Programs
4. International Assistance
5. Installation Energy
6. Master Planning
7. Protective Design
8. Standards and Criteria Program
9. Sustainable Buildings

The following pages provide brief descriptions of each of the military programs and initiatives listed above.

3.3.1 Control System Cybersecurity

The Control System Cybersecurity Mandatory Center of Expertise (CSC-MCX) aims to assure the confidentiality, availability and integrity of facility-related control systems (FRCS) that support DoD facilities and installation infrastructure. The CSC-MCX maintains cybersecurity technical expertise and provides expert-level support to the USACE Military Programs Enterprise and external stakeholders. It supports design and construction of functional and cyber-secure control systems and oversees and tracks consistent application of requirements by Districts, Centers, and Major Subordinate Commands. (USACE 2020b).

The CSC-MCX answers technical questions; performs technical submittal and design reviews focused on FRCS cybersecurity; provides specialized training related to FRCS cybersecurity; provides FRCS cybersecurity SME support for planning and design charrettes; supports construction phase support services / oversight for cybersecurity; investigates, identifies and solves cybersecurity-related problems; develops statement of work/performance work statements; develops criteria and specifications; evaluates products/technologies related to cybersecurity compliance; assists with performance verification / acceptance testing; and conducts FRCS inventories, and audits or studies related to cybersecurity.

3.3.2 Mission Assurance / Defense Critical Infrastructure

The Mission Assurance (MA) / Defense Critical Infrastructure (DCI) Line of Effort (LOE) is a USACE DCI portfolio risk-management program that seeks to ensure the availability of USACE-owned, operated, or maintained defense critical infrastructure assets and capabilities. The MA DCI LOE is a functional program within the Operational Protection Division which enables the development of adaptive plans and procedures to improve resilience by mitigating risk, restoring capability in the event of loss or degradation, supporting incident management and protecting DCI-related sensitive information.

As part of the DoD and Army Mission Assurance (MA) process, upon request, USACE supports the conduct of Army and Joint Mission Assurance Assessments on USACE DCI equities and supports efforts in the identification and evaluation of mitigation options. USACE supports and coordinates with DoD Component heads, federal departments, and agencies as needed to identify strategic risks and integrate MA with existing DoD risk management efforts.

3.3.3 Environmental Programs

Environmental Programs, conducted by approximately 4,000 environmental professionals across USACE, provide a wide range of environmental cleanup and compliance services that further resilience by preserving and recovering future choice for USACE, Department of Defense (DOD), other federal agencies, and other stakeholders around the world. Environmental Programs provides valuable services and expertise to both Military Programs and Civil Works stakeholders.

Environmental Programs supports the DoD, primarily the U.S. Army, including Army National Guard and Army Reserves, and the U.S. Air Force, including Air National Guard and Air Force Reserves. Environmental Programs also supports environmental restoration and compliance activities by the U.S. Navy, U.S. Marine Corps, Defense Logistics Agency, and many other DoD entities. Examples of how environmental compliance and cleanup actions enhance resilience include services at military installations such as conservation, pollution prevention, environmental compliance, sustainable design, and land management practices consistent with the ASA(IE&E)'s Installations, Energy, and Environment Strategy 2025. The strategy articulates how energy, water and land are an operational necessity and foundational enabler for all military capabilities. USACE's maintenance, compliance, and restoration allow for these sites to be adjusted and used as needed for all manners of resilience, including national security.

- Through efforts to address munitions, here and abroad, USACE helps to build resilience through programs that provide sustainable design and land management practices on installations. Sustainable land management supports resilience by preserving future choice. For instance, cleanup of contamination and unexploded ordnance allows reuse of land, reducing the need to impact unused land and allowing the Army to right-size operations. Demonstrating that the military is a "good neighbor" in terms of land management facilitates future land use activities.

- Other programs at installations help to build resilience into operations by integrating climate change considerations into natural infrastructure management. Adaptive management approaches are the foundation for the sustainable use of natural resources to support mission needs, meet stewardship requirements and contribute to ecosystem resilience in the face of climate change. These considerations are documented in Installation Natural Resources Management Plans.

- Maintaining ecosystem resilience is a key adaptation strategy given the uncertainty of potential impacts. For instance, USACE's work to support military installation wildland fire management programs directly increases carbon sequestration while reducing the need to move operations to areas not affected by wildland fires. USACE efforts in support of wildlife and endangered species management help to increase biodiversity; diverse ecosystems are inherently more resilient and adaptable to climate change.

- USACE support of air quality compliance efforts helps to reduce carbon emissions, directly reducing contributions to climate change. USACE programs that facilitate the use of clean (renewable) energy and composting support resilience by providing on-site redundancy in operational facilities, which increase adaptability for forces, while directly reducing impacts to climate and landfill space.

USACE's Environmental Programs also help to enable resilience beyond active installations, facilities, and other properties. USACE has restored thousands of acres of land through cleanup efforts under the DoD Formerly Used Defense Sites program, Base Realignment and Closure program, DoD–State Memorandum of Agreement program, and the Native American Lands Environmental Mitigation Program. These programs have made former military sites more available to states, Native American nations, and local communities. Many of these restorations include thoughtful community repurposing with a wide range of community resilience efforts. USACE also performs environmental cleanup through the Formerly Utilized Sites Remedial Action Program and supports the U.S. Environmental Protection Agency (EPA) through its Superfund and Brownfields programs.

More information on USACE Environmental Programs can be found at https://www.usace.army.mil/Missions/Environmental/.

3.3.4 International Assistance

USACE provides capacity building and technical assistance to international organizations and foreign governments. Support includes engineering and construction services, environmental restoration and management services, research and development assistance, management of water and land related natural resources, disaster mitigation, relief and recovery work, and other management and technical services.

Authority for USACE support can be provided by the President through the Foreign Assistance Act of 1961 and the Arms Export Control Act. Authority through the Secretary of the Army can also be provided by the Water Resources Development Act of 1999 for addressing problems related to water resources, infrastructure development, and environmental protection. Other

authorities to perform work for other entities is made available via several laws including but not limited to the Economy in Government Act [31 USC 1535], the Intergovernmental Cooperation Act [31 USC 6505], the Chief's Economy Act [10 USC 3036(d)], the Federal Technology Transfer Act [15 USC 3710(a)], among others.

USACE works through Combatant Commands (CCMD) with Partner Nations to improve their resilience frameworks, which have the following three key elements to support development of their abilities (i) to prepare for and absorb impacts of future natural disaster events; (ii) to recover from these events; and (iii) to adapt after these events.

One of the more active CCMDs promoting the resilience framework is the United States Indo-Pacific Command (USINDOPACOM). In this region, USACE expertise has been used during training and technical exchange workshops through the Pacific Ocean Division's (POD) Interagency & International Services (IIS) program, commonly known throughout the DOD as Security Cooperation. Examples of Operations, Activities, and Investments that build partner capacity can be found in Appendix C, USACE Resilience Examples. These activities have resulted in enhanced Partner Nation regional capabilities resulting in improved resilience.

To prepare for and absorb impacts of future natural disaster events in partner nations, USACE supports the CCMD, Department of State (DOS), and the U.S. Agency for International Development (USAID) to execute Build Partner Capacity activities, Humanitarian Assistance (HA) construction projects (i.e., schools, clinics, multi-purpose cyclone shelters, disaster management coordination centers, water wells, etc.), Bilateral and Multilateral engagements, Strategic Partnerships and Senior Leader Engagements. Training and technical exchanges to build in-country experts leverage USACE's Civil Works competencies and the whole of USACE enterprise to include but not be limited to the USACE Emergency Management Community of Practice, Institute for Water Resources (IWR), Engineering Research and Development Center (ERDC), and divisions/districts.

In preparation for disasters, the CCMDs and ASCCs leverage USACE expertise in training, technical exchanges, and exercises to develop and define civilian and military protocols for humanitarian assistance, and to develop standard operating procedures to implement during disaster and recovery.

To support Partner Nations' institutional capacity to adapt after these events occur or as updated information becomes available, USACE CW expertise is leveraged to enhance water governance under uncertainty, as well as conducting monitoring and vulnerability assessments. Best practices training and exchanges enhance integrated water resource management which include: hydrologic and hydraulic modeling, flood control, shared vision planning, watershed planning fundamentals, water resources education and training programs, investment decision analysis for water resource infrastructure planning, risk-informed decision making and communication, inter-basin and trans-boundary water supply management, as well as drought planning and system resilience.

These initiatives are executed in coordination with U.S. Embassy country teams to strengthen alliances and partnerships. An example of success in USINDOPACOM was an emergency

response plan for Nepal's only airport, which was developed through technical exchanges beginning in 2012. The plan was implemented successfully during a major earthquake in 2015. Partnerships built between the Civil Airport Authority of Nepal, the Nepal Army, and Nepal's Civil Ministries improved Nepal's resilience and facilitated excellent coordination with U.S. and international response teams. Another example is USACE support to the Mekong River Commission and National Mekong Committees from Cambodia, Laos, Thailand, and Vietnam in developing and implementing their 2021-2030 Mekong Basin Development Strategy, key to mitigating regional conflict and enhancing the sustainability of the Mekong River.

More information on International Assistance at USCE can be found at: https://www.usace.army.mil/Missions/Military-Missions/Interagency-International-Support/

3.3.5 Installation Energy

DoD defines energy resilience as "the ability to avoid, prepare for, minimize, adapt to, and recover from anticipated and unanticipated energy disruptions in order to ensure energy availability and reliability sufficient to provide for mission assurance and readiness including task critical assets and other mission essential operations related to readiness, and to execute or rapidly reestablish mission essential requirements." (NDAA 2018).

USACE coordinates with and supports other DoD and Army staff organizations regarding installation energy activities, including ESPC projects; Utility Energy Services Contracts; Energy Conservation Investment Program projects; Net Zero projects; and other energy-funded programs. Examples of specific support currently or recently provided by USACE are provided below.

Installation Energy and Water Plans

In conformance with AD 2020-03, USACE has assisted Army Installation Management Command in the preparation of Installation Energy and Water Plans (IEWPs). The IEWPs provide actionable pathways for installations to map their current state of energy and water resilience and to integrate courses of action to improve their site security posture in context of broader master planning trends and initiatives. Army installation energy and water resilience metrics are captured in installation status reports. Installation IEWPs supported by USACE include Fort Belvoir, White Sands Missile Range, Fort Meade, U.S. Army Garrison Miami, Fort Gordon, Fort Detrick, and Fort Benning.

Alternative Financing Programs

Alternative Financing (also known as Third Party Financing) offers the Army the opportunity to develop and execute projects using private sector financing. USACE engages in several programs that provide opportunities for private industry to engage with Army Installations to improve energy efficiency and resilience, and to reduce overall energy cost utilizing energy conservation measures or the construction of renewable energy facilities.

USACE has used many alternative financing vehicles, including ESPCs. ESPC contracts provide private party financing for energy conservation measures (ECMs) at Army Installations. In an

ESPC, a contractor provides capital and expertise to make infrastructure energy improvements on government facilities to significantly reduce energy utilization and costs and maintain them in exchange for a portion of the generated savings.

Since FY11, USACE has awarded more than a hundred ESPC contracts in excess of a combined capital investment of more than $1B. This includes the White Sands Missile Range (solar hot water), Fort Buchanan (Solar photovoltaic, or PV) and the Defense Intelligence Agency (PV system and Solar Domestic hot water generation and energy management). Many additional projects are in the development phase.

More information on ESPCs can be found at: http://energy.gov/eere/femp/energy-savings-performance-contracts-federal-agencies.

3.3.6 Master Planning

Resilience is part of a suite of planning considerations that must be integrated into all installation Master Plans. Master planning of Army bases, communities and projects is led by the installations. The decisions encountered by master planners include how the bases are developed, what types of facilities are grouped together and where they are located on each base. Master planning involves a systematic approach to present and future needs and direction of the installation's environment, productivity and performance. This results in a "living" vision document, engaging clients and stakeholders in order to develop and understand expectations, design criteria, long range capital improvement and infrastructure programs, future population or mission growth areas and land usage, identification and evaluation of alternatives/solutions, and financial capabilities and regulatory constraints.

USACE is designated by the Army as the technical lead for master planning for the Army and the Chair of the DoD Multi-Service Comprehensive Planning Working Group which champions common master planning services and products through the DoD. DoD Instruction 4165.70 (Real Property Management) establishes the requirement for installation master plans.

Unified Facilities Criteria (UFC) 02-100-01 Installation Master Planning prescribe the DoD minimum requirements for master planning processes and products consistent with the DoD instruction. The process is to use the tool of a master plan and its components to provide ongoing master planning of installations in support of the mission. DoD planners use this UFC, the DODI, and applicable agency instructions to prepare master plans and other planning documents. An installation master plan is the official plan that designates all siting and development on installations/federal properties. No project funded with any appropriation or real estate action can be built on a DoD installation without complying with the installation master plan.

Resilience considerations are embedded within the USACE Master Planning program's ten planning strategies. They are:

1. Sustainable Planning
2. Natural, Historic and Cultural Resource Management
3. Healthy Community Planning
4. Defensible Planning

5. Capacity Planning
6. Area Development Planning
7. Network Planning
8. Forms-based Planning
9. Facility Standardization
10. Plan-Based Programming

USACE produced the Army Climate Resilience Handbook (U.S. Army 2020b) in support of DA 2020-08 (see https://www.asaie.army.mil/Public/ES) and is working on several supplemental technical guidance efforts to enhance resilience planning. These include a Master Planning Product and Services Handbook that provides detailed instructions on how to produce the master planning products. This handbook outlines methods for asking stakeholders to consider resilience factors in forming and implementing master planning strategies and documenting them in the plan. USACE has kicked off development of a second UFC on Area Development Planning. This DoD guidance will create a common process of creating district development plans for installations that embed all the factors of resilience.

USACE has also developed a master planning internal review protocol to assist bases in completing an assessment of their master planning program. Through this process, bases learn what is expected, what factors should be included, how to identify gaps that need to be enhanced, and how to implement solutions. USACE conducted this effort at every Marine Corps base.

USACE was tasked through CENTCOM to provide master planning services in the planning and development of contingency bases. Teams from Fort Worth and other regional planning support centers are being deployed to provide this support. USACE's approach is similar to established planning process and ensures factors of resilience are embedded in the forward operating base to include NET ZERO factors, compactness, low impact development and operations.

3.3.7 Protective Design

USACE's Protective Design MCX maintains technical expertise in and provides expert support to mission areas including design to resist the effects of conventional weapons, nuclear weapons, and accidental explosions. Facility design includes munition and ammunition storage, maintenance, and production; providing protection from chemical agents, biological agents, or radiological agents; and providing EMP protection. The Protective Design Center (PDC) also provides security engineering and design expertise, including in the areas of physical security, force protection/anti-terrorism, threat and vulnerability assessments, and camouflage, concealment, and deception measures for critical infrastructure. The PDC may also identify a need for electronic security systems (ESS) which are designed by the ESS MCX.

More information on the Protective Design Center can be found in Section 3.2.4 Critical Infrastructure Protection and at: https://www.nwo.usace.army.mil/pdc/home/.

3.3.8 Sustainable Buildings

Architecturally, UFC 1-200-01 General Building Requirements sets the requirements that we follow as the International Building Code. Details and exterior finishes are designed to be durable and manage pressure differentials and water intrusion during severe weather events. Structurally, UFC 3-301-01 Structural Engineering and UFC 3-310-04 Seismic Design for Buildings puts in place our minimum structural requirements. These requirements are broken down by geographical zones that account for unique local structural requirements based on statistical probability (e.g. hurricanes in the east, earthquakes in the west, tornadoes in the mid-west, etc.). Resilience is incorporated within vertical construction in the form of the ability to absorb and withstand extreme events through two basic principles:

- The building should serve as a reasonable level of shelter for its occupants during a severe event but could have major damage or a need for replacement, and
- The structure should come through an average to below average extreme event with minimal damage.

Likewise, facilities are designed to UFC 1-200-02 High Performance Sustainable Building Requirements in order to meet federal sustainability mandates, including energy efficiency. There is a symbiotic relationship manifested between the pursuit of these sustainability goals and those of resilience. Many efforts to enhance facility sustainability also enhance or extend facility resilience. For example:

- Usability of a facility by its occupants in the event of a mechanical system failure is enhanced by the reduction of indoor air pollutants, which is a mutual sustainability goal for indoor air quality.
- Sustainable design practices also include natural ventilation strategies that take advantage of natural air currents coupled with operable windows that allow facilities to operate without reliance on powered mechanical ventilation.
- Natural daylighting design strategies for sustainability also provide lighting for facility use during a total failure of electrical lighting systems, including emergency lighting circuits. As with natural ventilation, this can allow facilities to continue some operations without access to power.
- Back-up power systems for resilience are significantly enhanced by sustainable energy efficiency measures. All on-site power systems, like a battery bank or generator, have a limitation in how much power they can provide in terms of total load or stored energy. An energy efficient facility will have smaller back-up power systems — reducing capital cost as well as energy use — and their associated fuel tanks or battery banks will be able to provide power for a longer period of time.
- Fresh water and wastewater elimination are essential for facility operation. Resilient measures for installations include bottled water for human consumption stored onsite. Additionally, on-site rainwater or non-potable “purple pipe” water re-use systems for sustainability can provide functional toilet facilities for an extended period of time in the event of municipal water system failure. Pressure tanks can also be installed in a water system to provide resilience in the event of a disruption of the water utility supply. The longevity of the stored water also has to be considered. Greater efficiency through low-

flow fixtures and high-efficiency toilets reduces the demand on the backup system, making the overall system more resilient.

More information on Military Architecture and Sustainability can be found at: http://www.usace.army.mil/Missions/Military-Missions/Installation-Support.

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3.4 USACE Resilience Activities in Research & Development

The USACE Engineering Research and Development Center (ERDC) performs research and development in support of both the Civil Works and Military Programs Directorates.

3.4.1 Civil Works Support

ERDC supports each of Civil Works primary missions, including in the areas of Navigation; Flood and Coastal Storm Risk Management; Ecosystem Restoration; Environmental Stewardship; Hydropower; Recreation; and Water Supply. Examples of resilience-related support provided by ERDC are discussed below.

Coastal Engineering Support

ERDC develops techniques for improving the ability of coastlines to absorb coastal and fluvial storm impacts and recover quickly with less intervention. Examples are provided below:

- Dune and beach ecology and morphology: Research on dunes and beaches that dissects morphological and ecological processes that occur naturally to better capitalize on the ability of dunes to recover and absorb erosional events.
- Beneficial use of dredged material: strategies for recovering dredged sediment from navigation channels to place them where needed. For example, studies exist documenting the movement of placed sediment in the nearshore and the separation of fines for on-beach placement. For more information about sediment management, visit the Regional Sediment Management homepage: https://rsm.usace.army.mil/.
- Wetlands as coastal risk reduction: laboratory, field, and numerical studies are being conducted on the ability of wetlands to absorb extreme events on coastlines – including surge and velocity reduction, wave attenuation, and trapping of sediment.
- Island and berm creation and restoration: studies intended to either create or increase the resilience of berms and barrier islands and fortify their risk reduction and ecological roles in coastal environments. For example, the evaluation of ecological benefits provided by a dredged material island created at Horseshoe Bend in the Atchafalaya River, LA, and a study of sediment placement at Assateague Island, MD, to provide habitat and reduce potential for breaching.
- Natural and Nature-based Features (NNBF): ERDC supports research in the integration of NNBF into fluvial and coastal systems and is leading a multi-stakeholder working group focused on developing international guidelines. For more information, visit the USACE Engineering with Nature homepage: https://ewn.el.erdc.dren.mil/index.html.

Coastal Hazard Data and Information

A critical part of studying resilience is understanding risks to systems and planning for response, recovery, and adaptation to those risks. ERDC specialists evaluate coastal hazards and provide critical information to USACE Districts and partners so that they can better evaluate their risks and plan for building more resilient communities and infrastructure. The USACE Probabilistic Coastal Hazard Assessment Framework provides a suite of numerical models and methods for risk-informed decision making including high-fidelity models, a database of potential storms,

and statistical and probabilistic storm estimates. This information is available at: https://chs.erdc.dren.mil/default.aspx.

Critical to analyzing and understanding coastal hazards is harnessing new datasets to build collective knowledge. ERDC has several ongoing efforts in this area including an effort to crowd-source flooding data from citizen scientists via the U.S. Coastal Research Program iFlood Citizen Science App (https://uscoastalresearch.org/news/f/ifloodcitizen-science-to-understand-coastal-groundwater-flooding), and Mini-Argus – a collaborative development within the Coastal Imaging Research Network. Mini-Argus is a turn-key self-contained deployable coastal imaging system to monitor shoreline change.

U.S. Coastal Research Program

The U.S. Coastal Research Program (USCRP) is a collaboration of federal agencies, academics, and stakeholders leading a national effort to coordinate federal coastal research activities, strengthen academic programs in coastal sciences, and focus on the growing needs of coastal communities to address their preparation and response to coastal hazards. The program represents a community of researchers and practitioners with shared interests in coastal science, coastal engineering and coastal applications, working together to identify research priorities and leverage resources that support research-to-user objectives.

The objectives of the USCRP is to identify societally relevant research priorities and the fundamental research gaps for addressing coastal challenges, enhance funding opportunities for academics and students to tackle coastal challenges, and to translate fundamental science problems and research into outcomes that benefit users. The USCRP aligns resources to support academic studies in fostering the nation's future coastal workforce. By facilitating existing partnerships and multi-agency collaborations, and leveraging limited resources, the USCRP increases the value and impact of coastal research and applications for the Nation.

Further information on the USCRP can be found at: https://uscoastalresearch.org/

Coastal Engineering Research Board

The Coastal Engineering Research Board (CERB) serves as a proponent for USACE coastal engineering research and development. In early 2015, CERB proposed a 3-tier strategy to integrate coastal system risk reduction and resilience into USACE practices based upon resource availability.

- First, tools would be developed that can be used to garner community input on the critical functions that the coastal system provides, the top priorities of the community, existing vulnerabilities, and future needs.
- Second, the tools would be used to understand what infrastructure and other resources those priority functions rely upon, to identify cascading failures and interdependencies, and to compare alternatives for improving resilience.
- Finally, the information would be used to inform design, support operations, and conduct detailed risk and resilience assessments as needed by USACE decision makers.

Based on CERB's recommendations, the Coastal System Resilience (CSR) R&D initiative began in FY16, falling within three specific ERDC R&D programs: the Ecosystem Management and Restoration Research Program (EMRRP), the Flood & Coastal Storm Damage Reduction Program (FCSDR) and the Navigation Program (NAV).

- EMRRP research includes documentation and prediction of barrier island and vegetated dune evolution. FCSDR research includes defining the capacity of natural and nature-based features to reduce storm hazards, including waves, wind, surge, and inundation. NAV research includes development of metrics and tools for CSR.
- A Civil Works resilience research plan was also developed, to include collaboration with others outside USACE; demonstration studies to refine, validate and infuse methodologies; development of design and operational guidance and assessment tools; documentation in peer-reviewed literature; and technology transfer using a variety of media including updates as needed to engineering manuals and guidance documents.

Further information on CERB can be found at:
https://www.erdc.usace.army.mil/Locations/CHL/CERB/

Marine Transportation System (MTS) Resilience

ERDC has informative tools that utilize existing datasets to better understand and manage its navigation portfolio. These tools include the Automatic Identification System Analysis Package which is built with data furnished by the U.S. Coast Guard, Channel Portfolio Tool which utilizes Waterborne Commerce Data, Channel Shoaling Analysis Tool which utilizes existing channel survey data, and the Dredge Optimization Tool which allows for better scheduling of dredging work due to existing demand, environmental windows, and geographical location of the USACE's dredge fleet.

ERDC also contributes significant support to the U.S. Committee of the Marine Transportation System (CMTS), including leading and participating in multiple Integrated Action Teams (IATs) including the MTS Resilience IAT, Maritime Data IAT, and the Future of Navigation IAT.

Further information on MTS support activities can be found in Section 3.2.12 Navigation and at:
https://www.cmts.gov/

3.4.2 Military Programs Support

ERDC regularly provides innovative technologies and capabilities to the warfighter in order to enable force protection and maneuver. This includes development of novel, lightweight, rapidly-constructed protection systems that can be expediently deployed.

From the research and development of protection systems, survivability decision aids have been developed to not only allow for rapid assessment of current protection postures, but also to provide enhanced designs to increase defense against attacks. For example, researchers have designed advanced numerical methods for characterization of blast fragmentation and mitigation on structures and have evaluated the effects of weapon systems based on worldwide building construction material types.

ERDC's Construction Engineering Research Lab focuses on the Army's ability to design, build, operate and maintain its installations and contingency bases and ensure environmental quality at the lowest life-cycle cost. The laboratory conducts research on Resilient Facilities and Infrastructure; Smart Sustainable Materials; Installation Decision Support; and Urban and Stability Operations.

ERDC is also working with the U.S. Army Environmental Command to advance their Military Installation Resilience Assessment initiative, aimed at informing operational decisions at military agencies to improve resilience.

Additionally, the Engineered Resilient Systems (ERS) program is underway to quantify and buy down acquisition risk through mission relevant tradespace analysis, collaborative analysis and decision-making, worldwide environmental representation, and capability integration and demonstration. ERS is led by ERDC, with partners including the Air Force, Secretary of Defense, and Navy.

Further information on ERDC's military programs support can be found at: https://www.erdc.usace.army.mil/Missions/Military-Engineering/

4.0 PARTNERSHIPS & FORUMS

4.1 Introduction

Considering the breadth of USACE's missions and operations, it is common to find other organizations with similar resilience goals and interests. Close collaboration with partners and stakeholders is an important aspect of developing and enhancing resilience. Areas in which USACE partners with other organizations spans many areas of resilience. This includes, but is not limited to, disaster management, coastal resilience, climate adaptation, inland flood mitigation, building standards, energy resilience, navigation, sustainability, and cybersecurity.

This section discusses various partnerships that USACE has had with other federal agencies, non-government organizations, the private sector, and others.

4.2 Resilience Forums

USACE has participated in many national-level committees and interagency groups formed over the past decade to promote the development of strategies to improve the resilience of infrastructure and communities. Examples of these resilience forums to improve resilience are described below.

Coastal Resilience Center of Excellence (CRCOE)

The Department of Homeland Security (DHS) established a Coastal Resilience Center of Excellence (CRCOE) in 2015 led by the University of North Carolina. The mission of the Coastal Resilience Center of Excellence (CRC) is to conduct research and education to enhance the resilience of the nation's people, infrastructure, economies and the natural environment to the impacts of coastal hazards such as floods and hurricanes, including the effects of future climate trends.

More information on CRCOE can be found at: http://coastalresiliencecenter.unc.edu.

Committee on the Marine Transportation System (CMTS)

The CMTS serves as a Federal interagency coordinating committee for the purpose of assessing the adequacy of the marine transportation system, promoting the integration of the marine transportation system with other modes of transportation and other uses of the marine environment, and coordinating, improving the coordination of, and making recommendations with regard to Federal policies that impact the marine transportation system.

More information on CMTS can be found at: https://www.cmts.gov/.

Critical Infrastructure Partnership Advisory Council (CIPAC)

Under the National Infrastructure Protection Plan, Government Coordinating Councils (GCCs) and Sector Coordinating Councils (SSCs) operate within the Critical Infrastructure Partnership Advisory Council (CIPAC) framework which facilitates collaboration between federal, state, local, tribal, and territorial governments, and the private sector in support of critical infrastructure security and resilience efforts. USACE is a member and/or key stakeholder in

multiple sector- and sub-sector coordinating councils, including the Dam Sector GCC and Maritime Modal Subsector GCC.

More information on CIPAC can be found at: https://www.dhs.gov/critical-infrastructure-partnership-advisory-council.

The Mitigation Framework Leadership Group (MitFLG)

The Mitigation Framework Leadership Group (MitFLG) was established to serve as a national coordinating structure focused on integrating federal efforts to deliver mitigation core capabilities identified in the NMF. To that end, the MitFLG facilitates information exchange, coordinates policy implementation recommendations on national-level issues, and oversees the successful implementation of the NMF. The MitFLG includes relevant local, state, tribal, territorial, insular area and federal government representatives, balanced to ensure appropriate integration of federal mitigation efforts across the whole community. USACE is a member agency of the MitFLG.

Among MitFLG's primary goals and functions, it gathers data on the effectiveness of current mitigation measures and coordinates with science and technology interagency groups on the development of better methods, techniques and standards to strengthen resilience.

More information on MitFLG can be found at: https://www.fema.gov/national-mitigation-framework.

National Security Council (NSC) Forums

In 2015 and 2016, the National Security Council (NSC) Resilience Directorate has been leading efforts to bring together relevant federal agencies in many areas of resilience, such as wildland-urban interface, building codes and building resilience, seismic challenges, and community resilience. USACE consistently actively participates in these forums to further national resilience aims.

More information on NSC Forums can be found at: https://www.whitehouse.gov/nsc/.

The National Academy of Sciences (NAS)

The National Academies of Sciences and Engineering support the Risk, Resilience, and Extreme Events (RREE) Roundtable and the Resilient America Initiative (RAI), which aim to progress the ideas conveyed in NAS' seminal report on resilience, "Disaster Resilience: A National Imperative" (2012). Between 2014 to 2018, RAI performed pilots in four cities: Seattle, WA; Charleston, SC; Cedar Rapids, IA; and Tulsa, OK, in which they tested resilience principles. RREE and RAI efforts are supported by member organizations comprised of federal agencies, academia, private industry, and non-governmental organizations. USACE previously served as a Roundtable member.

More information on NAS, RREE Roundtable, and RAI can be found at: https://www.nationalacademies.org/resilient-america.

The Recovery Support Function Leadership Group (RSFLG)

The Recovery Support Function Leadership Group (RSFLG) was established to serve as the national coordinating structure for the Recovery Support Functions (RSF) under the NDRF, bringing together the core recovery capabilities of federal departments and agencies and other supporting organizations — including those not active in emergency response — to focus on community recovery needs. USACE is the lead coordinating agency for the Infrastructure Systems RSF, providing vital public engineering services to disaster recovery coordination, support, planning and implementation and efficiently restore infrastructure systems that serve the community.

More information on RSFLG can be found at: https://www.fema.gov/recovery-support-functions.

4.3 Federal Resilience Partnerships

In addition to federal forums discussed above, USACE also partners with federal agencies in many other specific areas of resilience. These agencies have included: Bureau of Reclamation; Department of Energy; Department of the Army; Department of the Navy; Department of Housing and Urban Development; Environmental Protection Agency; Federal Emergency Management Agency; General Services Administration; National Aeronautics and Space Administration; National Institute of Standards and Technology; National Oceanic and Atmospheric Administration; and U.S. Geological Survey.

Table 4.1 below provides examples of additional resilience-related partnerships between USACE and other federal entities.

Table 4.1 – Sample of USACE Federal Resilience Partnerships

Organization(s)	Topic Area of Partnership
Army Office of Energy Initiatives (OEI)	Resilience of Army installations through the development and implementation of large-scale energy projects.
Bureau of Reclamation, National Center for Atmospheric Research (NCAR)	Hydrometeorology Program; assessing the sensitivity of adaptation questions to the numerical portrayals of climatology and hydrology
Bureau of Reclamation, NCAR, University of Colorado, University of Washington	Hydrometeorology Program; improving skill in streamflow prediction for climate-changed future conditions
Bureau of Reclamation, NOAA Earth System Research Laboratory, University of Colorado	Climate projections: characterizing variables and elements specific to hydrology
Bureau of Reclamation, University Corporation for Atmospheric Research (UCAR) Cooperative Program for Operational Meteorology, Education and Training (COMET) Program	Climate change training for water resource managers

Organization(s)	Topic Area of Partnership
Bureau of Reclamation, USGS, Climate Central, Lawrence Livermore National Laboratory, Scripps Institution of Oceanography, Santa Clara University, Climate Analytics	USACE guidance on CONUS inland hydrology and for USACE climate vulnerability assessments
Bureau of Reclamation, USGS, NOAA, EPA, FEMA, NASA, USDA, FHWA	Climate preparedness and resilience
Center for Army Analysis (CAA)	Climate change considerations for stationing analyses
Community Resilience Working Group (Alaska) – BIA, Denali Commission EPA, DHS, DoE, NOAA, others	Interagency group partnered with State of Alaska, NSF, and others focused on resilience of Alaskan communities
Department of the Interior (DOI)	Member of the Department of the Interior's Metrics Expert Group, Metrics for Ecosystem and Habitat Restoration projects
Department of the Navy	Vulnerability and resilience of Naval facilities
Deputy Assistant Secretary of the Army (Energy & Sustainability)	Senior Energy Executive, utilities privatization, energy policy review, energy partnerships.
Federal Energy Management Program (FEMP)	Expertise from all levels of project and policy implementation enabling federal agencies to meet energy-related goals and provide energy leadership
General Services Administration (GSA)	Federal agency climate change adaptation and mitigation
National Aeronautics and Space Admin. (NASA) Headquarters	Climate change adaptation - facilities
National Institute of Standards and Technology (NIST)	Resilient buildings, improving the standard design for climate preparedness and resilience
Office of the Assistant Secretary of the Army (Installations, Energy and Environment)	Oversight and coordination of energy security and management
Office of the Secretary of Defense (OSD)	Energy resilience metrics and standards; energy resilience and conservation investment validation; climate resilience
Resilient Nation Partnership Network (RNPN)	FEMA-led network for informing, educating, and motivating communities to protect from natural hazards
Sandy Regional Infrastructure Resilience Coordination (SRIRC) Group	HUD- and FEMA-led forum focused on strategic integration of resilience efforts

Organization(s)	Topic Area of Partnership
Strategic Environmental Research and Development Program (SERDP); Environmental Security Technology Certification Program (ESTCP)	Regional sea level scenarios for coastal risk management; ecosystem resilience, including climate change, wildfires, and threatened and endangered species
U.S. Army Environmental Command (AEC)	Military installation resilience assessment, operational decisions at military facilities
U.S. Committee on the Marine Transportation System, Resilience Integrated Action Team (CMTS R-IAT)	USACE and NOAA co-leads on R-IAT, comprised of 12 agency partners engaged in improving the resilience of the Marine Transportation System
U.S. EPA Office of Research and Development	Community resilience in the context of contaminated sites
U.S. Global Change Research Program (USGCRP), NOAA, FEMA, USACE	Interagency Hurricane Sandy sea level rise tool and follow-on demonstration projects

4.4 Other Resilience Partnerships

In addition to federal partnerships, USACE also partners with many other organizations including states and localities, non-governmental organizations, academic institutions, and the private sector. Examples of these partnerships are provided in Table 4.2 below.

Table 4.2 – Sample of Other USACE Resilience Partnerships

Organization(s)	Topic Area of Partnership
American Shore and Beach Preservation Association (ASBPA)	Training module as part of a "Coastal Credentialing" program designed for coastal practitioners; Coastal Resilience Assessment module
Arizona State University; Northeastern University	Resilience matrix and network science methodology for quantifying resilience
Association of State Floodplain Managers (ASFPM)	Flood risk management (nonstructural and mitigation)
Clemson University	Environmental monitoring
Coastal States Organization (CSO), ASFPM	Coastal and ocean management
Colorado State University International School for Water Resources	Integrated water resources management
Florida Earth Foundation (FEF)	Coastal resilience knowledge exchange collaborative
Illinois Sustainable Technology Center (ISTC)	Climate change adaptation - facilities
Integrated Water Resources Science and Services (IWRSS) Consortium	Access and integration of water resources data and forecasts
International Center for Water Hazards and Risk Management (ICHARM)	Water resource management research and capacity building

Organization(s)	Topic Area of Partnership
Mid-Atlantic Regional Council on the Ocean (MARCO)	Climate change adaptation
National Association of Flood & Stormwater Management Agencies (NAFSMA)	Flood damage reduction, environmental restoration, and green infrastructure
National Center for Atmospheric Research (NCAR); University of Colorado; University of Washington; University of Alaska; University of Hawaii	Hydrometeorology Program; developing climate information and hydrology for Alaska and Hawaii
National Fish and Wildlife Federation (NFWF)	Coastal ecosystem resilience data collection and synthesis
National Institute for Building Sciences (NIBS)	Climate change adaptation - facilities
New England Federal Partners (NEFP) Climate Working Group	Climate science
North Atlantic Landscape Conservation Cooperative	Adaptation strategies
Northeast Regional Ocean Council (NROC)	Coastal hazards resilience
Silver Jackets	Initiated by USACE, comprised of state-led interagency teams focused on flood risk and other natural disasters
Society of American Military Engineers (SAME)	Installations and infrastructure resilience.
Rockefeller Foundation Structures of Coastal Resilience (SCR)	Probabilistic coastal flood hazards mapping modeling and innovative approaches to coastal resilience
University of Illinois at Urbana-Champaign	Construction engineering research
University of Maryland	Ecosystem health reports
University of Rhode Island	Port resilience
University of Washington Climate Impacts Group (CIG)	Time of emergence of climate change signals for water resource-relevant variables in the Puget Sound

5.0 FRAMEWORKS, TOOLS & METHODOLOGIES

5.1 Introduction

Many products, including frameworks, tools, and guides, have been created in recent years to help organizations evaluate resilience. The products were developed by various groups, including USACE, and are used for multiple purposes, from promoting awareness of specific resilience challenges to identifying, prioritizing, and implementing strategies and measures. The products can be used to evaluate USACE's own projects and systems, as well as USACE's contributions to overall community resilience.

Use of standardized means for evaluating resilience allows decision-making to be transparent and replicable. This helps build credibility and allows risks and uncertainty to be more systematically managed. Ultimately, end users must determine which products are most appropriate for the desired application.

5.2 Major Resilience Assessment Frameworks and Programs

Tables are provided in this Section summarizing major resilience frameworks and programs that have been implemented and/or developed by USACE and others. These include the following:

1. USACE, Coastal Storm Risk Management (CSRM) Framework
2. Resilient Cities Network, City Resilience Framework
3. International Organization for Standardization (ISO), Multiple ISO Standards
4. National Academies of Science (NAS), Resilient America Initiative
5. United Nations Office for Disaster Risk Reduction (UNDRR), Sendai Framework for Disaster Risk Reduction
6. Zurich Foundation, Zurich Flood Resilience Measurement Framework

Central themes among these frameworks and programs include the incorporation of systems-based approaches to assessment, integration of both physical processes and outcomes, consideration of a wide variety of applicable dimensions (physical, social, financial, political, etc.) and inclusion of multiple disciplines (engineering, natural sciences, social sciences, etc.).

Table 5.1 – United States Army Corps of Engineers (USACE), Coastal Storm Risk Management (CSRM) Framework

<table>
<tr><td colspan="2">ORGANIZATION: United States Army Corps of Engineers (USACE)</td></tr>
<tr><td colspan="2">FRAMEWORK / PROGRAM: CSRM Framework</td></tr>
<tr><td>APPLICABILITY:</td><td>SCALE:</td></tr>
<tr><td>Coastal storm risk reduction</td><td>Coastal communities and their watersheds</td></tr>
<tr><td colspan="2">OBJECTIVE(S):</td></tr>
<tr><td colspan="2">To help states and local communities identify and reduce flood risk by providing a risk management framework and supporting resilient coastal communities and landscape systems</td></tr>
<tr><td>MAJOR TENETS:</td><td>TOOLS, METRICS, OR BEST PRACTICES:</td></tr>
<tr><td>The CSRM Framework consists of a multi-step approach and tools for conducting three levels of analysis:
- Tier 1: A regional scale analysis
- Tier 2: A state or watershed scale analysis
- Tier 3: A local-scale analysis using benefit-cost evaluations of CSRM plans
Resilience and vulnerability are assessed during the risk analysis phase for each tier (USACE 2015a).</td><td>For each step of the analysis, specific tools and resources have been developed. To assess vulnerability, flood inundation mapping tools may be used to an extent.</td></tr>
<tr><td colspan="2">TARGETED USERS:</td></tr>
<tr><td colspan="2">Local communities and their partners (local, state, federal) in coastal regions.</td></tr>
<tr><td colspan="2">STATUS, OUTCOMES, AND APPLICATIONS:</td></tr>
<tr><td colspan="2">States and local communities are encouraged to use the framework to identify their flood risk, and plan and implement strategies. The framework was applied toward USACE's North Atlantic Coast Comprehensive Study (NACCS), completed in 2015. It has been adapted and is currently being used for the South Atlantic Coastal Study (SACS). More information can be found at https://www.nad.usace.army.mil/CompStudy/ and https://www.nad.usace.army.mil/About/National-Centers-of-Expertise/Coastal-Storm-Risk-Management-Planning/.</td></tr>
</table>

Table 5.2 – Resilient Cities Network, City Resilience Framework

<table>
<tr><td>ORGANIZATION:</td><td colspan="2">Resilient Cities Network (formerly Rockefeller Foundation’s 100 Resilient Cities Program)</td></tr>
<tr><td colspan="2">FRAMEWORK / PROGRAM:</td><td>City Resilience Framework</td></tr>
<tr><td colspan="2">APPLICABILITY:</td><td>SCALE:</td></tr>
<tr><td colspan="2">Food, water and energy security; climate change; disease; economic fluctuation; urbanization; and social unrest</td><td>Cities (typically larger cities)</td></tr>
<tr><td colspan="3">OBJECTIVE(S):</td></tr>
<tr><td colspan="3">To identify critical areas of weakness and identify actions and programs to improve a city’s resilience (termed “urban resilience”).</td></tr>
<tr><td colspan="2">MAJOR TENETS:</td><td>TOOLS, METRICS, OR BEST PRACTICES:</td></tr>
<tr><td colspan="2">Urban resilience can be articulated using four dimensions:
- Health and Wellbeing
- Economy and Society
- Infrastructure and Ecosystems
- Leadership and Strategy
Each dimension can be broken down into twelve goals that describe fundamental outcomes of a resilient city (Arup and Rockefeller Foundation 2015).

The framework is guided by four main principles: (1) City-led: mayors, city leaders and CROs will participate in the governance of the network; (2) Impact-focused: the work will prioritize resilient projects that aim to improve the lives of the poor and vulnerable; (3) Regionally-driven: activities will be designed with more flexibility to cater to member cities’ needs; and (4) Partnership-based network: to attain self-sustainability in the near future.</td><td>Each goal is supported by specific indicators (for a total of 52 indicators) and qualitative/ quantitative prompt questions (for a total of 156 questions) as part of a City Resilience Index (Arup and Rockefeller Foundation 2016). An online platform can be used to generate profiles for each city. Qualitative, quantitative, completeness, and qualities profiles can be generated for any city.</td></tr>
<tr><td colspan="3">TARGETED USERS:</td></tr>
<tr><td colspan="3">Municipal governments and their partners interested in tracking city progress over time and using the assessment platform to inform planning and policy decisions.</td></tr>
<tr><td colspan="3">STATUS, OUTCOMES, AND APPLICATIONS:</td></tr>
<tr><td colspan="3">The City Resilience Index was released in 2016 for cities to measure and compare their resilience progress over time. The framework was applied for 98 member cities through Rockefeller Foundation’s 100 Resilient Cities initiative.

The Rockefeller initiative ended in July 2019 and its work has since continued through the Resilient Cities Network. More information can be found at https://resilientcitiesnetwork.org/urban_resiliences/city-resilience-framework/.</td></tr>
</table>

Table 5.3 – International Organization for Standardization (ISO), Multiple ISO Standards

<table>
<tr><td>ORGANIZATION:</td><td colspan="2">International Organization for Standardization</td></tr>
<tr><td>FRAMEWORK / PROGRAM:</td><td colspan="2">Multiple Standards, including:
- ISO 14090:2019 Adaptation to Climate Change - Principles, Requirements and Guidelines (ISO 2019a)
- ISO 22301:2019 Security and resilience — Business continuity management systems — Requirements (ISO 2019b)
- ISO 22316:2017 Security and resilience — Organizational resilience — Principles and attributes (ISO 2017)
- ISO 37123:2019 Sustainable Cities and Communities – Indicators for Resilient Cities (ISO 2019c)</td></tr>
<tr><td colspan="2">APPLICABILITY:</td><td>SCALE:</td></tr>
<tr><td colspan="2">Business continuity; climate change; and sustainability</td><td>Communities and Organizations</td></tr>
<tr><td colspan="3">OBJECTIVE(S):</td></tr>
<tr><td colspan="3">International, consensus-based standards prepared by committees composed of representatives from national standards bodies (e.g., National Institute of Science & Technology)</td></tr>
<tr><td colspan="2">MAJOR TENETS:</td><td>TOOLS, METRICS, OR BEST PRACTICES:</td></tr>
<tr><td colspan="2">- Climate adaptation consists of pre-planning; assessing impacts; adaptation planning; implementation; monitoring and evaluation; and reporting and communication.
- Business continuity management systems emphasize the importance of understanding the organization’s needs; operating and maintaining processes, capabilities and response structures; monitoring and reviewing system performance and effectiveness; and continual improvement based on qualitative and quantitative measures.
- Organizational resilience contributes to improved ability to anticipate and address risks and vulnerabilities; increased coordination and integration of management disciplines; and greater understanding of interested parties and dependencies.
- A resilient city can resist, absorb, accommodate, adapt to, transform and recover from the effects of disasters and shocks in a timely and efficient manner.</td><td>ISO standards are voluntary; however, organizations may choose to adhere to a specific standard. Conformance to standards may vary. A maturity-level assessment can be used to compare a current organization’s activities and processes to those specified in the ISO standard.</td></tr>
<tr><td colspan="3">TARGETED USERS:</td></tr>
<tr><td colspan="3">Owners and operators, both public and private, interested in climate adaptation, business continuity, and community resilience.</td></tr>
<tr><td colspan="3">STATUS, OUTCOMES, AND APPLICATIONS:</td></tr>
<tr><td colspan="3">ISO conducts a systematic review of each standard every five years. More information can be found at https://www.iso.org/home.html.</td></tr>
</table>

Table 5.4 – National Academies of Science (NAS), Resilient America Initiative

<table>
<tr><td colspan="2">ORGANIZATION: National Academies of Science (NAS)</td></tr>
<tr><td colspan="2">FRAMEWORK / PROGRAM: Resilient America Initiative</td></tr>
<tr><td>APPLICABILITY:</td><td>SCALE:</td></tr>
<tr><td>Weather and other extreme events</td><td>Communities</td></tr>
<tr><td colspan="2">OBJECTIVE(S):
To help communities and the nation build resilience to extreme events to save lives and reduce the physical and economic costs of disasters.</td></tr>
<tr><td>MAJOR TENETS:</td><td>TOOLS, METRICS, OR BEST PRACTICES:</td></tr>
<tr><td>The Resilient America Initiative began in 2014 focused on four key recommendations from a 2012 NAS report, Disaster Resilience: A National Imperative. (NAS 2012). The recommendations are listed below:
- Understand, communicate, and manage risk
- Share data and information about tools, best practices, hazards, and policies that build resilience
- Measure resilience
- Build and strengthen coalitions and partnerships with diverse community stakeholders across the public, private, nonprofit, and academic sectors</td><td>NAS formed the Resilient America Roundtable to aid in carrying out NAS' resilience objectives. Through meetings, workshops and other activities, the Roundtable brings together experts from the public, private, nonprofit and academic sectors to advance discussions about resilience; incubate ideas and projects; and conduct education, outreach, and community exchange that builds community and national resilience to disasters and extreme events.</td></tr>
<tr><td colspan="2">TARGETED USERS:
Local communities and their partners</td></tr>
<tr><td colspan="2">STATUS, OUTCOMES, AND APPLICATIONS:
Between 2014 and 2018, NAS conducted pilots in four U.S. cities, based on portions of the Zurich and Rockefeller resilience frameworks. The pilot cities included Seattle, Tulsa, Charleston, and Cedar Rapids. Many workshops were held and publications were also produced, including Developing a Framework for Measuring Community Resilience: Summary of a Workshop and Measures of Community Resilience for Local Decision Makers: Proceedings of a Workshop and (NAS 2015, NAS 2017). USACE previously served as a Roundtable member. More information can be found at https://www.nationalacademies.org/resilient-america.</td></tr>
</table>

Table 5.5 – United Nations, Sendai Framework for Disaster Risk Reduction 2015-2030

<table>
<tr><td colspan="2">ORGANIZATION:</td><td colspan="2">United Nations Office for Disaster Risk Reduction (UNDRR)</td></tr>
<tr><td colspan="2">FRAMEWORK / PROGRAM:</td><td colspan="2">Sendai Framework for Disaster Risk Reduction</td></tr>
<tr><td colspan="3">APPLICABILITY:</td><td>SCALE:</td></tr>
<tr><td colspan="3">Disaster risk reduction</td><td>Cities</td></tr>
<tr><td colspan="4">OBJECTIVE(S):</td></tr>
<tr><td colspan="4">To help local governments assess disaster resilience, develop strategies to reduce disaster risk and losses, and take into account future risk and uncertainties.</td></tr>
<tr><td colspan="2">MAJOR TENETS:</td><td colspan="2">TOOLS, METRICS, OR BEST PRACTICES:</td></tr>
<tr><td colspan="2">The Sendai Framework is a widely-encompassing international accord on disaster risk reduction. It emerged from three years' of talks, assisted by the United Nations International Strategy for Disaster Reduction (UNISDR), during which UN member states, NGOs, and other stakeholders made calls for an improved version of the existing Hyogo Framework for Action (2005-2015), with a set of common standards, a comprehensive framework with achievable targets, and a legally-based instrument for disaster risk reduction.

Four priorities for action are outlined in the Sendai Framework:
- Understanding disaster risk;
- Strengthening disaster risk governance to manage disaster risk;
- Investing in disaster risk reduction for resilience;
- Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction.</td><td colspan="2">UNDRR prepared the Disaster Resilience Scorecard for Cities in 2017 to help review progress and challenges in implementing the Sendai Framework.

The Scorecard offers the potential for scoring at two levels:
- Level 1: Preliminary level, responding to key Sendai Framework targets and indicators, and with some critical sub-questions. This includes a total of 47 questions/indicators, each with a 0 – 3 score; and
- Level 2: Detailed assessment. This is a multi-stakeholder exercise and can be a basis for a detailed city resilience action plan. It includes 117 indicator criteria, each with a score of 0 – 5.</td></tr>
<tr><td colspan="4">TARGETED USERS:</td></tr>
<tr><td colspan="4">Mayors, governors, city and local government leaders</td></tr>
<tr><td colspan="4">STATUS, OUTCOMES, AND APPLICATIONS:</td></tr>
<tr><td colspan="4">Detailed guidance on the Sendai Framework and use of the Disaster Resilience Scorecard is available online. It includes Excel-based tools for performing both preliminary and detailed assessments. More information can be found at https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030.</td></tr>
</table>

Table 5.6 – Zurich Flood Resilience Alliance, Zurich Flood Resilience Measurement Framework

<table>
<tr><td colspan="2">ORGANIZATION: Zurich Flood Resilience Alliance</td></tr>
<tr><td colspan="2">FRAMEWORK / PROGRAM: Zurich Flood Resilience Measurement Framework</td></tr>
<tr><td>APPLICABILITY:</td><td>SCALE:</td></tr>
<tr><td>Flooding</td><td>Communities</td></tr>
<tr><td colspan="2">OBJECTIVE(S):
To increase resilience to flooding by increasing knowledge, developing strategies, and testing innovative tools and approaches applicable to communities worldwide. To guide NGO program development.</td></tr>
<tr><td>MAJOR TENETS:</td><td>TOOLS, METRICS, OR BEST PRACTICES:</td></tr>
<tr><td>The Zurich Alliance community flood resilience measurement framework uses the 5C-4R framework (Keating et al. 2016).
The five key community “capitals” (5C) are based on the sustainable livelihoods (SL) approach and represent a measurement of well-being:
- Social capital
- Human capital
- Physical capital
- Financial capital
- Natural capital
- The four properties of a resilient system (4R) represent characteristics that could enhance the resilience of a community:
- Redundancy
- Resourcefulness
- Rapidity
- Robustness</td><td>The community flood resilience measurement tool consists of 88 indicators to identify sources of resilience for each capital; and 29 ex-post outcome measures.</td></tr>
<tr><td colspan="2">TARGETED USERS:
Communities in both OECD and developing countries. Communities are defined either by geographical or administrative boundaries.</td></tr>
<tr><td colspan="2">STATUS, OUTCOMES, AND APPLICATIONS:
Phase 1 of the alliance began in 2013 and completed in 2018. Phase 2 began in 2018 and will run through 2023. It continues to focus on pre-event resilience building and plans to scale up work in climate action. This includes rolling out best-practice community programs that demonstrate the value of resilience-building; compiling best practices and success stories; and advocating for more investment in resilience with authorities and public and private funders. More information can be found at https://www.zurich.com/en/sustainability/our-role-in-society/flood-resilience/measuring-flood-resilience.</td></tr>
</table>

5.3 Additional Frameworks, Tools, and Guides

Additional frameworks, tools, and guides exist in industry and vary in their degree of maturity with respect to development and application. Table 5.7 below lists these systems and provides brief descriptions of each. The systems include both top-down approaches, meaning they refer to relatively large-scale, strategic assessments of resilience, and bottom-up approaches, allowing stakeholders to understand and operationalize resilience at smaller spatial scales.

Table 5.7 – Additional Industry Frameworks, Tools, and Guides (as of 1 December 2020)

Name	Entity	Description
Applying Resilience Thinking	Stockholm Resilience Centre	Set of seven policy-relevant principles provides guidance on building resilience in social-ecological systems (Biggs et al 2012, Stockholm Resilience Centre 2016).
Army Climate Assessment Tool (ACAT)	U.S. Army	Web tool for assessing exposure to climate-related threats, including coastal and riverine flooding, drought, desertification, wildfire, and permafrost thaw (U.S. Army 2020c).
Army Climate Resilience Handbook (ACRH)	U.S. Army	Handbook for assessing and applying climate exposure impact risk. Includes a four-step risk-informed planning process, including: identifying climate resilience goals and objectives; identifying current and future exposure; identifying sensitive infrastructure, assets, mission, and readiness; and identifying measures to improve preparedness and resilience. (U.S. Army 2020b).
Assessing Resilience in Social-Ecological Systems: Workbook for Practitioners	Resilience Alliance	Workbook provides strategic questions and activities to guide practitioners in resilience assessments of social-ecological systems, focusing on how key components contribute to the dynamics of entire systems. The workbook provides case studies, including applications of the framework to mitigating dam effects along the Colorado River and reducing flood risk in New Orleans (Resilience Alliance 2010).
Baseline Resilience Indicator for Communities	University of South Carolina, Hazard and Vulnerability Research Institute (HVRI)	Measures community resilience. Composite indicator, referred to as BRIC, calculated as the arithmetic mean of five subindexes related to social, economic, institutional, infrastructure and community capital; ecological resilience is not included. (Cutter et al 2010).

Name	Entity	Description
Climate Change - Installation Adaptation and Resilience Planning Handbook	Naval Facilities Engineering Command	Analytical framework and methodology for considering climate change in plans and projects. Method consists of four stages: (1) establish scope and characterize impacts; (2) identify and screen action alternatives; (3) calculate benefits and costs of action alternatives; and (4) assemble portfolio of action alternatives. Details of steps and worksheet are provided to facilitate use of the methodology. (NAVFAC 2017)
Climate Change Readiness Index	Minnesota Sea Grant	Method for reviewing a community's potential vulnerabilities to climate change and begin to plan projects to address these vulnerabilities. The rating system contains a series of 60 qualitative questions and sub-questions.
Climate Resilience Evaluation and Awareness Tool (CREAT)	Environmental Protection Agency (EPA)	Software tool to assist drinking water and wastewater utility owners and operators in understanding potential climate change threats and in assessing the related risks to their individual utilities. Provides users with access to the most recent national assessment of climate change impacts in order to consider how these changes will impact utility operations and missions (EPA 2013).
Climate Risk Informed Decision Analysis (CRIDA)	UNESCO and International Center for Integrated Water Resources Management (ICIWaRM)	Step-by-step guidance for water resources planning for the developing world (UNESCO 2018).
Coastal Community Resilience Index (CRI)	Mississippi-Alabama Sea Grant Consortium (MASGC)	A tool for communities to examine how prepared they are for storms and storm recovery. To complete the index, community leaders get together and use the tool to guide discussion about their community's resilience to coastal hazards (MASGC 2010).
Coastal Resilience Mapping Portal	The Nature Conservancy (TNC)	Flexible, robust mapping platform and "apps" designed to examine coastal hazards, social, ecological and economic assets as well as engineered solutions intended to reduce risk (TNC 2015).

Name	Entity	Description
CoastSmart Communities Scorecard	Maryland Department of Natural Resources (DNR)	A State of Maryland self-assessment tool for evaluating preparedness against coastal hazards. Factors include risk and vulnerability assessment; people and property; infrastructure and critical facilities; natural resources; and economy and society (DNR 2013).
Communities Advancing Resilience Toolkit (CART)	National Consortium for the Study of Terrorism and Responses to Terrorism (START)	Designed to enhance community resilience through planning and action. Targets connection and caring, resources, transformative potential and disaster management (Pfefferbaum et. al. 2011). Also, community intervention that includes a survey instrument, focus groups script, and process for assessing and building community resilience to disasters (START 2013).
Community Disaster Resilience Index (CDRI)	Hazard Reduction and Recovery Center (HRRC)	Uses the four phases of the disaster management cycle (preparedness, response, recovery, mitigation) and combines these with community capital assets (social, economic, physical, human and natural capital). From the initial 120 candidate indicators, 75 were used in the index. Using sub-indices based on each community capital (excluding natural capital), scores were averaged by each of the four capital assets and then averaged to compute the CDRI (Peacock 2010).
Community Disaster Resilience Scorecard Toolkit	Torrens Resilience Institute (TRI)	Community Disaster Resilience Scorecard provides a tool for communities, in partnership with local governments, to assess the likelihood that those that live in a community can respond to and recover from a disaster (TRI 2015).
Community Recovery Tool: Disaster Recovery Tracking Tool	University of North Carolina	Index of 79 metrics to assess pre- and post-disaster conditions, allowing community officials to evaluate their communities and develop a baseline assessment and track changes after a disaster.
Community Resilience Assessment Methodology (CRAM)	National Institute of Standards and Technology (NIST)	Methodology for assessing resilience at the community scale. (Kwasinski et al 2016)

Name	Entity	Description
Community Resilience Benchmarks (CRB)	Alliance for National and Community Resilience (ANCR)	Consensus-based benchmarks for communities, including Buildings Benchmarks, Housing Benchmarks, and Water Benchmarks. (ANCR 2020).
Community Resilience Indicator Analysis	Federal Emergency Management Agency (FEMA) and Argonne National Laboratory (ANL)	County-level analysis of commonly used indicators. (FEMA 2019).
Community Resilience Planning Guide	National Institute of Science and Technology (NIST)	The guide aims to engage community stakeholders in six steps that define how vital social functions are supported by buildings and infrastructure systems including transportation, energy, communications, and water and wastewater. The six-step process is based on the community's social and economic needs and functions that drive goal setting for how the built environment performs (NIST 2015; NIST 2020a).
Community Resilience System (CRS)	Community and Regional Resilience Institute (CARRI)	Developed by the Community and Regional Resilience Initiative. Includes six stages: engage community leadership at large, perform resilience assessment, develop shared community vision, action planning, establish mechanism to implement plan and sustain program, and evaluate and review the community's resilience program (CARRI 2011 and 2013a).
Community Resilience Toolkit	RAND Corporation	Community resilience toolkit developed as part of the larger Los Angeles County Community Disaster Resilience (LACCDR) Project. The toolkit is designed for community coalitions to try resilience building and see what works for their residents (RAND 2015).
Comprehensive Preparedness Guides	FEMA	Series of guidance on fundamentals of planning and developing emergency operations plans, performing threat and hazard identification and risk assessments, conducting preparedness reviews, and fusion and emergency operations center considerations (FEMA 2020a).

Name	Entity	Description
Cybersecurity Framework	NIST	Framework of guidance for assessing and improving an organization's cybersecurity posture. The framework identifies 23 categories among five functions: Identify, Protect, Detect, Respond, and Recover (NIST 2018).
Cybersecurity Maturity Model Certification (CMMC) Framework	Office of the Under Secretary of Defense for Acquisition and Sustainment (OUSD (A&S))	Maturity-based cybersecurity framework consisting of 171 controls distributed across five practice categories: Basic Cyber Hygiene, Intermediate Cyber Hygiene, Good Cyber Hygiene, Proactive, and Advanced/Progressive. Certification is planned to be required of all DoD contractors to ensure controls are in place (DoD 2020a).
Digital Coast	NOAA Office for Coastal Management	More than 60 tools available for the following focus areas: Climate Adaptation (18), Coastal Conservation (27), Coastal Economy (20), Coastal Hazards (27), Community Resilience (39), Land Use Planning (26), Ocean Planning (23) and Water Quality (13). Tools by data type include Socioeconomics (17), Hydrography (10), Elevation (27), Imagery (11), Land Cover (21), Ocean Planning (12), and Benthic (12) (NOAA 2020a).
Disaster Resilience Framework	General Accountability Office (GAO)	Principles for analyzing federal efforts to facilitate and promote resilience to natural disasters (GAO 2019).
Disaster Resilience Scorecard for Cities	United Nations Office for Disaster Risk Reduction (UNDRR)	The scorecard helps cities establish a baseline measurement, identify priorities for future investment and action and track disaster resilience progress over time. It builds on UNDRR's LGSAT tool (Lavelle et al 2015, UNDRR 2014).
Disaster Resilience of Place (DROP)	HVRI	Framework designed to improve comparative assessments of disaster resilience at the local or community level (Cutter et al 2008).
Economic Decision Guide Software (EDGe$) Tool	NIST	Tool identifies and compares present and future resilience costs and benefits associated with new capital investment versus maintaining status-quo (NIST 2020b).

Name	Entity	Description
Energy Resilience 5Rs	U.S. Air Force	Concept of five key resilience attributes for assessing and prioritizing energy projects and ensuring targeted enabling system investments are effective in supporting mission needs. The 5R's refer to robustness, redundancy, resourcefulness, responsive, and recoverable (AFCEC 2019).
Getting to Resilience: A Coastal Community Planning Evaluation Tool	Jacques Cousteau National Estuarine Research Reserve, New Jersey Dept. of Environmental Protection, NOAA	Questionnaire for municipalities to identify areas of risk and vulnerabilities and how to address them (JCNERR 2020).
HAZUS	FEMA	Catastrophe modeling tool that provides communities with the capability to run scenarios or actual events (earthquake, flood, and hurricane wind) impacting the community in order to estimate losses (e.g., property damage, casualties, infrastructure disruption, and displaced households) for planning or post-disaster recovery operations (FEMA 2020b).
Hydropower Sector Climate Resilience Guide	International Hydropower Association (IHA)	Methodology for identifying, assessing and managing climate risks to enhance the resilience of hydropower projects. (IHA 2019).
Hyogo Framework for Action (HFA) 2005-2015	UNDRR	Prioritizes risk reduction in communities. Targets institutions and actions promoting risk reduction, preparedness and response (ISDR 2007). HFA is superseded by the Sendai Framework for Disaster Risk Reduction 2015-2030.
Interdependent Networked Community Resilience Modeling Environment (IN-CORE)	NIST / Center for Risk-Based Community Resilience Planning	Risk-based approach to decision-making leveraging measurement science to model the impact of natural hazards and resilience against the impact on communities. Users apply specific hazards to infrastructure in selected areas, propagating the effect of physical infrastructure damage and loss of functionality to social and economic impacts. The effects consider interdependencies, critical infrastructure, lifeline systems linkages, recovery processes, cascading failures, economic impacts of major disasters, and other variables (NIST 2020c).

Name	Entity	Description
In-Country Team Self-Assessment Tool for Natural Disaster Response Preparedness	Inter-Agency Standing Committee (IASC)	Checklist for an IASC In-Country Team to measure their level of preparedness for a disaster over several categories (IASC 2005).
Local Government Self-Assessment Tool (LGSAT)	UNISDR	Provides key questions and measurements against the Ten Essentials for Making Cities Resilient and builds upon the priorities and national indicators of the Hyogo Framework for Action. Aims to help cities and local actors set baselines, identify gaps and have comparable data across local governments, within the country and globally in order to measure advancements over time (UNISDR 2012).
Natural Hazard Mitigation Saves	National Institute of Building Sciences (NIBS)	Contains exhaustive benefit-cost analysis of natural hazard mitigation, from adopting up-to-date building codes and exceeding codes to addressing the retrofit of existing buildings and utility and transportation infrastructure. (NIBS 2019).
National Risk Index (NRI)	FEMA	Online mapping application for analyzing risk factors from 18 natural hazards in addition to expected annual losses, social vulnerability and community resilience (FEMA 2020c).
National Sea Grant Resilience Toolkit	National Sea Grant College Program	Over 250 tools available for the following topics: Coastal Economy (51), Planning and Coastal Intelligence (72), Climate and Hazard Adaptation (96), Water Resources (39), and Natural Infrastructure (19). Tools by type include: Decision Support Tools (70), Technical Assistance (58), Guides & Manuals (59), Training (23), Communities of Practice (16), Data & Assessments (24) and Legal Services (12) (NSGCP 2015).
Oregon Resilience Plan	State of Oregon	The goal of the plan is to eliminate gaps separating current performance from resilient performance through the determination of likely impacts of seismic events, acceptable timeframes to restore functions following an event and recommended changes in policies to reach resilience targets (Lavelle et al 2015, OSSPAC 2013).

Name	Entity	Description
PEOPLES Resilience Framework	Multidisciplinary Center for Earthquake Engineering Research (MCEER)	Holistic framework for designing and measuring resilience. Targets population, environment, government services, physical infrastructure, lifestyle, economic and socio-cultural capital (Renschler et. al. 2010).
Plan Integration for Resilience Scorecard (PIRS)	Texas A&M University	Provides a technique for communities to evaluate multiple planning documents and identify inconsistencies, conflicts, and gaps with respect to how hazards are addressed. District hazard zones are identified and scored based on the effectiveness of their policies in addressing vulnerabilities, including both physical and social (Texas A&M, 2017)
Ports Resilience Index	Gulf of Mexico Alliance (GOMA), NOAA	Self-assessment tool for ports and marine industry for preparing to maintain operations during and after disasters, with the goal of improving long-term resilience (GOMA 2016).
Reef Resilience Toolkit	The Nature Conservancy (TNC)	Reef management approach that uses knowledge of current and future drivers influencing ecosystem function to prioritize, implement, and adapt management actions that sustain ecosystems and human well-being. (TNC 2020a).
Regional Resilience Assessment Program	DHS CISA	CISA-led structured assessment approach to gauge and present options for improving regional infrastructure resilience.
Resilience Analysis and Planning Tool (RAPT)	FEMA and ANL	Geographic information system (GIS) tool including layers of community resilience indicators, infrastructure locations, and hazard data, and widgets to help with analysis, including a population counter. RAPT is based on a set of 20 commonly used quantitative indicators, including 11 with a population focus and 9 with a community focus. All the indicators are combined into a single county-level aggregate resilience indicator. (FEMA 2020d).
Resilience Assessment Framework	Resilience Alliance	Five-step method to help users build a conceptual model of a social-ecological system, representing the interactions among resources and stakeholders.

Name	Entity	Description
Resilience Capacity Index (RCI)	Building Resilient Regions (BRR)	Provides "a single statistic summarizing a region's status on twelve factors hypothesized to influence the ability of a region to bounce back from a future unknown stress. The index permits comparisons across metropolitan regions and identification of strong and weak conditions relative to other metropolitan regions" (BRR 2020; Foster 2007).
Resilience Measurement Index (RMI)	ANL	Index characterizing the resilience of critical infrastructure, based on multi-attribute utility theory and decision analysis principles. Resilience elements are aggregated into four major components: preparedness, mitigation measures, response capabilities, and recovery mechanisms (ANL 2013).
Resilient Cities	Organisation for Economic Co-operation and Development (OECD)	Framework for assessing the resilience of cities through four inter-related "drivers" of resilience: economy; society; environment; and institutions. (OECD 2016).
ResilUS: A Community Based Disaster Resilience Model	Huxley College of the Environment	Computer model that focuses on "recovery timepaths, spatial disparities, and linkages between different sectors of a community." Affiliated with CRI Recovery over time of critical services and community capital. Targets ability to perform; opportunity for critical infrastructure to perform (Miles et al 2013).
Rural Disaster Resilience Planning (RDPR)	Justice Institute of British Columbia	Four-step process comprising 16 activities and three tools: Rural Resilience Index (RRI), Hazard Resilience Index (HRI), and Hazard Risk Analysis (HRA). After evaluating a community's risk factors, strengths, and resilience improvement targets, the process begins to build a resilience plan—a roadmap—for how to achieve the goals laid out in the assessment. Resources are also provided for implementing plan and tracking progress.
Seismic Resilience	San Francisco Planning and Urban Research Association (SPUR)	Measures ability to recover from earthquakes. Targets buildings and infrastructure and services restoration (SPUR 2008).

Name	Entity	Description
Sendai Framework for Disaster Risk Reduction 2015-2030	UNISDR	Prioritizes risk reduction in communities. Targets institutions and actions promoting risk reduction, preparedness and response. Successor instrument to the Hyogo Framework for Action 2005-2015.
Severe Weather / Climate Hazard Screening and Risk Assessment Playbook	Air Force Civil Engineer	Systematic framework for screening and assessing severe weather, climate hazards, and associated current/future risks to Air Force installations (USAF 2020).
Social Vulnerability Index (SoVI)	HVRI	Statistically derived comparative metric to illustrate variability in capacity for preparedness, response, and recovery at county and sub-county levels of geography (HVRI 2013; Cutter et al 2010).
Socio-ecological Production Landscapes and Seascapes (SEPLS) Toolkit for Resilience Indicators	International Partnership for the Satoyama Initiative (ISPI)	Toolkit contains practical advice for holding resilience assessment workshops in local communities, to assist community members themselves in measuring, comprehending, and evaluating the resilience of their own landscapes and seascapes. It is also intended for use as an effective tool for researchers and development practitioners to understand resilience and develop resilience-strengthening management strategies (ISPI 2014).
STAR Community Rating System Profile	STAR Community Rating System	An indicator-based framework and self-assessment tool for assessing community sustainability efforts (including resilience efforts). It integrates economic, environmental, and social aspects of sustainability and includes quantitative and qualitative evaluation measures (STAR 2018).
Static and Dynamic Resilience In The Context Of Business Interruption Function	Center for Risk and Economic Analysis of Terrorism Events (CREATE)	Uses dollar values as a common denominator and is measured in terms of direct and indirect business interruption losses (usually as gross domestic product, or GDP). It is defined in terms of the standard "loss triangle," and includes static considerations of resilience through improved allocation of existing resources and dynamic considerations of optimal investment to hasten recovery and reconstruction. In essence, it is defined as avoided losses divided by maximum potential losses (Rose 2009).

Name	Entity	Description
Terrestrial Resilient Land Mapping Tool	TNC	Mapping tool to identify species-relevant microclimates and highly connected lands where species are most likely to persist. (TNC 2020b).
Toolkit for Health and Resilience in Vulnerable Environments (THRIVE)	Prevention Institute	Provides a toolkit "to help communities bolster factors that will improve health outcomes and reduce disparities experienced by racial and ethnic minorities" (Prevention Institute 2003).
U.S. Climate Resilience Toolkit	NOAA	Nearly 150 tools available for the following topics: Coastal Flood Risk (53), Ecosystem Vulnerability (39), Human Health (30), Food Resilience (18), and Water Resources (19). Tools also span the following functionalities: Planning (112), Mapping/Graphics (104), Risk Assessment (99), Analysis (86), Scenario Development (65), Stakeholder Engagement (34), Recovery & Rebuilding (22), and Climate Projections (16) (NOAA 2020b).
Vulnerability Assessment and Adaptation Framework	Federal Highway Administration	Guide for analyzing impacts of climate change and extreme weather on transportation infrastructure, assessing adaptation options, and modifying decisionmaking processe (FHWA 2017).
VT Resilient Communities Scorecard and Community Planning Toolbox	Vermont Natural Resources Council (VNRC)	Helps Vermont communities assess their resilience to the growing threat of community disruption caused by climate change and energy scarcity, among other challenges. Includes scorecard focusing on key areas including land use, transportation, energy and healthy community design (VNRC 2013 and 2020).

APPENDICES

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APPENDIX A: REFERENCES

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APPENDIX B: USACE RESILIENCE GUIDANCE

USACE activities in planning, design, construction, and operations adhere to specific policies and technical guidance developed by USACE, as well as DoD, Army, and others. Civil Works activities are guided by Engineer Regulations (ERs), Engineer Manuals (EMs), Engineer Pamphlets (EPs), Engineering and Construction Bulletins (ECBs), and various memoranda. USACE activities in support of military installations and facilities largely follow Unified Facilities Criteria (UFC), which provide common requirements across DoD for safety, sustainability, durability, and functionality. UFC incorporate a combination of consensus building codes, DoD-defined technical and user requirements, and applicable statutory and regulatory requirements.

EP 1100-1-2 USACE Resilience Initiative Roadmap encourages use of USACE's four key principles of resilience: prepare, absorb, recover, and adapt. A variety of terms are used to address resilience in policy and technical guidance, such as resiliency, robustness, redundancy, ductility, and adaptation. These terms apply differently based on particular needs and context but are moving toward standardization as policy and technical guidance are updated. Resilience principles can be explicitly called out in guidance or simply factored into and influencing requirements (e.g., factors of safety ensuring greater infrastructure resilience).

Examples of how guidance addresses resilience are provided below.

EM 1110-2-2502, Retaining and Flood Walls (1989 – Update pending)

EM 1110-2-2502 provides guidance and information for the selection, design, inspection, evaluation, maintenance, repair, and rehabilitation of floodwalls and other hydraulic retaining walls. Currently being updated, structural design criteria provided in the EM is the minimum required and may be exceeded by engineers to ensure adequate resilience. The EM identifies advantages and disadvantages of different structures and foundations with respect to resilience and other factors. Resilience is also a consideration in the performance of risk assessments, inspections, and structural modifications. (USACE 1989).

ER 1165-2-502, Ecosystem Restoration – Supporting Policy Information (1999)

ER 1165-2-502 outlines USACE policies with respect to aquatic ecosystem restoration, which is a primary mission of the CW program. Aquatic ecosystem restoration initiatives attempt to accomplish a return of natural areas or ecosystems to a close approximation of their conditions prior to disturbance, or to less degraded, more natural conditions. The goal is to partially or fully reestablish the attributes of a naturalistic, functioning, and self-regulating system. Protection may also include measures to prevent future degradation of elements of an ecosystem's structure and functions. (USACE 1999).

ER 1105-2-100, The Planning Guidance Notebook (2000)

ER 1105-2-100 includes resilience concepts in the planning process. Specifically, plans must be complete and effective and risk analysis must be used. Since the 1980s, decision-making has been driven by economics with priority given to reasonably maximizing net national economic development benefits (the NED plan). The ER requires the use of risk analysis "to compare plans in terms of the likelihood and variability of their physical performance, economic success, and

residual risk" so that the effect of risk and uncertainty on the project's design and viability are examined and decisions made reflecting the trade-off between risks and costs. Additionally, while benefits and costs are evaluated over a period of analysis, the policy states: "Appropriate consideration should be given to environmental factors that may extend beyond the period of analysis." (USACE 2000).

UFC 4-020-01, DoD Security Engineering Facilities Planning Manual (2008)

UFC 4-020-01 specifies the process for developing appropriate, effective, unobtrusive, and economical protective designs, incorporating security and antiterrorism into DoD facilities. The UFC provides the starting point for application of all security engineering UFCs, providing a standardized approach for identifying and justifying design criteria. The criteria consider the assets to be protected, threats to those assets, levels to which those assets are to be protected against those threats, and any design constraints imposed by facility users. Design criteria and protection options are based on cost and risk management. (DoD 2008).

ER 1130-2-551, Hydropower O&M Policy Bulk Power System Reliability Compliance Program / EP 1130-2-551, Hydropower O&M Policy Implementation of Bulk Power System Reliability Compliance Program (2009)

ER 1130-2-551 and EP 1130-2-551 outline policy and guidance to establish and maintain the USACE Compliance Monitoring and Enforcement Program (ACE-CME) for compliance with the applicable Federal Energy Regulatory Commission (FERC)-approved North American Electric Reliability Corporation (NERC) Bulk Power System Reliability Compliance Standards as defined in the Energy Policy Act of 2005. (USACE 2009a, 2009b).

ER 1110-2-1156, Safety of Dams – Policy and Procedures (2014c)

ER 1110-2-1156 establishes the framework for the physical and cyber protection of dams, locks, and related structures. The ER provides policy, guidance, and procedures for the completion of periodic security risk assessments as well as security plans, antiterrorism plans, project prioritization, and training. (USACE 2014).

ER 1105-2-101, Risk Assessment for Flood Risk Management Studies (2019)

ER 1105-2-101 provides guidance on risk-related requirements for flood and coastal storm risk management studies including but not limited to feasibility studies, post-authorization changes, general reevaluation studies, dam and levee safety studies, and major rehabilitation studies. Resilience is inherent to flood risk management in being able to address changing conditions and adverse events. The ER defines a risk framework for decision-making that includes risk assessment, risk communication, and risk management. Significant guidance is provided on variables to include as part of the assessments and how findings and results are documented. (USACE 2019c).

UFC 4-010-06 Change 1, Cybersecurity of Facility-Related Control Systems (2017)

UFC 4-010-06 Change 1 provides requirements for incorporating cybersecurity in the design of FRCS. FRCS monitor and control equipment and systems related to facilities, including building control systems, utility control systems, electronic security systems, and fire and life safety systems. The UFC is based on the NIST Risk Management Framework and associated DoD guidance (DoD 2017).

ER 1110-2-1941, Drought Contingency Plans (2018)

ER 1110-2-1941 provides policy and guidance for the preparation of drought contingency plans as part of USACE's overall water management activities. The policy requires recurring reviews of project operations and conditions, and, when appropriate, adjustment of water control plans and manuals in response to changing watershed conditions. This includes regulating USACE projects consistent with their authorized purposes for a range of flow conditions, including droughts; identification of modifications to project regulation that increases capability to respond to drought; development of drought contingency plans on a regional, basin-wide, and project basis; development of regulation strategies for droughts; and providing for coordination with appropriate state and Federal interests during drought conditions. (USACE 2018).

EP 1100-2-1, Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation (2019)

EP 1100-2-1 provides instructional and procedural guidance to analyze and adapt to direct and indirect physical and ecological effects of projected future sea level change (SLC). Key information is provided for understanding SLC: nonstationarity and changes in global mean sea level, which in turn lead to changes in relative local sea level. Detailed information provides scientific context for how USACE incorporates projections in planning, engineering, and operations. As part of USACE's planning processes, a risk-informed, decision-focused approach is recommended that includes a hierarchy of decisions and review points that identify the level of analysis required. A 100-year planning horizon (not to be confused with the period of analysis) is also recommended. (USACE 2019a).

EP 1110-2-18, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures (2019)

EP 1110-2-18 explicitly recognizes the importance of ecological resilience in the selection of plants, noting that "A diverse array of plant species is essential to a riparian system's resiliency and its ability to provide and sustain a number of functions." It then goes on to describe the characteristics of plants in the vegetation-free zone, whose primary function is to reliably protect against erosion. (USACE 2019d).

ECB 2019-8, Managed Overtopping of Levee Systems (2019)

ECB 2019-8 presents methods for configuring USACE riverine levee and floodwall systems, including setting top of levee profile, determining overtopping reach length and depth, considering resilience measures in the overtopping reach, and managing residual risk. Resilience measures provided by various forms of surface hardening, armoring, or resistance to overtopping scour, define one of the driving parameters in sizing the overtopping reach and establishing overtopping rates and overtopping volumes. (USACE 2019e).

UFC 2-100-01 Change 2, Installation Master Planning (2019)

UFC 2-100-01 Change 2 prescribes the DOD minimum requirements for master planning processes and products for military installations. Design and programming professionals refer to the Master Plan as they prepare site-specific design proposals. By incorporating current needs and mission requirements into a compelling vision with clear goals and measurable objectives,

installation planners can prepare a Master Plan that sustainably accommodates future change. (DoD 2019c).

UFC 1-200-02 Change 4, High Performance and Sustainable Building Requirements (2019)

UFC 1-200-02 Change 4 provides minimum requirements and guidance to achieve high performance and sustainable facilities that comply with various federal statutes, executive orders, and other requirements, including the 2016 Guiding Principles for Sustainable Federal Buildings and Associated Instructions. The UFC seeks to improve mission capability through reduced total ownership costs of buildings; improved energy and water efficiency; enhanced building and installation performance and sustainability; promoting sustainable resource and environmental stewardship; and enhanced energy and water security. (DoD 2020b, CEQ 2016).

ECB 2020-6, Implementation of Resilience Principles in the Engineering & Construction (E&C) Community of Practice (2020)

ECB 2020-6 requires the USACE E&C community to consider the four resilience principles (prepare, absorb, recover, adapt) in practices and in new and updated standards and criteria. An evaluation of the principles should be performed during planning and design as needed and should be based on engineering judgment and reflective of project complexity and assessed risk. Analyses and outcomes should be formally documented and may result in recommendations for measures to improve resilience. (USACE 2020a).

ECB 2018-14 Revision 1, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs and Projects (2020)

ECB 2018-14 Revision 1 fulfills the requirements of the USACE overarching policy on climate change, which requires "consideration of climate change in all current and future studies to reduce vulnerabilities and enhance the resilience of communities." The guidance recommends applicable projects consider climate change early in the planning process to inform plan formulation, evaluation, and selection. The ECB recognizes that quantitative projections of specific climatic changes that may occur in the future can be highly uncertain. As such, the ECB requires the performance of qualitative analyses to identify potential climate change threats and impacts. Details for performing qualitative analyses are provided in the ECB. (USACE 2020c).

UFC 1-200-01 Change 1, DoD Building Code (2020)

UFC 1-200-01 Change 1 is the foundational document of the UFC program providing general building requirements and overarching criteria, establishing the use of consensus building codes and standards, establishing criteria implementation rules and protocols, and identifying unique military criteria. The UFC references regularly updated industry codes, including the International Building Code (IBC) and the International Existing Building Code (IEBC), as well as distinguishes between core and other UFCs and Facility Criteria (FC) as applicable. (DoD 2020c).

UFC 4-010-01 Change 1, DoD Minimum Antiterrorism Standards for Buildings (2020)

UFC 4-010-01 Change 1 establishes minimum engineering standards for DoD projects that incorporate antiterrorism-based mitigating measures not associated with an identified threat or level of protection. The intent of the standards is to reduce collateral damage and the scope and

severity of mass casualties in buildings or portions of buildings owned, leased, privatized, or otherwise occupied, managed, or controlled by or for DoD in the event of a terrorist attack. (DoD 2020d).

UFC 3-201-01 Change 4, Civil Engineering (2020)

UFC 3-201-01 Change 4 provides civil engineering requirements for all new and renovated government facilities for DoD, including extensive criteria and best practices for site design. The UFC provides guidance for determining the Design Flood Elevation, including use of the DoD Regional Sea Level Database for tidally influenced locations. The UFC also discusses flood resistant design options and consideration of flood protection systems (i.e., levees, floodwalls, etc.). (DoD 2020e).

UFC 3-600-01 Change 5, Fire Protection Engineering for Facilities (2020)

UFC 3-600-01 Change 5 establishes fire protection engineering policy and criteria for DoD. The UFC applies to all types of facilities and their contents, structures, whether considered permanent, semi-permanent or temporary construction, mobile and stationary equipment, civil works or military facilities, hydroelectric plants, waterfront facilities, outside storage, and shore protection for ships and aircraft. The requirements reflect the need for the protection of life, mission continuity, and property (building or contents) while considering the costs of implementing the criterion and risks associated with the facility. (DoD 2020f).

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APPENDIX C: USACE RESILIENCE EXAMPLES

Resilience is an integral part of what USACE does across its multiple business lines. Additional examples of how USACE practices resilience are provided below.

Pacific Ocean Division (POD) International Assistance

USACE works with partner nations in the U.S. Indo-Pacific Command (USINDOPACOM) area of responsibility. The work emphasizes three key elements: (i) to prepare for and absorb impacts of future natural disaster events; (ii) to recover from these events; and (iii) to adapt after these events. USACE expertise has been facilitated, through POD's IIS Program which enhances Partner Nation regional capabilities and resilience with institutional capacity building, strategic partnerships, technical assistance, training, and reciprocal exchanges.

To help Partner Nations prepare for and absorb impacts of future natural disaster events, POD executes Humanitarian Assistance (HA) construction projects for both USINDOPACOM and USAID. HA projects are typically schools, clinics, and bridges. These projects are executed in coordination with the U.S. Embassy country teams, promoting alliances and partnerships, as well as building partner capacity with an added focus on disaster risk management (i.e., multi-purpose cyclone shelters, tube deep water wells, and coastal crisis management centers).

To prepare for and absorb impacts of future natural disasters, POD also leverages USACE Civil Works competencies by 'reaching back' to the whole of USACE enterprise to include IWR, ERDC, Huntsville Center, USACE Centers of Expertise, and sister divisions/districts for specific expertise in training and technical exchanges with partner nations. The work concentrates on the following themes: water and environmental security, dam operation and management (dam safety, flood risk management, hydropower program management and sediment management), hydrology and hydraulic modeling (including analytical supporting tools and methods), disaster risk management and infrastructure. However, adverse impacts from natural disasters do occur regardless of the level of preparation and infrastructure improvements. Regional capabilities to improve recovery efforts are also enhanced through training and technical exchanges.

To support USINDOPACOM's regional capability to recover from the impacts of future natural disaster events, POD leverages USACE expertise for strategic partnerships, representation at international forums, training and technical exchanges and exercises with Partner Nations. This is especially important since the U.S. Government is often one of the first sources of international assistance during such events.

Areas of emphasis include the following disaster risk management-related themes: flood risk mitigation, flood fighting, water resources management, conducting disaster related surveys/assessments, defining civilian and military protocol in humanitarian assistance and disaster relief strategies; defining military to military protocols and standard operating procedures in disaster response; and developing geospatial information systems for use in disaster response planning and training and completion of environmental sensitivity mapping. Specific training occurs in partially collapsed building structural assessment, building demolition, critical infrastructure integrity assessments (i.e. roads), and seismic retrofitting of

structures. For example, after the Nepal Earthquake, the USACE-supported GIS disaster response product was implemented which assisted the coordination of international assistance.

To support USINDOPACOM's capability to improve partner nations' institutional capacity to adapt after disasters or as updated information becomes available, POD leverages USACE expertise to enhance water governance. The training and technical engagements support monitoring and vulnerability assessments that are needed for adaptation capacities like monitoring and recharge scenarios training, sea level change vulnerability assessment, adaptive management, and shoreline (ocean) effects management.

The training and technical engagements to support improved water governance follow best practices of integrated water resource management which include shared vision planning, watershed planning fundamentals, water resources education and training programs, investment decision analysis for water resource infrastructure planning, risk-informed decision making and communication, inter-basin and trans-boundary water supply management, as well as drought planning and resilience.

An example of this work was USINDOPACOM's interagency efforts in Nepal as part of the Pacific Resilience Disaster Response Exercise and Exchange (DREE) initiative. Since 2011, the U.S. has held a series of security cooperation engagements and HA Construction projects in order to enhance Nepal's capacity to respond to a natural disaster, particularly an earthquake. Highlights of those multi-year efforts include the development of the emergency response plan for Nepal's only international airport in 2012, analysis of the airport's pavement capacity for heavy-lift aircraft in 2012, and the construction of a blood bank center and tube deep water wells in 2014. The April 2015 Nepal earthquake tested both the effectiveness of the disaster response plans and the resilience of this infrastructure, critically supporting the Nepalese government's disaster recovery efforts.

Emergency Action Plan Guidebook

Following a request from the state, the Minnesota Silver Jackets team developed a guidebook with templates that communities can use to develop emergency action plans that identify risks and mitigation opportunities, incorporating flood response, evacuation plans and communication to the public.

Intended for use by communities and tribes in coordination with other flood risk management partners, the guidebook offers a straightforward process to get started. Key chapters include identify the flood organization, developing contacts and mutual aid agreements, understanding flood elevations and how they relate to the local community, and developing a list of tasks and prioritized actions. Based on the premise that getting anything down on paper is better than not having a plan, each chapter begins with specific advice regarding what to do "if you only have time to do one thing." The end of each chapter has a more detailed checklist of important tasks and products for that section. Developing a local plan allows valuable institutional knowledge of past flood experiences to be recorded for wider use and preservation.

The guidebook addresses a broad range of considerations including understanding local authority and overall role during a disaster, evacuation routes, emergency shelters, utilities, critical

facilities and hazardous materials, communications, training and exercises, and mitigation and floodplain management. The guidebook lays out steps in plain English with minimal acronyms and proposes an eight-month process for a local team to develop an emergency action plan. Available in hardcopy and digitally, it includes fillable and customizable forms or samples (including sample resolutions and press releases), a sample plan, and links to other examples, guidebooks and related articles.

The guidebook was implemented with the Fond du Lac Tribe in Minnesota as a case study, and other Silver Jackets teams have been looking to make use of it with their partners. The guidebook has also been used in conjunction with various day-long workshops in Minnesota, Wisconsin, Utah, Nevada, and North Dakota, with the goal of reaching all municipal and county officials in a watershed and then providing follow-up support for their emergency action plan development. The workshops have proven successful in generating community excitement about the concept of resilience by giving communities a clear path to the things they can do to help themselves. Initial questions from participants of "are we safe" have been reformulated by workshop end to "what's going to happen next time and what will we do differently to prepare," with broadly-based follow-up on who can take action to make the future better and advice on how to do so.

In addition to in-person assistance through workshops, CDs have been distributed at various meetings, including FEMA RiskMAP meetings, and the guidebook has been presented in numerous national, regional and state venues.

The development of the emergency action plans improves community preparation, readiness and response to flood events, thus improving community resilience. The guidebook allows communities to take matters into their own hands to promote shared responsibility, with enough examples and guidance to provide assistance without being overwhelming. The follow-up through workshops and beyond provides personal support, particularly important because it takes time for a community to develop its plan (nine months or longer is typical), as well as the opportunity for two-way exchange that can help the communities sort out their particular challenges with an informed occasional advisor.

USACE's approach differs from more typical support in that the community ultimately is, and must be, primarily responsible for execution. One of the greatest benefits of the approach is that the process creates new personal connections and enhances existing relationships among people at the local and county levels who need to work together during flood emergencies. However, USACE is providing information and occasional assistance as needed for community implementation. The guidebook, whether in combination with workshops or as a stand-alone resource, provides strong support for community resilience, promotes shared responsibility and results in local ownership.

Inland Community Resilience Assistance Pilot Project

USACE is in the process of creating a "Workshop-in-a-Box" to assist local communities seeking to increase community resilience. Workshop-in-a-Box is a set of tools and templates, including workshop agendas and guidebook and workbook templates, that can be tailored by USACE Districts or Silver Jackets Teams to address a community's individual needs.

Two Workshop-in-a-Box pilot projects were completed in FY20 by the USACE Jacksonville District (SAJ). SAJ partnered with the State of Florida Silver Jackets Team, funded by the FPMS authority, in undertaking the Inland Community Resilience Project for the rural inland counties of Columbia and Highlands. The project included preparing a guidebook and workbook identifying potential funding and partnering solutions to reduce identified risks, with a focus on building a network of relationships between county emergency managers and state, federal, and local agencies. Scaled at the county level, this work served as a pilot for expanding implementation to other rural communities in Florida and across the nation.

The Inland Community Resilience Project consisted of the following steps:

- Identify risk and vulnerabilities for each county;
- Identify potential funding opportunities, programs and authorizations to address the identified risks and vulnerabilities;
- Facilitate the establishment of long-term relationships between the county government and the state and federal agencies with applicable programs and partnering opportunities at a workshop; and
- Provide a guidebook and workbook tailored specifically for each county designed for county officials to reference and utilize to increase community resilience.

The purpose of the guidebook is to assist the county with increasing community resilience. The team developed the guidebook as a one stop shop to serve as a reference and is customized to address the county's individual risks. Chapters in the guidebook provide detailed information about the county's characterization, existing infrastructure, reported risks, resilience opportunities already underway, and additional funding programs and partnering opportunities not yet utilized by the county.

The workbook contains the same untapped funding programs and partnering opportunity information as the guidebook, but also includes space to take notes and pockets to keep applications, business cards, and other literature collected at the final workshop with the applicable government agencies. The purpose of the workbook is to provide an organized way for the county to keep information on applicable programs, including contact names and phone numbers, web sites, eligibility details, and application steps, as well as information on other programs not listed. The workbook was developed to be used over time as a continual reference with up-to-date information at their fingertips.

A major outcome of the Inland Community Resilience Project was to establish relationships between county and Federal and State agencies. Resilience is an ongoing process based on four PARA principles intended to occur cyclically to continually increase resilience in all areas throughout the life of the communities involved. Once these relationships are established and the resilience processes are started, these lead to establishing more relationships and collaboration throughout the resilience community in a continual process.

Fast Track to Borrow Tool on the Upper Mississippi

An important step in the USACE Flood Response process is determining suitable borrow area locations used to provide material for levee repairs during and after flood events. Each site must be extensively analyzed and meet the requirements of the National Environmental Policy Act (NEPA), which takes time. The St. Louis District developed the Fast Track to Borrow Tool to accelerate the response time to comply with the standard borrow process: research, data collection, state historic preservation office consultation, emergency response review, real estate review, geotechnical review, cultural resources review and contracting review. This information is now compiled, filtered and navigated for immediate consideration and action to determine appropriate borrow areas and, in some cases, pre-approved borrow areas.

The tool synthesizes pertinent data and compiles it into one layered GIS product that can be easily accessed for quick and efficient determination of suitable borrow area locations. The product provides a standard levee district map and base coordinates indicating the boundaries and contains a cultural resources information layer, a pertinent levee district information layer, a geotechnical information layer and a real estate information layer.

USACE and stakeholders use the tool to help prioritize and select borrow areas during and after a flood event. The normal process, involving several stakeholders and partners, can take up to 75 days *per borrow site*. Using the tool and accelerating the borrow process, as well as determining suitable borrow locations, can reduce response time by weeks. The tool helps lower risks associated with flood event response and reduce costs by creating a path to a quicker borrow selection process and subsequent clearance.

The tool supports resilience by improving preparedness and response for flood events by substantially reducing the amount of time needed to identify borrow areas while respecting cultural and environmental resources. It addresses system resilience through improving the linkages among various agencies and their data. It also addresses community resilience at the location where borrow may be needed for advanced measures in order to better respond to a flood event. Compiling and maintaining historical data of the types included in this tool enables both agencies and communities to anticipate vulnerable areas within levee systems. The deliberate reach across agency boundaries, and planning ahead to reduce coordination time, are unique features that distinguish this approach from previous, more reactionary approaches.

Regional Sediment Management (RSM) Optimization

Regional Sediment Management (RSM) is an actionable strategy to sustainably maintain or enhance current levels of coastal storm risk reduction. It is a systems approach for deliberately managing sediments in a manner that maximizes natural and economic efficiencies to contribute to sustainable water resource projects, environments, and communities. RSM is accomplished by recognizing sediment as a valuable resource; developing regional implementation strategies across multiple projects and USACE missions; enhancing relationships with regional stakeholders and partners to better manage sediments; and sharing data, tools, technology, and lessons learned. The benefits of RSM are improved sediment management, reduced project lifecycle costs, enhanced partnerships with stakeholders, and more resilient projects. (USACE 2020d).

North Atlantic Coast Comprehensive Study (NACCS)

The North Atlantic Coast Comprehensive Study (NACCS) was prompted in 2013 in the aftermath of Hurricane Sandy. The study identified regional and national opportunities to increase coastal resilience and reduce vulnerability to high risk areas. Many technical products, including models, tools, and reports, were prepared to assist communities implement strategies. A Coastal Program Guide was also produced, outlining Federal and state coastal programs and partnerships to help communities prepare, absorb, recover, and adapt to coastal hazards.

South Atlantic Coastal Study (SACS)

Following the success of NACCS, the South Atlantic Coastal Study (SACS) was initiated in 2018 in response to the historic 2017 hurricane season. The SACS vision is to provide a common understanding of risk from coastal storms and sea level rise to support resilient communities and habitats. This effort leverages stakeholders' actions to plan and implement cohesive coastal storm risk management strategies along the South Atlantic and Gulf Coast shorelines, including the territories of Puerto Rico and the U.S. Virgin Islands. The goals of SACS are to:

1. Provide a common operating picture of coastal risk;
2. Identify high-risk locations/focus current and future resources;
3. Identify and assess risk reduction actions;
4. Promote and support resilient coastal communities;
5. Promote sustainable projects and programs; and
6. Leverage supplemental actions.

Mississippi River & Tributaries (MR&T)

The Great Mississippi River Flood of 1927 inundated 27,000 square miles of land and left more than 700,000 persons homeless. Following the flood, the Mississippi River & Tributaries (MR&T) project was authorized and included levees, floodways, channel stabilization, tributary basin improvements, and other measures. In 2011, the Mississippi River experienced river discharges 25 percent greater than in 1927. Despite the higher flow, the MR&T project protected more than 60 percent of the land previously flooded. No lives were lost and $234 billion in damage was prevented. Nearly one million households and critical infrastructure escaped the flood. Since 1928, the MR&T system received a $45 return for every dollar invested, not including positive environmental impacts.

Hurricane & Storm Damage Risk Reduction System (HSDRRS)

The Hurricane & Storm Damage Risk Reduction System (HSDRRS) consists of 133 miles of levees, floodwalls, gated structures and pump stations in and around Greater New Orleans. The system was a major improvement over the “Hurricane Protection System (HPS)”, which failed during Hurricane Katrina. The HPS had been in construction for 40 years and was only 50 percent complete when Hurricane Katrina hit. Hurricane Isaac in 2012 was the first significant test for the HSDRRS, and the system performed largely as designed.

Navigation Standardization Criteria

The Inland Navigation Design Center (INDC) is developing a plan for implementing national standardization criteria for the design of locks and major components for existing facilities. Standardization allows parts and major components to be more easily maintained, operated, and

replaced when needed. The national universal standard designs are being sought for lock configuration and construction, gate systems, lock wall rehabilitation, gate sill renewal, hydraulic systems, maintenance closures, and other items. The plan includes consideration of best practices, lessons learned, and life cycle costs, and initially concentrates on high value opportunities and strategies.

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