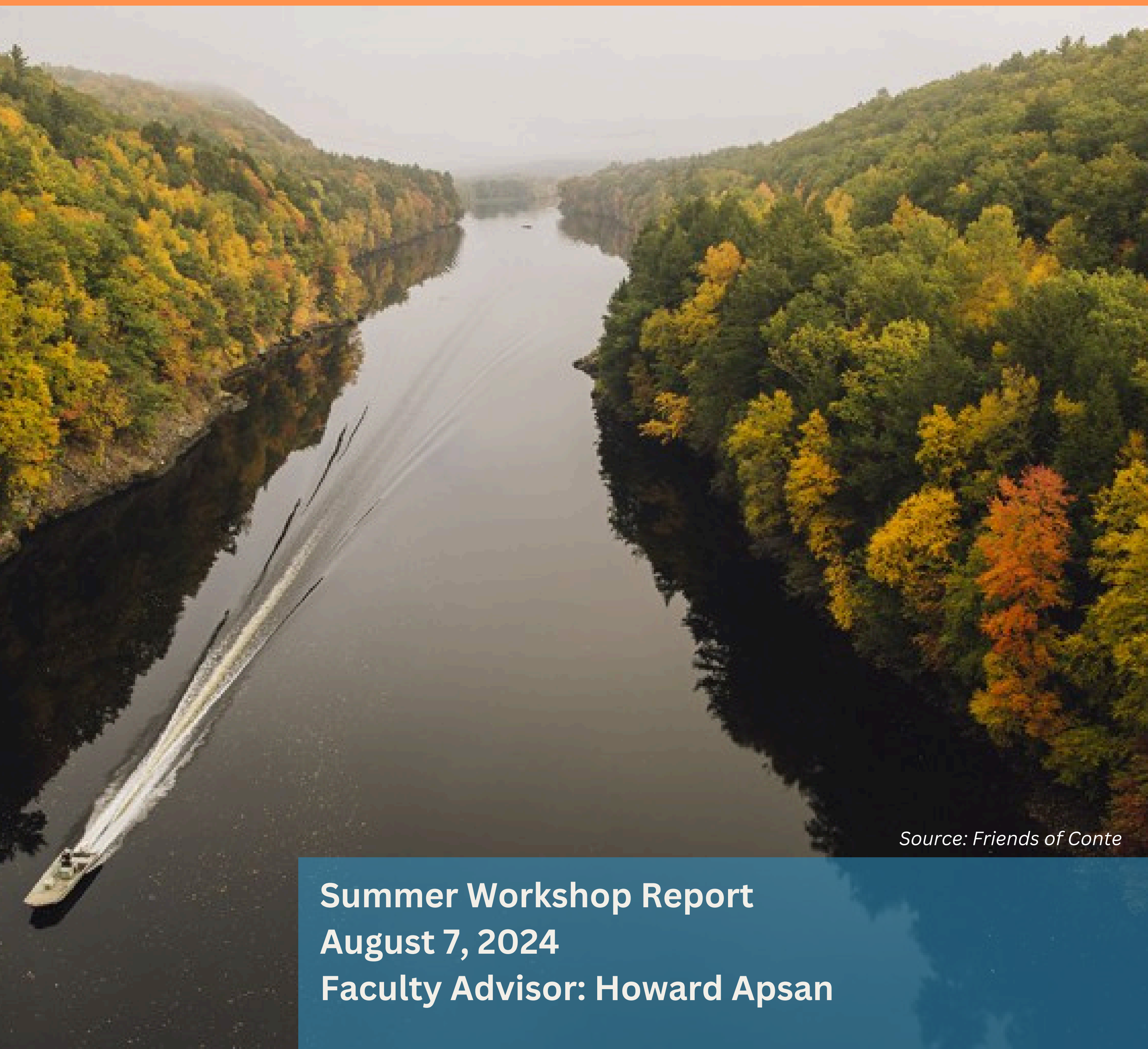
CRWPA

# H.R. 5216

# Connecticut River Watershed Partnership Act



Source: Friends of Conte

**Summer Workshop Report**
**August 7, 2024**
**Faculty Advisor: Howard Apsan**

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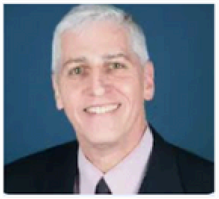

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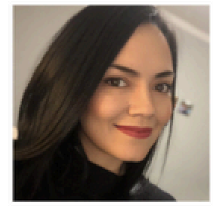

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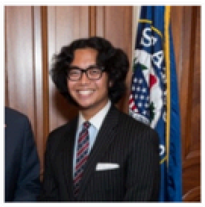

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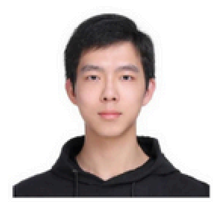


Cheng Chen


Satellite image of the Connecticut River spewing muddy sediment into the Long Island Sound
*Source: Landsat Image Gallery, NASA*

# Executive Summary


*Map of the Connecticut River Watershed;*
*Source: EcoRI News*

The Connecticut River Watershed Partnership Act (H.R. 5216) aims to address the environmental degradation of the Connecticut River Watershed through a comprehensive, multi-faceted approach. The watershed, home to more than 2.4 million residents across 400 municipalities, faces significant challenges due to urbanization, industrial development, and agricultural use. These issues include water pollution, altered river flow, and impacts on biodiversity.

The bill addresses specific environmental concerns such as:

- Land use changes and urban runoff
- Industrial and agricultural discharge
- River modification impacts on fish passages and sedimentation
- Climate change effects on precipitation and flooding

Key components of H.R. 5216 include:

1. Creation of a non-regulatory program to coordinate restoration and preservation efforts
2. Establishment of a grant program to fund local and nongovernmental organizations
3. Focus on fostering interstate partnerships and efficient resource distribution
4. Emphasis on environmental justice, with increased funding for related projects
5. Fifteen main conservation goals categorized under Administrative, Public Access, Biodiversity, Local Engagement, and Land and Water Conservation

H.R. 5216 proposes solutions that include, improving water quality, restoring fish and wildlife populations, controlling invasive species, ensuring safe fish passage at dams, and promoting nature-based solutions for community resilience.

# Introduction to H.R. 5216

Connecticut River Watershed; *Source: Friends of Conte*

The Connecticut River Watershed Partnership Act (H.R 5216) was introduced by U.S. Senators Chris Murphy (D-Conn.) and Richard Blumenthal (D-Conn.) and aims to support the restoration and protection efforts of the five-state Connecticut River Watershed region, including its tributaries and land area. At 410 miles long, the Connecticut River is the largest in New England and runs along Connecticut, Massachusetts, Maine, New Hampshire, and Vermont (NHDES). The environmental degradation of the Connecticut River is a contemporary problem with historical roots; the watershed tells the story of how these states developed and have survived until today. Urbanization, industrial development, and agricultural use have left visible environmental marks in the valley that persist today. Problems like water pollution and changes in flow have seriously affected the region's biodiversity, soil, and water quality.

H.R. 5216 creates a non-regulatory program to coordinate restoration and preservation efforts in the Connecticut River. This program will administer grants to local, nongovernmental, and educational organizations to continue their conservation and restoration work in the watershed. The bill places importance on fostering inter-state partnerships and finding sources of funding to ensure the most efficient distribution of resources for the restoration of the watershed. H.R. 5216 aims to accomplish fifteen main conservation goals with significant reach and overlap; these objectives can be split into five different categories: Administration, Local Engagement, Public Access, Biodiversity, and Land and Water Conservation.

# Story of the Connecticut River Watershed

## Native Peoples

The earliest inhabitants of the Connecticut River were Native Americans, who hunted land animals and relied upon the river for its abundant fish. The river's name is derived from "Quinnetukut" and similar words in various Algonquian dialects, all translated as "long tidal river" in recognition of the ocean's influence on water levels as far as 60 miles upriver from the Long Island Sound. The native people were able to live in harmony with nature, without overburdening the river and its resources.

The River's farmland, fish, waterpower, and access to transportation made it a lucrative place for immigrant settlements. As more and more Europeans moved to this area, it became a hub for trade, agriculture, and industry. In the mid 19th to late 20th century, the watershed underwent significant development of steel rails, brick mills, concrete dams, and highways. Today the watershed runs along five states: Connecticut, Maine, Massachusetts, New Hampshire, and Vermont.

Above: Early log drive on the Connecticut River near Hanover, NH. Below: Harvard Forest Dioramas of the agricultural land in the Connecticut River. *Source:* *The Trust For Public Land Report*

## Driver of the American Industrial Revolution

After the American Civil War, the wider Connecticut River area experienced its first heavy wave of industrialization, with many factories emerging along the river's path. For over a century, the Connecticut River Valley has been at the forefront of industrial development, innovation, and entrepreneurial efforts, in fields like metalworking, motorized transportation, and industrial products and design. While industrialization benefited the American economy, it was detrimental to the watershed due to an absence of environmental regulations during the 19th and 20th centuries.

# Connecticut River Today

**2.4 million**

population across

**7.2 million acres**

Drinking water supplied to

**4.9 million people**

**195,000 jobs**

in the outdoor recreation industry

**$1 billion**

annual contribution to state economies through tourism, fisheries, drinking water, and cultural heritage.

**$17 billion**

value of outdoor recreation industry in the watershed

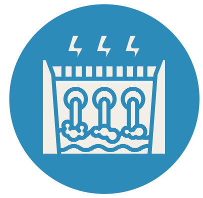
*Source: The Value of the Connecticut River,*

The Connecticut River Watershed is an economic asset, boosting tourism, recreation, agriculture, and fisheries. It supports commercial and recreational fishing, attracts tourists, and provides essential water for agriculture. Additionally, it offers valuable ecosystem services like water purification and flood regulation, enhancing economic stability and reducing environmental management costs.

# Problems Addressed

Land Use Change

Industrial and Agricultural Runoff



River Modification

Climate Change

## Land Use Change

As a major economic hub, the Connecticut River is a driver of urbanization for the communities along its watershed. Today, more than 2.4 million residents in approximately 400 municipalities call the watershed home. While this urbanization has brought many economic and social benefits, more people living around the river means more land surface modifications, vegetation reduction, water quality degradation from urban runoff, and sewage discharge related to combined sewer overflows (Chen et al.). The following section will detail the impacts of these changes on the ecosystem of the Connecticut River.

### Land Surface Modification

The ecological impacts of land surface modification include soil compaction due to the loss of vegetation and the development of impervious surfaces. This decreases infiltration, leading to higher peak flows even from low precipitation events and increased damage resulting from floods.

### Urban Runoff

Non-point-source pollution comes from snowmelt and rainfall transport and can carry contaminants such as oil, grease, metals, and pesticides from yards, parks, and gardens to the river (EPA). This movement of pollutants in the form of runoff can significantly impact wildlife in the river and cause drinking/recreational water contamination for communities.

### Sewage Discharge

Many urban cities use a combined sewer system to manage municipal wastewater and stormwater in the same treatment system. During heavy precipitation events, water running through the pipes can overload the system, causing the pipes to burst. This leads to sewage and stormwater mixing and emptying into the nearby river. Pathogenic bacteria from fecal coliforms enter the river through wastewater effluents, impacting water quality and posing a risk to fish, wildlife, and people. In Springfield, Massachusetts, a major combined sewage overflow event occurred in 2024 due to heavy rains and

## Case Study: Combined Sewage Overflow (CSO) at Springfield, MA

Source: WBUR

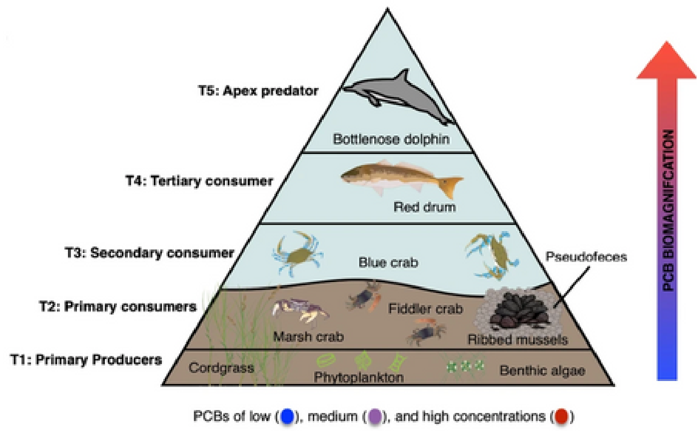

Source: New England Public Media

Springfield, Massachusetts, one of the largest cities in the New England region, is situated along the Connecticut River. In May 2024, heavy rains caused an overflow of sewage and introduced harmful bacteria into the Connecticut River. Consequently, residents were prohibited from approaching the river for 48 hours until the contaminants were diluted. It is estimated that 8 million gallons of untreated sewage water entered the river. This event occurred largely because stormwater runoff and sewage are carried through the same pipes in some older cities, and during heavy rain events these pipes discharge untreated sewage into surrounding environments (Connecticut River Combined Sewage Overflows Fact Sheet).

leaked sewage into the Connecticut River. For humans, this risk arises from close contact with the water during recreational activities or consuming contaminated fish or shellfish (Mitch et al.). Contaminated fish store the toxins in their tissues through absorption and in their organs through ingestion (Noman et al.). These contaminants travel through organisms in the food chain through a process known as bioaccumulation. The contaminant concentration increases with each trophic level. As heavy metals accumulate in aquatic systems, they are most concentrated in fish, particularly those higher in the food chain like salmon, tuna, and swordfish. Eating contaminated fish is one of the primary ways humans are exposed to PCBs.

### Industrial Waste

The Connecticut River Valley has been a large source of economic growth since the post-Civil War era, with several manufacturing industries including metallurgy, textiles, and paperboard located in the area. Untreated waste from these factories has been




Bioaccumulation of PCBs in aquatic animals due to industrial waste runoff. Source: Nature.com

discharged into the river for decades, resulting in chronic pollution by heavy metals, polychlorinated biphenyls (PCBs), and other toxic substances. Heavy metals such as chromium, copper, lead, mercury, nickel, and zinc pose a critical threat to wildlife by damaging aquatic life and bioaccumulating in the food chain, affecting predators including humans. PCBs are a group of compounds that are less soluble in water and tend to accumulate in sediments. Once in the environment, most PCBs do not break down easily and can remain for long periods (USGS).

Despite being banned, PCBs persist in the environment due to poorly maintained industrial waste facilities and thus continue to contaminate streambed sediments and local fish. PCBs can build up in fish to levels that are thousands of times higher than in the water. Even if spills have been stopped, it can take years for the PCB levels in fish to drop to safe levels (USGS). This contamination disrupts ecosystems by causing mutations, reproductive issues, and population declines in fish, impacting the entire food chain.

## Agricultural Runoff

The Connecticut River has also supported agricultural expansion as the human population has grown. Farming practices focus on higher yields from smaller plots of land, using large quantities of fertilizer and pesticides to accomplish this. As a result, significant amounts of excess nutrients and pesticides end up in the river and impact local ecosystems due to precipitation and flooding.

### Excess Nutrients

In agriculture, nitrogen and phosphorus are used in fertilizers to increase plant growth. However, when these nutrients enter the river through precipitation and surface runoff, they stimulate the rapid growth of algae. As the algae and aquatic plant growth increases, it consumes more dissolved oxygen in the water. Decomposition of the plants and algae further reduces dissolved oxygen concentrations in the water and creates hypoxic conditions, in which fish and other aquatic animals cannot survive.

Eutrophication in Connecticut Lakes, Source: Connecticut DPH

This process, called eutrophication, poses a significant threat to biodiversity and water quality. In addition, nitrogen in the form of ammonia can be toxic to aquatic life, the toxicity level depends on the temperature and pH of the water.

Pesticides

Pesticides are harmful chemicals, mixtures, or biological agents released into the environment to manage or eradicate pests such as insects, weeds, rodents, fungi, or other organisms that can lead to crop failure (Mahmood et al.). Pesticides can significantly change the makeup of ecosystems by favoring only species that can tolerate the pesticides. They pollute water sources by seeping into ground and surface water. This has a detrimental effect on human health, as well as on insects and birds that drink this contaminated water.

## River Modification

Since their initial construction, dams have been a vital source of electricity, hydropower, flood control, and drinking water for the communities surrounding the Connecticut River. They have also been crucial in fueling the region's economic growth and development. However, these benefits have unintended ecological consequences, impacting fish, wildlife, and local communities.

Impacts on Fish Passages

The river is a habitat for eight species of migratory fish that travel thousands of miles annually to grow, reproduce, and spawn (Connecticut River Conservancy). When fish migrate, dams can restrict or delay their journey, making them more vulnerable to predators and causing stress and physical harm as they try to find alternative routes to complete their life cycle (Schilt). Dams can also impact water quality and quantity, as low flow can introduce contaminants from runoff pollutants that do not have enough water to dissolve. This stress can ultimately lead to injury and, in some cases, death for the fish.

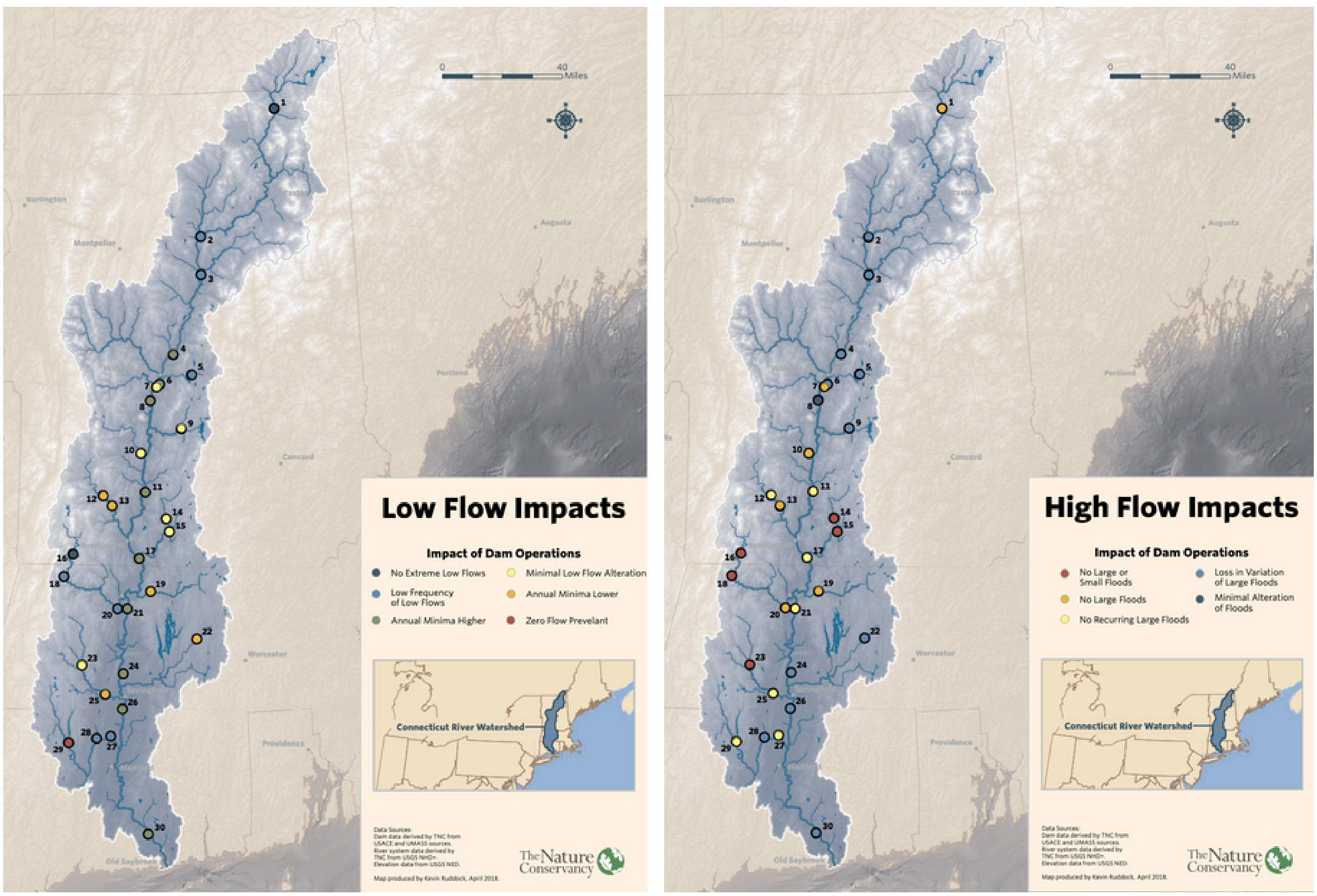
Source: Native Fish Coalition

Impacts on Sedimentation

Sedimentation plays a vital role in river ecosystems by enriching soils with nutrients and providing habitats for various aquatic organisms. Dams disrupt the natural flow of sediments in rivers by trapping them in place. When these sediments are eventually released due to factors such as dam operations or maintenance activities they flow in unnatural quantities, making the water murky. This murkiness impairs not only the ability of fish to feed and grow but also affects the growth of natural vegetation that serves as a food source for fish and other wildlife. According to the EPA, high concentrations of sediments can clog fish gills, reduce their resistance to disease, and harm the development of eggs and larvae. For local human communities, high concentrations of sediments increase the cost of treating drinking water and can cause the water to have an unpleasant taste and smell.

## Impacts on the Hydrologic Regime

Although alterations in flow regimes depend on the reservoir's storage capacity and the dam's operational methods, the most common effects of flow regulation include a decrease in the magnitude of flood peaks and an increase in low flows. Hydropower dams in particular withhold and release water to meet peak power demands, disrupting seasonal flow variations that are crucial for the growth and reproduction of many species (McCartney & Sally).




Impacts of dam operations on high and low flows at 30 locations throughout the Connecticut River watershed. The most significant impacts on high flows occur in the tributaries, while the main stem experiences reduced impacts due to the intervening flows from tributaries that have little to no effect on high flows. For low flows, the impacts are variable across the watershed. The one location with prevalent zero flows (site 29) is below a water supply dam; the two locations without extreme low flows are below hydropower storage dams.

*Source: Connecticut River Flow Restoration Study by The Nature Conservancy, UMass Amherst, and US Army Corps of Engineers*

## Climate Change

Climate change is observed through the increase of temperature, humidity, and precipitation in the Connecticut River Watershed. While not a unique issue to the region, climate change has significantly increased precipitation across the United States and has influenced the occurrence of floods. The total precipitation events in the Connecticut River region increased by nearly 240% between 1950 and 2011, while the proportion of extreme events as a fraction of total precipitation increased by nearly 20% during the same period (Parr & Wang, 2014). Rising temperatures and increased precipitation can impact the habitats and physiological adaptation and phenology of freshwater species. This further alters ecosystem dynamics considering their food web structure and can make certain diseases more prevalent. Climate change indirectly affects the nutrient and ionic loads of river systems.

### Climate Change and Nitrogen

An increase in precipitation can increase the amount of run-offs from land to water, bringing more nitrogen from land to the river. An increase in temperature, however, increases evaporation and can prevent nitrogen from entering streams. The temperature change can also change microbial life interaction with nitrogen, meaning that nitrogen will not necessarily flow into the river. Rising temperature can thus offset the excess nitrogen running off into the river from increased precipitation. However, more research analyzing the Connecticut River Watershed is needed to determine whether the climate impact on nitrogen can be offset (DiSalvo, 2023).

### Climate Change and Flooding

Flooding during spring is common in the watershed, where parks and walking trails become inaccessible for several days. However, with the rise in temperature of the air as a result of the climate crisis, flooding in the Connecticut River is projected to worsen. With the rise of temperature, occurrences of storms rise, which increases the moisture content in the atmosphere. This leads to more rain within a short period. This dense precipitation makes riverine floods more frequent as well as constant stormwater flooding on streets. Flooding impacts households nearby as their impervious surfaces make flood water seep into people’s basements (DiSalvo, 2023).

# Proposed Solutions

Biodiversity

Land Preservation

Local Engagement

Improving Water Quality

### 15 Tenets of H.R. 5216

H.R. 5216 aims to accomplish fifteen main conservation goals with significant reach and overlap. These objectives can be split into five different categories: Administrative, Public Access, Biodiversity, Local Engagement, and Land and Water Conservation. The Administrative tenets largely encompass how to facilitate collaboration and issue grants within the non-regulatory program, and Public Access includes those that aim to expand publicly available areas of the watershed by strengthening the local ecosystems until they can support these activities. Most of these tenets fall under the last three categories and articulate what solutions the bill aims to support to remedy the environmental issues of the Connecticut River.

### Biodiversity

The main objectives are to restore, recover, and manage local fish, wildlife, and plant populations. To this end, some of the projects that the bill suggests are improving fish passage and fish monitoring.

#### Fish Passage

Access to critical habitats: Dams pose significant challenges for migratory fish species such as American Shad, River Herring, Atlantic Salmon, Sea Lamprey, and Sturgeon, which need to reach freshwater habitats to reproduce. Fish populations have declined due to river blockages, predation, deteriorating water quality, and the fishing industry. Fish passages, or fish ladders, are sloped structures with steps and channels built on dams, enabling fish to swim upstream. These structures help migratory fish access spawning and nursery habitats, aiding in the recovery of threatened and endangered populations (Connecticut Corridor Management Plan).

American Shad (Alosa sapidissima), native fish of the Connecticut River. *Source: US Fish and Wildlife Service*

Technical enhancement: Building and modernizing fish passages at dams is the first step to supporting fish migration, and using updated techniques improves the rate of recovery and growth. Updating the dams makes the fish lifting system more stable and reliable to operate, allowing workers to easily make adjustments according to the real-time data of flow rates and temperature. This innovation would increase the annual fish count, as it did in the case of the American Shad at the Holyoke Dam in Massachusetts.

## Land Preservation

Key solutions for addressing land preservation include maintaining and increasing riparian buffers and floodplain restoration.

### Preserving Riparian Buffers

Riparian buffers are "areas next to streams, wetlands, or lakes that are made up of trees, shrubs, and other perennial plants and provide a buffer zone between agricultural land and waterways" (USDA). They play a crucial role in the ecosystem, and serve many purposes:

**Filtration of Pollutants:** Surface runoff is a significant source of pollutants consisting of sediments, fertilizers, pesticides, and heavy metals. Riparian buffers can filter out this pollution before it enters the river. Riparian forest buffers can reduce nitrogen by 40-100%, while grass buffers reduce nitrogen by 10-60% (Beddoes et al. 2007, USDA).

**Sediment Trapping:** Vegetation roots in riparian areas bond together with the soil, limiting erosion and capturing sediments that would otherwise be swept into rivers. Riparian buffers that are properly built will remove up to 90% of sediment carried by runoff, reducing

## Case Study: Fish Counting at the Holyoke Dam in MA

The Robert E. Barrett Fishway (built in 1955, second fishway turbines added in 1976), in the updated versions one can see how the improvements have successfully passed 277,367 American Shad upstream at Holyoke Dam in 2023, a 46% increase from the previous year. The data demonstrates the high effectiveness and safety of the improved fish passage compared to the past by modifying the structure (Connecticut Corridor Management Plan).

The team at Holyoke Dam counting fish
*Source: US Fish and Wildlife Service*

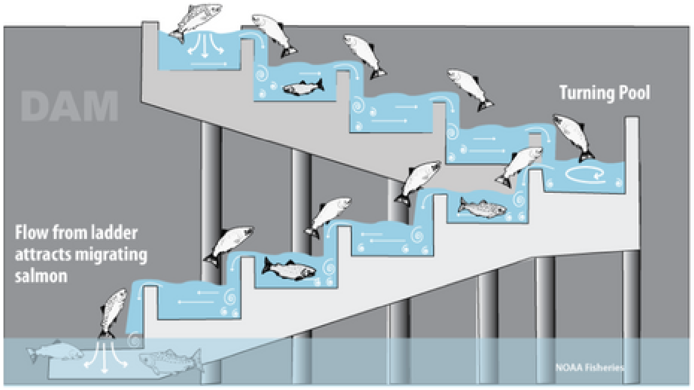


Diagram of how fish ladders enable fish to cross over dams.
Source: : NOAA

soil sediments reaching surface water by 40-70%. The physical obstruction of this vegetation slows down runoff to the extent that most sediments settle out before the water reaches the river. The roots of trees and plants reach 3 to 20 feet below the surface, forming a network that firmly holds soil particles together (Birkland et al., 2003).

Nutrient Uptake: These buffers provide vegetation of trees, shrubs, and grasses that help in absorbing excess nutrients from fertilizers and animal wastes. Plant roots absorb nutrients like nitrogen and phosphorus from the soil, preventing them from leaching into the river (Michael G. et al, 2010).

Reduce water temperatures: The riparian buffers provide shade and are pivotal to reducing water temperatures. By moderating temperature fluctuations, effective riparian buffers can reduce stream temperature increases by around 32.72°F, mitigating thermal stress on organisms and helping maintain a stable aquatic environment.

### Floodplain Restoration

Floodplains are a crucial aspect of watershed ecosystems for flood prevention, pollutant filtration, and wildlife habitat. Floodplain restoration usually takes one of two different approaches – the first is raising the river or stream bed of an incised channel by adding compacted soil or sediment and stabilizing stream banks. Another way is to excavate soil and sediment around a stream and restore the land to its historic floodplain elevation. The latter helps enhance infiltration, reduces flow levels, and mitigates peak discharge volumes during storm events. When coupled with natural stream design and planting native species, restoration of floodplains can be an effective tool that this bill helps to fund (Pennsylvania Department of Environmental Protection). Restored and reconnected floodplains can remove on average 40% of the nutrients in the river (Freshwater network).

## Water Quality

The main solutions outlined in the bill towards this end are drinking water access, dam management, and improving and monitoring water quality to support fish, wildlife, and aquatic habitats.

### Water Quality Monitoring

Water monitoring is essential for maintaining water quality. It identifies chemical changes and emerging problems, informs pollution prevention programs, and assesses the effectiveness of actions taken.

## Case Study: Floodplain Restoration Project, Longmeadow MA

Floodplain Restoration Project in Longmeadow, MA
Source: : Fish and Wildlife Service

The Floodplains Restoration Project in Longmeadow, Massachusetts is an example of a multi-partner restoration project. In 2017, a partnership was formed among Friends of Conte, The Nature Conservancy, Friends of Fannie Stebbins, Silvio O. Conte National Wildlife Refuge, Allen Bird Club, and the Longmeadow Conservation Commission to restore 223 acres of rare floodplain forest. Through the Floodplain Restoration Project, they planted 8,000 plants of 20 species, creating the largest floodplain forest of its kind in the watershed.

The Connecticut River's monitoring program provides crucial data for scientists, public agencies, and policymakers to manage the river's health. Collected data supports programs in advocacy, restoration, and recreational access. Volunteers play a key role in gathering samples, and ongoing lab testing drives new initiatives. A significant effort is the microplastic monitoring program, started in 2021, which tracks microplastic distribution and its impact on surrounding communities (Connecticut River Conservancy).

<u>Drinking Water</u>

The Connecticut River Watershed provides drinking water for 2.3 million people directly, and an additional 2.5 million people through reservoirs filled by the river. However, pollution in the river has degraded water quality, making it

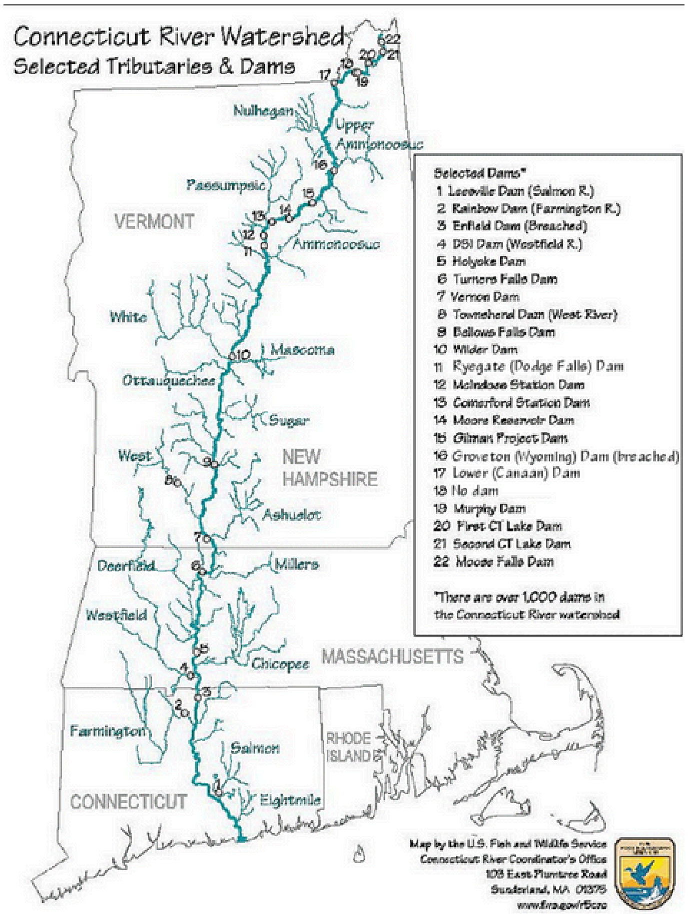
Water Sampling. Source: NOAA and Connecticut River Conservancy undrinkable for surrounding communities. Interstate coordination will improve access to clean water, enhance well-being, and prevent infections.

The Connecticut River Conservancy, a leading organization in water quality monitoring, continuously tests for pollutants and collects samples. Their efforts in 2021 and 2022 found microplastics in every sample. Due to changing water chemistry from agricultural, industrial, and urban runoff, constant monitoring is essential (Connecticut River Conservancy).

Dam Removal

While well-designed dams offer numerous social and economic benefits, including navigation, flood control, and power, small and outdated dams significantly disrupt natural water conditions. Dams impede the natural flow of water and sediment, adversely affecting populations of native fish and other aquatic organisms. Given the river's capacity for rapid recovery, removing those dams can enhance overall water quality and flood resilience.

Hydrology: The construction of a dam drastically alters the flow of water both upstream and downstream. Upstream, a deep, still reservoir replaces the once free-flowing river, creating a lake-like habitat unsuitable for many fish, and other aquatic animals. Downstream, the natural seasonal variations in a river’s flow are often diminished or eliminated.




Dams along the Connecticut River Watershed


Removal of an old mill dam, Beaver Brook Dam, in Wilmington Vermont by the Connecticut River Conservancy

Flood Resilience: Each dam removal lowers the flood elevation level and provides additional storage capacity within the river channel during large storm events. Non-flood control dams do not offer significant flood storage capacity during such events; they merely act as minor obstructions during high-flow conditions. Removing these obsolete dams can significantly enhance flood resilience by allowing rivers to manage excess water more effectively.

## Local Engagement

The goal of local engagement is to coordinate restoration and protection among federal, state, regional, local, and tribal entities. Additionally, education and outreach are tools to increase public engagement and promote tribal river knowledge and cultural practices. A crucial aspect of the grant program is its focus on environmental justice. For most projects the federal share of the funding provided via grants cannot exceed 75% of its total cost, however, for environmental justice communities, the maximum federal funding is 90% of the project cost. This initiative delegates more funding towards projects in environmental justice communities.

The Connecticut River has been a focal point for environmental justice efforts in recent years. One significant example is the $27 million agreement between the City of Holyoke, Massachusetts, and federal and state authorities to reduce sewage overflow discharges into the river. This initiative aims to address the disproportionate impact of pollution on lower-income communities along the river (Environmental News Service, 2023).


Joint community effort to clean up the Connecticut River; *Source: Connecticut River Conservancy*

# Issues and Controversies

Land Use

Biodiversity

Water Quality

## Land Use

Controversy: Fertilizer Use

While fertilizers allowed for a massive expansion in food production across the globe, their introduction comes with significant controversy surrounding how much is used and where. This is especially true in a modern context where farms are increasingly intensifying operations over smaller plots of land while aiming to make those plots as productive as possible. For local communities and farmers, this produces a difficult question as to how much fertilizer is too much. Excess usage can lead to algal blooms as mentioned earlier in this report, as well as to nitrates in drinking water (Keena). Misapplication can further lead to a decrease in soil fertility due to changes in pH and chemical composition of soil when over exposed to these chemicals.

## Biodiversity

Controversy: Effectiveness of River Restoration Projects

River restoration projects often utilize the natural channel design method, which involves physically reconstructing river channels to create habitat for native plants and animals. This requires the removal of trees close to the stream channel, and decreasing tree canopy and vegetation in the area. This method is highly controversial and criticized for the radical change it creates in the local ecosystem, and many even question its effectiveness. One study shows that fish abundance and diversity did increase in the first few years after restoration, but this increase was short-term (France). The rise of fish abundance and diversity could be due to more sunlight reaching the stream from tree cover loss when trees along the bank are cleared for the project. As tree cover increases, streams become shaded, where fish abundance and diversity decrease over time simultaneously (France). This controversy questions whether projects like this bill would restore biodiversity, given that some past intended projects did not result in long-term success.

Controversy: Invasive Species

While invasive species are a natural

occurrence; globalization, and human activity have increased the rate and range of their exposure. As a result, invasive species are a pervasive problem in most ecosystems. Some suggest mitigation and restoration practices can lead to the introduction of these invasive species into the Connecticut River Watershed. H.R. 5216 strives to improve water quality not just for the wildlife and plants but to improve opportunities for public access. Unfortunately, under-informed people or careless mistakes can transfer invasive species from one water body to the next. Didymosphenia geminata, Didymosphenia hullii, and Cymbella janischii is a conglomeration of diatoms that blanket stream and river beds. These tiny organisms out compete benthic macro invertebrates and other beneficial algae for space, which has a cascading effect on aquatic food chains. Didymo is transferred by the improper cleaning of aquatic clothes or gear.

Water Quality

<u>Controversy: Agricultural Runoff</u>

According to the EPA, reducing water quality impacts from agricultural runoff requires implementing management practices such as customized tillage and drainage methods, cover crops, and vegetated buffers. Farmers are also encouraged to leave the soil undisturbed between harvests (SARE). Although these practices benefit soil productivity long-term, they can be controversial among farmers because leaving the land untouched for a season can have a significant economic impact. Additionally, adopting new drainage methods and better management practices requires a substantial capital investment, which is often a limiting factor for farmers.

## Case Study: Hydrilla

Hydrilla weeds covering the surface of the Connecticut River; *Source:* <u>*UConn*</u>

Hydrilla (hydrilla verticillata) is an aquatic invasive species in the Connecticut River that has grown across at least 774 acres of the river. It forms coarse entangled webs that can block boats and prevent peoplefrom accessing the docks, leading to a loss of income. It spreads through fragmentation, and in order to overcome this, recreational activities promotions need to include education about prevention of this spread, such as working with the Connecticut River Conservancy who is already ensuring community members clean, drain, and dry their boats to prevent hydrilla from spreading (Hydrilla | Connecticut River Conservancy, n.d.).

## Case Study: Long-Term Effect of Instream Habitat-Improvement Structures on Channel Morphology Along Blackledge and Salmon Rivers in Connecticut

Low-flow photograph of a 1930s era log deflector. *Source: Douglas 2002*

In the 1930s and 1950s, extensive stream restoration was performed on the Blackledge and Salmon Rivers in Connecticut. These structures were studied to determine their impact on the stream hydrology and habitat health. During this time period Connecticut experienced extreme flooding just shy of a hundred-year event. Of the 40 surviving structures found along Blackridge River, only four remained intact while others have been damaged or modified. Most importantly, the cover structures and the riprap had a demonstrable adverse effect on vegetation. Tree recruitment along stretches modified saw a 30% decrease in tree recruitment which in turn led to 75% less undercut habitat. On the other hand, in some cases cribbing over structures combined with sediment being scoured out created good undercut habitat. Ultimately, this study may show that increasing climatological effects, cost of maintenance, and cost of monitoring, may end up outweighing the marginal impacts stream restoration can have on habitat and hydraulics.

# Measuring Success


Source: The Valley Reporter

Performance metrics are crucial to evaluating the success of the Connecticut River Watershed Partnership Act. The criteria we followed was the Input, Process, Output, and Outcome structure to determine what constitutes a successful outcome, and the actionable measures that need to be taken to achieve these outcomes. This model allows one to better identify the causes of a problem and evaluate exactly how the solution intends to solve them.

The input section includes data, information, or the solution being implemented in the watershed. This is the action being taken towards the outcome. The process involves the steps taken to implement the input. This includes activities, steps, or actions. The output is the result of the process, and in this case, also determines how to assess the success of the input. It may, for example, include a metric that the river needs to adhere to in order to be within national or state regulations. The outcome refers to the overarching goal of the inputs. We have listed three processes as part of this section: Improving Biodiversity, Environmental Restoration, and Human Health.

With regards to Human Health, this metric is even more important from an environmental justice perspective. Poorer communities, often historically BIPOC neighborhoods, tend to be those with the lowest water quality at the same time as being the most underserved and therefore also lacking in resources to fix these issues.

| Input | Process | Output | Outcome |
|---|---|---|---|
| Fish Passage | Fish Assemblage: Variety and abundance of fish species in the waterbody | Variety of fish is determined and assessed based on the water body's biodiversity and historic characteristics | Improving Biodiversity |
| Small Dam removal | Fish Species Richness: Number of different fish species present in the waterbody | High species richness indicates a healthy ecosystem | Improving Biodiversity |
| Riparian Buffer Restoration | Dissolved Oxygen (DO) | Appropriate DO levels are essential for the survival of aquatic species. Less than 2 mg/L is considered hypoxic waters | Environmental Restoration |
| Riparian Buffer Restoration | Suspended Sediments | Excessive sediments degrades habitats, clogs gills and filter feeders, and prevents light penetration | Environmental Restoration |
| Floodplain Restoration | Water Temperature | Temperature directly related to metabolic processes. Lower temperature water holds more DO | Environmental Restoration |
| Water Quality Management | Lead Concentration | High concentrations in drinking water leads to severe health impacts especially to pregnant women and children | Improved Human Health |
| Water Quality Management | pH | Low pH leads to pipe corrosion and metal leaching, and high pH levels lead to scaling, high maintenance costs | Improved Human Health |

# Case Study: Fenwick - Hepburn Dune Living Shoreline Project (Old Saymoore, CT)

Fenwick living shoreline project area before restorations implemented *Source: Sumco Eco-Consulting*

This project is an example of our solutions in action. Living shoreline projects incorporate natural elements used for protection against erosion and weather events. Rather than installing a concrete wall or sandbags, these shorelines are meant to grow with the environment. They provide habitat to fish and birds as well as flood resilience to the communities that live there.

Situated right at the mouth of the Connecticut River, the borough of Fenwick is home to only 50 residents but contains landmarks like the Lynde Point Lighthouse, and important conservation areas such as the Lynd Point Marsh and Crab Creek. This part of the Fenwick peninsula acts as a barrier between the Long Island sound and the Connecticut River and as an important nesting habitat for migratory bird species like osprey and purple martins. Storms have repeatedly battered Fenwick's shoreline, eroding the sediment away and flooding the surrounding buildings and roads. The migration of the shoreline towards the tidal marsh and Crab Creek means it is more likely that the sand barrier between Crab Creek and the Long Island Sound could be breached. This could increase erosion potential of the restored tidal marsh as well as threaten increased flooding to the surrounding properties.

## Case Study: Fenwick - Hepburn Dune Living Shoreline Project (Old Saymoore, CT)

Fenwick living shoreline with restoration measures completed *Source: Estuary Magazine*

The goal of this living shoreline project is to stabilize the shoreline, mitigate erosion, and prevent Crab Creek from connecting to the Long Island Sound. To do this restoration experts took a few different approaches. Crab Creek was excavated, a new culvert was placed, backfilled, and reconstructed. A wider, higher, and more robust dune was constructed. 9 rock sills were placed to distribute wave energy and mitigate storm impacts. Marsh Vegetation, including 36,000 marsh grass plugs, were planted to enhance existing habitat, improve sediment trapping, and protect against flooding. It took collaboration between many partners like the Connecticut River Conservancy, CT Department of Energy and the Environment, and the Lynde Point Land Trust and many years of design to implement a restoration project like this. The real test of a project like this will be hurricanes or superstorms that are becoming more severe and more frequent due to climate change, but for now the shoreline is safe, and revegetating.

# Conclusion

The Connecticut River Watershed Partnership Act (H.R. 5216) presents a comprehensive and collaborative approach to addressing the complex environmental challenges facing the Connecticut River. By focusing on local engagement, land and water preservation, and biodiversity, the bill aims to create a sustainable framework for long-term conservation and restoration efforts.

The proposed solutions target key issues such as biodiversity loss, water quality degradation, and the impacts of climate change. The emphasis on nature-based solutions and traditional ecological knowledge demonstrates a forward-thinking approach to environmental management. This watershed is a cornerstone of the community and has been a crucial piece to the development of the United States as it is today. This legislation takes the early steps towards a coordinated approach to its restoration, which is especially important in light of climate change and its increasing adverse impacts on local environments.

While the success of this legislation will ultimately depend on its implementation and the continued commitment of various stakeholders, H.R. 5216 provides a solid foundation for improving the ecological health of the Connecticut River. By balancing conservation efforts with community needs and promoting adaptive management strategies, this act has the potential to significantly enhance the environmental and socioeconomic well-being of the region for generations to come.

Connecticut River Watershed; Source: ctriver.org

# References

Parr, D., Wang, G. and Ahmed, K.F. (2015) Hydrological changes in the U.S. northeast using the Connecticut River Basin as a case study: Part 2. projections of the future, Global and Planetary Change. Available at: https://www.sciencedirect.com/science/article/pii/S0921818115300059#s0055

“Basic Information about Nonpoint Source (NPS) Pollution.” EPA, Environmental Protection Agency, www.epa.gov/nps/basic-information-about-nonpoint-source-nps-pollution.

Chen, Jingqiu, et al. "Urbanization impacts on surface runoff of the contiguous United States." Journal of environmental management 187 (2017): 470-481

Connecticut River Combined Sewage Overflows Fact Sheet, Pioneer Valley Planning Commission, Feb. 2005, www.pvpc.org/sites/default/files/cso_fs.pdf. Accessed 18 June 2024.

Mahmood, Isra, et al. "Effects of pesticides on environment." Plant, soil and microbes: volume 1: implications in crop science (2016): 253-269.

McCartney, Matthew P., and Hilmy Sally. Managing the Environmental Impact of Dams, International Water Management Institute , www.iwmi.cgiar.org/africa/East/Documents/Managing the environmental impact of dams.pdf.

“Migratory Fish: Connecticut River Conservancy.” Ctriver.Org, www.ctriver.org/migratory-fish#:~:text=The%20Connecticut%20River%20hosts%208,sea%20lampreys%2C%20and%20shortnose%20sturgeon.

Mitch, Azalea A., Katherine C. Gasner, and William A. Mitch. "Fecal coliform accumulation within a river subject to seasonally-disinfected wastewater discharges." Water Research 44.16 (2010): 4776-4782.

Noman, Md Abu et al. “Bioaccumulation and potential human health risks of metals in commercially important fishes and shellfishes from Hangzhou Bay, China.” Scientific reports vol. 12,1 4634. 17 Mar. 2022, doi:10.1038/s41598-022-08471-y

Rooker, Sarah. “Industry and Commerce in the Connecticut River Valley.” Flow of History, 21 Feb. 2014, www.flowofhistory.org/industry-commerce/.

Schilt, Carl R. “Developing Fish Passage and Protection at Hydropower Dams.” Applied Animal Behaviour Science, Elsevier, May 2006, www.sciencedirect.com/science/article/abs/pii/S016815910600298X.

Sheldon, Benjamin. “Phosphorus - Element Information, Properties and Uses: Periodic Table.” Phosphorus - Element Information, Properties and Uses | Periodic Table, www.rsc.org/periodic-table/element/15/phosphorus.

Sterling, Clarence I. "Status of Sewage Treatment in the Connecticut River Valley." Sewage Works Journal: 624-635.

“What Is Phosphate?” OCP Group, www.ocpgroup.ma/what-is-phosphate#:~:text=Phosphate%20rock%20is%20processed%20to,to%20animal%20feed%20and%20electronics.

“What Is Sediment Pollution? .” Environmental Protection Agency, cfpub.epa.gov/npstbx/files/ksmo_sediment.pdf.

“2018 Integrated Water Quality Report.” EPA, July 2019, www.epa.gov/sites/default/files/2019-10/documents/2018-ct-integrated-rpt.pdf. Accessed 18 June 2024.

“Chesapeake Wild: U.S. Fish & Wildlife Service.” FWS.Gov, www.fws.gov/program/chesapeake-wild. Accessed 21 June 2024.

American Water Works Association. "| Lead in Water: What Level Should Prompt Action?" Www.awwa.org, 2 Mar. 2017, www.awwa.org/AWWA-Articles/lead-in-water-what-level-should-prompt-action.

Beddoes, Jenifer, et al. "Redirecting." Google.com, 2024, www.google.com/url?q=www.nrcs.usda.gov/plantmaterials/idpmstn7248.pdf&sa=D&source=docs&ust=1722992519500391&usg=AOvVaw3TetfapUU197yEDEP3oCPq.

Accessed 7 Aug. 2024.
Blood, Kari. "A Flood of Evidence: Local Climate Change Impacts Show the Need for Conservation & Restoration." Kestrel Land Trust, 28 July 2023, www.kestreltrust.org/local-floods-climate-conservation-oped/.

Bright, Matt, and Toby Lockwood. "What Does the Latest IPCC Report Say about Carbon Capture?" Clean Air Task Force, 20 Apr. 2022, www.catf.us/2022/04/what-does-latest-ipcc-report-say-about-carbon-capture/.

Chaplin, Diana. "29 Restoration Projects Completed in 2023 by Connecticut River Conservancy & Partners." Ctriver.org, ctriver.org, 2 Jan. 2024, www.ctriver.org/post/river-restoration-2023. Accessed 6 Aug. 2024.

Chen, Jingqiu, et al. "Urbanization Impacts on Surface Runoff of the Contiguous United States." Journal of Environmental Management, vol. 187, Feb. 2017, pp. 470–81, https://doi.org/10.1016/j.jenvman.2016.11.017.

Connecticut River Conservancy. "Hydrilla | Connecticut River Conservancy." Ctriver.org, 2016, www.ctriver.org/hydrilla. Accessed 7 Aug. 2024.
---. "Migratory Fish | Connecticut River Conservancy." Ctriver.org, 2014, www.ctriver.org/migratory-fish. Accessed 6 Aug. 2024.

"Migratory Fish | Connecticut River Conservancy." Ctriver.org, 2014, www.ctriver.org/migratory-fish. Accessed 6 Aug. 2024.

"Recreation | Connecticut River Conservancy." Ctriver.org, 2018, www.ctriver.org/recreation-access. Accessed 6 Aug. 2024.

"Water Quality | Connecticut River Conservancy." Ctriver.org, 2021, www.ctriver.org/water-quality-monitoring. Accessed 7 Aug. 2024.

Connecticut State Website. "Carbon and Forests." CT.gov - Connecticut's Official State Website, Apr. 2021, portal.ct.gov/DEEP/Forestry/Climate-Change/Carbon-and-Forests.

CT Energy & Environment. "Introduction to Dams." CT.gov - Connecticut's Official State Website, Oct. 2020, portal.ct.gov/DEEP/Water/Dams/Introduction-to-Dams.

Cumbler, John T. "The Land, the River, and the People : The Connecticut Valley, 1790-1830." Oxford University Press EBooks, Oxford University Press, Mar. 2001, https://doi.org/10.1093/oso/9780195138139.003.0005. Accessed 7 Aug. 2024.

Dawson, Rachel, and Jessica Coordinator. Delaware Watershed Conservation 2018 Grant Slate NFWF CONTACTS. www.nfwf.org/sites/default/files/delaware/Documents/dwcf-2018-grant-slate.pdf. Accessed 6 Aug. 2024.

Degani, Erika, et al. "Crop Rotations in a Climate Change Scenario: Short-Term Effects of Crop Diversity on Resilience and Ecosystem Service Provision under Drought." Agriculture, Ecosystems & Environment, vol. 285, Dec. 2019, p. 106625, https://doi.org/10.1016/j.agee.2019.106625.

Dorch, Amelia, and Chad Douglas. "Farm Community Effort Leads to Improved Drinking Water for Thousands." Www.usda.gov, 16 Mar. 2018, www.usda.gov/media/blog/2018/03/16/farm-community-effort-leads-improved-drinking-water-thousands.

Dosskey, Michael G., et al. "The Role of Riparian Vegetation in Protecting and Improving Chemical Water Quality in Streams1." JAWRA Journal of the American Water Resources Association, vol. 46, no. 2, Mar. 2010, pp. 261–77, https://doi.org/10.1111/j.1752-1688.2010.00419.x.

Environmental Protection Agency. Help Keep Excess Sediment out of Our Creeks, Streams and Rivers. cfpub.epa.gov/npstbx/files/ksmo_sediment.pdf. Accessed 6 Aug. 2024.

Environmental protection Agency. 6-1 Discounting Future Benefits and Costs. 2010, 19january2021snapshot.epa.gov/sites/static/files/2017-09/documents/ee-0568-06.pdf. Accessed 6 Aug. 2024.

EPA. "5.3 Temperature | Monitoring & Assessment | US EPA." Archive.epa.gov, archive.epa.gov/water/archive/web/html/vms53.html.

Office of Water WATER QUALITY STANDARDS HANDBOOK CHAPTER 3: Water Quality Criteria. 2023, www.epa.gov/sites/default/files/2014-10/documents/handbook-chapter3.pdf.
"Why We Use Pesticides." US EPA, 21 Feb. 2013, www.epa.gov/safepestcontrol/why-we-use-pesticides#:~:text=Pesticides%20are%20used%20to%20control.

Ernst, Anne G., et al. "Natural-Channel-Design Restorations That Changed Geomorphology Have Little Effect on Macroinvertebrate Communities in Headwater Streams." Restoration Ecology, vol. 20, no. 4, June 2011, pp. 532–40, https://doi.org/10.1111/j.1526-100x.2011.00790.x. Accessed 5 July 2020.

FEMA. "Benefits of Natural Floodplains | FEMA.gov." Www.fema.gov, 1 Apr. 2022, www.fema.gov/floodplain-management/wildlife-conservation/benefits-natural.

Fondriest. "Measuring Dissolved Oxygen - Environmental Measurement Systems." Environmental Measurement Systems, 2014, www.fondriest.com/environmental-measurements/measurements/measuring-water-quality/dissolved-oxygen-sensors-and-methods/.

France, Cheryth. "Are Stream Restoration Projects Working for Fish? Not Long-Term, New Research Finds. - the River Basin Center." The River Basin Center, 5 July 2023, rivercenter.uga.edu/are-stream-restoration-projects-working-for-fish-not-long-term-new-research-finds/. Accessed 7 Aug. 2024.

Freshwater Network. "The Value of Floodplains | Freshwater Network - the Nature Conservancy." Freshwaternetwork.org, 2017, freshwaternetwork.org/innovative-tools/floodplain-prioritization-tool/the-value-of-floodplains/. Accessed 7 Aug. 2024.

Hydropower. "Strategies." Hydropower.org, 2023, www.hydropower.org/sediment-management/sediment-management-strategies#:~:text=Pressure%20Flushing. Accessed 7 Aug. 2024.

Johnson, Ashanti, and Melanie Harrison. "The Increasing Problem of Nutrient Runoff on the Coast." American Scientist, 6 Feb. 2017, www.americanscientist.org/article/the-increasing-problem-of-nutrient-runoff-on-the-coast

Keena, Mary. "Environmental Implications of Excess Fertilizer and Manure on Water Quality."
NDSU Agriculture, NDSU, 21 Feb. 2023, www.ndsu.edu/agriculture/extension/publications/environmental-implications-excess-fertilizer-and-manure-water-quality.

Ken Sprankle. “Connecticut River Basin Fishway Passage Counts | U.S. Fish & Wildlife Service.” FWS.gov, 2023, www.fws.gov/project/connecticut-river-basin-fishway-passage-counts.

Kremen, C., and A. M. Merenlender. “Landscapes That Work for Biodiversity and People.” Science, vol. 362, no. 6412, Oct. 2018, p. eaau6020, https://doi.org/10.1126/science.aau6020.

Landscape Partnership. “Product Description: Ecologically Important Floodplain Forests in the Connecticut River Watershed.” Landscapepartnership.org, 2014, www.landscapepartnership.org//projects/connecticut-river-watershed-pilot/connecticut-river-pilot-core-team/connecticut-river-pilot-core-team-meeting-03-28-2014/product-description-ecologically-important-floodplain-forests-in-the-connecticut-river-watershed. Accessed 7 Aug. 2024.

Larsen, Kathy. “The Science behind It: Corrosion Caused Lead-Tainted Water in Flint, Michigan.” Www.materialsperformance.com, 4 May 2020, www.materialsperformance.com/articles/material-selection-design/2016/06/the-science-behind-it-corrosion-caused-lead-tainted-water-in-flint-michigan.

Leopold, L. B. “Downstream Change of Velocity in Rivers.” American Journal of Science, vol. 251, no. 8, Aug. 1953, pp. 606–24, https://doi.org/10.2475/ajs.251.8.606.
Longmeadow, MA. “Longmeadow, MA | Official Website.” Longmeadowma.gov, 28 July 2024, www.longmeadowma.gov. Accessed 6 Aug. 2024.

Lowrance, Richard, and Joseph M. Sheridan. “Surface Runoff Water Quality in a Managed Three Zone Riparian Buffer.” Journal of Environment Quality, vol. 34, no. 5, 2005, p. 1851, https://doi.org/10.2134/jeq2004.0291. Accessed 8 May 2019.

Mahmood, Ferdous, et al. “CORROSION CONTROL: Using Caustic Soda to Control Corrosion and Calcium Carbonate Precipitation.” Waterworld.com, WaterWorld, Nov. 2000, www.waterworld.com/home/article/16191536/corrosion-control-using-caustic-soda-to-control-corrosion-and-calcium-carbonate-precipitation. Accessed 7 Aug. 2024.

Mahmood, Isra, et al. “Effects of Pesticides on Environment.” Plant, Soil and Microbes, vol. 1, 2016, pp. 253–69, https://doi.org/10.1007/978-3-319-27455-3_13.

Mathu, Patricia, and Alex Smith. “Conservation vs. the Climate.” The Breakthrough Institute, 26 June 2023, thebreakthrough.org/issues/food-agriculture-environment/conservation-vs-the-climate.

McCartney, Matthew. “Living with Dams: Managing the Environmental Impacts.” Water Policy, vol. 11, no. S1, Mar. 2009, pp. 121–39, https://doi.org/10.2166/wp.2009.108.

McGinn, Matthew. “New Report Shows Rising Cost of Repairing the Nation’s Dams | ASCE’s 2021 Infrastructure Report Card.” ASCE’s 2021 Infrastructure Report Card |, 20 Apr. 2023, infrastructurereportcard.org/new-report-shows-rising-cost-of-repairing-the-nations-dams/.

Mitch, Azalea A., et al. “Fecal Coliform Accumulation within a River Subject to Seasonally-Disinfected Wastewater Discharges.” Water Research, vol. 44, no. 16, Sept. 2010, pp. 4776–82, https://doi.org/10.1016/j.watres.2010.05.060.

National Geographic. “Understanding Rivers.” Education.nationalgeographic.org, 2023, education.nationalgeographic.org/resource/understanding-rivers/.

National Park Service. “Invasive Zebra Mussels (U.S. National Park Service).” Www.nps.gov, 2 Apr. 2021, www.nps.gov/articles/zebra-mussels.htm#:~:text=Environmental%20impacts.

New Hampshire Department of Environmental Services. The Connecticut River. 2023, www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/rl-4.pdf.

NIWA. “Sediments and Hydro.” NIWA, 2023, niwa.co.nz/freshwater/kaitiaki-tools/what-impacts-interest-you/sediment/causes-sedimentation/sediments-and-hydro#:~:text=Dams%20impact%20on%20the%20amount. Accessed 7 Aug. 2024.

Noman, Md Abu, et al. “Bioaccumulation and Potential Human Health Risks of Metals in Commercially Important Fishes and Shellfishes from Hangzhou Bay, China.” Scientific Reports, vol. 12, no. 1, Mar. 2022, p. 4634, https://doi.org/10.1038/s41598-022-08471-y.

North Carolina Agricultural Research Service. “Riparian Buffers and Controlled Drainage to Reduce Agricultural Nonpoint Source Pollution | NC State Extension Publications.” Content.ces.ncsu.edu, Sept. 2002, content.ces.ncsu.edu/riparian-buffers-and-controlled-drainage-to-reduce-agricultural-nonpoint-source-pollution.

North Carolina Stream Restoration Institute and North Carolina Sea Grant. Stream Restoration Prep8AICI by the North Carolina Stream Restonltlon Institute and North Carolina Sea Grant *554360* SDMS Doc ID 554360. semspub.epa.gov/work/01/554360.pdf.

OCP Group. “What Is Phosphate and How Is It Used? | OCP Group.” Www.ocpgroup.ma, www.ocpgroup.ma/what-is-phosphate#:~:text=Phosphate%20rock%20is%20processed%20to.

Oklahoma State. “Using Vegetation for Erosion Control on Construction Sites - Oklahoma State University.” Extension.okstate.edu, Feb. 2017, extension.okstate.edu/fact-sheets/using-vegetation-for-erosion-control-on-construction-sites.html.

Parr, Dana, et al. “Hydrological Changes in the U.S. Northeast Using the Connecticut River Basin as a Case Study: Part 2. Projections of the Future.” Global and Planetary Change, vol. 133, Oct. 2015, pp. 167–75, https://doi.org/10.1016/j.gloplacha.2015.08.011.

Pennsylvania Department of Environmental Protection. Pennsylvania Stormwater Best Management Practices Manual. 2006, www.stormwaterpa.org/assets/media/BMP_manual/chapter_6/Chapter_6-7-4.pdf. Accessed 7 Aug. 2024.

Phalan, B., et al. “Reconciling Food Production and Biodiversity Conservation: Land Sharing and Land Sparing Compared.” Science, vol. 333, no. 6047, Sept. 2011, pp. 1289–91, https://doi.org/10.1126/science.1208742.

Poff, N. Leroy, and David D. Hart. “How Dams Vary and Why It Matters for the Emerging Science of Dam Removal.” BioScience, vol. 52, no. 8, 2002, p. 659, https://doi.org/10.1641/0006-3568(2002)052[0659:hdvawi]2.0.co;2.

Quinn, Dan, et al. “Benefits and Challenges of Cover Crop Use.” Purdue University - College of Agriculture, 29 Jan. 2019, ag.purdue.edu/news/department/agry/kernel-news/2019/01/benefits-challenges-cover-crop-use.html.

Richter, Brian D., and Gregory A. Thomas. “Restoring Environmental Flows by Modifying Dam Operations.” Ecology and Society, vol. 12, no. 1, 2007, https://doi.org/10.5751/es-02014-120112.
Rooker, Sarah. “Industry and Commerce in the Connecticut River Valley - Flow of History.” Flow of History, 8 Jan. 2014, www.flowofhistory.org/industry-commerce/. Accessed 6 Aug. 2024.

Royal Society of Chemistry. “Phosphorus - Element Information, Properties and Uses | Periodic Table.” Rsc.org, Royal Society of Chemistry, 2011, www.rsc.org/periodic-table/element/15/phosphorus.

Schilt, Carl R. “Developing Fish Passage and Protection at Hydropower Dams.” Applied Animal Behaviour Science, vol. 104, no. 3-4, May 2007, pp. 295–325, https://doi.org/10.1016/j.applanim.2006.09.004.

THOMPSON, DOUGLAS M. “Long-Term Effect of Instream Habitat-Improvement Structures on Channel Morphology along the Blackledge and Salmon Rivers, Connecticut, USA.” Environmental Management, vol. 29, no. 2, 1 Feb. 2002, pp. 250–265, doi:10.1007/s00267-001-0069-0.

U.S. Department of Agriculture. “Cover Crops and Crop Rotation.” Www.usda.gov, www.usda.gov/peoples-garden/soil-health/cover-crops-crop-rotation.
U.S. Environmental Protection Agency. Managing Urban Runoff. Feb. 2003, www3.epa.gov/npdes/pubs/nps_urban-facts_final.pdf.

UC IPM. “What Is Integrated Pest Management (IPM)? / UC Statewide IPM Program (UC IPM).” Ucanr.edu, 2015, ipm.ucanr.edu/what-is-ipm/#gsc.tab=0.

US Department of Agriculture. “Riparian Forest Buffers.” Www.fs.usda.gov, www.fs.usda.gov/nac/practices/riparian-forest-buffers.php#:~:text=Riparian%20forest%20buffers%20can%20deliver.

US EPA. “Basic Information about Nonpoint Source (NPS) Pollution | US EPA.” US EPA, 22 Dec. 2022, www.epa.gov/nps/basic-information-about-nonpoint-source-nps-pollution.

“Framework for Developing Suspended and Bedded Sediment (Sabs) Water Quality Criteria | Risk Assessment Portal | US EPA.” Epa.gov, June 2006, cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=164423#:~:text=Suspended%20and%20bedded%20sediments%20(SABS)%20are%20defined%20by%20EPA%20as. Accessed 7 Aug. 2024.

“Sediments | US EPA.” US EPA, 4 Nov. 2015, www.epa.gov/caddis/sediments#tab-3. Accessed 7 Aug. 2024.

US EPA OW. “Basic Information about Lead in Drinking Water | US EPA.” US EPA, 2 Feb. 2016, www.epa.gov/ground-water-and-drinking-water/basic-information-about-lead-drinking-water#health.
US EPA, ORD. “Definition and Characteristics of Low Flows.” Www.epa.gov, 17 Oct. 2018, www.epa.gov/hydrowq/definition-and-characteristics-low-flows#:~:text=However%2C%20during%20a%20low%20flow.

US EPA, OW. “Indicators Used in the National Aquatic Resource Surveys.” US EPA, 3 Sept. 2013, www.epa.gov/national-aquatic-resource-surveys/indicators-used-national-aquatic-resource-surveys.

“Nonpoint Source: Agriculture.” Www.epa.gov, 7 July 2015, www.epa.gov/nps/nonpoint-source-agriculture#:~:text=Farmers%20can%20leave%20the%20soil.

US Fish & Wildlife Service. “Chesapeake WILD | U.S. Fish & Wildlife Service.” FWS.gov, 2020, www.fws.gov/program/chesapeake-wild. Accessed 6 Aug. 2024.

“Delaware River Basin Restoration | U.S. Fish & Wildlife Service.” FWS.gov, 8 July 2024, www.fws.gov/program/delaware-river-basin-restoration. Accessed 6 Aug. 2024.

Delaware River Basin Restoration Program. www.fws.gov/sites/default/files/documents/Delaware-River-Basin-Restoration-Program-Framework_508_2022.pdf.

US Reaproject. “New England vs. United States | Population Trends over 1958-2022.” United States Regional Economic Analysis Project, 2023, united-states.reaproject.org/analysis/comparative-trends-analysis/population/tools/10072001/0/.

USGS. “Dissolved Oxygen and Water | U.S. Geological Survey.” Www.usgs.gov, 5 June 2018, www.usgs.gov/special-topics/water-science-school/science/dissolved-oxygen-and-water#overview.

Vara, Saritha, and Sravani Pericherla. “Agricultural Activities and Their Environmental Impact on Surface Waters: A Review.” Tuijin Jishu, vol. 44, no. 2, Science and Engineering Research Support Society, July 2023, https://doi.org/10.52783/tjjpt.v44.i2.216. Accessed 16 July 2024.

Water Research Center. “Surface Water: The Importance of the Water Temperature.” Www.knowyourh2o.com, 2020, www.knowyourh2o.com/outdoor-4/stream-water-quality-importance-of-temperature.

Wato, Tamirat. “The Agricultural Water Pollution and Its Minimization Strategies – a Review.” Journal of Resources Development and Management, Apr. 2020, https://doi.org/10.7176/jrdm/64-02.

The Value of the Connecticut River, legislature.vermont.gov/Documents/2018/WorkGroups/House Natural/Value of the Connecticut River Report/W~Ronald Shaiko~The Value of the Connecticut River Report~4-21-2017.pdf. Accessed 07 Aug. 2024.

Wheeler, Timothy B. “Stream Restoration Techniques Draw Pushback.” Bay Journal, 7 Oct. 2020, www.bayjournal.com/news/pollution/stream-restoration-techniques-draw-pushback/article_ffc96960-0895-11eb-b36f-efa466158524.html.

Yarn, Robert D., et al. “Dealing with Change in the Connecticut River Valley - Lincoln Institute of Land Policy.” Lincoln Institute of Land Policy, 30 May 2024, www.lincolninst.edu/publications/books/dealing-change-connecticut-river-valley/. Accessed 7 Aug. 2024.

Holahan, David. “The Battle for Fenwick’s Shoreline.” Estuary, www.estuarymagazine.com/2021/09/the-battle-for-fenwicks-shoreline/. Accessed 7 Aug. 2024.

**H.R. 5216: Connecticut River Watershed Partnership Act**
Summer Workshop MPA-ESP Program
2024