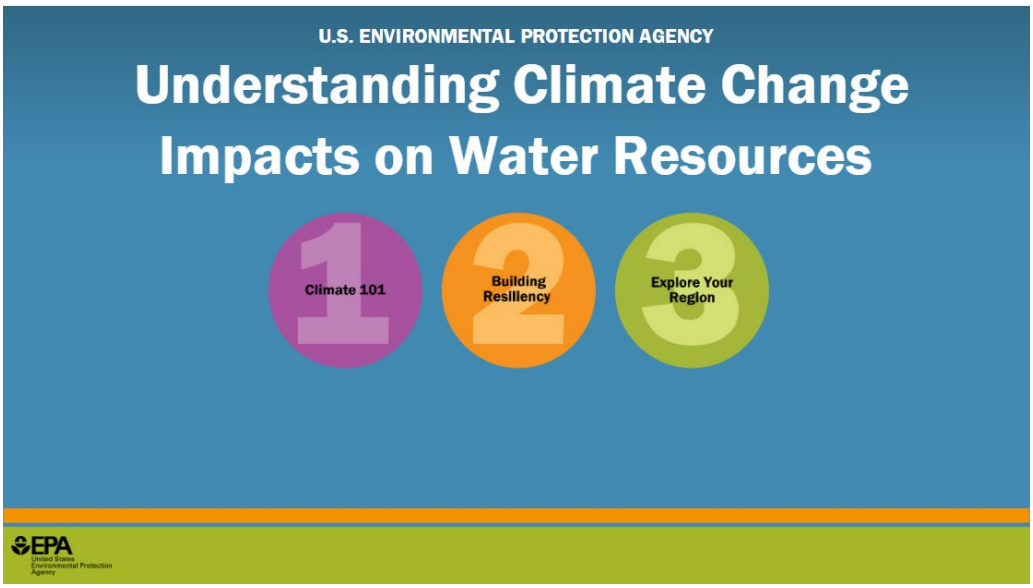
Transcript for
Understanding Climate Change Impacts on Water Resources

Below is the transcript for the Understanding Climate Change Impacts on Water Resources course.

Introduction

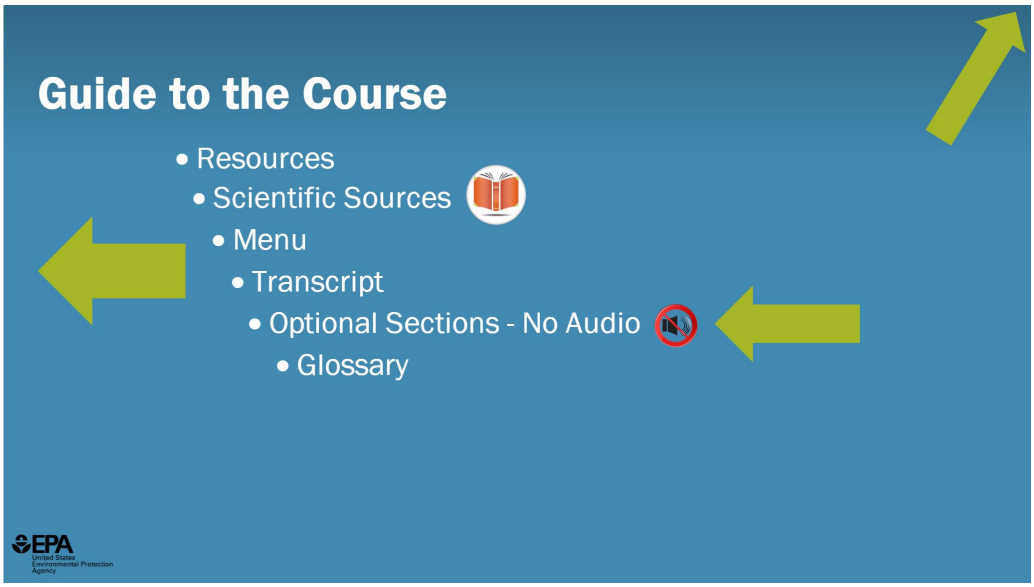


Notes:

Welcome to the U.S. Environmental Protection Agency's training on Understanding Climate Change Impacts on Water Resources in the United States.

This training module is intended to increase your understanding of the causes of climate change, its potential impacts on water resources, and the challenges water resource managers are facing. You also will learn about how water resource managers are working to make the United States more resilient to the impacts of climate change. This training focuses on the clean water and drinking water programs that the EPA implements in cooperation with state, Tribal, and local governments, and other partners.

Guide to the Course



Notes:

Before we get started, let me explain how to navigate this course.

The course contains three parts that will take about 45 minutes to complete. You will also be asked to complete three short quizzes during the course.

I refer to a number of references and sources of information throughout the course. You can always pause the course and access these references by clicking on the Resources Tab on the upper-right side of the course player.

Because there is quite a bit of data presented in this course, we have provided a source book icon on many slides. You can click on the icon using your cursor to open the source information for that slide. To make the source information disappear, click the cursor outside of the source information box.

I'd also like to point out that while this course is intended to be completed from start to finish, we hope that you will use it as a reference after you become more familiar with the material. If you need a refresher on one or more parts of the course, click on the topic you'd like to view from the Menu.

A copy of the transcript for this course can be found under the Transcript Tab.

All required portions of the course will have audio; however, there are optional portions of the course that will not have audio. You will need to open the Transcript Tab for these sections and read the material. These slides are noted with a volume icon.

In addition, a copy of the glossary can be found under the Glossary Tab. The glossary contains terms that are used in this training.

Finally, you can enlarge many of the images and maps throughout this course by clicking on the text under each image.

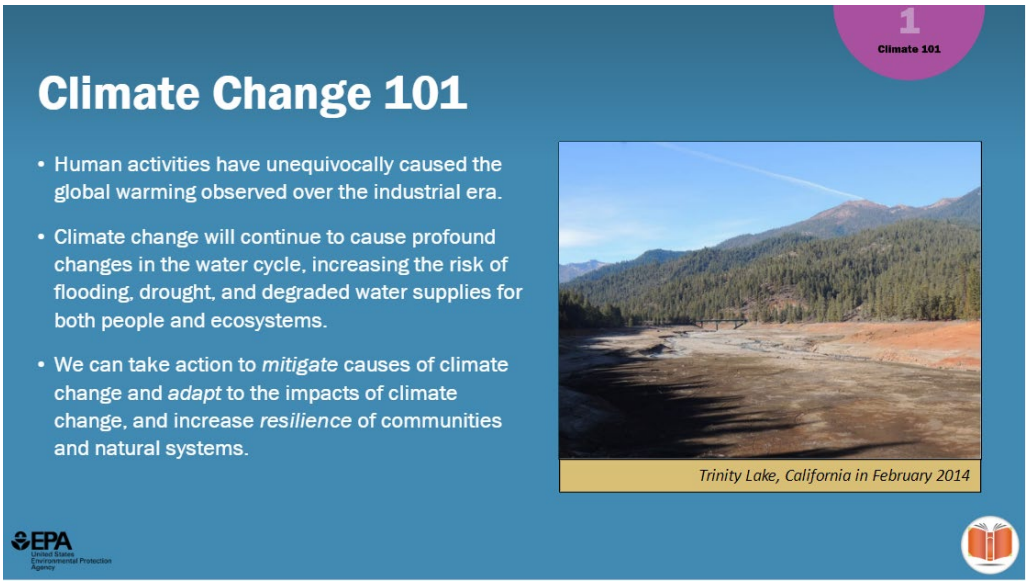
Please click the 'Next' button on the bottom of the course window to advance to the next slide.

Climate Change 101

Notes:

Let's get started with Part 1, Climate Change 101.

Climate Change 101



Notes:

According to the U.S. National Climate Assessment, our Earth is warming. Earth's average temperature has risen by about 2 degrees Fahrenheit on average since the late 1800s and is projected to rise another 2-9 degrees Fahrenheit by the end of this century. Even small changes in the average temperature of the planet can translate into large and potentially dangerous shifts in climate and weather.

Changes to the climate and weather have already presented challenges for water resource managers, and those changes are expected to become more pronounced in the coming decades.

Before we go any further, let's pause to clarify three key terms used in this module.

- Mitigation refers to measures to reduce the amount and rate of future climate change by reducing emissions of heat-trapping gases (primarily carbon dioxide) or removing greenhouse gases from the atmosphere.
- Adaptation refers to the process of adjusting to an actual or expected environmental change and its effects in a way that seeks to moderate harm or exploit beneficial opportunities.
- Resilience is the ability to prepare for threats and hazards, adapt to changing conditions, and withstand and recover rapidly from adverse conditions and disruptions.

Scientific Source:

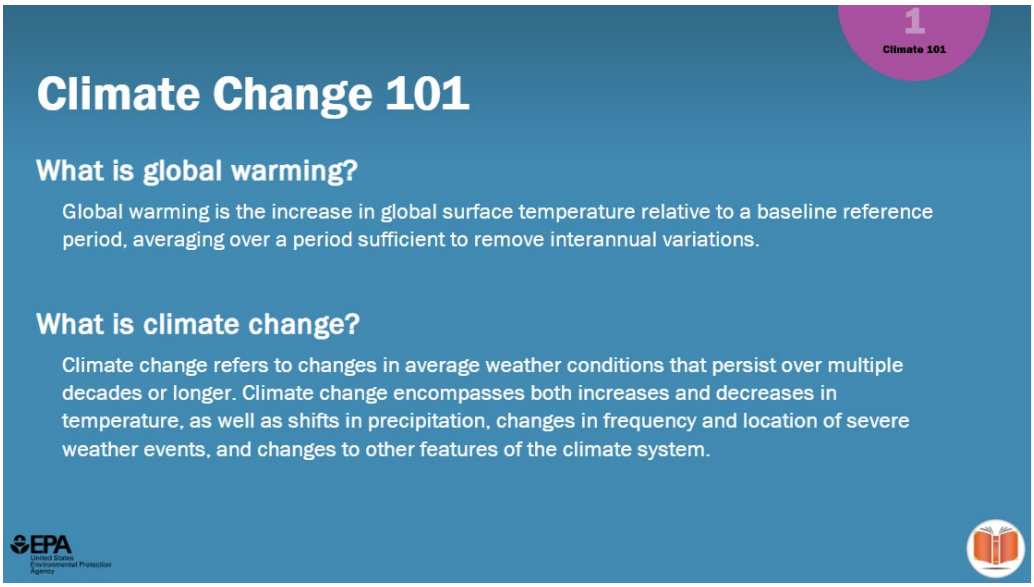
- https://nca2023.globalchange.gov/
- The most recent National Climate Assessment can always be found at https://www.globalchange.gov/
- The National Climate Assessment (NCA) is a quadrennial assessment conducted by the US Global Change Research Program which is comprised of 15 federal agencies. The NCA:
    - Integrate[s], evaluate[s], and interpret[s] the findings of the Program and discuss[es] the scientific uncertainties associated with such findings

- Analyze[s] the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity
- Analyze[s] current trends in global change, both human-induced and natural, and project[s] major trends for the subsequent 25 to 100 years

Graphic:

- Trinity Lake, California in February 2014 - U.S. Geological Survey, http://ca.water.usgs.gov/data/drought/images/carousel/Trinity-Lake-drought-04Feb2014.jpg

Climate Change 101



Notes:

Most people are familiar with the term "global warming," which is defined as "the increase in global surface temperature relative to a baseline reference period, averaging over a period sufficient to remove interannual variations." In common use, it often refers to the warming that has occurred as a result of increased emissions of greenhouse gases from human activities.

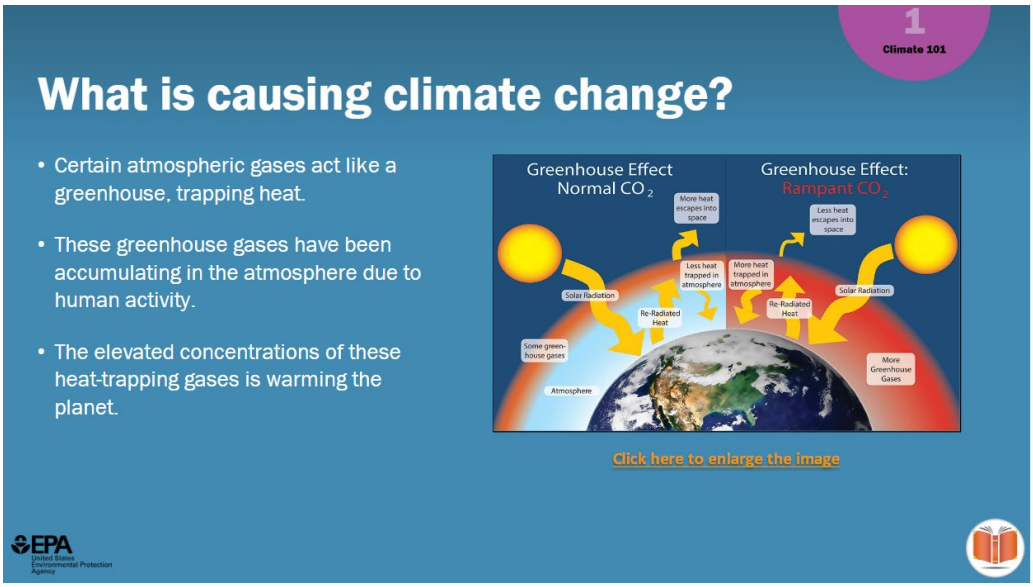
Climate change refers to changes in average weather conditions that persist over multiple decades or longer. Climate change encompasses both increases and decreases in temperature, as well as shifts in precipitation, changes in frequency and location of severe weather events, and changes to other features of the climate system.

You might be wondering what the difference is between weather and climate. Weather is the day-to-day conditions of a particular place. Climate, on the other hand, refers to the observed patterns, range of extremes, and frequency of events over time in that place.

Scientific Source:

- https://nca2023.globalchange.gov/

What is causing climate change?



Notes:

Let's talk about the cause of climate change. When sunlight reaches the Earth's surface, it can either be reflected back into space or absorbed by the Earth. The planet then releases some of the absorbed energy back into the atmosphere as heat. Certain gases are known as "greenhouse gases" because they trap the solar radiation in the Earth's atmosphere, acting much like a greenhouse.

Greenhouse gases are vital to making Earth a habitable planet, but the amounts of the gases in the atmosphere – gases such as carbon dioxide, methane, and nitrous oxide – have been accumulating.

The increase in greenhouse gases is warming the planet and driving other observed climate trends, including increases in the frequency and severity of many types of extreme weather events. Future changes and impacts depend largely on the choices humans make about future greenhouse gas emissions.

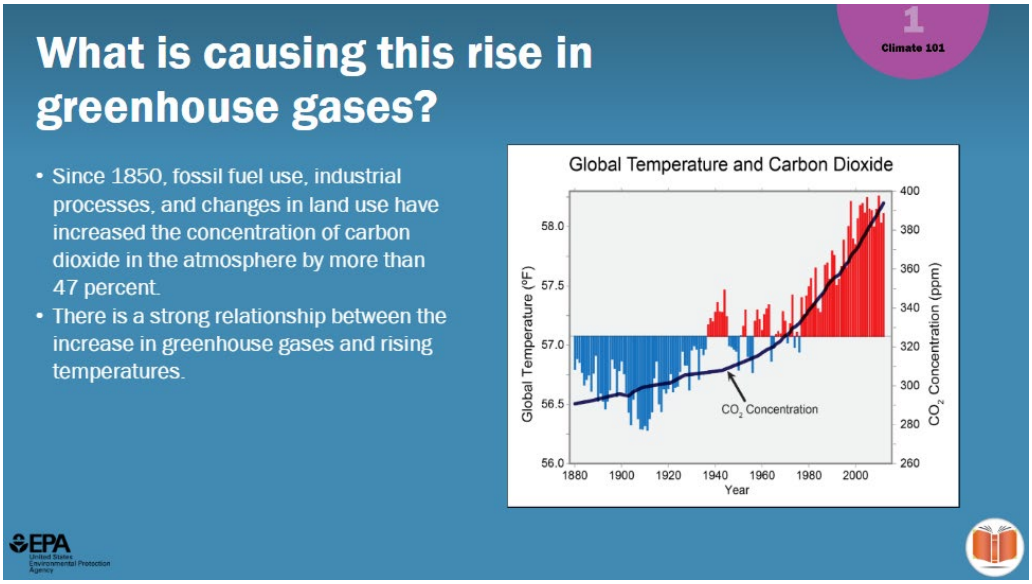
Scientific Source:

- https://nca2023.globalchange.gov/chapter/2/

Graphic:

- U.S. National Park Service, Golden Gate National Recreation Area – What is Climate Change? https://www.nps.gov/goga/learn/nature/climate-change-causes.htm

What is causing this rise in greenhouse gases?



Notes:

So what is causing the rise in greenhouse gases?

In the past, climate change was driven exclusively by natural factors such as Earth's movements in space, volcanic eruptions, forest fires, ocean dynamics, and other natural processes. But since 1850, fossil fuel use, industrial processes, and changes in land use have increased the concentration of carbon dioxide in the atmosphere by more than 47 percent. Agriculture and other human activities have also added methane and nitrous oxide to the atmosphere.

As you can see on this graph, there is a strong relationship between the increase in greenhouse gases and rising temperatures.

Human activities are changing the climate. The evidence for warming across multiple aspects of the Earth system is incontrovertible, and the science is unequivocal that increases in atmospheric greenhouse gases are driving many observed trends and changes. There are more greenhouse gases in the atmosphere primarily because humans have burned and continue to burn fossil fuels for transportation and energy generation.

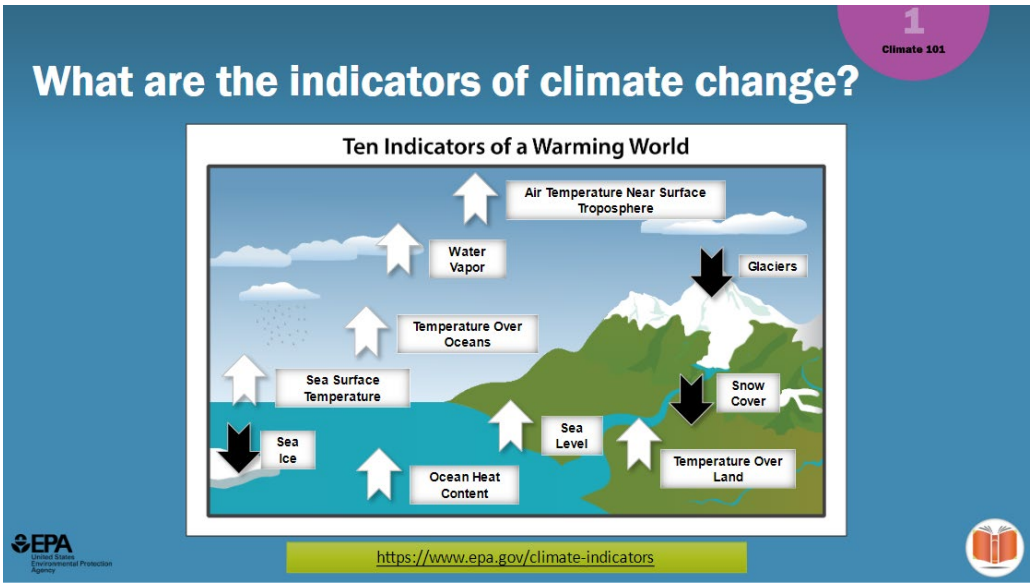
Scientific Source:

- https://nca2023.globalchange.gov/chapter/2/
- Xi-Liu YUE, Qing-Xian GAO, Contributions of natural systems and human activity to greenhouse gas emissions, Advances in Climate Change Research, Volume 9, Issue 4, 2018, Pages 243-252, ISSN 1674-9278, https://doi.org/10.1016/j.accre.2018.12.003. (https://www.sciencedirect.com/science/article/pii/S1674927818300376)

Graphic:

- National Climate Assessment; Our Changing Climate - http://nca2014.globalchange.gov/highlights/report-findings/our-changing-climate#tab2-images

What are the indicators of climate change?



Notes:

Climate change is apparent worldwide and across the United States in a wide range of observations. This graphic illustrates just some of the many indicators that have been measured globally over many decades and show that the Earth's climate is changing. White arrows indicate increasing trends, black arrows indicate decreasing trends.

For example:

Temperatures at the Earth's surface, in the troposphere, and heat stored in the world's oceans have all increased over recent decades. Since 1901, the average surface temperature across the contiguous 48 United States has risen at an average rate of 0.17 degrees Fahrenheit per decade. Average temperatures have risen more quickly since the late 1970s. Rising temperatures lead to many large-scale changes in Earth's climate system, and the consequences increase with warming. Some of these changes can be further amplified through feedback processes at higher levels of warming, increasing the risk of potentially catastrophic outcomes. Changes in sea surface temperature can alter marine ecosystems, and because the oceans continuously interact with the atmosphere, sea surface temperature can also have profound effects on global climate. Snow and ice cover have decreased in most areas. Reduced snowfall and less snow cover on the ground could diminish the beneficial insulating effects of snow for vegetation and wildlife, while also affecting water supplies, transportation, cultural practices, travel, and recreation for millions of people. Such changing climate conditions can have worldwide implications because snow and ice influence air temperatures, sea level, ocean currents, and storm patterns.

Atmospheric water vapor is increasing in the lower atmosphere. The surface warming caused by human production of greenhouse gases leads to an increase in atmospheric water vapor because warmer temperatures make it easier for water to evaporate and stay in the air in vapor form. This creates a positive "feedback loop" in which warming leads to more warming.

Global average sea level is rising. Rising sea level inundates low-lying wetlands and dry land, erodes shorelines, contributes to coastal flooding, and increases the flow of salt water into estuaries and nearby groundwater aquifers. Higher sea level also makes coastal infrastructure more vulnerable to damage from storms.

In addition to these, the EPA tracks a set of more than 50 indicators describing trends related to the causes and effects of climate change. You can view these indicators by navigating to www.epa.gov/climate-indicators, or clicking on the scientific sources icon on this slide.

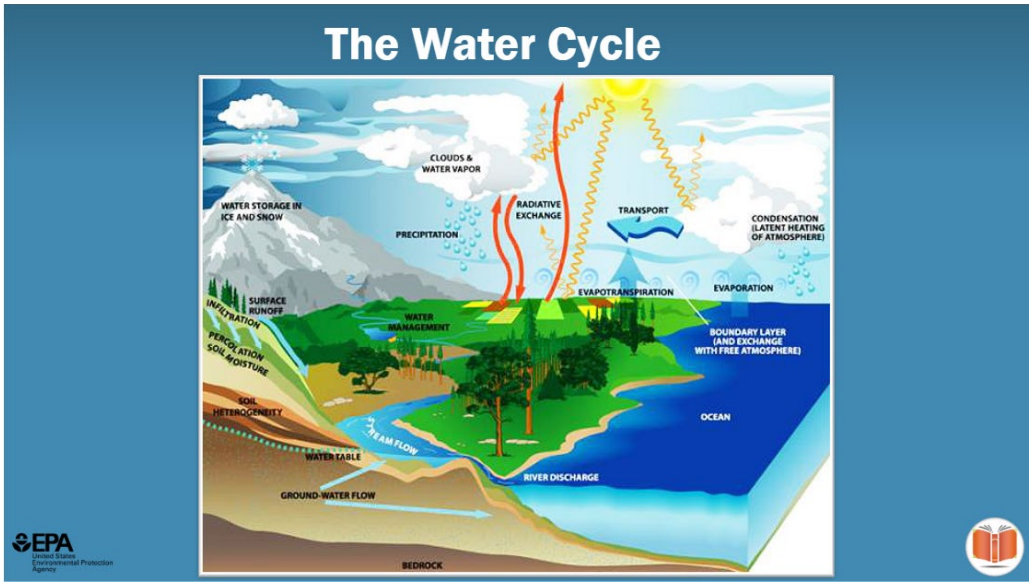
Scientific Sources:

- https://nca2023.globalchange.gov/#overview-section-4
- https://www.epa.gov/climate-indicators

Graphic:

- *Ten Indicators of a Warming World* [Image]. National Oceanic and Atmospheric Administration, National Climatic Data Center. https://nca2014.globalchange.gov/report/our-changing-climate/observed-change

The Water Cycle



Notes:

In the Earth's water cycle, water evaporates from the ocean and the land surface and is carried over the Earth in atmospheric circulation as water vapor. The water vapor condenses to form clouds and precipitates over the ocean and land as rain or snow – which on land can be intercepted by trees and vegetation, potentially accumulating as snow or ice. This precipitation provides runoff on the land surface, infiltrates into soils, recharges groundwater, discharges into streams, and ultimately flows into the oceans as rivers, polar glaciers, and ice sheets, from which it will eventually evaporate again. The various systems involved in the water cycle are usually referred to as hydrological systems.

Climate change has and will continue to cause profound changes in the water cycle, increasing the risk of flooding, drought, and degraded water supplies for both people and ecosystems. These impacts will disproportionately impact frontline communities.

Alaska and northern and eastern regions of the U.S. are seeing and expect to see more precipitation on average, while the Caribbean, Hawai'i, and southwestern regions of the U.S. are seeing and expect to see less precipitation. Heavier rainfall events are expected to increase across the Nation, and warming will increase evaporation and plant water use where moisture is not a limiting factor. Groundwater supplies are also threatened by warming temperatures that are expected to increase demand. Snow cover will decrease and melt earlier. Increasing aridity, declining groundwater levels, declining snow cover, and drought threaten freshwater supplies.

<u>Scientific Sources:</u>

- https://nca2023.globalchange.gov/chapter/4/
- http://water.usgs.gov/edu/watercycle.html

<u>Graphics:</u>

- Our Changing Planet: The Fiscal Year 2003 U.S. Global Change Research Program, http://data.globalchange.gov/file/d7b7addb-6458-4587-87b4-d82661811e8b

What are the observed and projected changes in the U.S.?

Notes:

The U.S. Global Change Research Program has been studying climate change since the organization was formed by Congress in 1990. This cooperative program among federal agencies publishes the National Climate Assessment approximately every four years. You can access the most recent National Climate Assessment by visiting globalchange.gov and clicking on "Read the Report."

Key conclusions of the assessments are that the frequency and intensity of extreme cold events have declined over much of the U.S., while the frequency, intensity, and duration of extreme heat have increased. Across all regions of the U.S., people are experiencing warming temperatures and longer-lasting heatwaves. Over much of the country, nighttime temperatures and winter temperatures have warmed more rapidly than daytime and summer temperatures. Many other extremes, including heavy precipitation, drought, flooding, wildfire, and hurricanes, are becoming more frequent and/or severe, with a cascade of effects in every part of the country.

One of the most direct ways that people experience climate change is through changes in extreme events. Harmful impacts from more frequent and severe extremes are increasing across the country – including increases in heat-related illnesses and death, costlier storm damages, longer droughts that reduce agricultural productivity and strain water systems, and larger, more severe wildfires that threaten homes and degrade air quality.

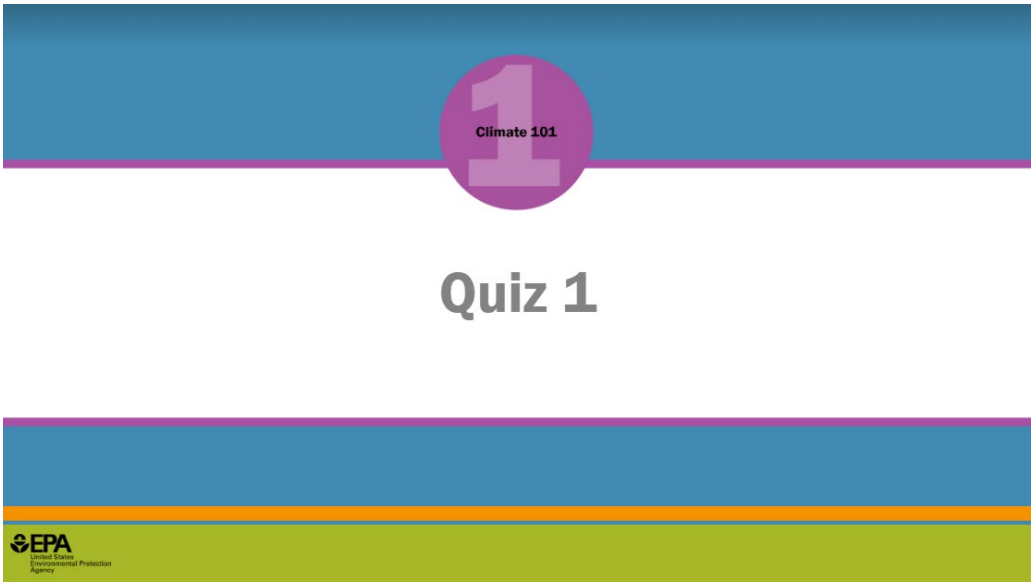
Scientific Source:

- https://nca2023.globalchange.gov/#overview-section-2

Graphic:

- https://nca2023.globalchange.gov/downloads/

Quiz 1

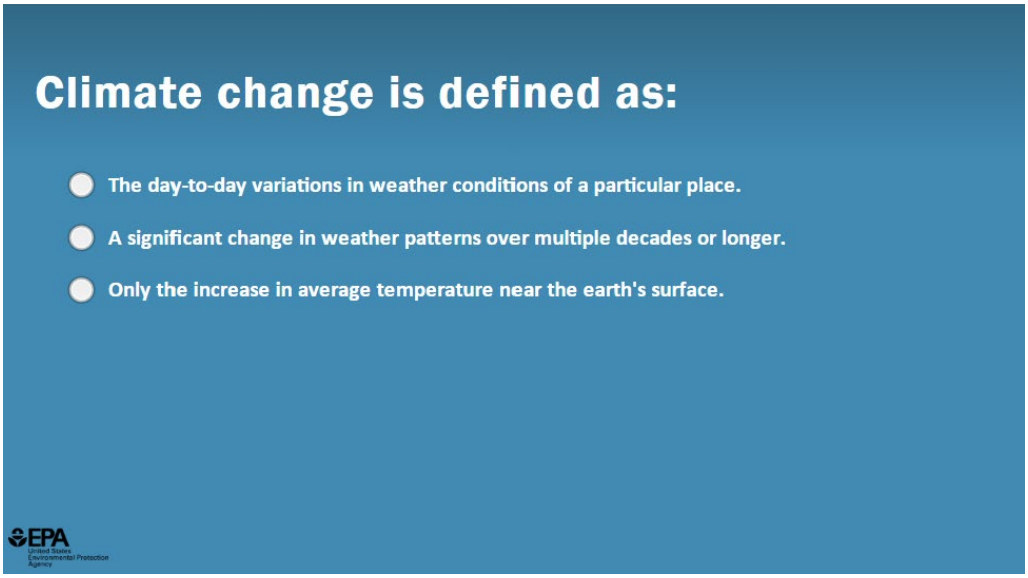


Notes:

Let's stop here and see what you've learned so far.

Quiz 1.1

(Multiple Choice, 0 points, unlimited attempts permitted)



Correct	Choice
	The day-to-day variations in weather conditions of a particular place.
X	A significant change in weather patterns over multiple decades or longer.
	Only the increase in average temperature near the earth's surface.

Feedback when correct:

"Weather" refers to short-term variations in the atmosphere, such as changes in temperature, air pressure, humidity, wind and precipitation.

"Global warming" refers to the rise in global temperatures relative to a baseline reference period, averaging over a period sufficient to remove interannual variations, for example 20-30 years.

"Climate change" refers to changes in average weather conditions that persist over multiple decades or longer.

Feedback when incorrect:

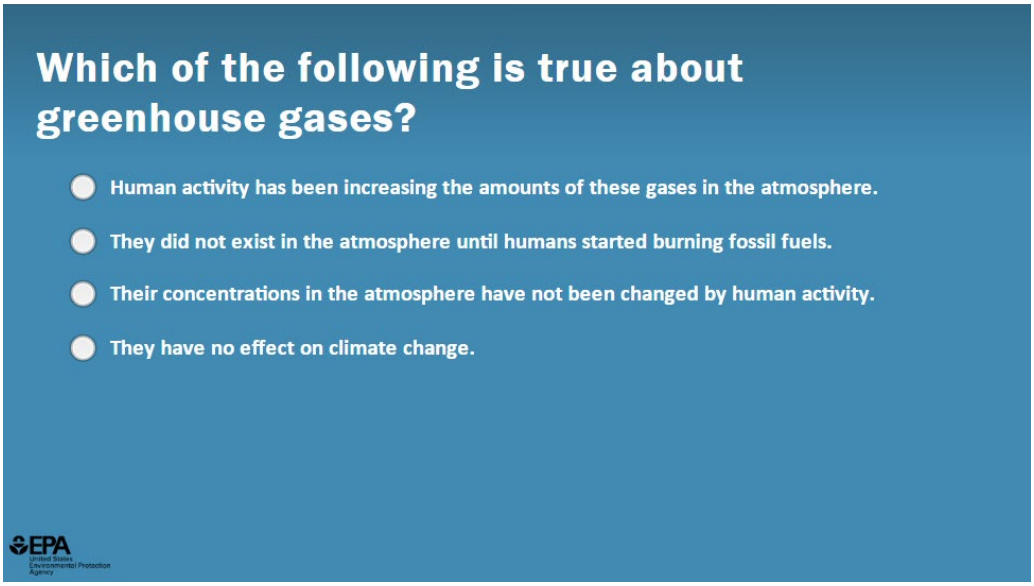
"Weather" refers to short-term variations in the atmosphere, such as changes in temperature, air pressure, humidity, wind and precipitation.

"Global warming" refers to the rise in global temperatures relative to a baseline reference period, averaging over a period sufficient to remove interannual variations, for example 20-30 years.

"Climate change" refers to changes in average weather conditions that persist over multiple decades or longer.

Quiz 1.2

(Multiple Choice, 0 points, unlimited attempts permitted)



Correct	Choice
X	Human activity has been increasing the amounts of these gases in the atmosphere.
	They did not exist in the atmosphere until humans started burning fossil fuels.
	Their concentrations in the atmosphere have not been changed by human activity.
	They have no effect on climate change.

Feedback when correct:

Human activity has been increasing the amounts of greenhouse gases in the atmosphere — gases such as CO_2, methane, and nitrous oxide — through the burning of fossil fuels and other activities. This accumulation of greenhouse gases is causing global average temperatures to rise and has many other impacts as well.

Feedback when incorrect:

Human activity has been increasing the amounts of greenhouse gases in the atmosphere — gases such as CO_2, methane, and nitrous oxide — through the burning of fossil fuels and other activities. This accumulation of greenhouse gases is causing global average temperatures to rise and has many other impacts as well.

Quiz 1.3

(Multiple Choice, 0 points, unlimited attempts permitted)

Correct	Choice
	Snow and ice cover have decreased in most areas.
	Sea level is rising.
	Atmospheric water vapor is increasing.
	Temperatures at Earth's surface have increased over recent decades.
X	All the above.

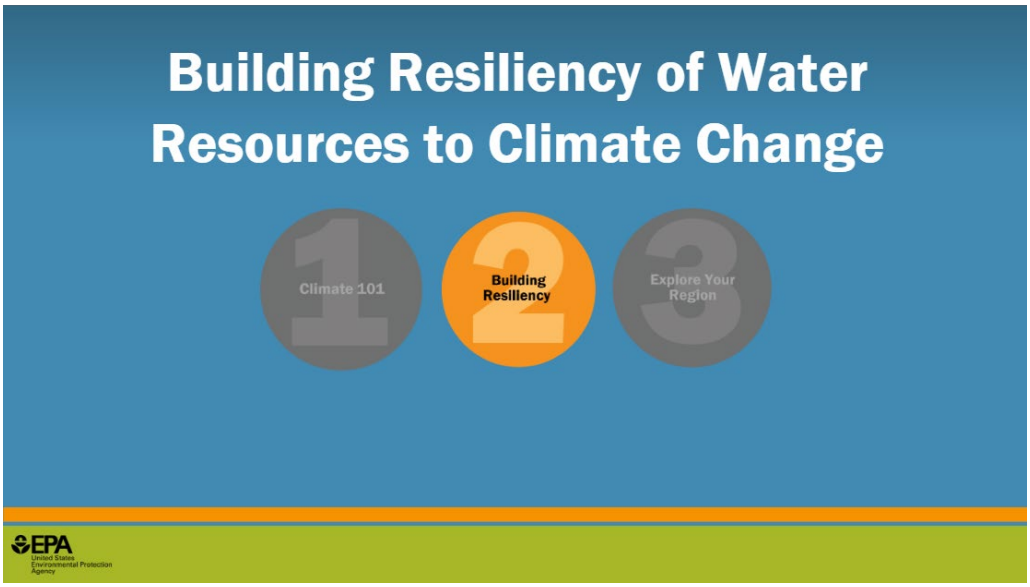
Feedback when correct:

All of these are indicators of climate change.

Feedback when incorrect:

All of these are indicators of climate change.

Building Resiliency of Water Resources to Climate Change



Notes:

Now we are ready to start Part 2, Building Resiliency of Water Resources to Climate Change.

Vulnerabilities of Water Resources to Climate Change

Notes:

The vulnerabilities of water resources include: critical water infrastructure, impacts to the availability of water for human and agricultural use, waterborne illness and water treatment needs, aquatic ecosystem health, and transportation and energy infrastructure interfacing with water.

As we discuss the various aspects of vulnerability, keep in mind that climate change will affect different places in different ways, just as weather varies across the country.

Over the next several slides we'll cover the different ways in which water resources can be affected by climate change.

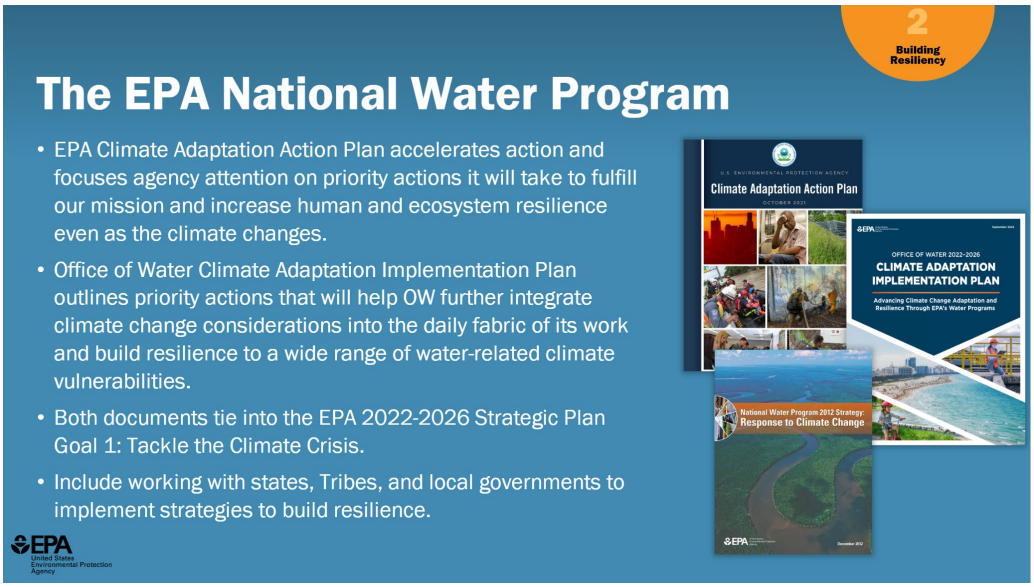
Scientific Source:

- Office of Water 2022-2026 Climate Adaptation Implementation Plan, https://www.epa.gov/system/files/documents/2022-10/bh508-OW-12113_ClimateAdaptatImplementPlan_508final.pdf

Graphics:

- Upper: McCall, K. [Flooded cropland in southwest Iowa]. Natural Resources Conservation Service, U.S. Department of Agriculture.
- Lower: (2010). [View over Devil's Golf Course in Death Valley National Park, CA]. IStock Photo. https://www.istockphoto.com/photo/devils-golf-course-in-death-valley-np-gm146961907-11945953?st=5f50600

The EPA National Water Program



Notes:

As we discuss climate impacts, we will share information on what the EPA has been doing to understand and address the risks to water resources posed by climate change. We also will provide specific examples of local adaptation strategies.

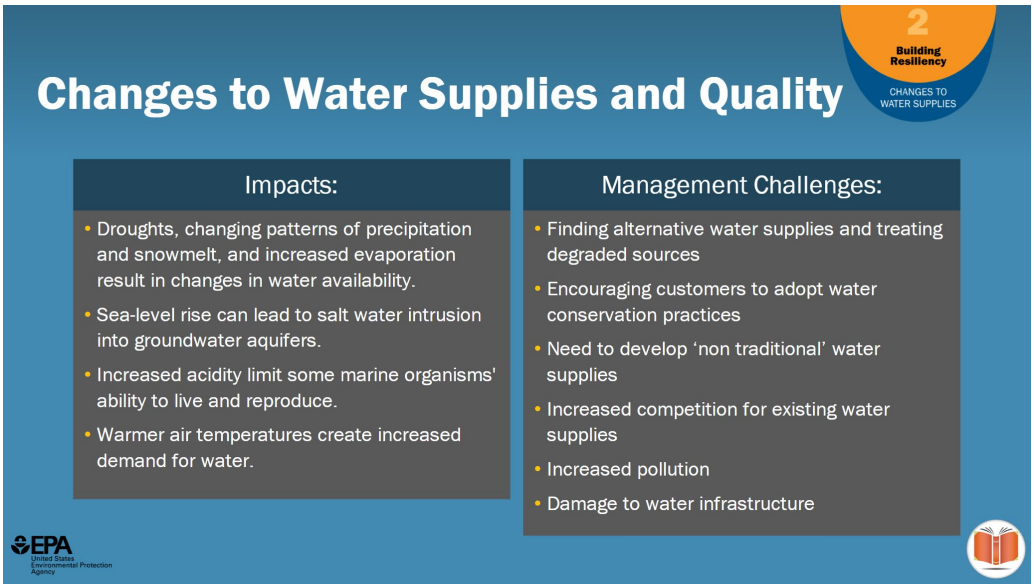
The National Water Program first developed a strategy to respond to climate change in 2012. The actions described in the following slides are part of a larger, comprehensive strategy adopted by the Office of Water in 2022. We are working to mainstream climate change sciences into everything we do, acknowledging that the scientific understanding upon which our programs function has changed and will continue to evolve in the future. And to do this, we are working closely with states, Tribes, local governments and other partners.

This response to climate change by the Office of Water is part of a larger effort by the EPA, including the 2021 EPA Climate Adaptation Action Plan and the development of climate adaptation implementation plans by the Office of Water, other EPA national programs, and the EPA's ten Regional Offices. The EPA's climate adaptation work is part of an effort by all federal agencies to make federal programs and investments more resilient to climate change risks.

Graphics:

- The National Water Program 2012 Strategy - https://www.epa.gov/sites/default/files/2015-03/documents/epa_2012_climate_water_strategy_full_report_final.pdf
- The 2021 EPA CAAP - https://www.epa.gov/system/files/documents/2021-09/epa-climate-adaptation-plan-pdf-version.pdf
- The 2022 OW CAIP - https://www.epa.gov/system/files/documents/2022-10/bh508-OW-12113_ClimateAdaptatImplementPlan_508final.pdf

Changes to Water Supplies and Quality



Notes:

Many areas of the United States, especially the West, already face water supply and drinking water quality issues due to growing populations, longer droughts, and declining snowpack.

Sea level rise can lead to saltwater intrusion and land inundation, thereby increasing the salinity of groundwater and rendering it unusable for human consumption or crop irrigation.

Changes in water chemistry are now limiting the ability of some marine organisms to live and reproduce because of increased acidity. In addition, warmer air temperatures often result in increased demand for water.

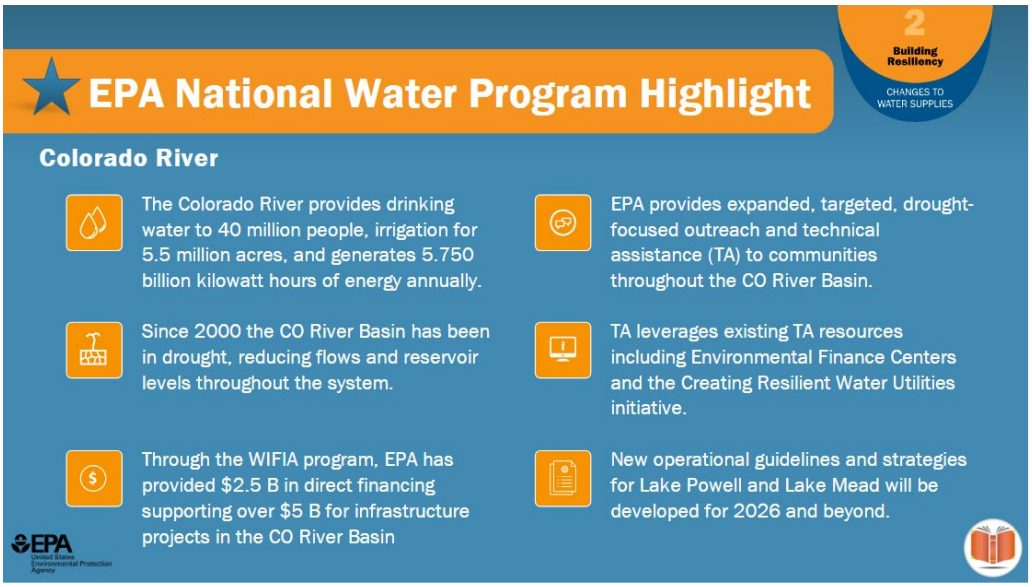
Examples of some of the challenges that water resource managers are facing include:

- Costs to find alternative water supplies or to pay for treating degraded sources;
- Encouraging customers to support and implement water conservation;
- The need to develop, and ensure safe use of, 'non traditional' water supplies such as using water from showers and dishwashers for irrigation or toilet flushing;
- Increased competition for stressed water supplies between urban demand, agriculture, energy production and ecological needs;
- Increased pollution associated with lower water flow and supply; and
- More frequent and larger precipitation events, flooding and damages to water infrastructure.

Scientific Source:

- https://nca2023.globalchange.gov/chapter/4/

EPA National Water Program Highlight: Colorado River



Notes:

The Colorado River is a critically important source of water that provides drinking water to 40 million people, irrigation for 5.5 million acres, and generates 5.750 billion kilowatt hours of energy annually.

Since 2000, the Colorado River Basin has been in drought, reducing flows and reservoir levels throughout the system. In May 2023, amidst a megadrought, Colorado River Basin states and the federal government reached an historic agreement to protect the stability and sustainability of the Colorado River System amidst severe drought conditions.

Through the WIFIA program, the EPA has provided 2.5 billion dollars in direct financing and supporting over 5 billion dollars for infrastructure projects in the Colorado River Basin. As part of the federal response, the EPA provides expanded, targeted, drought-focused outreach and technical assistance to communities in the Colorado River Basin.

This technical assistance leverages existing EPA resources including its network of regional Environmental Finance Centers and the Creating Resilient Water Utilities initiative.

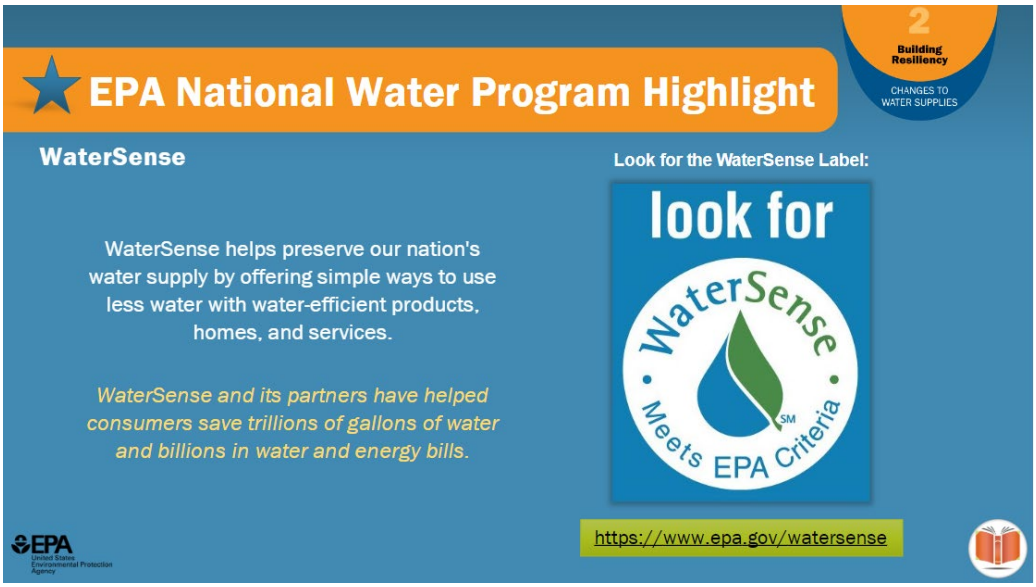
The focus is to maximize long-term water savings in the basin.

New operating guidelines for Lake Powell and Lake Mead are currently being developed that will replace the operating guidelines that expire in 2026.

<u>Scientific Sources:</u>

- https://www.usbr.gov/ColoradoRiverBasin/index.html
- https://www.whitehouse.gov/briefing-room/statements-releases/2023/04/06/fact-sheet-biden-harris-administration-announces-new-investments-to-protect-the-colorado-river-system/
- https://www.usbr.gov/watersmart/bsp/docs/finalreport/ColoradoRiver/CRBS_Executive_Summary_FINAL.pdf

EPA National Water Program Highlight: WaterSense



Notes:

The EPA is working on a number of ways to ensure that people have access to safe water, including conserving water, helping utilities adopt new technologies for water use and other practices.

For example, the EPA's WaterSense program partners with manufacturers, retailers, distributors, builders and utilities to bring WaterSense-labeled products to the marketplace and make it easy for consumers to purchase high-performing, water-efficient products and homes.

WaterSense also labels professional certifying organizations that certify landscape irrigation professionals who are trained for water efficiency.

WaterSense and its partners have helped consumers save trillions of gallons of water and billions in water and energy bills. By reducing water use, WaterSense has also reduced the amount of energy needed to pump, treat and heat water, eliminating millions of metric tons of carbon emissions.

WaterSense resources include:

- Specifications for WaterSense-labeled products for residential indoor, outdoor, and commercial uses;
- Specifications for WaterSense-labeled homes;
- Best management practices for commercial and institutional water efficiency and outdoor water use; and,
- Consumer campaigns to engage the public.

Scientific Source:

- http://www.epa.gov/watersense/

Colorado Springs, CO Case Study

Notes:

The following case study provides an example of how one utility is rising to the challenge of increasing demand for water and a less predictable pattern of precipitation. Colorado Springs Utilities helped home and business owners significantly reduce their water use through an education campaign that advocated the use of WaterSense-labeled products. The utility provided thousands of WaterSense-labeled product rebates and retrofits to consumers eager to save water and energy.

Colorado Springs Utilities hosts a Conservation and Environmental Center that houses a WaterSense showcase and serves as a centerpiece for its outreach efforts, hosting more than 20,000 visitors per year. The showcase displays fully functioning WaterSense-labeled products; a 1-gallon water jug savings comparison between labeled products and less efficient fixtures; and facts about the water, energy and cost savings achieved with WaterSense-labeled products.

By coupling educational programs with efficient technologies, Colorado Springs Utilities has implemented a successful campaign that will continue to reduce water and energy use for years to come.

The resulting water savings was an estimated 80 million gallons of water in a single year.

Graphics:

- Left: Juhan Sonin, www.flickr.com, Creative Commons
- Middle and Right: Mary, Monterey Bay Aquarium, www.flickr.com, Creative Commons

Castine, ME Case Study

Notes:

Here is an example of how a utility in Maine is dealing with its water shortages.

The Castine Water Department in Castine, Maine, serves a population of 1,400 that grows to 2,000 during the summer. Located on a peninsula with limited water supplies, a major infrastructure project in 2015 caused numerous line breaks, required flushing and resulted in over a million gallons of water lost. This water loss, coupled with one of the driest Septembers on record, proved too much for the groundwater sources to meet demand.

In response, the utility implemented several drought response actions, including mandatory water use restrictions; purchase and hauling of water from Bucksport, approximately 17 miles away; and construction of a horizontal well collection and filtration system that captured surface water runoff. When another severe drought gripped Castine in late 2016, the new system was able to successfully meet water demand.

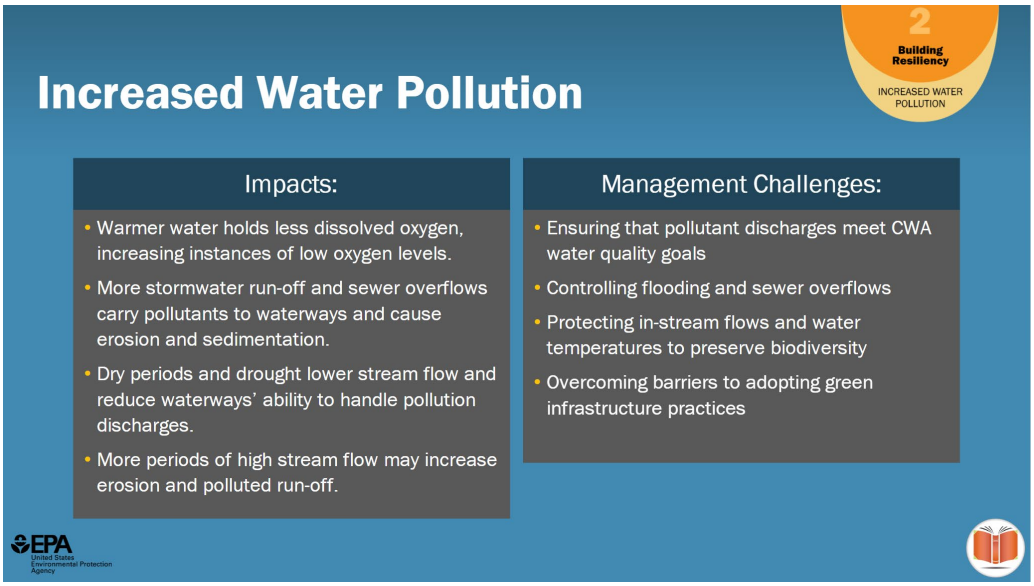
Sources:

- https://epa.maps.arcgis.com/apps/MapSeries/index.html?appid=22ce8bf3bcd742b68101d679828a00d7
- Drought Response and Recovery; A Basic Guide for Water Utilities - (https://www.epa.gov/sites/default/files/2017-10/documents/drought_guide_final_508compliant_october2017.pdf)

Graphic

- Drought Response and Recovery; A Basic Guide for Water Utilities (https://www.epa.gov/sites/default/files/2017-10/documents/drought_guide_final_508compliant_october2017.pdf)

Increased Water Pollution



Notes:

The EPA works with states, Tribes, municipalities, and other partners to implement the Clean Water Act "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters," and the Safe Drinking Water Act to protect public health by regulating the nation's public drinking water supply.

But, as we described earlier, climate change is affecting hydrological patterns that will make protecting surface and drinking water quality more difficult. Examples of the water quality impacts include:

- The reduced ability of warm water to hold dissolved oxygen, making instances of low oxygen levels or "hypoxia" more likely. The combination of warm waters, hypoxia, and nutrient pollution can lead to harmful algal blooms which can sicken or kill people and animals, among other harmful effects;
- More intense precipitation, potentially increasing stormwater runoff and causing sewer overflows;
- Intense rainfall events increasing velocity of stream flow, causing more erosion and sedimentation;
- Dry periods and drought lowering stream flow and reducing dilution of pollution discharges, and
- More frequent periods of high streamflow that may increase erosion and the amount of runoff carrying pollutants into waterways, which decreases drinking water quality.

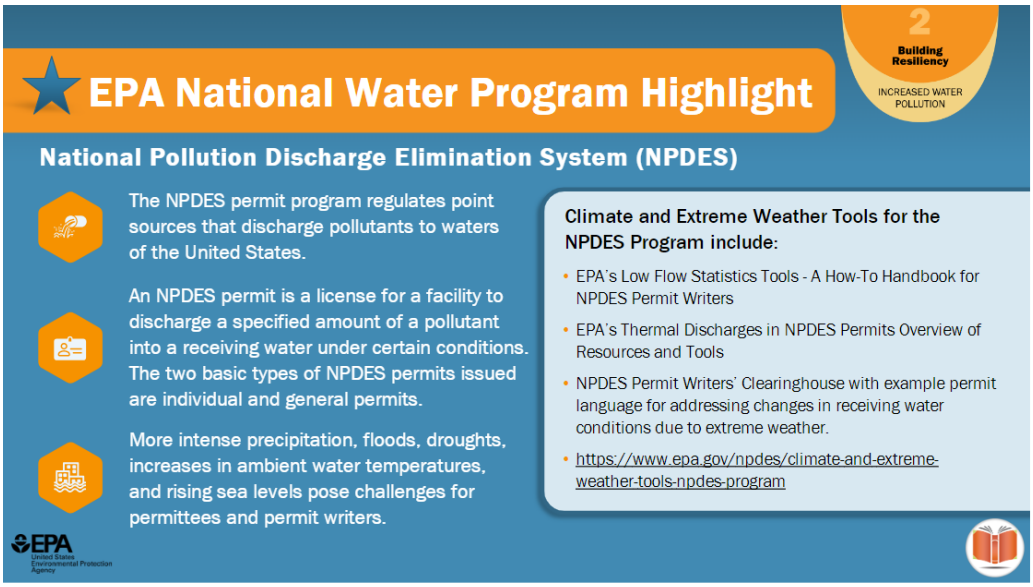
Water resource managers have and continue to need to adopt new strategies to:

- Ensure that Clean Water Act and Safe Drinking Water Act standards and permits can meet water quality protection goals;
- Control stormwater and sewer overflow;
- Work to preserve biodiversity of species that rely on certain seasonal stream flows or water temperatures; and,
- Overcome barriers to adopting green infrastructure practices.

Scientific Sources:

- https://nca2023.globalchange.gov/chapter/4/
- https://www.epa.gov/nutrientpollution/effects-environment
- Office of Water 2022-2026 Climate Adaptation Implementation Plan, https://www.epa.gov/system/files/documents/2022-10/bh508-OW-12113_ClimateAdaptatImplementPlan_508final.pdf

EPA National Water Program Highlight: NPDES



Notes:

The National Pollution Discharge Elimination System, or NPDES program, regulates point sources of pollution.

An NPDES permit is a license for a facility to discharge a specific amount of a pollutant into a receiving water under certain conditions. The two basic types of NPDES permits issued are individual and general permits.

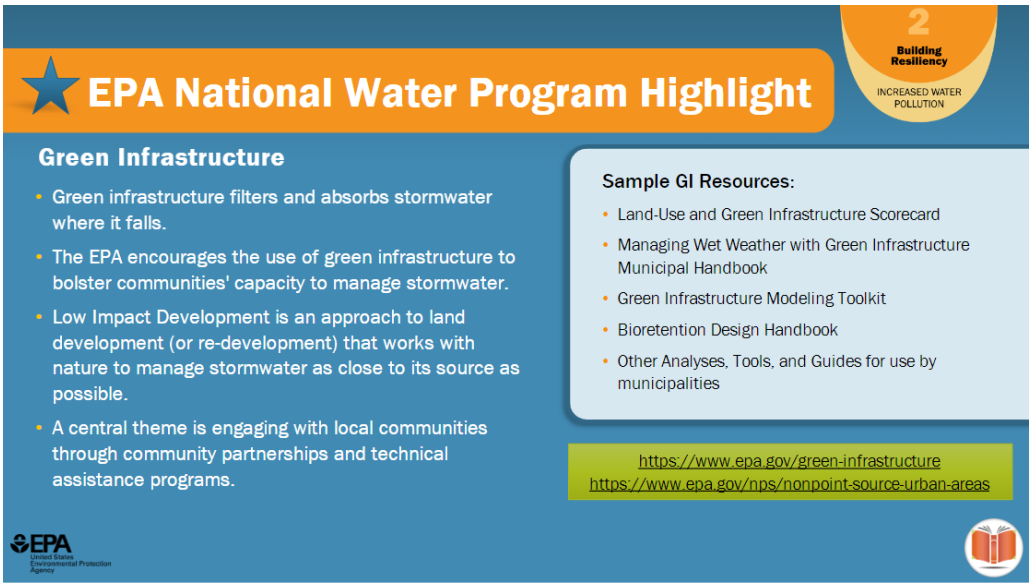
More intense precipitation, floods, droughts, increases in ambient water temperatures, and rising sea levels pose challenges for permittees and permit writers. Managing discharges to protect water quality under these changing conditions can be aided by the refinement of the methods, tools, and information used to develop and implement NPDES permits and programs.

The EPA provides a number of resources to help permittees and permit writers confront the challenges of changing climatic conditions, including Low Flow Statistics Tools - A How-To Handbook for NPDES Permit Writers, Thermal Discharges in NPDES Permits Overview of Resources and Tools, and the NPDES Permit Writers' Clearinghouse with example permit language for addressing changes in receiving water conditions due to extreme weather.

Scientific Source:

- https://www.epa.gov/npdes/climate-and-extreme-weather-tools-npdes-program

EPA National Water Program Highlight: Green Infrastructure



Notes:

Green infrastructure filters and absorbs stormwater where it falls. The EPA encourages the use of green infrastructure to bolster communities' capacity to manage stormwater, thereby becoming more resilient and achieving environmental, social, and economic benefits.

Green infrastructure can help build resilience to climate change as different parts of the country become hotter, drier, or wetter. For example: Rain gardens, bioswales, underground storage and infiltration systems, and other green infrastructure tools can help reduce localized flooding.

More specifically, green infrastructure is defined as "the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or surface waters."

Low Impact Development is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles, such as preserving and recreating natural landscape features, to create functional and appealing site drainage that treat stormwater as a resource rather than a waste product. A central theme of green infrastructure planning is engaging with local communities through community partnerships and technical assistance programs.

The EPA's website has a wide variety of resources to help communities adopt these practices, including:

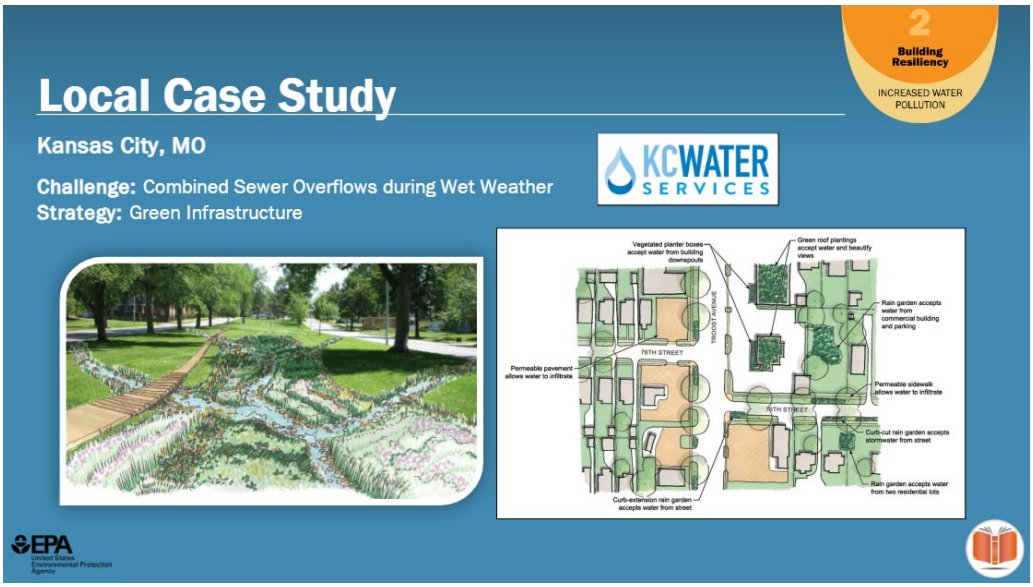
- Land-Use and Green Infrastructure Scorecard guides municipalities through a review of local plans, policies, and municipal practices to illuminate opportunities to better protect water resources.
- Managing Wet Weather with Green Infrastructure Municipal Handbook provides local governments with a step-by-step guide to growing green infrastructure in their communities.

- Green Infrastructure Modeling Toolkit which includes resources that include green or a combination of green and gray infrastructure practices to help communities manage their water resources in a more sustainable way, increasing resilience to future changes.
- Bioretention Design Handbook informs practitioners about the latest trends and approaches for bioretention design, construction, inspection, and maintenance.
- Other Analyses, Tools, and Guides for use by municipalities

Scientific Sources:

- Green Infrastructure websites:
- https://www.epa.gov/green-infrastructure
- https://www.epa.gov/nps/urban-runoff-low-impact-development
- https://www.epa.gov/system/files/images/2021-08/climate_res_infographic-1.jpg

Kansas City, MO Case Study



Notes:

Many communities have sewers that combine both sewage and urban stormwater. With the advent of more intense downpours, controlling overflows of the combined sewers has become a critical issue.

Green infrastructure can help slow down and reduce the amount of stormwater running into sewers.

Controlling combined sewer overflows is a priority in Kansas City, Missouri, and they understand that increasingly intense storm events are exacerbating their wet-weather water pollution problem.

Kansas City's Overflow Control Plan incorporates green infrastructure as part of its strategy to capture 88 percent of stormwater and reduce overflow events. In the first pilot project under the plan, a variety of green infrastructure practices were installed in a 100-acre portion of the city. The use of rain gardens, bioretention cells, pervious pavement, and infiltration infrastructure was shown to be a more cost-effective solution than grey infrastructure alternatives. The 25-year implementation plan now includes extensive use of green infrastructure across their service area, involving seven basins covering 58 square miles.

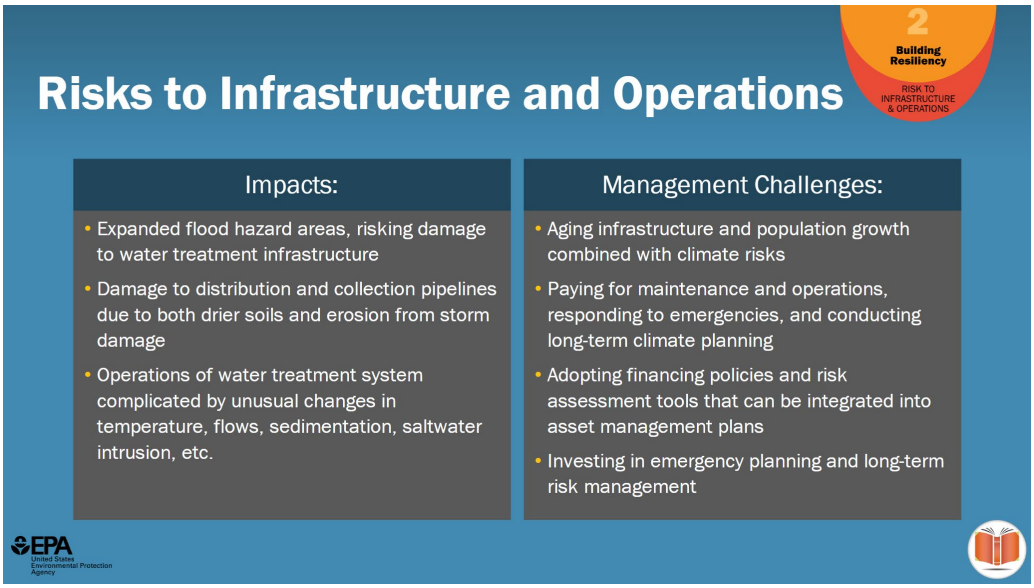
<u>Scientific Sources:</u>

- Stormwater Management Model-Climate Adjustment Tool; http://www.epa.gov/water-research/storm-water-management-model-swmm
- National Stormwater Calculator-Climate Assessment Tool; http://www.epa.gov/water-research/national-stormwater-calculator

<u>Graphics:</u>

- Kansas City Water Services; https://www.kcwater.us/

Risks to Infrastructure and Operations



Notes:

If water is the lifeblood of a community, water infrastructure is the circulatory system. Water infrastructure is the conduit that delivers fresh supplies and carries away and treats wastes.

Unfortunately, we have already witnessed some of the effects of climate change on water infrastructure, such as:

- Expanded flood hazard areas, risking damage to water treatment infrastructure.
- Damage to distribution and collection pipelines due to both drier soils and erosion from storm damage.
- Operations of water treatment systems complicated by unusual changes in temperature, flows, sedimentation, saltwater intrusion, etc.

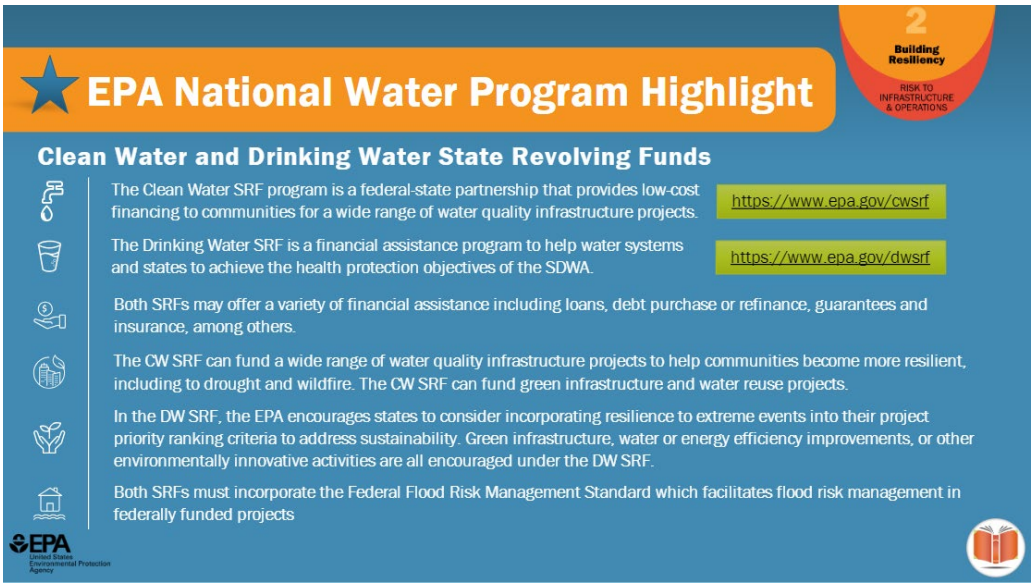
Water resource managers are challenged by aging infrastructure and population growth, combined with climate risks.

Other challenges include paying for maintenance and operations, responding to emergencies, conducting long-term climate planning, adopting policies and practices that integrate planning for climate change into their overall management plans, and investing in emergency response planning.

Scientific Sources:

- https://nca2018.globalchange.gov/
- https://www.epa.gov/climate-adaptation
- http://www.epa.gov/climate-change-water-sector/planning-and-management-programmatic-response-climate-change-and-water

EPA National Water Program Highlight: Clean Water and Drinking Water State Revolving Funds



Notes:

The EPA's Clean Water and Drinking Water State Revolving Funds are federal state partnerships that provide low-cost financing to communities for a wide range of water quality and drinking water infrastructure projects.

Under both SRF programs, the EPA provides grants to all 50 states, plus Puerto Rico, to capitalize loan programs. The states contribute an additional 20 percent to match the federal grants.

The 51 SRF programs function like environmental infrastructure banks by providing low interest loans to eligible recipients for water infrastructure projects. As money is paid back into the state's revolving loan fund, the state makes new loans to other recipients. Repayments of loan principal and interest earnings are recycled back into individual state SRF programs to finance new projects that allow the funds to "revolve" at the state level over time.

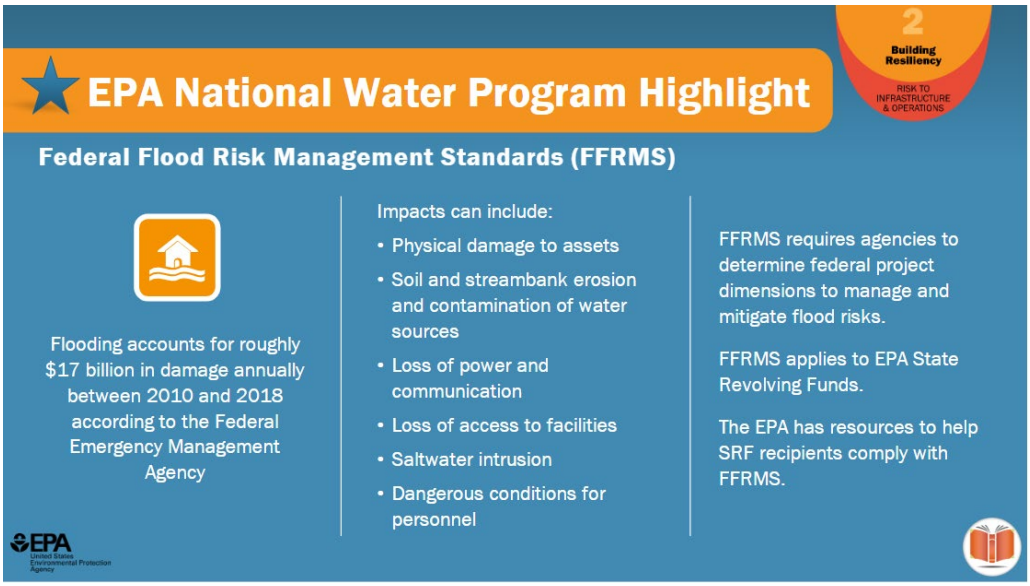
Both SRFs may offer a variety of financial assistance including loans, debt purchase or refinance, guarantees and insurance, and more.

Both SRFs encourage and support the funding of resilient and sustainable water infrastructure, including green infrastructure and incorporation of the Federal Flood Risk Management standard which facilitates flood risk management in federally funded projects.

Scientific Sources:

- https://www.epa.gov/cwsrf
- https://www.epa.gov/dwsrf

EPA National Water Program Highlight: FFRMS



Notes:

Flooding is one of the most common hazards in the United States, accounting for roughly $17 billion in damage annually between 2010 and 2018 according to the Federal Emergency Management Agency, and it will continue to be an ongoing challenge for water infrastructure. Impacts can include physical damage to assets, soil and streambank erosion and contamination of water sources, loss of power and communication, loss of access to facilities, saltwater intrusion, and dangerous conditions for personnel.

The Federal Flood Risk Management Standard, or FFRMS, requires agencies to determine specific federal building or project dimensions – that is, how high, how wide, and how expansive a building or project should be – in order to manage and mitigate any current or potential flood risks.

In this way, the FFRMS will increase the resilience of infrastructure to flooding events.

The FFRMS went into effect in fiscal year 2022 for EPA's State Revolving Fund (SRF) capitalization grants, including the Bipartisan Infrastructure Law funding.

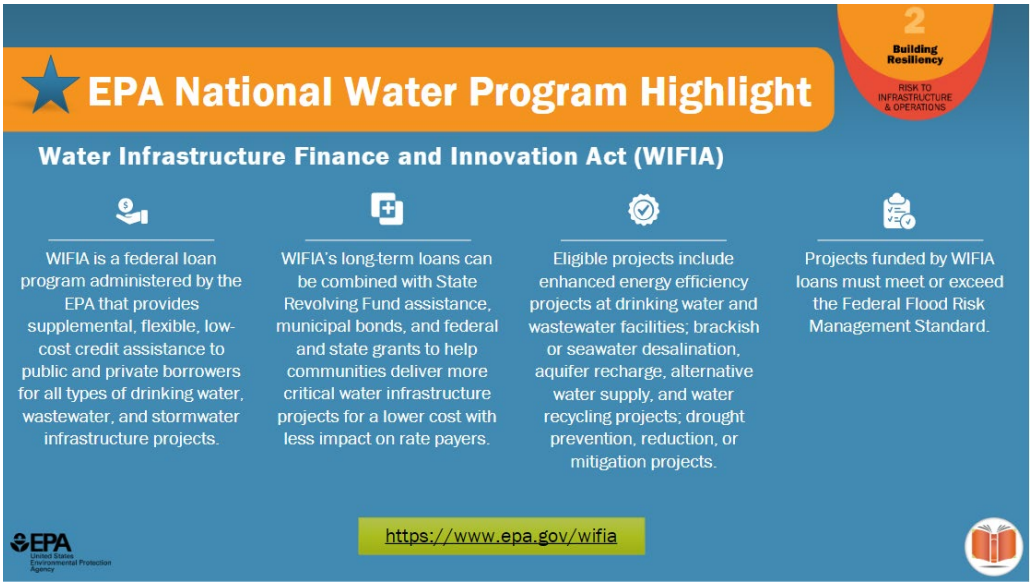
The FFRMS applies to actions where federal funds are used for new construction, substantial improvement (i.e., projects worth more than 50% of the market value or replacement cost of the facility), or to address substantial damage to structures and facilities.

The EPA has several tools and resources to help potential SRF recipients with evaluating their water system or project with respect to this standard, including Creating Resilient Water Utilities, or CRWU, technical assistance and resources; the guide Flood Resilience: A Basic Guide for Water and Wastewater Utilities; the Fed FUNDS web page which presents information tailored to water and wastewater utilities on federal disaster and mitigation funding programs from the EPA, FEMA, HUD, and SBA; and others.

<u>Scientific Source:</u>

- https://www.epa.gov/system/files/documents/2022-09/Federal%20Flood%20Risk%20Managment%20Standard%20.pdf

EPA National Water Program Highlight: WIFIA



Notes:

The Water Infrastructure Finance and Innovation Act, or WIFIA, program is a federal loan program operated by US EPA headquarters that provides supplemental, flexible, low-cost credit assistance to public and private borrowers for all types of wastewater, drinking water, and stormwater projects.

The WIFIA program offers long-term loans that can be combined with State Revolving Fund assistance, municipal bonds, and federal and state grants to help communities deliver more critical water infrastructure projects for a lower cost with less impact on rate payers.

Several different types of climate mitigation projects are eligible under the WIFIA program, including: enhanced energy efficiency projects at drinking water and wastewater facilities; brackish or seawater desalination, aquifer recharge, alternative water supply, and water recycling projects; drought prevention, reduction, or mitigation projects. All projects must meet or exceed the Federal Flood Risk Management Standard.

Scientific Source:

- https://www.epa.gov/wifia

EPA National Water Program Highlight: CRWU

Notes:

The EPA Creating Resilient Water Utilities initiative – or "crew" for short – provides drinking water, wastewater, and stormwater (water sector) utilities with practical tools, training, and technical assistance to increase system resilience to climate change impacts. CRWU helps promote a clear understanding of climate data and helps water sector utilities identify potential adaptation strategies, implementation options, and infrastructure financing.

CRWU has been working with water utilities and climate experts to develop several tools to help water utility managers in communities of all sizes. One of its most notable tools is the Climate Resilience Evaluation and Awareness Tool (or CREAT).

The EPA also has a variety of resources to help increase the sustainability of infrastructure, including improving energy efficiency.

A few of these resources are listed here. Sample CRWU Resources:

- Climate Resilience Evaluation and Awareness Tool (CREAT)
- Resilient Strategies Guide
- Climate Scenarios Projection Maps
- Climate Risk and Resilience Trainings by Climate Region

Scientific Sources:

- http://www.epa.gov/crwu
- https://www.epa.gov/sites/default/files/2016-06/documents/rural_and_small_systems_guidebook_-_may_2016_508.pdf

South Monmouth, NJ Case Study

Notes:

How is it that, when Superstorm Sandy hit New Jersey in October 2012, the South Monmouth Regional Sewerage Authority sustained no appreciable damage to their Sea Girt Pump Station? Other sewage plants and pump stations along the coast were inundated by flood waters and without power for as long as three days, resulting in the discharge of about 2 billion gallons of untreated and partially treated sewage into New Jersey waterways.

In 2006, the Authority used EPA's Climate Resilience Evaluation and Awareness Tool to determine that there was the risk of repeated flooding. Without substantial funding to build a new facility, they devised an innovative solution: to house their most sensitive equipment in a mobile trailer. Subsequently, as Superstorm Sandy approached, the trailer was moved and replaced with an expendable generator that enabled the facility to remain operational until the generator was damaged or destroyed. When the storm subsided, the trailer was moved back into place and the generator was put back online, allowing for cost savings and minimal downtime.

The result was that the sewerage authority saved $1.5 million in potential damage and had no loss of sewer service to residents and no sewer service overflows.

Scientific Sources:

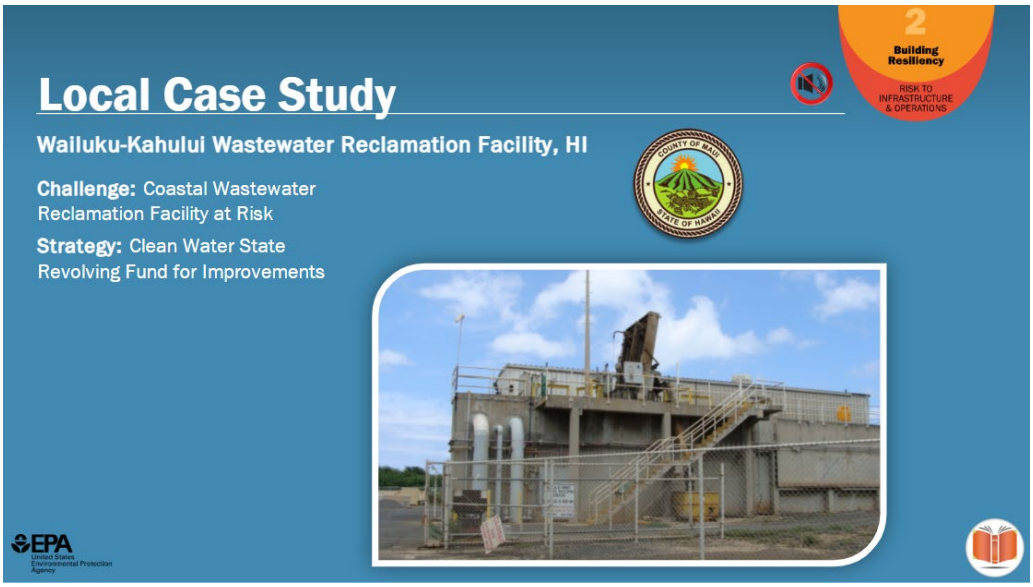
- http://www.onewaterohio.org/docs/1300._EPAs_Climate_Resilience_Evaluation_and_Awareness.pdf
- Video: https://www.fema.gov/media-library/assets/videos/86134
- https://femacontract.com/news/sewerage-authority-mitigation-plan-reduces-risk-of-environmental-disaster/

Graphics:

- http://www.smrsa.org/

- Left: (2013). [An esthetically designed portable trailer houses an emergency generator, a successful mitigation project South Monmouth Regional Sewerage Authority (SMRSA) implemented in their Sea Girt pump station before Superstorm Sandy struck.]. Federal Emergency Management Agency. https://femacontract.com/news/sewerage-authority-mitigation-plan-reduces-risk-of-environmental-disaster/
- Right: [South Monmouth Regional Sewerage Authority Executive Director Michael Ruppel, systems mechanic Steve Harsin, apprentice Barney Bigley and plant maintenance worker Thomas Valerio (from left) stand behind the portable pump station/trailer in Sea Girt, N.J.]. Municipal Sewer and Water Magazine.

Wailuku-Kahului, HI Case Study



Notes:

In many ways, Pacific Islands face the brunt of climate change impacts. Tropical cyclones, unpredictable precipitation patterns, and sea-level rise are just a few of the climate challenges they face.

Located close to the ocean, the Wailuku-Kahului Wastewater Reclamation Facility in Hawaii is an example of an important coastal facility at risk. Recognizing these risks, Maui County, the operator of the facility, studied its vulnerabilities and determined that structural modifications, repairs, and reinforcement of the facility were needed. The county used the Clean Water State Revolving Loan Fund to help finance facility improvements to adapt to the long-term effects of climate change. This included constructing a new second floor room and moving all electrical components to that level. An extended foundation for the facility also was built. The county also constructed a revetment designed to absorb the energy of tidal flows and guard against erosion.

These measures ensure the continued operation of the facility during extreme weather, and ensure that the facility can remain functional for many years under various sea-level rise scenarios.

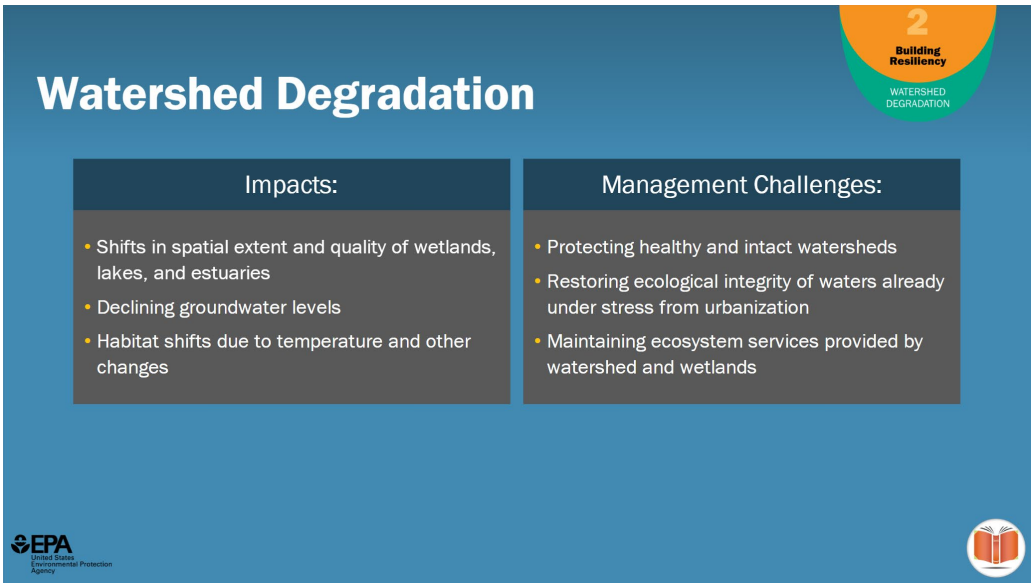
Scientific Source:

- Wailuku-Kahului; http://files.hawaii.gov/dlnr/meeting/submittals/140411/K-2.pdf

Graphic:

- Kahului Wailuku Wastewater Treatment Plant, Juan Rivera, County of Maui, Wastewater Reclamation Division http://mauinow.com/2012/09/20/shoreline-protection-proposed-at-kahului-wastewater-facility/

Watershed Degradation



Notes:

Watersheds provide benefits to humans known as "ecosystem services," which include water storage, water filtration, flood control, nutrient cycling, carbon storage, erosion and sedimentation control, and more. Watersheds are stressed by urbanization and pollution, making them less resilient to climate change.

These stressors, combined with changes in climate, affect watersheds in a number of ways:

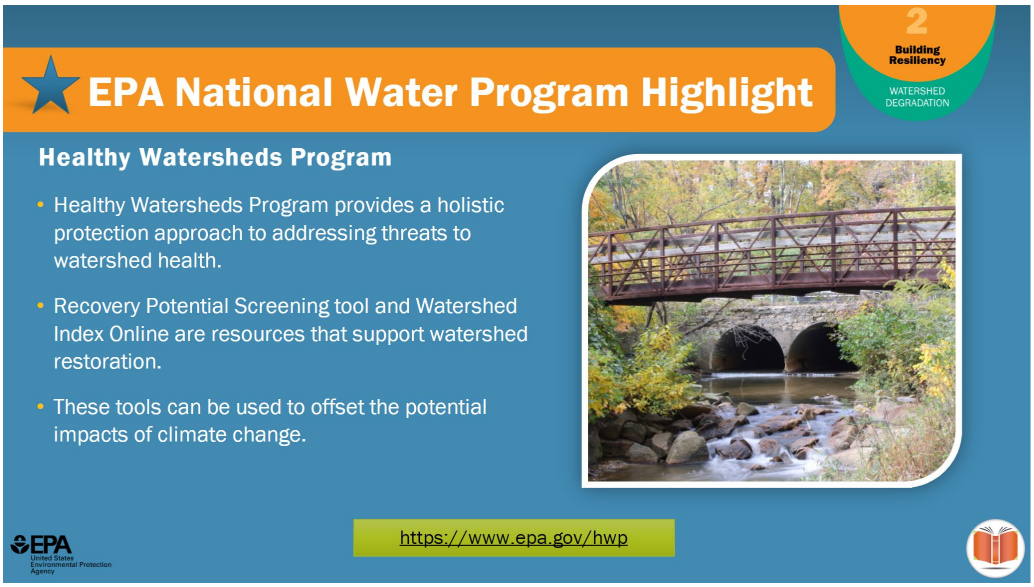
- Changes in precipitation and increased evaporation change streamflow patterns to lakes and streams, affecting the extent and quality of water supplies, wetlands, lakes, and estuaries.
- Declining groundwater levels due to withdrawals and reduced recharge are likely to reduce stream flows.
- Temperature and other changes will affect habitat for certain species, such as cold-water fish and corals.

Water resource managers are challenged to protect and restore watersheds, including the ecological integrity of waters already under stress from urbanization. The maintenance of ecosystem services provided by watersheds and wetlands is essential to our social, environmental and economic well-being.

Scientific Sources:

- https://www.epa.gov/hwp/benefits-healthy-watersheds
- https://nca2023.globalchange.gov/chapter/8/#fig-8-4

EPA National Water Program Highlight: Healthy Watersheds Program



Notes:

The EPA created the Healthy Watersheds Program to provide a holistic protection approach to addressing threats to watershed health, including loss and fragmentation of aquatic habitat, hydrologic alteration, invasive species and climate change.

In addition, Recovery Potential Screening is a systematic desktop tool that can be used to identify differences and set priorities among watersheds that might influence their relative likelihood to be successfully restored or protected.

The Watershed Index Online is an EPA website and database that hosts a library of hundreds of watershed indicators that include ecological condition metrics, stressor metrics, and social metrics to help when using other tools like the Healthy Watersheds Program and Recovery Potential Screening.

All these watershed tools can be used to offset the potential impacts of climate change by:

- Remediating water quality impairments.
- Maintaining baseflow during periods of drought.
- Reducing Flooding.
- Maximizing surface water and groundwater recharge.
- Abating water temperature extremes.
- Preserving habitat corridors for species migration, and
- Restoring and protecting native vegetation and soils.

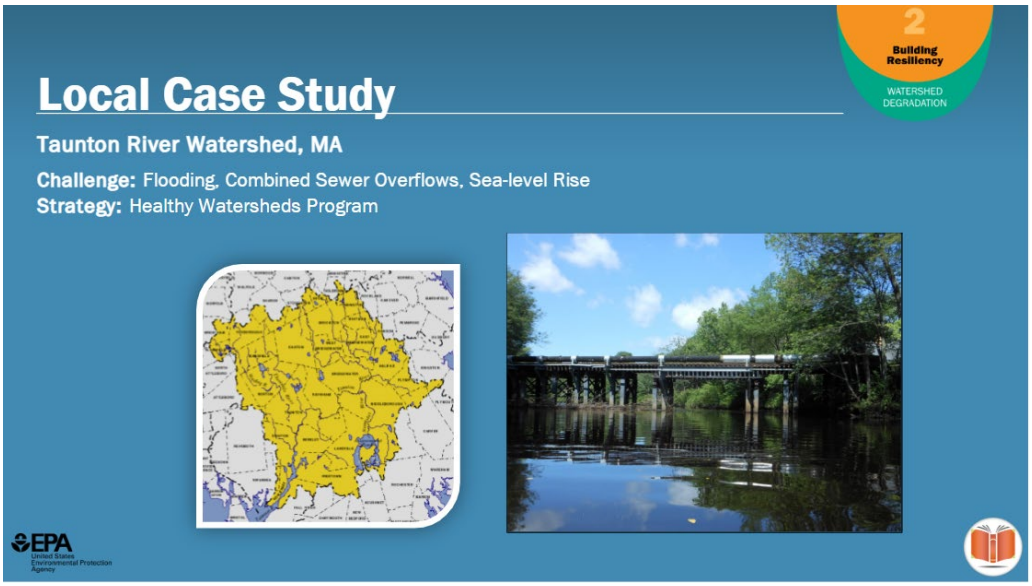
Scientific Sources:

- https://www.epa.gov/hwp
- http://www.epa.gov/rps/
- https://www.epa.gov/wsio

Graphic:

- Photo by Tetra Tech, Inc., Fairfax County, VA

Taunton River, MA Case Study



Notes:

As the longest undammed river in the region, the Taunton River in Southeastern Massachusetts forms a unique ecosystem and is designated a National Wild & Scenic River. Climate change is already affecting the Taunton River watershed in a variety of ways, threatening the attributes that make the river and its watershed special to residents and visitors.

In the past 50 years, heavy precipitation events have increased 67 percent, increasing flooding and threatening water quality. Over the past 100 years, sea level has risen 3/4 of a foot in the Narragansett Bay and is projected to increase more, further impacting the Taunton River watershed.

To ensure the long-term health of this watershed in the face of climate change, the EPA's Healthy Watersheds Program worked with partners to develop a comprehensive climate adaptation plan.

The plan calls for a network of watershed-scale green infrastructure, including a network of working lands, urban forests, bioswales, riparian buffers, and urban stormwater management. Protecting and restoring blocks of habitat and the corridors that connect them improves watershed resilience while reducing flooding and combined sewer overflows that impact water quality.

Over the long term, the adaptation plan calls for the protection of prime agricultural soils to foster new agricultural opportunities while preventing an increase in impervious surfaces.

The Taunton River watershed exemplifies how to use a variety of approaches to design a robust, yet adaptable, response to climate change.

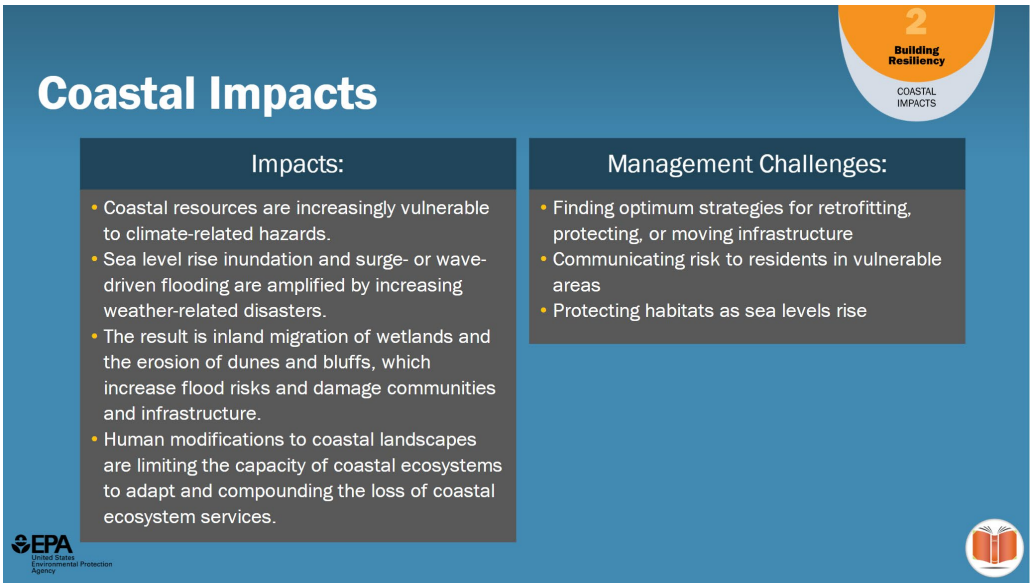
Scientific Sources:

- https://www.manomet.org/publication/manomet-climate-change-adaptation-plan-guides-efforts-in-taunton-river-watershed/
- http://kresge.org/sites/default/files/Uploaded%20Docs/Manomet%20CCS.pdf

Graphics:

- Left: Taunton River Watershed, USGS, https://en.wikipedia.org/wiki/Taunton_River_Watershed#/media/File:Taunton_River_Watershed.gif
- Right: Railroad Bridge over Taunton River near Dean Street, Taunton, Massachusetts, by Marbela, https://en.wikipedia.org/wiki/List_of_crossings_of_the_Taunton_River#/media/File:Taunton_River_third_RR_bridge.JPG

Coastal Impacts



Notes:

Coastal resources, ranging from water infrastructure to fisheries, are increasingly vulnerable to sea-level rise, storm surge, erosion, flooding, and related hazards.

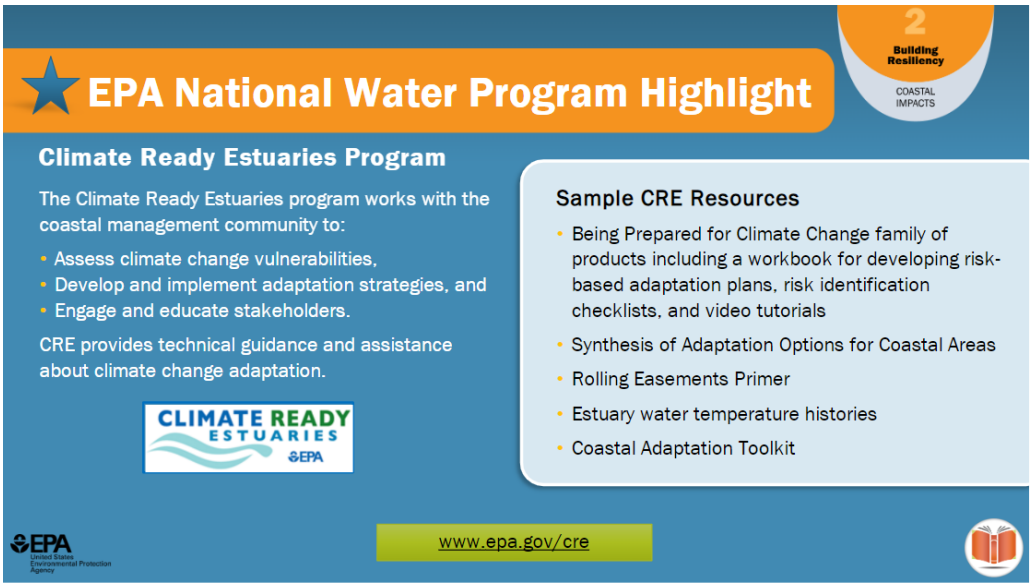
Sea level rise inundation (i.e. permanent inundation by daily high tides) and surge- or wave-driven flooding (i.e. temporary flooding driven by storm events) are amplified by increasing weather-related disasters across US coasts. As a result, coastal communities, coastal ecosystems, and natural shorelines are experiencing inland migration of wetlands and storm erosion of dunes and bluffs, changes that increase flood risks and damages to coastal communities and major infrastructure. Human modifications to coastal landscapes, such as seawalls, levees, and urban development, are both limiting the capacity of coastal ecosystems to adapt naturally and are compounding the loss of coastal ecosystem services.

Because of these impacts, managers are being challenged to find optimum strategies for retrofitting, protecting or moving infrastructure. They must also find ways to better communicate risk to residents in vulnerable areas and protect habitat as sea levels rise and coastlines erode.

Scientific Source:

- https://nca2023.globalchange.gov/chapter/9/

EPA National Water Program Highlight: Climate Ready Estuaries



Notes:

The Climate Ready Estuaries program works with the coastal management community to: Assess climate change vulnerabilities; Develop and implement adaptation strategies; and Engage and educate stakeholders.

CRE provides technical guidance and assistance about climate change adaptation.

Since its first awards in 2008 CRE supported more than six dozen demonstration and capacity building projects.

CRE currently focuses on helping partners develop adaptation plans, creating methodological guides, curating high quality resources in its online toolkit, and filling coastal change data gaps.

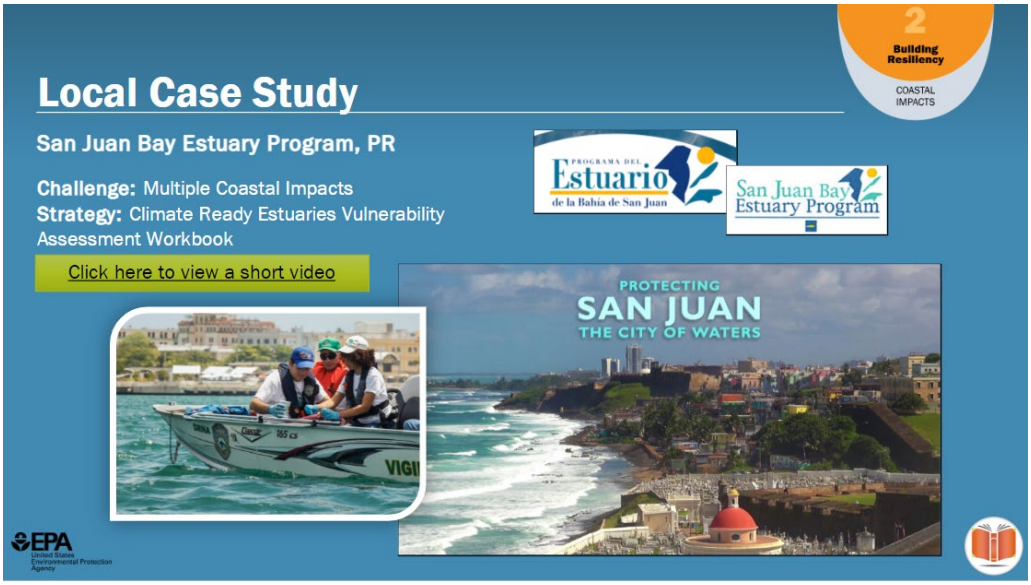
Sample CRE Resources include:

- Being Prepared for Climate Change family of products including a workbook for developing risk-based adaptation plans, risk identification checklists, and video tutorials
- Synthesis of Adaptation Options for Coastal Areas
- Rolling Easements Primer
- Estuary water temperature histories
- Coastal Adaptation Toolkit

Scientific Source:

- http://www.epa.gov/cre

San Juan, PR Case Study



Notes:

Residents along the highly valued San Juan Bay in Puerto Rico have become aware of multiple climate change impacts that are affecting both the health of the estuary and their quality of life.

Local leaders decided to use the Climate Ready Estuaries guide, titled: Being Prepared for Climate Change: A Workbook for Developing Risk-Based Adaptation Plans. They have supported broad public engagement-which has resulted in identifying 27 high risks to address-and have subsequently instituted projects to increase the resilience of the ecosystem.

At every step, they have involved the community to ensure that local residents are educated and invested in the long-term success of the project. Actions underway include:

- Eliminating sewage discharge and reducing runoff to prevent nutrient and pathogen loading;
- Planting red mangroves and restoring seagrass beds to protect shorelines and to sequester carbon;
- Removing invasive species to facilitate succession of native species; and
- Using “citizen science” to monitor water quality and sea-level rise.

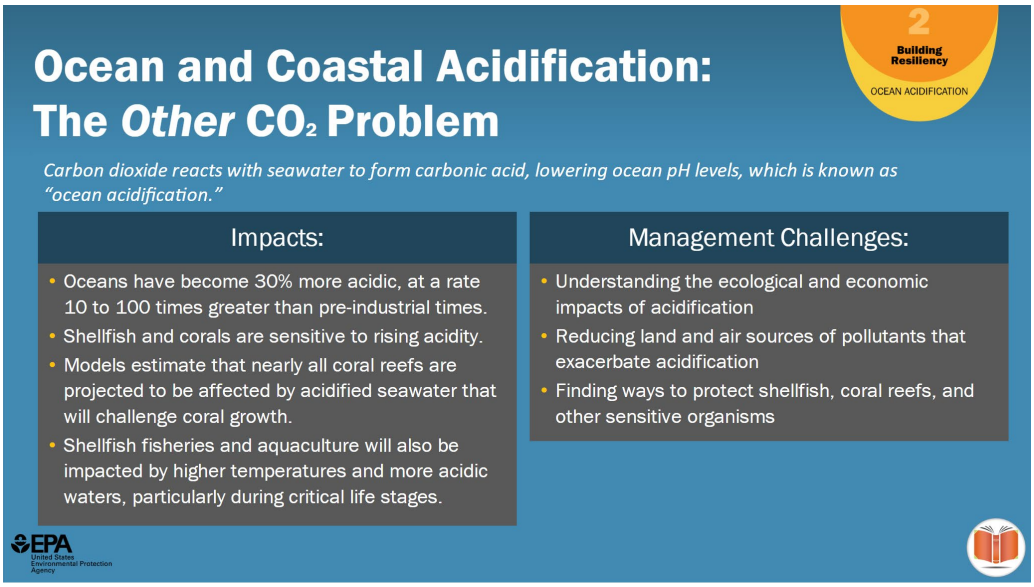
Scientific Sources:

- http://water.epa.gov/type/oceb/nep/programs_sjb.cfm
- http://www.estuario.org/
- http://www.epa.gov/national-aquatic-resource-surveys/national-coastal-condition-assessment

Graphics:

- http://water.epa.gov/type/oceb/nep/programs_sjb.cfm
- http://sanjuanbayestuary.blogspot.com/

Ocean and Coastal Acidification: The Other CO_2 Problem



Notes:

Ocean acidification is often referred to as "the other carbon dioxide problem." It is not caused by climate change; rather, it is another effect of the increase of CO_2 in the atmosphere.

When carbon dioxide (CO_2) is released into the atmosphere, approximately one third is absorbed by the ocean. The carbon dioxide reacts with seawater to form carbonic acid, lowering ocean pH levels, which is known as "ocean acidification." In addition, land-based sources of pollution can contribute to localized acidification of coastal waters.

Oceans have become 30% more acidic, at a rate 10 to 100 times greater than pre-industrial times.

Shellfish and corals are sensitive to rising acidity, which makes it difficult for them to create and maintain the skeletal structures they need for support and protection.

Models estimate that by 2050 under the higher emissions modeling scenario, 86 percent of marine ecosystems will experience combinations of temperature and pH that have never before been experienced by modern species, and that by the end of this century, nearly all coral reefs are projected to be affected by acidified seawater that will challenge coral growth.

Shellfish fisheries and aquaculture will also be impacted by higher temperatures and more acidic waters, particularly during critical life stages.

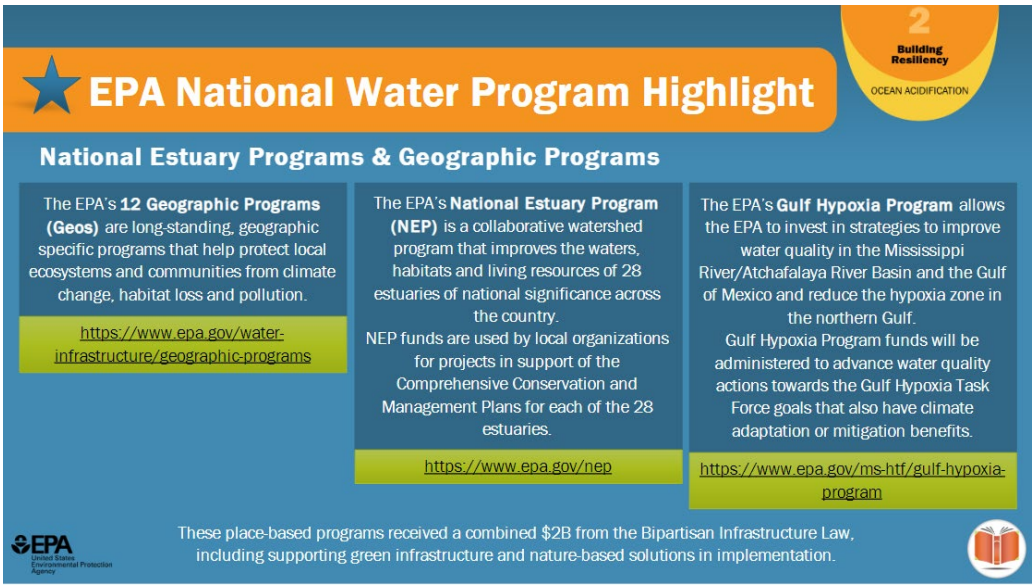
Managers are being challenged to understand the ecological and economic impacts of acidification, reduce land and air sources of pollutants that exacerbate acidification, and find ways to protect shellfish, coral reefs, and other sensitive organisms.

The bottom line is that ocean and coastal acidification is anticipated to bring about significant impacts to our oceans and coastal waters in the coming years.

<u>Scientific Sources:</u>

- https://oceanacidification.noaa.gov/wp-content/uploads/2023/08/IWGOA_Vulnerability_Assessment_2023.pdf
- https://www.epa.gov/ocean-acidification
- https://nca2023.globalchange.gov/

EPA National Water Program Highlight: National Estuary Programs & Geographic Programs



Notes:

The EPA's place-based water programs, including 12 geographic programs, 28 National Estuary Programs, and the Gulf Hypoxia Program, focus on specific waterbodies of regional and national significance.

They aim to protect and improve water quality and ecosystems, and support communities.

In addition to the regular annual appropriations for the Geos and NEPs, these programs received a combined $2 Billion from the 2021 Bipartisan Infrastructure Law. The Office of Water leveraged the implementation plans for these funds to build climate benefits and resilience tools like green infrastructure and nature based solutions into these federal investments.

Gulf Hypoxia Program funds will be administered to advance water quality actions towards the Gulf Hypoxia Task Force goals that also have climate adaptation or mitigation benefits.

NEP funds are used by local organizations for projects in support of the Comprehensive Conservation and Management Plans for each of the 28 estuaries.

Scientific Sources:

- https://www.epa.gov/water-infrastructure/geographic-programs
- https://www.epa.gov/nep
- https://www.epa.gov/ms-htf/gulf-hypoxia-program

Casco Bay Estuary, ME Case Study

Notes:

Residents of Portland, Maine, and neighboring communities have been concerned about the declining productivity of clam flats.

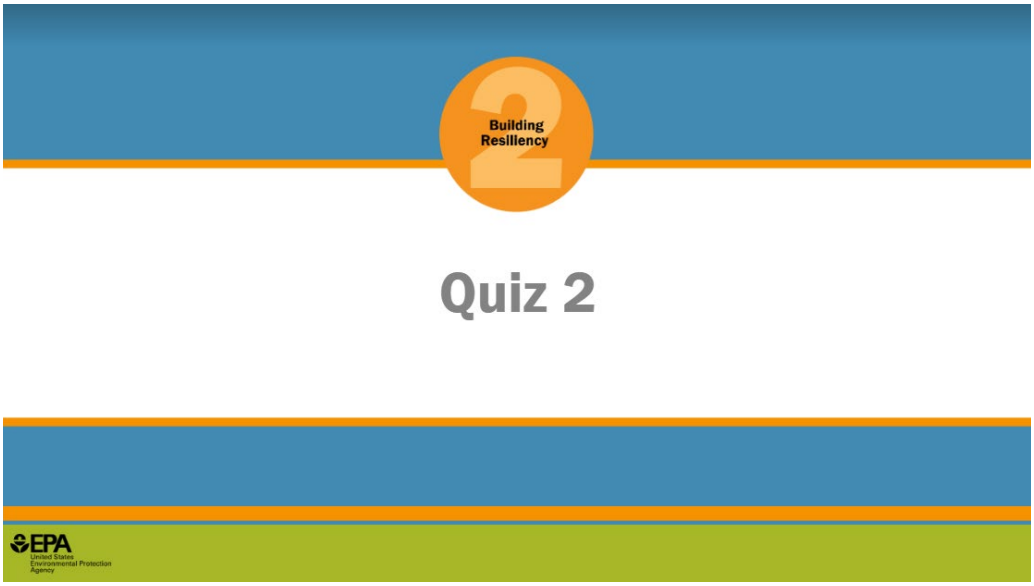
In an effort to understand the causes of this decline, the Casco Bay Estuary Partnership is monitoring pH and CO_2 in near-shore waters. This work is being coupled with ongoing studies of nutrient concentrations to better understand how nutrients can exacerbate acidification.

The outcome of this effort will help communities identify cost effective response options.

Graphics:

- Left: Sea Snail, Nina Bednarsek, National Oceanic and Atmospheric Administration Pacific Marine Environmental Laboratory, http://nca2014.globalchange.gov/report/regions/oceans#tab2-images
- Middle and Bottom Right: Landscape photo/little boy photo, http://www.cascobayestuary.org/about-us/
- Upper Right: People moving pH monitor, Brian Rappoli, USEPA

Quiz 2

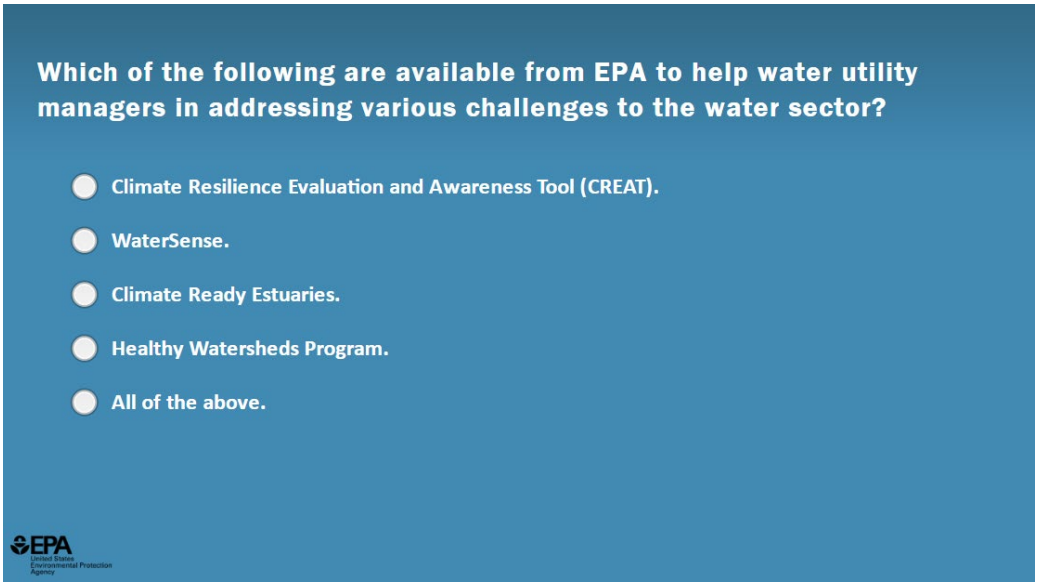


Notes:

We've completed part 2 of the course. Let's take a moment to test your knowledge.

Quiz 2.1

(Multiple Choice, 0 points, unlimited attempts permitted)



Correct	Choice
	Climate Resilience and Awareness Tool (CREAT).
	WaterSense.
	Climate Ready Estuaries.
	Healthy Watersheds Program.
X	All of the above.

Feedback when correct:

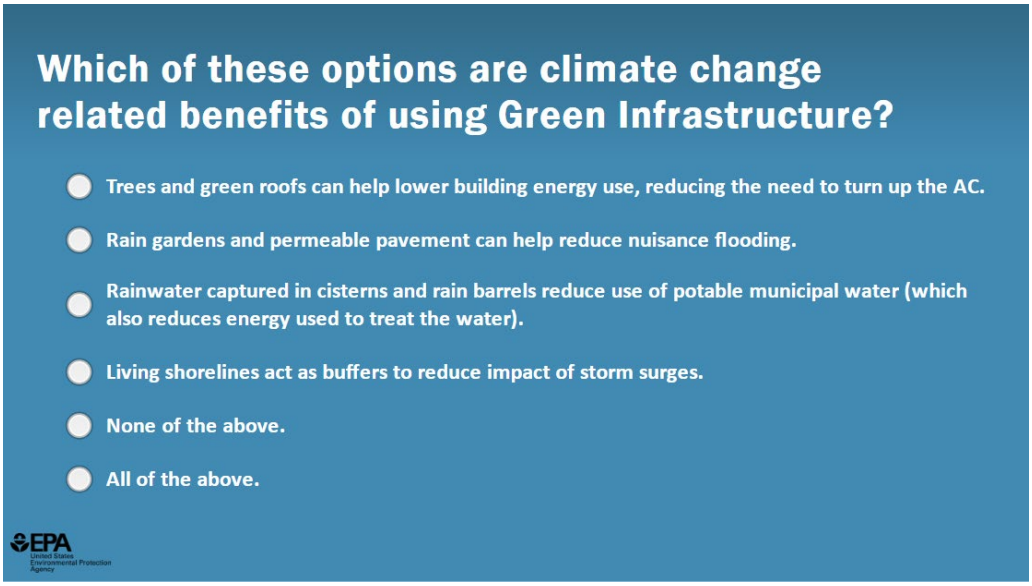
The Climate Resilience Evaluation and Awareness Tool (CREAT) is available to help water utilities evaluate risk. The WaterSense program works with manufacturers, retailers and distributors, and utilities, to bring WaterSense-labeled, water-efficient products to the marketplace. Climate Ready Estuaries (CRE) works with estuaries and coastal programs. The Healthy Watersheds Program assists states to maintain healthy watersheds and habitat corridors.

Feedback when incorrect:

The Climate Resilience and Awareness Tool (CREAT) is available to help water utilities evaluate risk. The WaterSense program works with manufacturers, retailers and distributors, and utilities, to bring WaterSense-labeled, water-efficient products to the marketplace. Climate Ready Estuaries (CRE) works with estuaries and coastal programs. The Healthy Watersheds Program assists states to maintain healthy watersheds and habitat corridors.

Quiz 2.2

(Multiple Choice, 0 points, unlimited attempts permitted)



Correct	Choice
	Trees and green roofs can help lower building energy use, reducing the need to turn up the AC.
	Rain gardens and permeable pavement can help reduce nuisance flooding.
	Rainwater captured in cisterns and rain barrels reduces use of potable municipal water (which also reduces energy used to treat the water).
	Living shorelines act as buffers to reduce impact of storm surges.
	None of the above.
X	All of the above.

Feedback when correct:

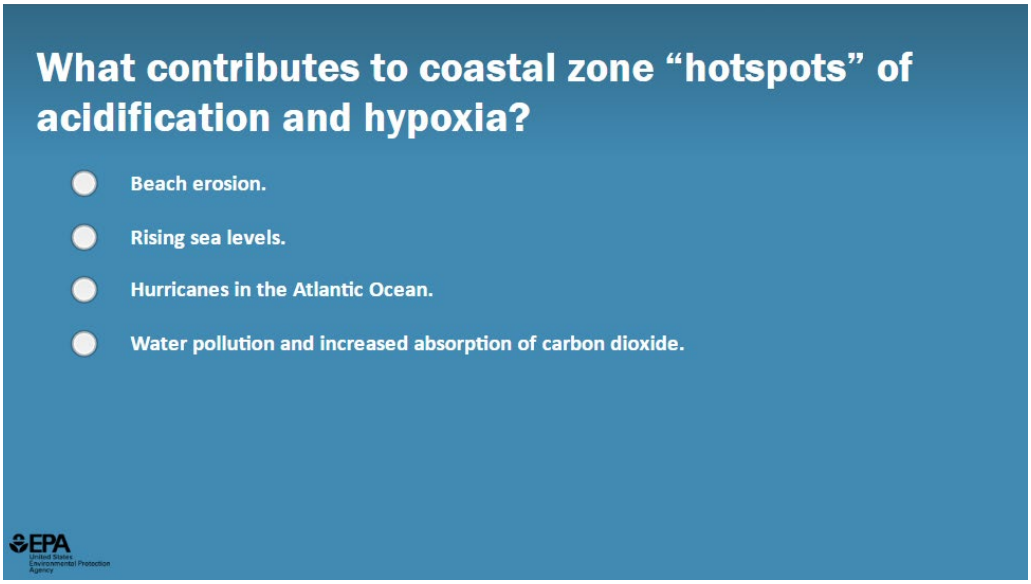
All of the above are climate change related benefits of using green infrastructure.

Feedback when incorrect:

All of the above are climate change related benefits of using green infrastructure.

Quiz 2.3

(Multiple Choice, 0 points, unlimited attempts permitted)



Correct	Choice
	Beach erosion.
	Rising sea levels.
	Hurricanes in the Atlantic Ocean.
X	Water pollution and increased absorption of carbon dioxide.

Feedback when correct:

Water pollution and increased absorption of carbon dioxide from both the atmosphere and polluted runoff in certain areas can lower the pH of sea water making it more acidic. Polluted runoff containing excess nutrients can create algal blooms that deplete oxygen levels and create hypoxic conditions.

Feedback when incorrect:

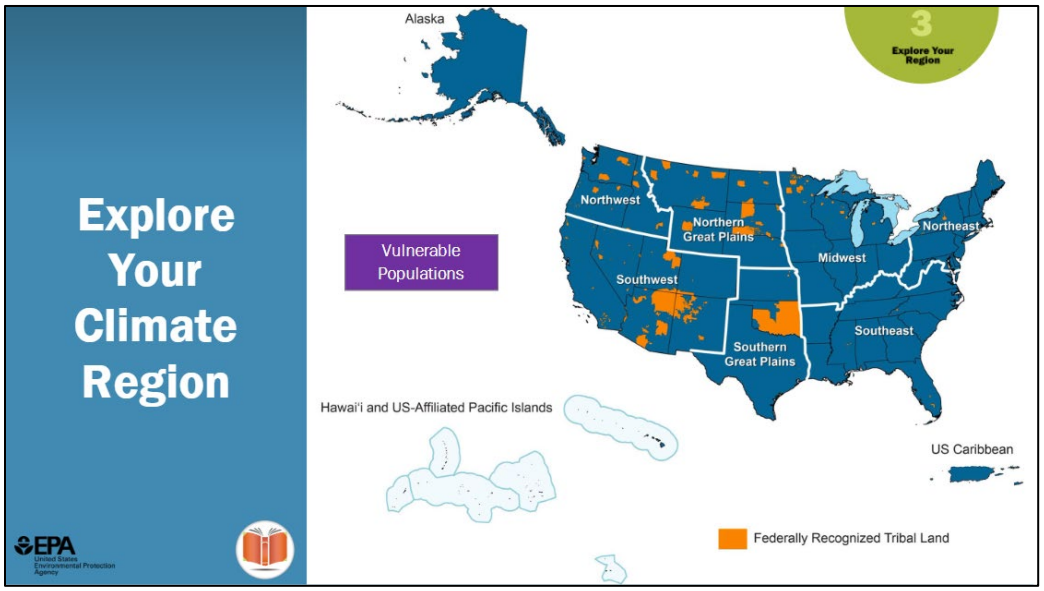
Water pollution and increased absorption of carbon dioxide from both the atmosphere and polluted runoff in certain areas can lower the pH of sea water making it more acidic. Polluted runoff containing excess nutrients can create algal blooms that deplete oxygen levels and create hypoxic conditions.

Explore Your Region

Notes:

Climate change impacts vary by geographic region. For this reason, adaptation measures need to address local issues, depending on vulnerabilities and local conditions. In Part 3, you can explore the specific changes to water resources expected in your region as a result of a changing climate.

Explore Your Climate Region



Notes:

To see some of the projected impacts on water resources specific to your part of the country, click on the different regions of the map. You will need to click on the Transcript Tab to read about each region. There is no audio for these optional regional slides. Because they are optional, clicking "Next" below the map slide on this screen skips over the regional slides to take you directly to the Final Test for the course.

This material is provided for your information and is not included in the Final Test.

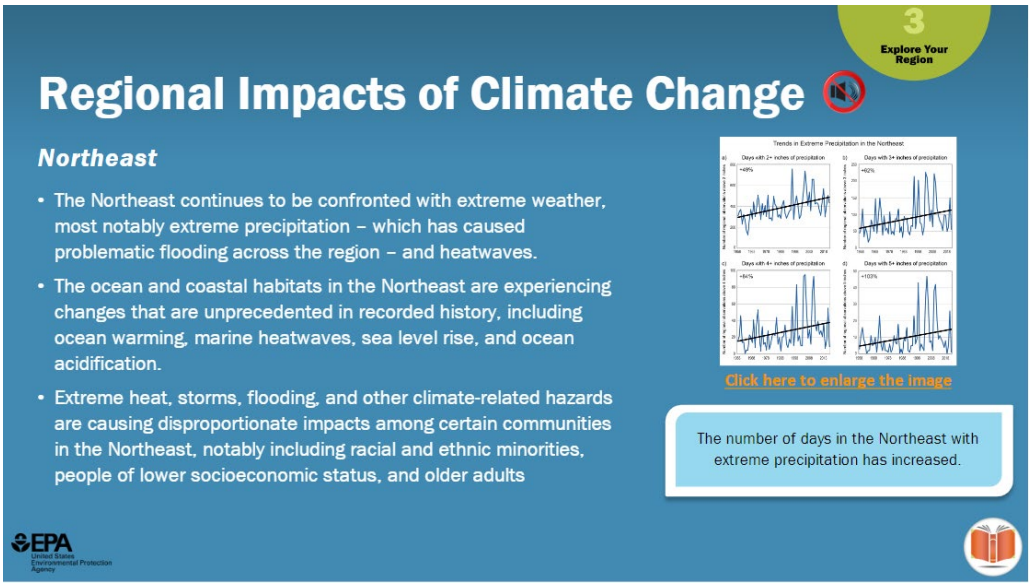
Graphic:

- https://nca2023.globalchange.gov/chapter/front-matter/#fig-1

Supplemental Scientific Resource:

- Thomas Johnson, Jonathan Butcher, Stephanie Santell, Sara Schwartz, Susan Julius, Stephen LeDuc; *A review of climate change effects on practices for mitigating water quality impacts.* Journal of Water and Climate Change 1 April 2022; 13 (4): 1684-1705. doi: https://doi.org/10.2166/wcc.2022.363

Regional Impacts of Climate Change: Northeast



Notes:

The Northeast continues to be confronted with extreme weather, most notably extreme precipitation – which has caused problematic flooding across the region – and heatwaves.

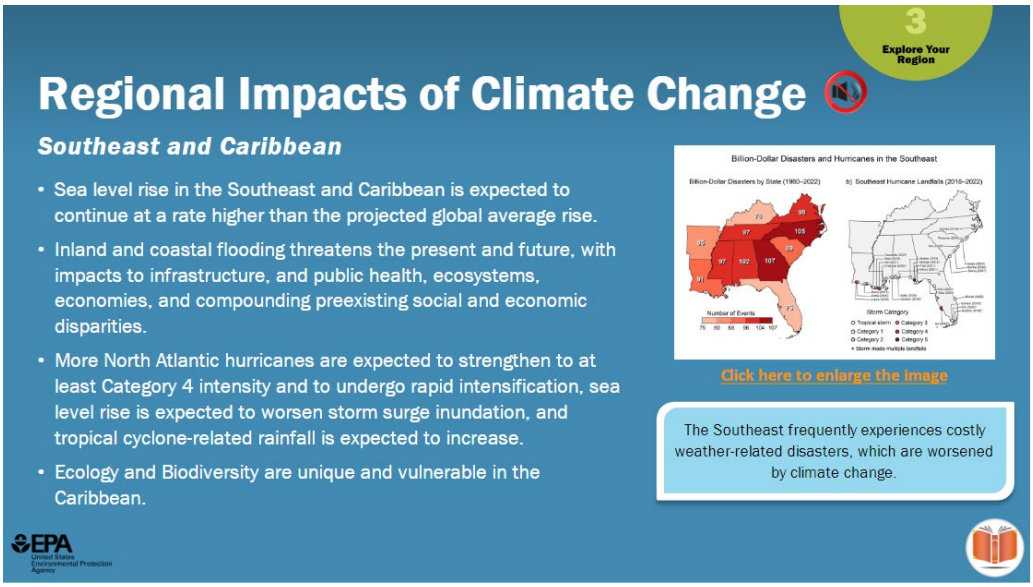
The ocean and coastal habitats in the Northeast are experiencing changes that are unprecedented in recorded history, including ocean warming, marine heatwaves, sea level rise, and ocean acidification.

Extreme heat, storms, flooding, and other climate-related hazards are causing disproportionate impacts among certain communities in the Northeast, notably including racial and ethnic minorities, people of lower socioeconomic status, and older adults.

Scientific Source:

- https://nca2023.globalchange.gov/chapter/21/

Regional Impacts of Climate Change: Southeast and Caribbean



Notes:

The Southeast's growing population faces increasing threats from climate change, with impacts on human health, ecosystems, economies, infrastructure, and food systems. While there have been notable advancements in adaptation throughout the region, these efforts tend to be concentrated in wealthier coastal and metropolitan areas, leaving rural and other under-resourced communities at risk. Coordinated climate strategies could improve equity, well-being, and economic vitality.

Hurricanes, increasingly powerful storms, and rising sea levels are already harming human health, ecosystems, water and food supplies, and critical infrastructure in the US Caribbean, with underserved communities suffering disproportionate impacts. Effective adaptation to support resilience in the region could be enhanced by decentralization, shared governance, and stronger partnerships across the Caribbean region and the US mainland.

Sea level rise in the Southeast and Caribbean is expected to continue at a rate higher than the projected global average rise.

Inland and coastal flooding threatens the present and future, with impacts to infrastructure, and public health, ecosystems, economies, and compounding preexisting social and economic disparities.

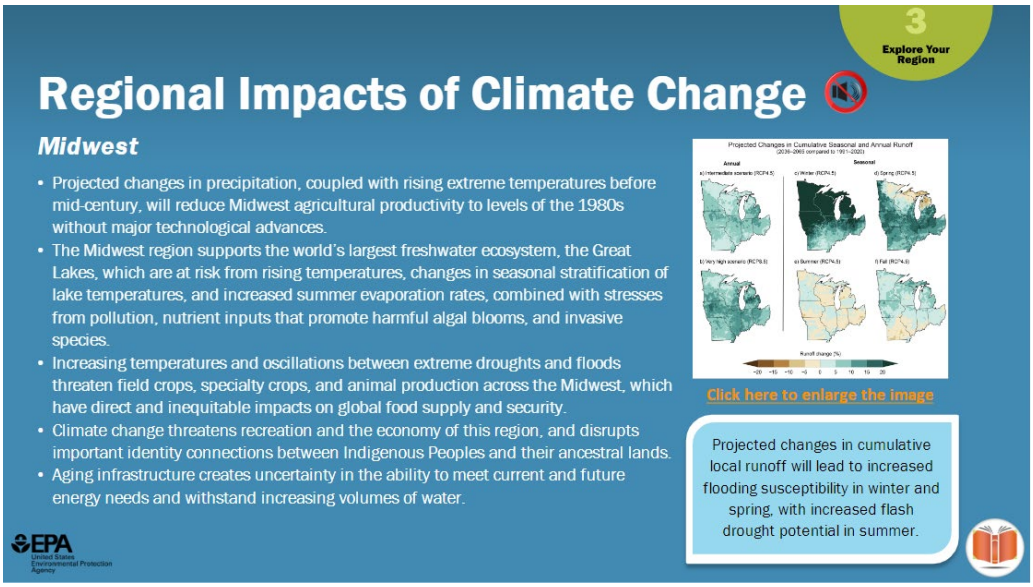
More North Atlantic hurricanes are expected to strengthen to at least Category 4 intensity and to undergo rapid intensification, sea level rise is expected to worsen storm surge inundation, and tropical cyclone-related rainfall is expected to increase.

Ecology and Biodiversity are unique and vulnerable in the Caribbean.

Scientific Sources:

- https://nca2023.globalchange.gov/chapter/22/
- https://nca2023.globalchange.gov/chapter/23/

Regional Impacts of Climate Change: Midwest



Notes:

Increasing temperatures and oscillations between extreme droughts and floods threaten field crops, specialty crops, and animal production across the Midwest, which have direct and inequitable impacts on global food supply and security.

Climate change threatens recreation and the economy of this region, and disrupts important identity connections between Indigenous Peoples and their ancestral lands.

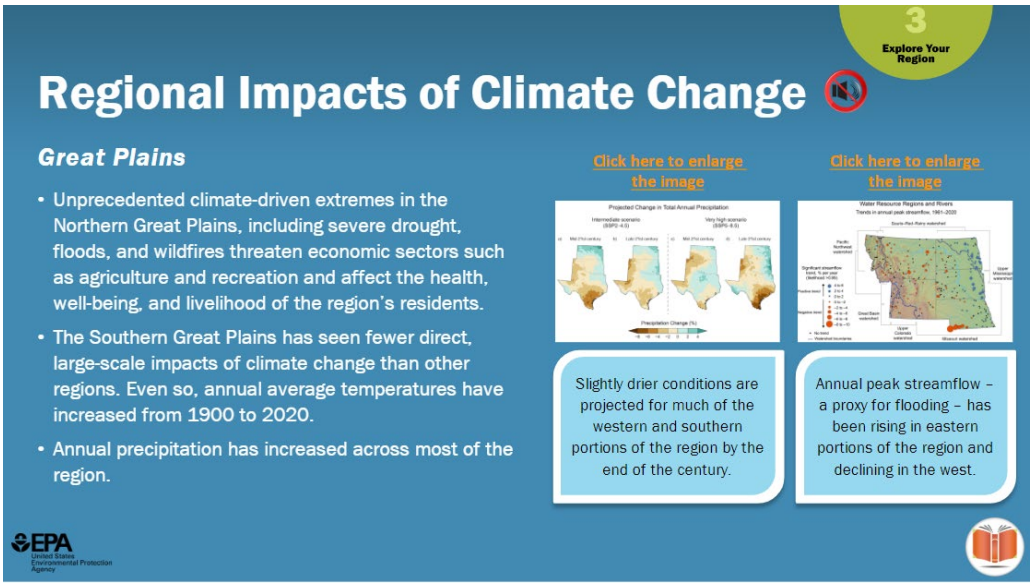
Aging infrastructure creates uncertainty in the ability to meet current and future energy needs and withstand increasing volumes of water.

Climate-related changes to water quantity and quality are increasing the risks to ecosystem health, adequate food production, surface water and groundwater uses, and recreation. Projected increases in droughts, floods, and runoff events across the Mississippi River basin and the Great Lakes will adversely impact ecosystems through increased erosion, harmful algal blooms, and expansion of invasive species.

Scientific Source:

- https://nca2023.globalchange.gov/chapter/24/

Regional Impacts of Climate Change: Great Plains



Notes:

The Great Plains are characterized by an east to west gradient of increasing elevation and decreasing precipitation. Intraregional gradients in precipitation, temperature, and water availability drive east-west differences in land use and climate.

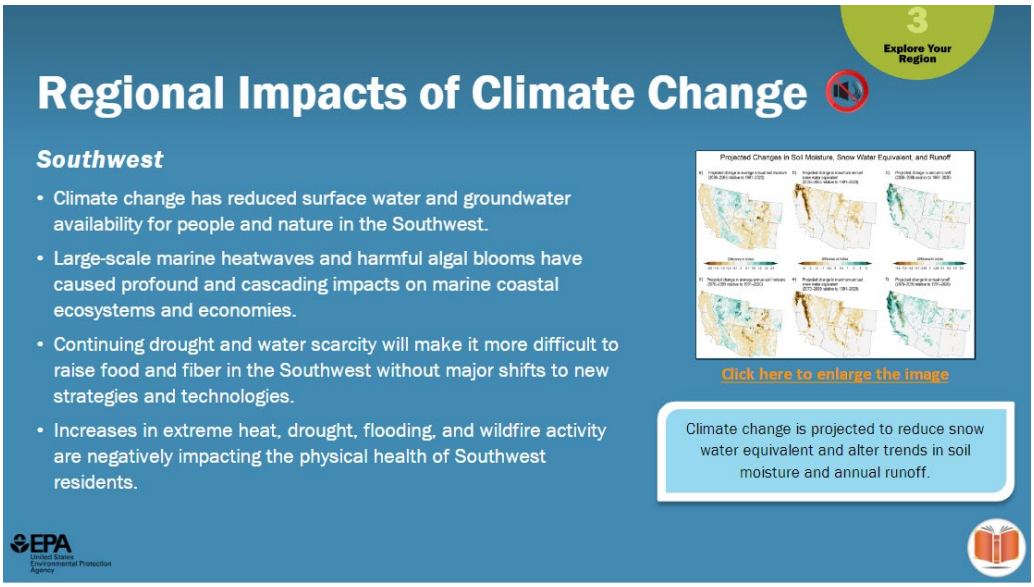
The Northern Great Plains is experiencing unprecedented climate-driven extremes, including severe drought, floods, and wildfires. These changes threaten economic sectors such as agriculture and recreation, and affect the health, well-being, and livelihood of the region's residents. While adaptation efforts are underway, climate change creates complex tradeoffs and tests the resilience of the region's residents, especially rural, Indigenous, and low-income immigrant populations.

Thus far, the Southern Great Plains has seen fewer direct, large-scale impacts of climate change than other regions because of its relatively low latitude, flat terrain, and high natural climate variability. Even so, annual average temperatures have increased from 1900 to 2020: 1.5 degrees Fahrenheit for Texas and Kansas and 0.6 degrees Fahrenheit for Oklahoma. Annual precipitation has increased across most of the region except far west Texas. In addition, days with 2 or more inches of precipitation have become more frequent across the Southern Great Plains, with larger increases in the eastern half of the region than the western half.

Scientific Sources:

- https://nca2023.globalchange.gov/chapter/25/
- https://nca2023.globalchange.gov/chapter/26/

Regional Impacts of Climate Change: Southwest



Notes:

Climate change has reduced surface water and groundwater availability for people and nature in the Southwest.

Large-scale marine heatwaves and harmful algal blooms have caused profound and cascading impacts on marine coastal ecosystems and economies.

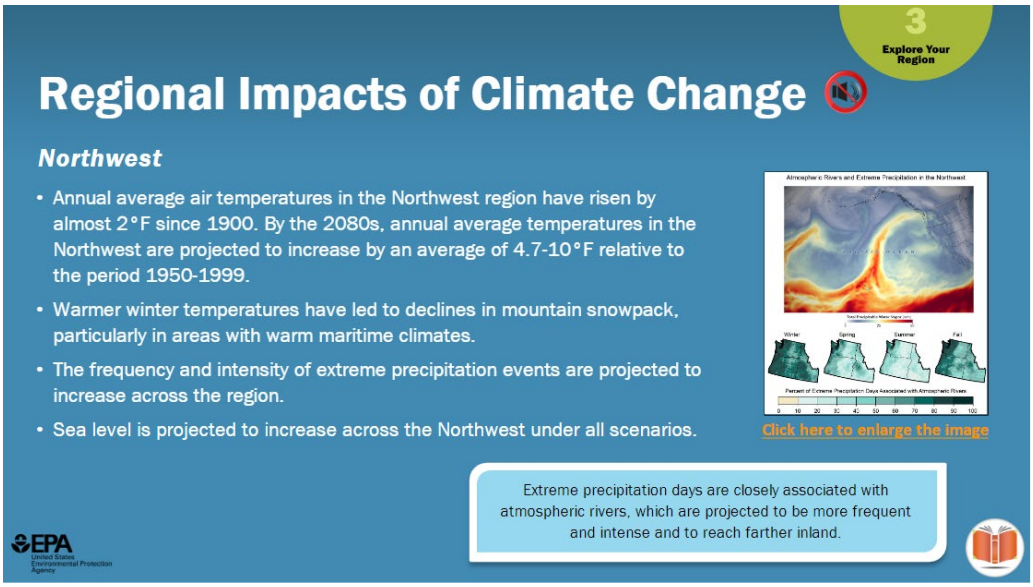
Continuing drought and water scarcity will make it more difficult to raise food and fiber in the Southwest without major shifts to new strategies and technologies.

Increases in extreme heat, drought, flooding, and wildfire activity are negatively impacting the physical health of Southwest residents.

Scientific Source:

- https://nca2023.globalchange.gov/chapter/28/

Regional Impacts of Climate Change: Northwest



Notes:

Annual average air temperatures in the Northwest region have risen by almost 2 degrees Fahrenheit since 1900. By the 2080s, annual average temperatures in the Northwest are projected to increase by an average of 4.7-10 degrees Fahrenheit relative to the period 1950-1999.

Warmer winter temperatures have led to declines in mountain snowpack, particularly in areas with warm maritime climates.

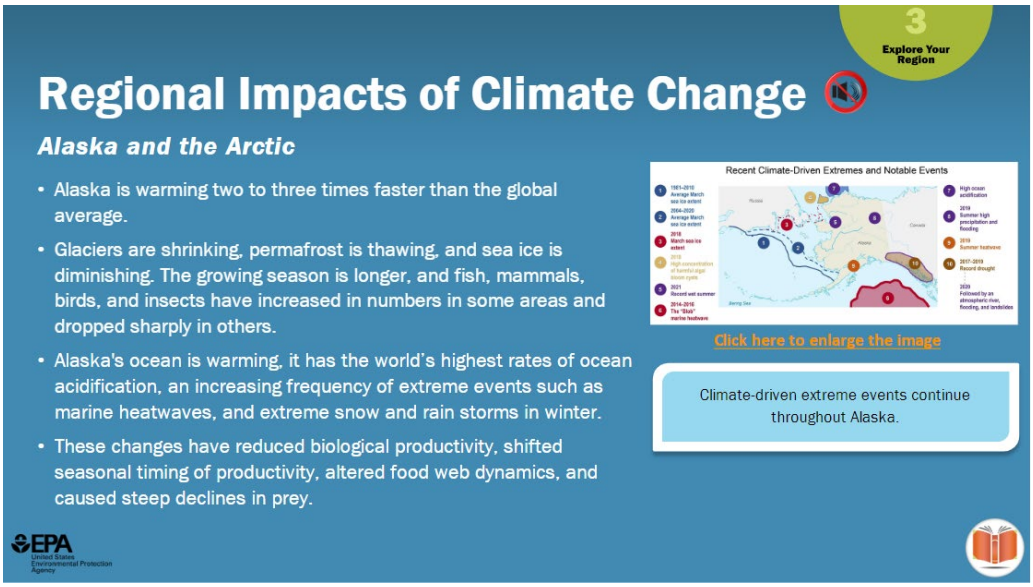
The frequency and intensity of extreme precipitation events are projected to increase across the region.

Sea level is projected to increase across the Northwest under all scenarios.

Scientific Source:

- https://nca2023.globalchange.gov/chapter/27/

Regional Impacts of Climate Change: Alaska and the Arctic



Notes:

Alaska is warming two to three times faster than the global average.

Glaciers are shrinking, permafrost is thawing, and sea ice is diminishing. The growing season is longer, and fish, mammals, birds, and insects have increased in numbers in some areas and dropped sharply in others.

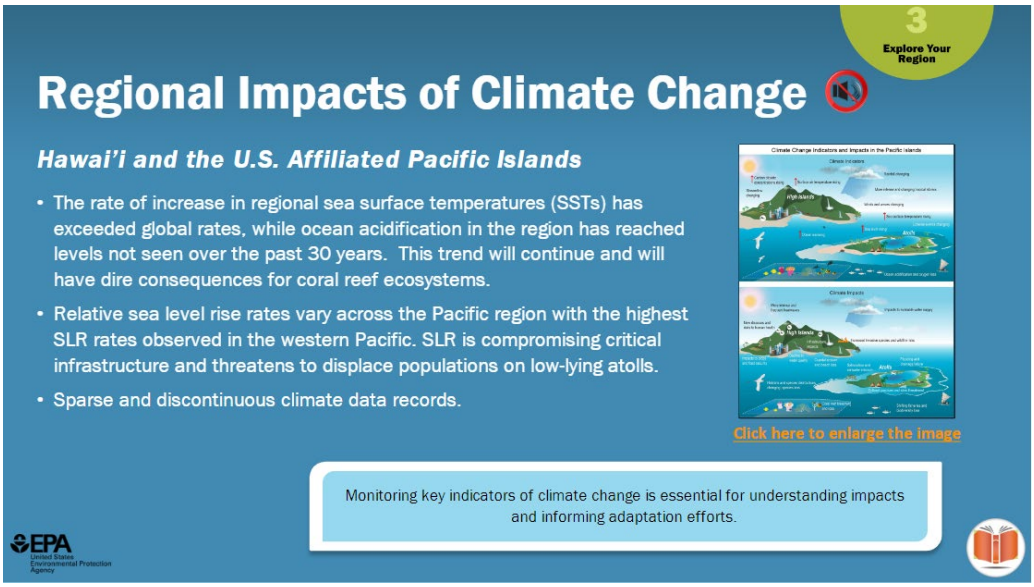
Between the publication of NCA4 in 2018, and NCA5 in 2023, Alaska has continued to experience rapid, widespread, and extreme climate-related changes in the form of ocean warming, the world's highest rates of ocean acidification, an increasing frequency of extreme events such as marine heatwaves, and extreme snow and rain storms in winter.

These changes have reduced biological productivity, shifted seasonal timing of productivity, altered food web dynamics, and caused steep declines in prey. In many freshwater environments, these changes result in a combination of reduced summer streamflows, increased summer water temperatures, hypoxia, and decreased prey abundance, which are lethal to many aquatic species. There is no indication that these trends will slow or reverse in the near future.

Scientific Source:

- https://nca2023.globalchange.gov/chapter/29/

Regional Impacts of Climate Change: Hawai'i and the U.S. Affiliated Pacific Islands



Notes:

The rate of increase in regional sea surface temperatures (SSTs) has exceeded global rates, while ocean acidification in the region has reached levels not seen over the past 30 years. This trend will continue and will have dire consequences for coral reef ecosystems.

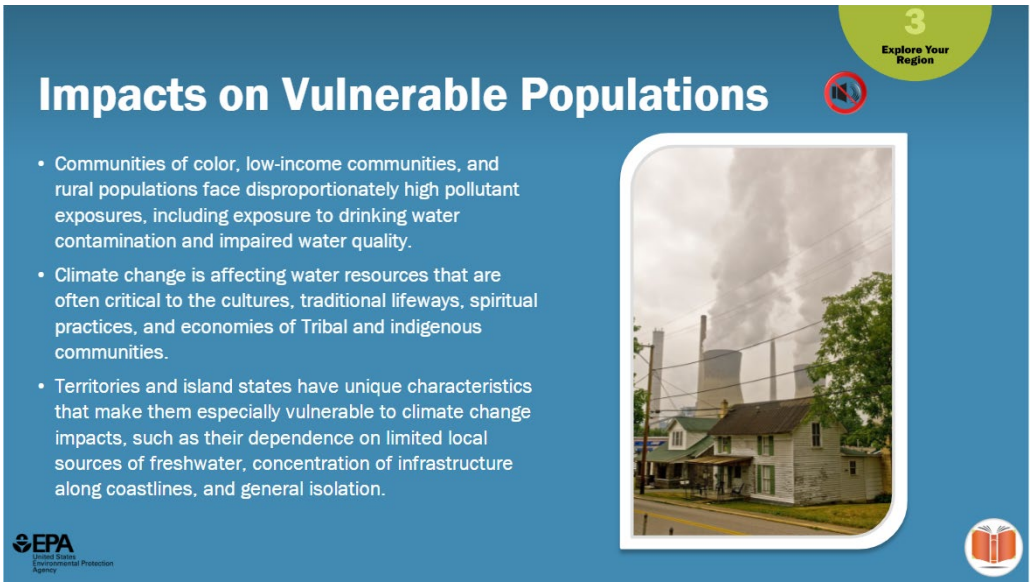
Relative sea level rise rates vary across the Pacific region with the highest SLR rates observed in the western Pacific. SLR is compromising critical infrastructure and threatens to displace populations on low-lying atolls.

Sparse and discontinuous climate data records. Filling these data gaps could better enable data-driven decision-making and improve climate services in the region.

Scientific Source:

- https://nca2023.globalchange.gov/chapter/30/

Impacts on Vulnerable Populations



Notes:

Climate change poses risks to our nation's water resources that, in turn, create significant vulnerabilities for public health and the economic and social wellbeing of communities. Certain communities and populations are uniquely and disproportionally vulnerable to climate change impacts due to a variety of factors, including higher pollution burdens, greater exposure to environmental contaminants, lack of financial resources, limited access to quality health care, and other issues. While communities of color, low-income communities, children, persons with disabilities, the elderly, Tribes, and Indigenous people may experience the same water-focused climate threats described in the previous sections, these groups face unequal and often greater risks from climate change. In addition, these populations generally have fewer resources to prepare for or cope with climate-related events-including those that impact the quality and quantity of their water resources-and are expected to experience greater hardships from climate change in the future.

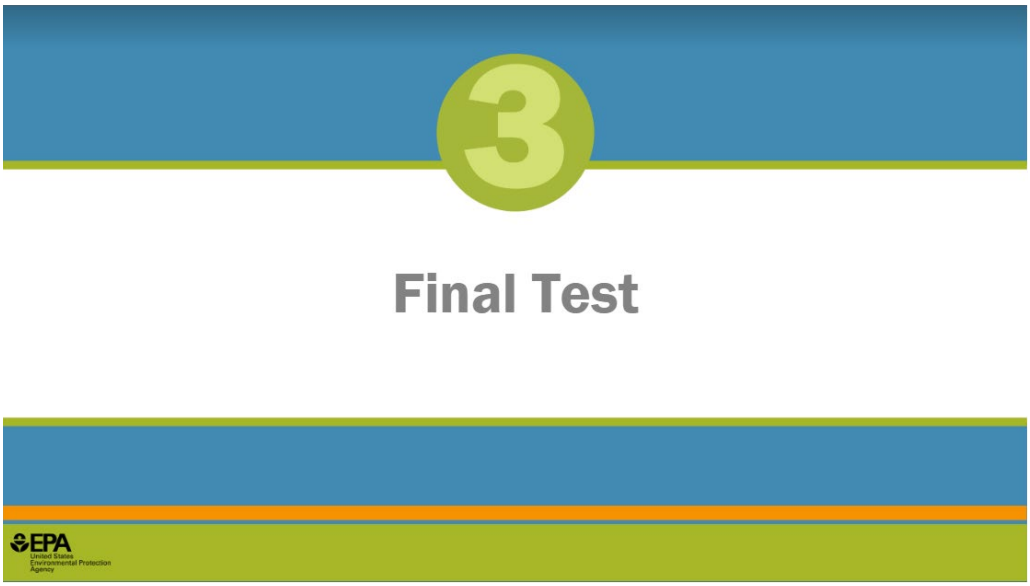
Scientific Sources:

- Office of Water 2022-2026 Climate Adaptation Implementation Plan, https://www.epa.gov/system/files/documents/2022-10/bh508-OW-12113_ClimateAdaptatImplementPlan_508final.pdf

Graphic:

- Istockphoto.com

Final Test



Notes:

Now that you've completed the three parts of the course, let's test your knowledge.

Final Test 1

(True/False, 25 points, 1 attempt permitted)

Correct	Choice
X	True.
	False.

Feedback when correct:

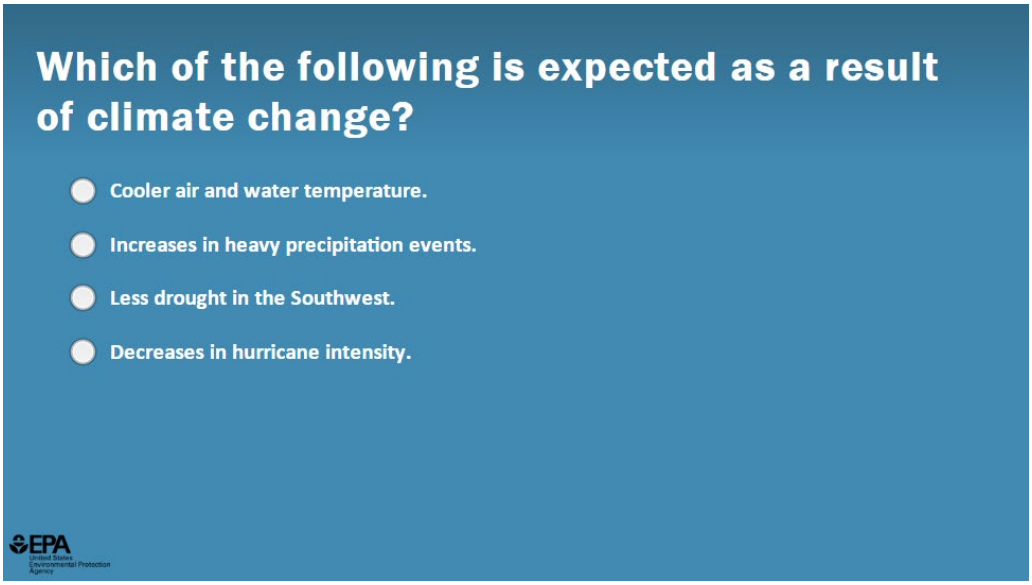
Observations of continued warming and multiple other sources of evidence, have strengthened our confidence in the conclusions that the warming trend is clear and primarily the result of human activities. In fact, multiple lines of independent evidence confirm that human activities are the primary cause of the global warming of the past 50 years.

Feedback when incorrect:

Observations of continued warming and multiple other sources of evidence, have strengthened our confidence in the conclusions that the warming trend is clear and primarily the result of human activities. In fact, multiple lines of independent evidence confirm that human activities are the primary cause of the global warming of the past 50 years.

Final Test 2

(Multiple Choice, 25 points, 1 attempt permitted)



Correct	Choice
	Cooler air and water temperature.
X	Increases in heavy precipitation events.
	Less drought in the Southwest.
	Decreases in hurricane intensity.

Feedback when correct:

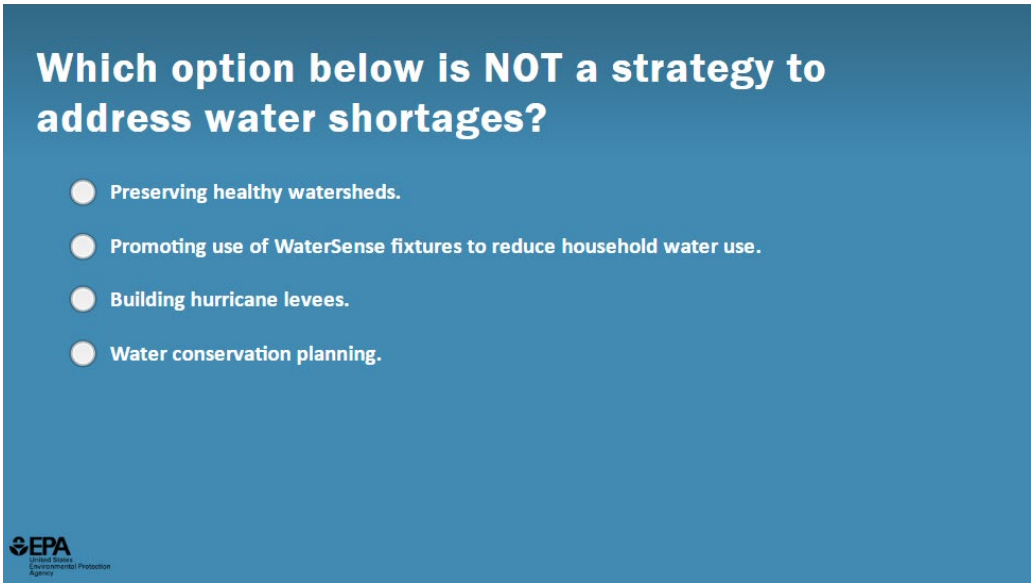
More frequent and intense heat waves have been observed in some areas, but cold waves have been less frequent and intense. The intensity of the strongest hurricanes will continue to increase as the oceans continue to warm. Droughts in the Southwest and heat waves everywhere will become more intense.

Feedback when incorrect:

More frequent and intense heat waves have been observed in some areas, but cold waves have been less frequent and intense. The intensity of the strongest hurricanes will continue to increase as the oceans continue to warm. Droughts in the Southwest and heat waves everywhere will become more intense.

Final Test 3

(Multiple Choice, 25 points, 1 attempt permitted)



Correct	Choice
	Preserving healthy watersheds.
	Promoting use of WaterSense fixtures to reduce household water use.
X	Building hurricane levees.
	Water conservation planning.

Feedback when correct:

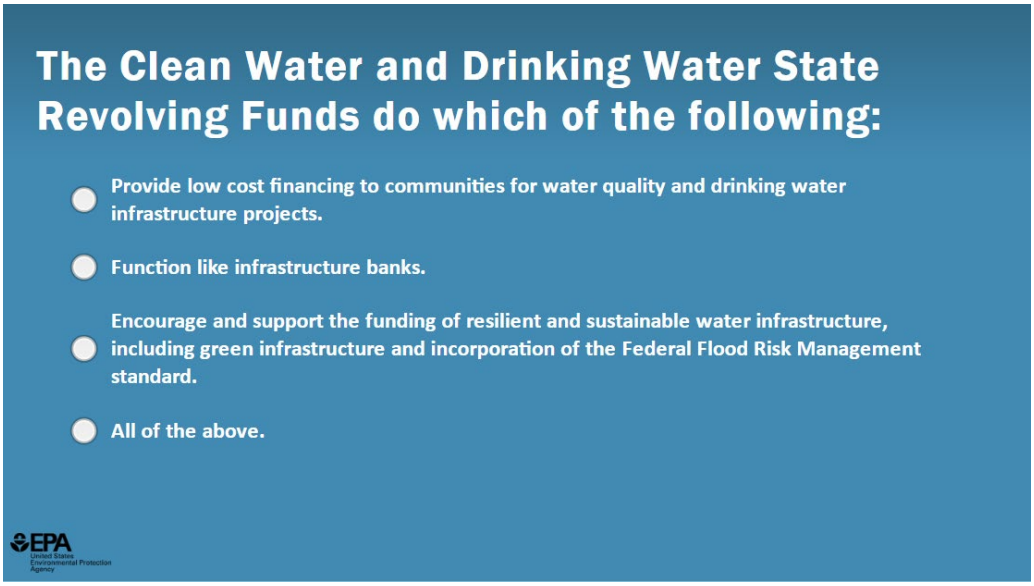
While hurricane levees can prevent some flooding, they do not address water shortages. Water conservation planning can help identify ways to reduce water use and adjust to shortages. WaterSense fixtures can also reduce water use. Preserving healthy watersheds helps keep drinking water supplies clean.

Feedback when incorrect:

While hurricane levees can prevent some flooding, they do not address water shortages. Water conservation planning can help identify ways to reduce water use and adjust to shortages. WaterSense fixtures can also reduce water use. Preserving healthy watersheds helps keep drinking water supplies clean.

Final Test 4

(Multiple Choice, 25 points, 1 attempt permitted)



Correct	Choice
	Provide low cost financing to communities for water quality and drinking water infrastructure projects
	Function like infrastructure banks.
	Encourage and support the funding of resilient and sustainable water infrastructure, including green infrastructure and incorporation of the Federal Flood Risk Management standard.
X	All of the above.

Feedback when correct:

The EPA's Clean Water and Drinking Water State Revolving Funds are federal state partnerships that provide low-cost financing to communities for a wide range of water quality and drinking water infrastructure projects.

The 51 SRF programs function like environmental infrastructure banks by providing low interest loans to eligible recipients for water infrastructure projects. As money is paid back into the state's revolving loan fund, the state makes new loans to other recipients. Repayments of loan principal and interest earnings are recycled back into individual state SRF programs to finance new projects that allow the funds to "revolve" at the state level over time.

Both SRFs encourage and support the funding of resilient and sustainable water infrastructure, including green infrastructure and incorporation of the Federal Flood Risk Management standard which facilitates flood risk management in federally funded projects.

Feedback when incorrect:

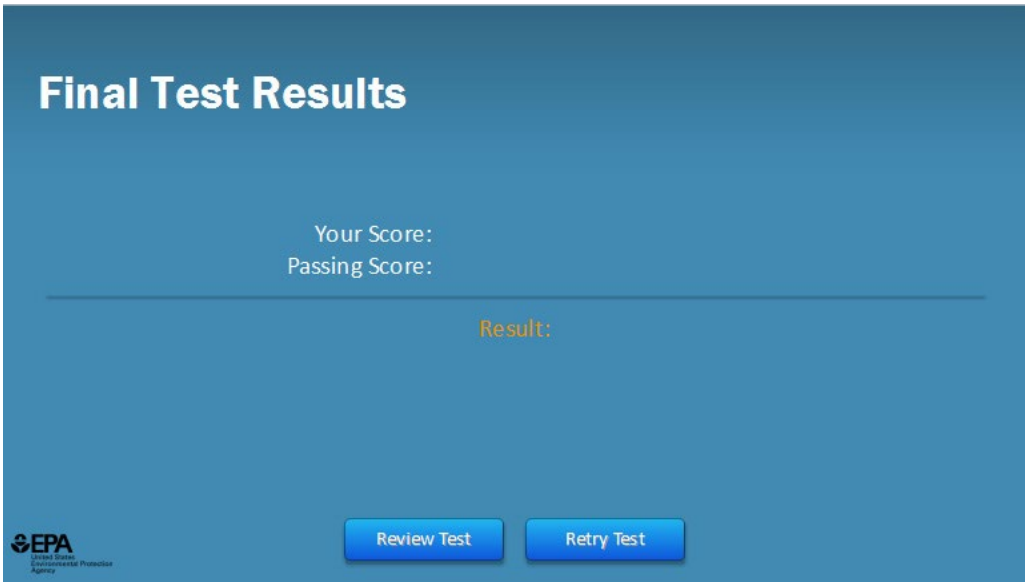
The EPA's Clean Water and Drinking Water State Revolving Funds are federal state partnerships that provide low-cost financing to communities for a wide range of water quality and drinking water infrastructure projects.

The 51 SRF programs function like environmental infrastructure banks by providing low interest loans to eligible recipients for water infrastructure projects. As money is paid back into the state's revolving loan fund, the state makes new loans to other recipients. Repayments of loan principal and interest earnings are recycled back into individual state SRF programs to finance new projects that allow the funds to "revolve" at the state level over time.

Both SRFs encourage and support the funding of resilient and sustainable water infrastructure, including green infrastructure and incorporation of the Federal Flood Risk Management standard which facilitates flood risk management in federally funded projects.

Final Test Results

(Results Slide, 0 points, 1 attempt permitted)



Passing Score 70%

You Have Completed This Course!

Notes:

That concludes this training module on understanding climate change impacts on water resources. We hope you have gained some insight into this important issue, including what you can do to build resilience in your community. Be sure to check out the additional resources listed in the Resources Tab. The list of additional resources in the Resources Tab includes a link to an additional EPA climate training at our website, epa.gov/arc-x.

Scientific Source:

- https://www.epa.gov/arc-x

Graphic:

- Streambank willow planting in the Johnson Creek Watershed in Portland, OR. Photo by Tetra Tech.