Final Fish and Wildlife Coordination Act Report
Upper Susquehanna Comprehensive
Flood Damage Reduction Study

Prepared For:
U.S. Army Corps of Engineers

Prepared By:
Department of the Interior
U.S. Fish and Wildlife Service
New York Field Office
Cortland, New York

Preparers: Anne Secord & Andy Lowell
New York Field Office Supervisor: David Stilwell

February 2019

EXECUTIVE SUMMARY

Flooding in the Upper Susquehanna watershed of New York State frequently causes damage to infrastructure that has been built within flood-prone areas. This report identifies a suite of watershed activities, such as urban development, wetland elimination, stream alterations, and certain agricultural practices that have contributed to flooding of developed areas. Structural flood control measures, such as dams, levees, and floodwalls have been constructed, but are insufficient to address all floodwater-human conflicts. The U.S. Army Corps of Engineers (USACE) is evaluating a number of new structural and non-structural measures to reduce flood damages in the watershed. The New York State Department of Environmental Conservation (NYSDEC) is the "local sponsor" for this study and provides half of the study funding. New structural flood control measures that USACE is evaluating for the watershed largely consist of new levees/floodwalls, rebuilding levees/floodwalls, snagging and clearing of woody material from rivers and removing riverine shoals. Non-structural measures being evaluated include elevating structures, acquisition of structures and property, relocating at-risk structures, developing land use plans and flood proofing. Some of the proposed structural measures, if implemented as proposed, have the potential to adversely impact riparian habitat, wetlands, and riverine aquatic habitat.

In addition to the alternatives currently being considered by the USACE, the U.S. Fish and Wildlife Service proposes environmentally beneficial "watershed restoration" flood control measures. These watershed restoration measures include reconnecting streams to floodplains, wetland restoration, creation of detention basins, planting winter cover crops, reforestation, and environmentally sensitive roadside ditch management. These measures are designed to intercept precipitation closer to where it falls, encourage water infiltration into soils, and slow downstream flows. Although these types of projects are not traditionally considered by the USACE and may fall outside of the USACE Flood Risk Management mission and project authorization, they are consistent with the USACE and NYSDEC environmental principles that support sustainable use, stewardship and restoration of natural resources. We recommend these measures be evaluated as part of the study in order to identify opportunities for watershed-based flood reduction to be considered by the USACE and other stakeholders. The Upper Susquehanna Conservation Alliance membership, including the NYSDEC, Nature Conservancy, Otsego Land Trust, some local municipalities and members of the general public have also expressed support for watershed-based flood reduction measures as described in this report. The U.S. Fish and Wildlife Service has identified four pilot watersheds in the Upper Susquehanna watershed, Wharton Creek, Upper Chenango River, Charlotte Creek and West Branch Tioughnioga, that are characterized by low slopes, a high percentage of agriculture and hydric soils. We recommend these watersheds as candidates for these types of watershed restoration flood control measures.

In addition to recommending the evaluation of watershed restoration flood control measures, we recommend that design alternatives minimize levee footprints and clearly identify the flood benefits of clearing, snagging, and shoal removal. We also recommend that the cost/benefit analysis provide costs of the proposed non-structural options (e.g., buyouts and flood elevation) and determine the economic value of environmental and human use recreational features affected by any structural flood control project.

This report discusses watershed restoration flood mitigation methods that both reduce flood flows and are **environmentally restorative.** They are designed to restore and protect habitat and water quality, while also providing flood water reduction in some flood prone areas. It is understood that these measures alone may not resolve issues related to flooding of human infrastructure, but we recommend that they be fully evaluated along with more traditional flood reduction measures, such as levees and floodwalls, and that their benefits be factored into cost/benefit ratios for various flood control alternatives.

Contents

A. Introduction

The Upper Susquehanna watershed has experienced a large number of flood events over the last hundred years that have damaged property and infrastructure. Floods in Binghamton, Hornell, and other upstate New York communities spurred the development of the Flood Control Acts of 1936 and 1938 that empowered the U.S. Army Corps of Engineers (USACE) and other agencies to undertake structural flood control projects, including in the study area (Arnold 1986). These structural flood control projects have included measures such as floodwalls and levees along the Susquehanna and Chenango Rivers at Binghamton, Endicott, Vestal, and Johnson City, federal or state flood control dams, such as Whitney Point, Genegantslet, and East Sidney Reservoir and a series of PL 566 flood control dams[1] (Figures 1, 2 and 5; Table 1).

Figure 1. Floodwall along Susquehanna River at Binghamton (Google Earth)

Figure 2. East Sidney Flood USACE Control Dam, Ouleout Creek. Photo by Anne Secord

[1] PL 566 flood control dams were installed by the Natural Resource Conservation Service in the latter half of the 20 century under Public Law 566.

Table 1. Existing USACE Flood Risk Management Projects in Upper Susquehanna Watershed, New York		
Project	County	Type
Bainbridge	Chenango	Channel improvement
Binghamton	Broome	Levee/floodwall
Binghamton	Broome	Snagging/clearing
Cincinnatus	Cortland	Snagging/clearing
Conklin-Kirkwood	Broome	Channel improvement
Cortland	Cortland	Channel improvement
East Sidney Lake	Delaware	Reservoir
Endicott, Johnson City, Vestal	Broome	Levee/floodwall
Greene	Chenango	Channel improvement/levee
Lisle	Broome	Levee/floodwall/channel improvement
Nichols	Tioga	Levee/floodwall/channel improvement
Norwich	Chenango	Channel improvement
Oneonta	Otsego	Snagging/clearing
Owego	Tioga	Snagging/clearing/channel improvement
Oxford	Chenango	Levee/floodwall/channel improvement
Port Dickinson	Broome	Snagging/clearing
Sherburne	Chenango	Snagging/clearing
Unadilla	Otsego	Channel improvement
Whitney Point Village	Broome	Levee/floodwall/channel improvement
Whitney Point Lake	Broome	Reservoir

Although structural measures such as levees and floodwalls have provided significant protection to infrastructure from some damaging floods, they have not been adequate to provide comprehensive protection during major rainfall events such as in 1993, 2006, and 2011 (Figures 3 and 4).

Figure 3. Flooding in Owego, NY 2011. Photo courtesy of AccuWeather

Figure 4. Washington Street Bridge, Binghamton 2006. Photo from National Weather Service

This report, in addition to providing comments on new structural flood management measures evaluated by the USACE for the study area, serves to offer restoration-based measures within the watershed that may be used to further mitigate flood damage by keeping precipitation closer to where it falls, encouraging water infiltration into soils, storing water, and slowing downstream flows. This type of watershed approach to flooding, in which land management to encourage water infiltration is a critical component of flood management, is being promoted broadly across Europe (Environment Agency 2017; SEPA 2015; UNECE 2000) and the United States (NYRCR 2014; Ahilan et al. 2016; Interagency Floodplain Management Review Committee 1994 {IFMRC} 1994).

> "By controlling runoff, managing ecosystems for all of their benefits, planning the use of the land and identifying those areas at risk, many hazards can be avoided."
> Galloway Report (IFMRC 1994)

B. PROJECT PURPOSE, SCOPE, AUTHORITY, AND STUDY AREA

The USACE is comprehensively evaluating flood reduction management (FRM) needs and opportunities in the Upper Susquehanna River Basin in New York, in partnership with the New York State Department of Environmental Conservation (NYSDEC). Study efforts are being coordinated with the Federal Emergency Management Agency (FEMA) and other federal and state agencies and local governments.

The Susquehanna River Basin is the second largest river basin – next to the Ohio River Basin – east of the Mississippi River and the largest on the Atlantic seaboard. The 444-mile Susquehanna River drains 27,500 square miles covering portions of New York, Pennsylvania and Maryland before emptying into the Chesapeake Bay. The Upper Susquehanna River Basin begins at Canadarago and Otsego Lakes near Cooperstown, New York, and flows southward and westward where it meets the Chemung River in Sayre, Pennsylvania, near Waverly, New York. The FRM study area includes only the Upper Susquehanna River Basin within New York State (4,520 square miles of land area) and excludes the Chemung River Basin. The study area includes most of Broome, Chenango, Cortland, Otsego, and Tioga Counties, portions of northern Delaware, southern Madison, and eastern Chemung Counties, and small parts of Schuyler, Tompkins, Onondaga, Oneida, Herkimer, and Schoharie Counties (Figure 5).

The USACE is preparing a feasibility report and Environmental Impact Statement (EIS) for the study. A Notice of Intent to Prepare an EIS for the study was published in the Federal Register on November 4, 2016. The notice provided a preliminary overview of anticipated study scope and outcome. In November 2016, the USACE and NYSDEC held public/agency scoping meetings for the study, followed by a March 2018 stakeholder meeting, at which input from public officials was solicited. An initial conceptual effort is being completed using existing information to identify locations in the study area that currently do not have FRM infrastructure in place. These locations are being screened for structural and non-structural flood risk reduction opportunities. The study will then evaluate the level of FRM currently provided by existing FRM infrastructure (i.e., levees and floodwalls) under current conditions and projected future conditions.

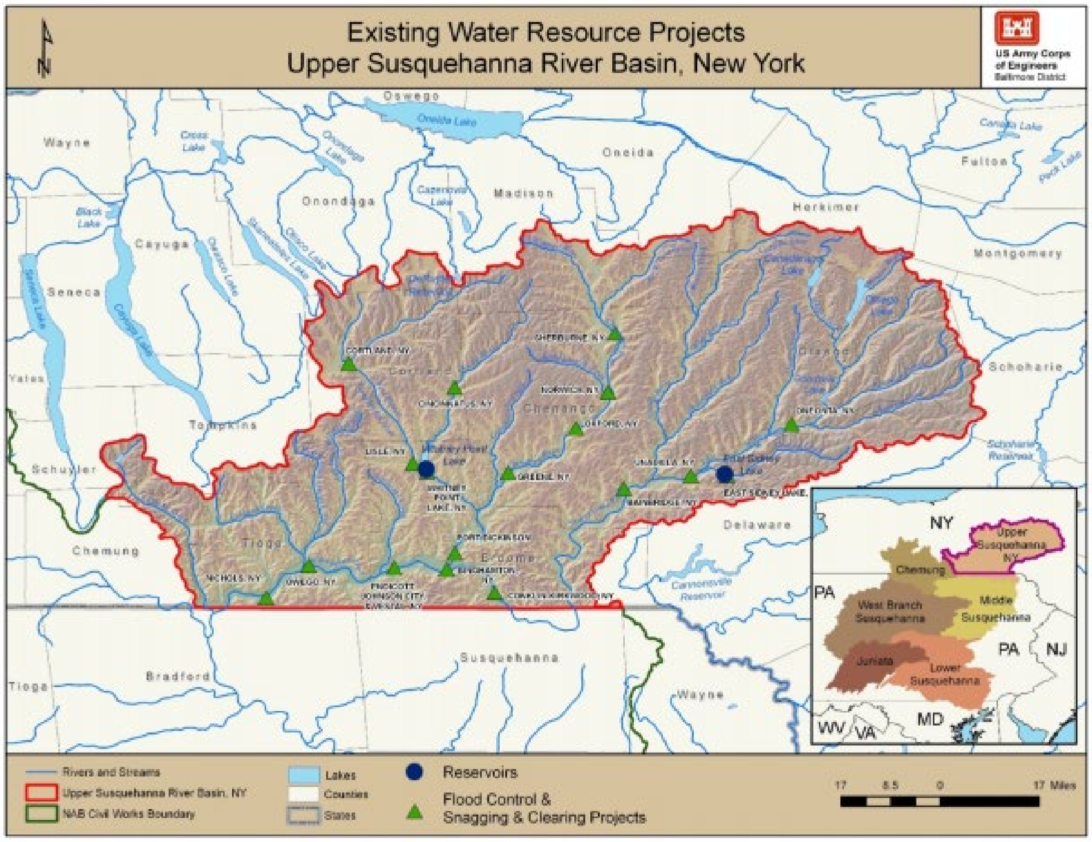


Figure 5. Existing FRM Projects within Upper Susquehanna River Basin

Within the study area, there are 20 existing USACE FRM projects (Table 1, Figure 5), as well as other non-federal FRM projects. The study will investigate FRM strategies to reduce flood and residual risk in densely populated areas within the study area, including structural and nonstructural FRM. The USACE is currently evaluating FRM measures in six "Flood Risk Candidate Areas", in which structural work is proposed and an additional six "Flood Risk Focus Areas", in which no structural work is proposed. These 12 Flood Risk Areas will be described in Section D of this report. Hydrologic and hydraulic modeling will be developed for the majority of the Susquehanna River main stem and major tributaries in the basin to aid plan formulation. It is anticipated that the study will take three years to complete and lead to the future implementation of one or more FRM projects by the USACE and recommendations for future actions (including non-structural measures) to be addressed by other agencies and entities.

It is anticipated that any recommended USACE construction would be in densely populated areas. It is not anticipated that any new dams would be recommended for FRM purposes because preliminary economic analyses have demonstrated inadequate benefits while environmental and social impacts pose substantial concerns. According to the USACE, although minimal effects on U.S. Fish and Wildlife Service (USFWS) trust resources are anticipated from any proposed USACE FRM projects, impacts to wetlands in the floodplains and structure encroachment into waterways may occur.

C. FISH AND WILDLIFE RESOURCES AND RECREATIONAL USES IN THE STUDY AREA

Flooding is a natural process and floodplains are a part of a functioning river system. River and stream flooding transfers water, energy, nutrients and sediment to floodplains. The nutrients and sediment contribute to fertile habitat for wildlife in floodplains and sometimes spawning or nursery habitat for fish such as northern pike. Floodplains serve to recharge aquifers and restore water back to the river during drier times of the year.

1. FISHERIES

The Susquehanna River supports fish species such as walleye (*Sander vitreus*), smallmouth bass (*Micropterus dolomieu*), northern pike (*Esox lucius*), muskellunge (*E. masquinongy*), channel catfish (*Ictalurus punctatus*), rock bass (*Ambloplites rupestris*), crappie (*Pomoxis spp*.), yellow perch (*Perca flavescens*), suckers (*Catostomus spp*.), sunfish (*Lepomis spp*.), and darters. The Susquehanna River and tributaries also support the catadromous American eel (*Anguilla rostrata*). This species has suffered severe declines due to the cumulative impacts of habitat loss, dam construction, turbine mortality, and over-fishing. Multiple dams in Pennsylvania, Maryland and New York block the passage of eels into their historic range (MacGregor et al. 2009). The Susquehanna River in New York used to support American shad (*Alosa sapidissima*) prior to impacts from human activities, primarily dam building. It is the goal of natural resource management agencies to restore the American shad, American eel, and other migratory species to their historic ranges within the Susquehanna watershed (SRAFRC 2010).

2. FRESHWATER MUSSELS

There are about a dozen species of unionid mussels in the Upper Susquehanna watershed (Strayer and Fetterman 1999). Species commonly found include eastern elliptio (*Elliptio complanata*), triangle floater (*Alismadonta undulata*), elktoe (*A. marginata*), creeper (*Strophitus undulatus*), and yellow lampmussel (*Lampsilis cariosa*). Mussels in many parts of the country (including the Susquehanna River watershed) are declining due to a host of factors, such as impaired water quality (e.g., sediment, dissolved oxygen, un-ionized ammonia), lost habitat connectivity, lack of fish hosts, sediment instability, mining, and oil extraction (Richter et al. 1997; Strayer and Fetterman 1999; Strayer and Malcolm 2012).

There is habitat in the Susquehanna watershed for the brook floater (*Alismidonta varicosa*), a New York State listed threatened mussel species. The brook floater has experienced significant declines (including in the Upper Susquehanna watershed) due to altered river flows, loss and fragmentation of habitat, siltation and sedimentation from dams and surface run-off, water pollution, and invasive non-native mussels (http://www.acris.nynhp.org/guide.php?id=8378&part=1).

3. AMPHIBIANS

A number of river/stream amphibians and reptiles may occur in the Upper Susquehanna watershed study area. These include New York State Species of Greatest Conservation Need (SGCN) such as the longtail salamander (*Eurycea longicauda*), eastern ribbonsnake (*Thamnophis sauritus*), wood turtle (*Glyptemys insculpta*), and the eastern hellbender (*Cryptobranchus a. alleganiensis*). According to the 2003 "Eastern Hellbender Status Assessment" (Mayasich et al. 2003), hellbenders are found in habitats with swift running, fairly shallow, highly oxygenated water. Hellbenders have experienced declines due to destruction and modification of habitat, influenced by factors such as siltation, chemical pollution, thermal pollution, stream channelization, impoundment, agricultural runoff, and mining activities. In the study area, impacts may include the reduction of forest cover and changes to stream physical and chemical parameters (Pugh et al. 2015).

4. BIRDS

The Susquehanna River supports wintering waterfowl such as American coots (*Fulica americana*), common and hooded mergansers (*Mergus merganser, Lophodytes cucullatus*), American black ducks (*Anas rubripes*), and Canada geese (*Branta canadensis*). A variety of passerines (e.g., belted kingfisher –*Megaceryle alcyon*, willow flycatcher - *Empidonax traillii*), wading birds (e.g., great blue heron –*Ardea herodias*, green heron – *Butorides virescens*), and raptors (e.g., osprey – *Pandion haliaetus*) breed in the riparian zones of the Susquehanna River and forage in or over the river. A number of SGCN riparian bird species may occur in the Flood Risk Candidate Areas. These include the Cooper's hawk (*Accipiter cooperii*), red-shouldered hawk (*Buteo lineatus*), common nighthawk (*Chordeiles minor*), American woodcock (*Scolopax minor*), willow flycatcher, wood thrush (*Hylocichla mustelina*), blue-winged warbler (*Vermivora cyanoptera*), golden-winged warbler (*V. chrysoptera*), prairie warbler (*Setophaga discolor*), and black-billed cuckoo (*Coccyzus erythropthalmus*) (https://www.dec.ny.gov/docs/wildlife_pdf/susquehannatxt.pdf).

Bald eagles (*Haliaeetus leucocephalus)* may nest, forage, or over-winter in the study area. Under the Bald and Golden Eagle Protection Act (BGEPA; 16 U.S.C. 668 et seq.), take of bald eagles is prohibited unless otherwise permitted by the USFWS. The BGEPA defines take to include "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb." If bald eagles are determined to occur in the vicinity of a USACE FRM project proposed for implementation, we recommend that the USACE visit the USFWS New York Field Office's project review page and determine if a permit is required under BGEPA [website: https://www.fws.gov/northeast/nyfo/es/step6.htm].

In addition, the USFWS 2007 National Bald Eagle Management Guidelines can be found at: https://www.fws.gov/northeast/ecologicalservices/eaglenationalguide.html. The guidelines provide recommendations for avoiding disturbance at nest sites, including activity-specific guidelines (i.e., development). The guidelines recommend that no activities be conducted with 330 feet of the nest site; however activities can be conducted between 330 feet and 660 feet of a nest outside the breeding season (January-August). We also recommend that you contact the

New York State Natural Heritage Program and the regional NYSDEC office for more information on eagle activity/nests, as bald eagles are listed as threatened by the state.

5. Threatened and Endangered Species

The federally listed as threatened northern long-eared bat (*Myotis septentrionalis*) occurs in the Upper Susquehanna watershed. This species spends the winter hibernating in caves and mines. During the summer, these bats roost singly or in colonies underneath bark, in cavities or in crevices of both live and dead trees. Northern long-eared bats may be adversely affected by the proposed activities, especially if tree removal is proposed during the summer months while bats are foraging and roosting and the females are forming maternity colonies and raising their pups. Tree removal during the winter while bats are hibernating (October 31 – March 31) would minimize adverse impacts to bats.

6. Water-Based Recreation

The Susquehanna River in New York is an important recreational river, with over 100 boat launches and river access sites that provide access for boaters and anglers http://www.chemungriverfriends.org/launches_srw.php). Flood control efforts may conflict with other uses if they impede access to rivers and streams, modify hydrology or impact fish and wildlife habitat. Boat launches within or adjacent to the proposed Flood Risk Candidate Areas include:

Flood Risk Candidate Area	**Boat Launches/Fishing Access Sites**
Binghamton	Washington St. Bridge, River Plaza, Port Dickinson Community Park, Sandy Beach Park
Conklin	Schnerbush Park, Sullivan Park, Kirkwood Veterans River Park
Endicott-Johnson-Vestal	Grippen Park, Harold Moore Park
Oneonta	West Oneonta DEC # 145 just downstream of study area
Owego	Hickories Park
Unadilla	Unadilla DEC #148

D. Proposed Flood Reduction Management Infrastructure

The USACE is considering six "Flood Risk Candidate Areas" for flood reduction measures:

1. **Binghamton**
2. **Conklin**
3. **Endicott/Johnson City/Vestal**
4. **Oneonta**
5. **Owego**
6. **Unadilla**

Other USACE “Flood Risk Focus Areas” include: **Bainbridge, Chenango Bridge, Cortland, Greene, Norwich, Sidney, and Waverly**.
Projects under consideration for the various Flood Risk Candidate Areas include:

- Constructing new levees and floodwalls
- Raising or extending berms/levees/floodwalls
- Clearing, snagging, and shoal removal
- Dredging of the Susquehanna River
- Constructing pumping stations
- Installing ice jam structures
- Nonstructural measures, including elevating structures, acquisition of structures and property, relocating at-risk structures and flood-proofing

1. General Impacts of Proposed USACE Flood Reduction Projects on Fish and Wildlife Resources

Certain aspects of the six Candidate Flood Risk projects will have impacts on fish and wildlife resources. The impacts of levees and floodwalls, snagging, clearing, shoal removal and dredging are discussed below, with more specific impacts discussed after the Flood Risk Candidate Area project descriptions.

a. Levees and Floodwalls

Levees and floodwalls are intended to restrict water to the river channel and as such, they disconnect the river from its floodplain. This can reduce nutrient and sediment transport to the floodplain, cut off wetlands from riverine inputs of water and nutrients, and reduce the recharge of aquifers. Levee and floodwall construction removes shoreline vegetation, thereby eliminating fish and wildlife habitat and riverine shading (Franklin et al. 2009; Makhdoom 2013). Levees tend to have a larger footprint than floodwalls and may, therefore, contribute to greater habitat loss than a vertical floodwall structure. Although levees may be more aesthetically pleasing than floodwalls, they provide little habitat value since vegetation is generally maintained as a mowed grass cover. The construction of the levee may remove habitat, including riparian shoreline, tributaries, swales and wetlands.

The habitat likely to be impacted by levees and floodwalls is riparian corridor habitat that is important for a number of nesting and migrating birds, such as warblers, flycatchers, woodpeckers, and raptors. Riparian habitat also provides shade that maintains cooler stream temperatures for fish and other aquatic species and the river banks provide water access and habitat for terrestrial species of wildlife such as deer (*Odocoileus virginianus*), fox (*Vulpes vulpes; Urocyon cinereoargenteus*), mink (*Neovison vison*), fisher (*Martes pennanti*) and river otter (*Lontra canadensis*). The loss of habitat caused by levee and floodwall construction may also adversely affect the threatened northern long-eared bat.

While levees and floodwalls may provide flood protection to adjacent lands and structures, these structures may contribute to flooding and erosion in areas upstream and downstream of levee/floodwall construction. As the river is forced into a narrow channel by the levee/floodwall, it backs up, raising water levels upstream. Water is subject to less friction as it flows through a leveed section vs. a section with a sloped and vegetated bank, gaining velocity and contributing to flooding and erosion downstream. Consequently, upstream and downstream flooding exacerbated by levees or floodwalls may result in the call for additional levee and floodwall construction upstream or downstream. Levees may trap water on the landward side, which can cause flooding behind the levee without the maintenance and adequate capacity of pumping stations. Levees also may encourage additional floodplain development, potentially exacerbating damages from future flooding events. Levees may also be overtopped during storms exceeding design protection levels, often with disastrous consequences, as with the levee failures during hurricane Katrina.

b. Minimizing Levee Impacts

An option to minimize the adverse impacts of levees on the riparian corridor is to consider vegetative options other than mowed grass. Prior to 2005, the USACE policy for vegetation on levees was generally supportive of vegetation and allowed for regional considerations, so long as the structural integrity and functionality of the levee system was retained. In April 2009, the USACE vegetation-free policy was formally adopted. The USACE issued the Engineering Technical Letter (ETL) 1110-2-571[2], establishing a uniform nationwide vegetation policy that applied to all levees under direct USACE control (Figure 6 - left). This policy established vegetation-free and root-free zones for levees throughout the entire country. The USACE ETL 1110-2-571 maintains that vegetation on levees can harm the structural integrity of levees, obscure visibility, impede access for maintenance and inspection and hinder emergency flood fighting operations. The minimum acceptable vegetation-free zone is defined as including the levee itself plus a corridor fifteen feet in width on either side of the levee. The vegetation-free zone applies to all vegetation except for grass (Tuel 2017). In accordance with ETL 1110-2-571, if the levee structure is not compromised, the local sponsor may request a variance from the standard vegetation guidelines to enhance environmental values or meet state or federal laws or regulations.

This relatively new levee vegetation policy has been researched and debated by levee maintenance officials and natural resource agencies (Shields 2016, Tuel 2017). For example, the USACE ETL 1110-2-571 indicates that trees and other woody vegetation can create structural and seepage instabilities. However, Shields (2016) pointed out that it can be difficult to determine the role of vegetation in levee stability or failure in the event of a breach because physical evidence is often washed away or altered during the high-water event. Section 3013 of the 2014 Water Resources Reform and Development Act required the USACE to carry out a comprehensive review of their vegetation management guidelines for levees, taking into consideration the benefits of woody vegetation and protection, preservation, and enhancement of natural resources. The USACE has determined that until the review and update of the vegetation guidelines is complete, USACE will take the following interim actions to comply with Section 3013 (g)(1), namely that "… the Secretary shall not require the removal of existing vegetation as a condition or requirement for any approval or funding of a project, or any action, unless the specific vegetation has been demonstrated to present an unacceptable safety risk."

[2] https://www.publications.usace.army.mil/Portals/76/Publications/EngineerTechnicalLetters/ETL_1110-2-583.pdf

((http://cdm16021.contentdm.oclc.org/utils/getfile/collection/p16021coll5/id/1213).
Tuel (2017) maintains that although there are certain areas where more research on levee vegetation is needed, research to date has not shown a causal link between levee vegetation and substantial increased risk to levee integrity.

Some communities have been exploring vegetation management on levees that differs from the USACE "mowed grass" policy pursuant to ETL 1110-2-571. Pierce County in Washington State has developed a levee vegetation management strategy that balances the needs of flood risk reduction with the habitat needs of aquatic and riparian species (PCPW 2016). The Pierce County strategy operates under a system-wide improvement framework (called a SWIF) that is essentially a variance under the auspices of the USACE ETL (Figure 6 - right).

California has developed a strategy that newly constructed levees must meet the guidelines of the ETL (vegetation-free zones) on the entirety of the levee, but for existing levees, woody vegetation on the lower waterside slope is generally retained and additional woody vegetation is allowed to grow. For this portion of the levee, woody vegetation is only removed when it poses an unacceptable threat to levee integrity (Cowin and Bardini 2012; Tuel 2017).

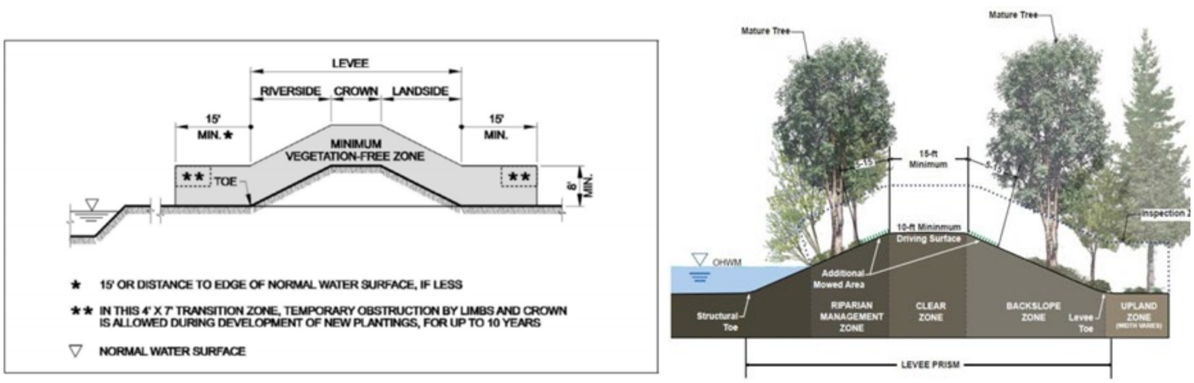


Figure 6. Vegetation Free Zone Proposed by USACE in ETL 1110-2-581 (left) and Conceptual Levee Design, Pierce County, WA (PCPW 2016) (right)

We recommend that the USACE evaluate the literature on the effects of vegetation management on levee function, including any review that occurs as part of the Water Resources Reform and Development Act of 2014, and use that information to consider more environmentally beneficial alternatives for vegetation management on levees.

c. Clearing and Snagging

Clearing and snagging of woody material from rivers and streams would have negative direct and indirect effects on fish and wildlife resources. Downed trees and other woody material in streams and rivers provide habitat for fish and other aquatic organisms and also serve to dissipate energy and capture and retain sediment (Saldi-Caromile et al. 2004; Lassettre and Kondolf 2012). Clearing of trees from river banks may cause destabilization and erosion of sediments into the waterway, which may impair water quality. Removal of woody material from rivers and streams removes foraging, reproductive, and sheltering habitat for fish and other aquatic resources, including the eastern hellbender.

Although large woody material in streams may increase roughness and collect at bridges, thereby contributing to local upstream flooding of structures, the influence of woody material on infrastructure flooding is not always significant and the wood removal may be a short term solution (Young 1991; Lassettre and Kondolf 2012). In Australia, a flume study of the hydraulic effects of large woody material found that the levels of woody material commonly occurring in the lowland rivers of southeastern Australia seldom cause any significant effect on flood levels (Young 1991). Any flood reduction benefits predicted from the removal of woody material from rivers and streams should be weighed against the impacts to aquatic habitat.

d. Dredging

Dredging of rivers is conducted to reduce flood risk by increasing channel capacity. The effectiveness of dredging, however, may be temporary in that subsequent flood flows often transport a large amount of sediment that can fill the dredged channel, eliminating any increased channel capacity and adversely impacting aquatic habitat. Dredging may need to be more routinely conducted to achieve the desired channel capacity, thereby repeatedly degrading water quality, causing biological disturbance along the bed and banks of the river (alteration of fish and benthic habitat; disturbance of riparian communities that support birds, amphibians, and reptiles), and increasing costs (https://www.sepa.org.uk/media/151049/wat-sg-26.pdf). Turbidity caused by dredging may adversely impact fish species, amphibians like the eastern hellbender, and freshwater mussels, including the brook floater, which could be smothered by sediment or crushed during dredging. Dredging may also contribute to channel instability and increase flooding downstream. The USACE has determined that dredging is currently highly unlikely for all Flood Risk Areas. If dredging ultimately becomes a proposed flood control option, we recommend that it be adequately justified as part of a sustainable flood reduction strategy, with consideration for environmental consequences and the impacts to river stability.

e. Shoal Removal

River shoals (shallow, gravelly, or rocky reaches) can cause increased roughness and a reduction in channel capacity, both of which are considered as contributing to flooding of structures. Shoals develop in rivers as a result of sediment supply exceeding the transport capacity of the river. If a new shoal or gravel bar forms, it may be due to an increase in sediment washed into the stream or a local reduction in the stream's energy and its ability to transport sediment. Shoal removal, like dredging, is a temporary way to increase channel capacity. Shoal removal may impact river stability and contribute to erosion (SEPA 2012).

Shoals provide unique riverine habitat, often supporting a different fish assemblage than is found in deeper water (Marcinek et al. 2003). Underwater shoals provide spawning habitat for species such as walleye, suckers, and darters (Lane et al. 1996). Exposed shoals provide loafing and feeding habitat for bird species such as geese, gulls, and herons. Shoals are also important habitat for freshwater mussels, providing a stable substrate and variety of flow conditions (Sherer 2011; Garner and McGregor 2001). For example, 60% of the mussel fauna of the Big Sunflower River in Mississippi was located on two shoals within the river, prompting a change in river dredging to avoid shoal habitat (Miller and Payne 2004). Shoal removal may contribute to turbidity and impaired water quality, and impact fish species, amphibians like the eastern hellbender, and freshwater mussels, including the brook floater.

2. Specific Impacts of Proposed USACE Flood Reduction Projects on Fish and Wildlife Resources

a. Binghamton Flood Risk Area

Major Features:

- Raising all levees and floodwalls deemed feasible (~ 4-5 miles)
- New levee along unprotected area near Dickinson (~ 9,000 feet) - more detailed analyses required
- Clearing, snagging, and shoal removal (65 acres) deemed maybe feasible
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible

Raising levees may have some environmental impacts if the base of the levee would need to be widened, potentially impacting riparian habitat and wetlands within the footprint. Raising levees and floodwalls also increases flood peak flow, which can exacerbate flooding upstream and downstream. The USACE guidance requires induced flooding impacts be examined and mitigated when economically feasible. Replacing existing floodwalls and levees would create temporary disturbance, but long-term impacts would be no greater than those caused by the original levee or floodwall. Clearing, snagging, and shoal removal of 65 acres of the Chenango River would negatively impact fish and wildlife resources, as described above.

The proposed new levee segment between the Dickinson North Boundary and Dickinson Town Court appears to be approximately 9,000 feet long and extends along the western bank of the Chenango River along Otsiningo Park. If the levee footprint is 130 feet wide[3], approximately 27 acres of riparian habitat would be impacted by levee construction. Otsiningo Park is a mixture of riparian woods, grassy playing fields, and biking/pedestrian paths. The riparian habitat would be significantly affected and the levee may serve to disconnect the river from recreational users at Otsiningo Park.

b. Conklin Flood Risk Area

Major Features:

- New levee system being analyzed (4 sections ~ 7 miles in length)
- Clearing, snagging, and shoal removal along Susquehanna River (7 miles) deemed feasible

---

[3] Assumes a levee height of 20 feet with a top width of 10 feet and a 3:1 side slope, yielding an approximate levee footprint of 130 feet

- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible

The Conklin FRM project will have significant impacts on fish and wildlife resources. The levee project examined at Conklin extends along approximately 6 – 7 miles of the western shore of the Susquehanna River and would be expected to significantly affect this stretch of riverine habitat by eliminating all riparian habitat along one bank of the Susquehanna River. Assuming a levee footprint (width) of 130 feet and a levee length of 7 miles, levee construction would impact 110 acres of riparian habitat.

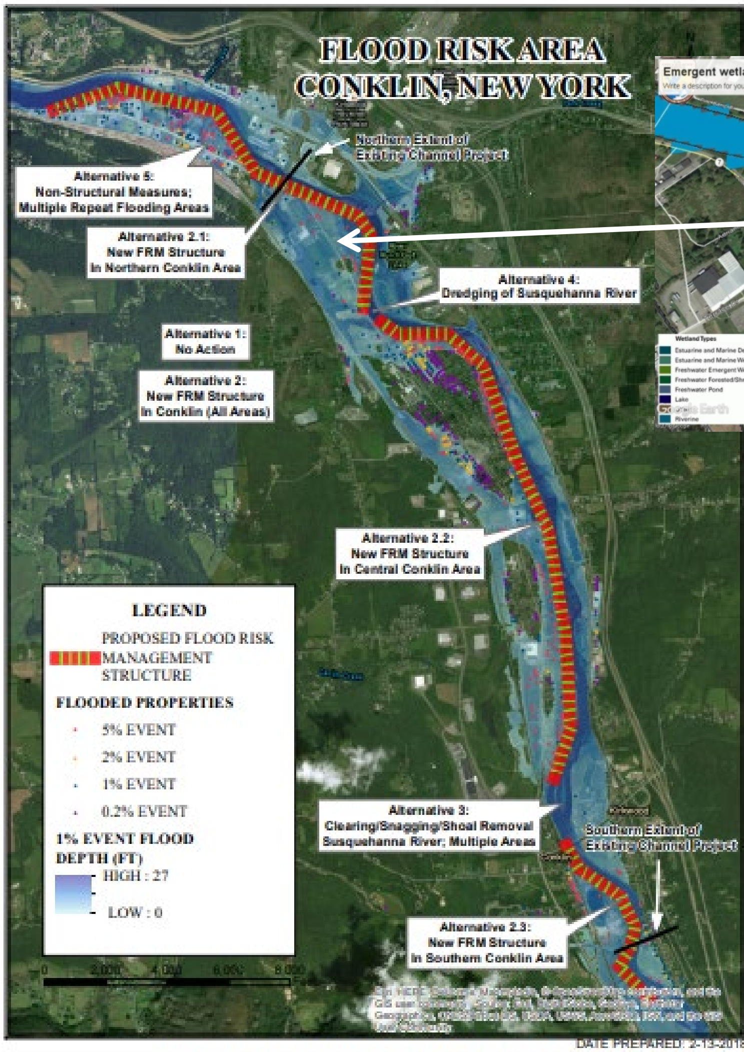
The Breeding Bird Atlas for New York State documents breeding activity of a number of SGCN in the block associated with the Conklin flood risk area. These species include the Cooper's hawk, red-shouldered hawk, common nighthawk, American woodcock, willow flycatcher, wood thrush, blue-winged warbler, golden-winged warbler, prairie warbler, and black-billed cuckoo. The proposed levee may eliminate habitat for a number of these species, if present – notably the willow flycatcher, Cooper's hawk, and black-billed cuckoo.

There are a few emergent wetlands along this reach of the Susquehanna River that may be adversely affected by the proposed levee under Alternative 2.1 (See Figure 7). Either the wetlands would fall within the footprint of the levee or their hydrology may be impacted by the levee.

Clearing, snagging, shoal removal, and dredging of approximately 7 miles of the Susquehanna River would have negative direct and indirect effects on fish and wildlife resources, as described above.

The USACE project proposal acknowledges the potential for impacts to downstream flooding, as well as flooding in Kirkwood, located on the opposite bank of the Susquehanna River, a consequence that may result in the call for additional levee construction.

We have recently been advised that further evaluation of measures for Conklin has been discontinued because local officials did not express interest in them to NYSDEC and USACE following the March, 2018 stakeholder meeting.



DATE PREPARED: 2-13-2018
*LEVEE SYSTEM IN KIRKWOOD WOULD HAVE TO BE BUILT IN CONJUNCTION WITH CONKLIN.

Figure 7. Conklin Flood Risk Area

c. Endicott/Johnson City/Vestal Flood Risk Area

Major Features:

- Raising existing levee system feasible
- Replacing or relocating existing floodwalls/levees feasible
- Clearing, snagging, and shoal removal in Susquehanna River (66 acres) maybe feasible
- Levee modifications in Nanticoke Creek
- Clearing, snagging, shoal removal, and levee modification in Little Choconut Creek (3.8 acres) feasible
- Pump stations at various locations feasible
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible

Raising levees may have some environmental impacts if the base of the levee would need to be widened, potentially impacting riparian habitat within the footprint. Raising levees and floodwalls also increases flood peak flow, which can exacerbate flooding upstream and downstream. Replacing existing floodwalls and levees would create temporary disturbance, but long-term impacts would be no greater than those caused by the original levee or floodwall. Clearing, snagging, and shoal removal of ~ 66 acres of the Susquehanna River would negatively impact fish and wildlife resources, as described above. There are a few emergent wetlands along this reach of the Susquehanna River that may be adversely affected by the proposed levee modifications if the levee footprint is increased (Figure 8).

The more significant impacts to fish and wildlife may result from the proposed clearing, snagging, shoal removal, and levee modifications under consideration in Little Choconut Creek and levee raising in Nanticoke Creek. There are emergent and forested wetlands along Nanticoke Creek in the vicinity of the proposed levee modifications that could be impacted by filling or altered hydrology (Figure 8). Little Choconut Creek supports annually stocked rainbow trout (*Oncorhynchus mykiss*), largemouth bass (*Micropterus salmoides*), and brown bullhead (*Ameirus nebulosus*). A NYSDEC regulated forested wetland exists at the mouth of Little Choconut Creek (Figure 8). Clearing, snagging, and shoal removal may adversely impact these wetland and fishery resources.

We note that there are a number of river blockages downstream of Binghamton that may affect water flow. These include the Rock Bottom dam and Willow Point dam, and two utility crossings (Figure 9). We recommend that the USACE evaluate the impact of these barriers on river flows.

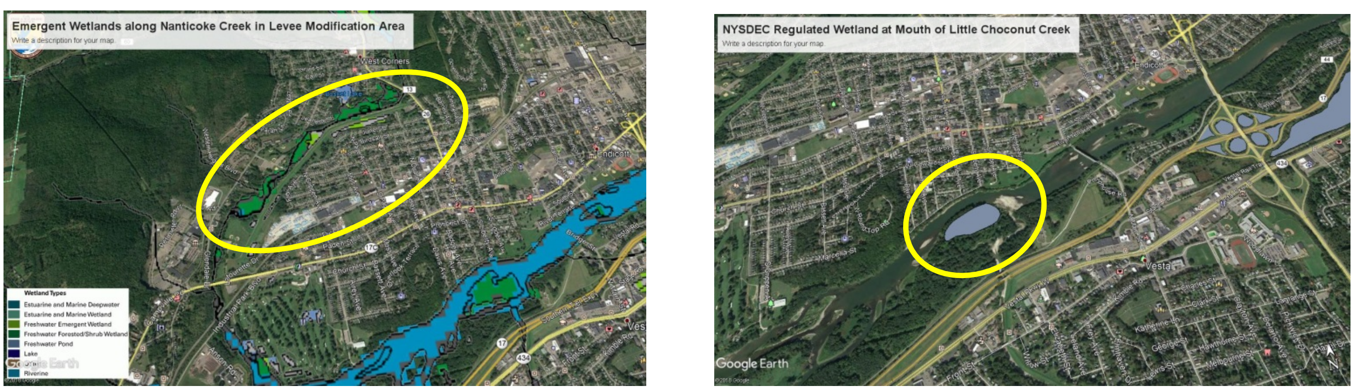


Figure 8. EJV Flood Risk Area -Wetlands Nanticoke Creek (left) & Choconut Creek (right)

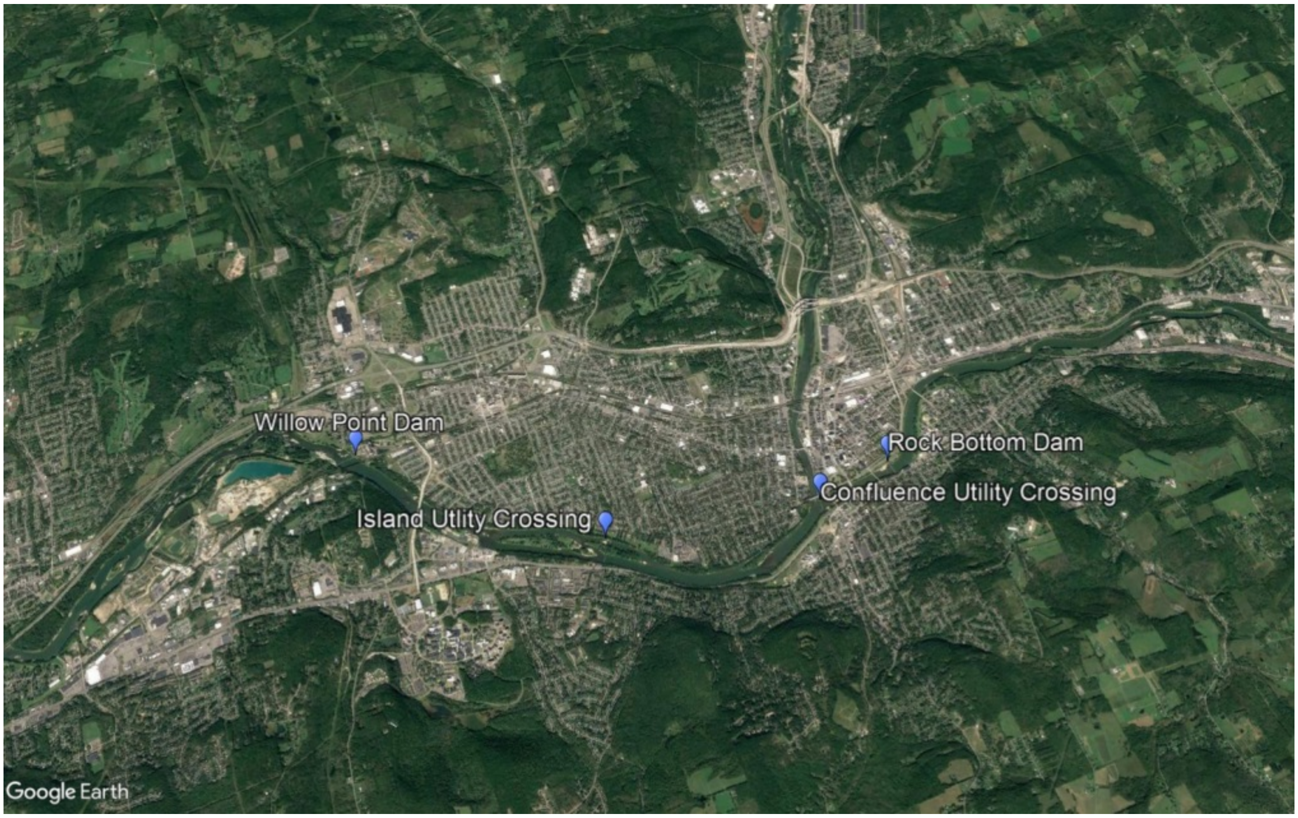


Figure 9. Barriers on Susquehanna River downstream of Binghamton

d. Oneonta Flood Risk Area

Major Features:

- Levee modification feasible
- Pump station feasible
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible

Raising the levee may have some environmental impacts if the base of the levee would need to be widened, potentially impacting habitat within the footprint. There appears to be limited space to expand the levee at the proposed location, with development existing to the west and a side channel of the Susquehanna River to the east of the existing levee. Raising levees and floodwalls also increases flood peak flow, which can exacerbate flooding upstream and downstream. No wetlands are likely to be impacted by the proposed levee or pump station. There may be an opportunity with this project to enhance river capacity and facilitate fish passage by restoring the channel that connects the Susquehanna River near the proposed levee modification to the river upstream of the Southside dam.

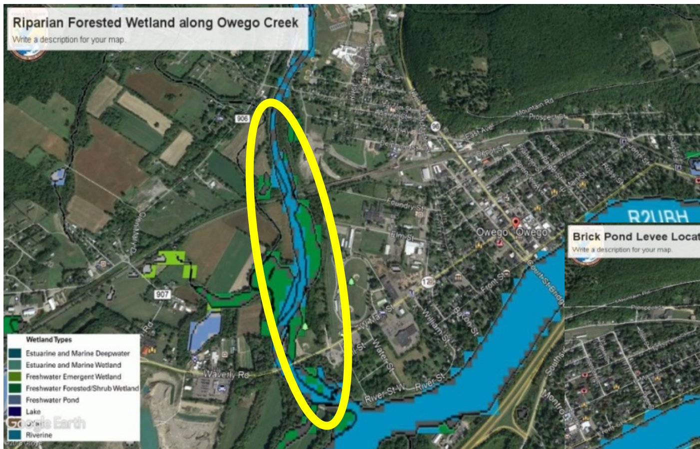
e. Owego Flood Risk Area

Major Features:

- Modification of existing berm along Owego Creek feasible
- Construction of new levee system along Downtown Owego and Brick Pond Park feasible (includes 2,600 feet of floodwall and 10,000 feet of levee)
- Clearing, snagging, shoal removal in Susquehanna River and Owego Creek (70 acres) with potential but likely not feasible
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible

Modification of the existing berm along Owego Creek may impact habitat if the width of the berm/levee is increased. Habitat in the potential footprint includes riparian forested wetland (Figure 10). The construction of a 10,000 foot long levee would eliminate about 30 acres of riparian habitat (assuming a levee width of 130 feet). There would likely be some tree removal for levee/floodwall construction along the Owego waterfront and potential impacts to forested wetland associated with levee construction at Brick Pond Park. Clearing, snagging, and shoal removal of approximately 70 acres of the Susquehanna River and Owego Creek would negatively impact fish and wildlife resources, as described above. According to the USACE, Owego Creek, near its mouth, has an existing channel project where regular maintenance shoal removal and clearing takes place.

Within the Upper Susquehanna watershed, Owego Creek is the only watershed designated by the Eastern Brook Trout Joint Venture as a "watershed best for protection." Owego Creek received Trout Unlimited's highest Conservation Success Index score for brook trout conservation. These designations indicate that not only does the Owego Creek watershed remain intact enough to support viable wild brook trout populations, but also that brook trout populations persisting here are relatively robust. The status of Owego Creek as a stronghold for wild brook trout production in the Southern Tier is confirmed by the regional state fisheries biologists (FLLT 2012).
The brook trout has recently been found to serve as a host for the brook floater mussel. The importance of Owego Creek is further supported by designation of its headwater streams as Ecoregional priority aquatic systems by The Nature Conservancy (http://www.landscope.org/new-york/priorities/). The proposed berm modification, clearing, snagging, and shoal removal in and along Owego Creek may adversely impact brook trout in Owego Creek.



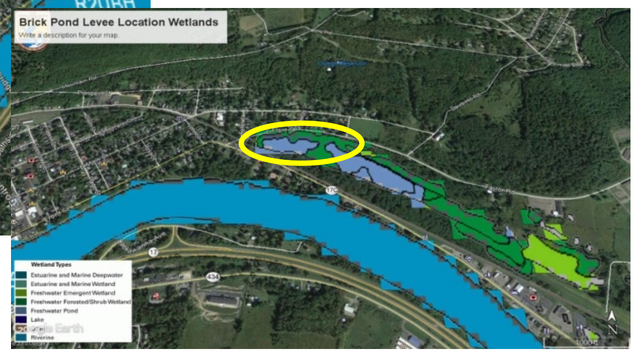


Figure 10. Owego Flood Risk Area - Wetlands

f. Unadilla Flood Risk Area

Major Features:

- New levee system feasible
- Clearing, snagging, and shoal removal Susquehanna River upstream and riverfront Unadilla feasible
- Pump station feasible
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible

Forested shoreline riparian habitat would be eliminated by the proposed levee system. One mile of levee with a footprint of 130 feet would eliminate 16 acres of riparian habitat. Clearing, snagging, and shoal removal would have impacts to fish and wildlife, as described above.

The downstream Village of Sidney is proposing to use home buy-outs, elevating or moving structures, and environmentally restorative methods to reduce flood risk. They are discussing interdependent needs for flood hazard mitigation with Bainbridge, Afton, and Unadilla (https://stormrecovery.ny.gov/sites/default/files/crp/community/documents/sidney nyrcr_plan.pdf).
It is, therefore, important that the USACE communicate with adjacent communities regarding any work proposed in Unadilla.

g. Other Flood Risk Focus Areas

For all of the following Flood Risk Focus Areas, flood control measures such as levees, clearing, snagging, and shoal removal were considered by the USACE. For all areas, according to draft project alternatives submitted to us by the USACE in February, 2018, these measures were considered to have no potential for federal interest or were deemed not feasible by the USACE. There are no significant environmental issues associated with these proposals, as presented by the USACE.

Bainbridge

- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.

Chenango

- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.

Cortland

- Debris removal in Dry and Otter Creek was considered but not examined in detail because it extended beyond the hydraulic modeling scope of the study.
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.

Greene

- A pump station was deemed feasible and more detailed analysis required.
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.

Norwich

- A pump station was deemed feasible and more detailed analysis required.
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.
- An ice jam structure along Canasawacta Creek needed more detailed analysis and may be referred to the Continuing Authorities Program 205 Cold Regions Program.

Sidney

- A pump station was deemed feasible and more detailed analysis required.
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.

Waverly

- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.

E. WATERSHED FACTORS CONTRIBUTING TO INCREASED FLOODING

Flooding is a natural phenomenon that is important for the regeneration of natural habitats; however, it can create significant problems for human infrastructure (e.g., buildings, highways, bridges, and culverts), depending on severity, timing, duration, and location of flood waters. The Binghamton area has a history of flooding-human conflicts due to the historical pattern of development in low-lying areas at the confluence of two major rivers – the Susquehanna and Chenango. Other communities along the Upper Susquehanna River have also been developed within the flood-prone area, increasing the potential for flooding damage to structures, roads and other infrastructure. Flooding impacts have been exacerbated by watershed land use practices that change the landscape (e.g., development including urbanization, energy delivery, and agriculture), all of which can alter hydrology by increasing the amount of water entering our rivers. Climate change is influencing the frequency and intensity of precipitation events, causing an increase in the frequency, intensity and duration of flood events. Flood amelioration is best achieved with a multi-faceted approach that includes (1) not developing new infrastructure in flood-prone areas, (2) removing existing infrastructure in flood-prone areas, (3) implementing engineered alternatives like levees as barriers between the river and infrastructure, (4) flood-proofing or elevating structures and (5) utilizing a watershed restoration approach to better manage rainfall, runoff and stream flow. This last approach precludes or minimizes negative human-flooding interactions by keeping rain and snow as close to where it falls as possible, increasing the ability of soils to absorb and retain water, increasing the cross-sectional area of floodplains, and slowing the downstream flow of water (Dadson et al. 2017; Hey and Philippi 1995). Activities that reduce water infiltration, evaporative loss, and habitat roughness, and increase overland flow and downstream flow of water may contribute to downstream flooding (Table 2). The following section focuses on a watershed approach to minimize flooding impacts to human infrastructure.

Table 2. Watershed Activities that May Contribute to Flooding Conflicts							
Activity	Reduces infiltration	Reduces roughness	Reduces evaporative loss	Increases overland flow	Increases downstream volume of water	Reduces biodiversity	Impairs water quality
Timber harvest	✓	✓	✓	✓		✓	✓
Vegetation removal	✓	✓	✓	✓		✓	✓
Hedgerow removal	✓	✓	✓	✓		✓	
Narrow or no riparian corridors	✓	✓	✓	✓	✓	✓	
Urbanization – impermeable surfaces	✓			✓		✓	✓
Waterway channelization		✓			✓	✓	✓
Removal of in-water woody material & vegetation		✓			✓	✓	
Wetland draining or ditching	✓	✓	✓	✓		✓	✓
Soil compaction or loss	✓			✓			✓
Some agricultural tillage				✓			✓
Some roadside ditch management		✓			✓	✓	✓
Inappropriately designed or sized culverts					✓	✓	

1. VEGETATION REMOVAL

Vegetation removal in the watershed (e.g., tree harvesting, hedgerow removal, removal of riparian vegetation) may exacerbate flooding via a number of mechanisms. Trees and other plants serve to intercept rain, thereby reducing the amount of water reaching the ground surface. Trees also increase evaporative loss (Hynicka et al. 2017). Vegetation (either on land or in streams/rivers) increases roughness in the watershed, slowing water down and allowing it more time to infiltrate into the ground (Dadson et al 2017; SEPA 2015). Vegetation contributes to soil and slope stability; its removal increases sedimentation and transport of pollutants (Dadson et al. 2017; SEPA 2015). Hynicka et al. (2017) calculated that compared to turf grass, medium and large broadleaf deciduous trees planted in the northeastern United States reduce runoff by approximately 68%.

2. Urbanization

Urbanization in the watershed creates impermeable surfaces (e.g., buildings, roads, parking lots), thereby reducing infiltration of rain into the ground and increasing overland flow of water to low-lying areas (Dadson et al. 2017). Urban stormwater may contain contaminants such as polycyclic aromatic hydrocarbons, metals, and salt, thereby contributing to impaired water quality in receiving streams and rivers.

3. Stream Channelization and Wetland Drainage

Channelization of waterways, including removing woody material, decreases hydraulic resistance and increases downstream velocity, potentially reducing flooding of infrastructure in the channelized reach, but increasing infrastructure flooding downstream (SEPA 2015). Waterway channelization also creates slope instability, thereby increasing sedimentation and decreasing water quality in the channelized and down-gradient streams or rivers (Dadson et al. 2017; SEPA 2015). Ditching and draining of wetlands decreases water infiltration and increases water flow to low-lying areas (SEPA 2015).

4. Agricultural Practices

Agricultural practices, such as the use of heavy machinery and livestock, may compact soils and reduce infiltration of rain water. Tillage may impair soil structure, contributing to a loss of organic matter that may inhibit rainwater absorption into soils (Hey and Philippi 1995; SEPA 2015).

Tillage or crop harvesting during the rainy season or leaving fields without cover crops in winter may contribute to increased overland flows and soil erosion and decreased water quality and biodiversity in down-gradient waterways (Dadson et al. 2017; SEPA 2015).

5. Roadside Ditch Management

Roadside ditch management may contribute to down-gradient flooding. Removal of vegetation in ditches reduces hydraulic resistance, speeding water to receiving streams. By reducing residence time within the ditch, infiltration of rain is reduced. Soil instability within excavated ditches may increase erosion of sediments (that may contain a variety of highway, residential, and agricultural pollutants), contributing to siltation and reduced water quality in receiving waters. Roadside ditches may contribute to increased peak stream heights (Schneider and Boomer 2016).

6. Climate Change

Climate change is contributing to increased frequency and intensity of precipitation events (Mallakpour and Villarini 2015; Ning et al. 2015; Thibeault and Seth 2014). The U.S. Environmental Protection Agency (USEPA) concluded, based on an evaluation of river flooding in the United States over the past 50 years, that floods have become larger in rivers and streams across large parts of the Northeast and Midwest and large floods have become more frequent across the Northeast, Pacific Northwest, and northern Great Plains (https://www.epa.gov/climate-indicators/climate-change-indicators-river-flooding). Climate models predict an increase in the magnitude of the estimated 100-year flood in the Northeastern United States (Arnell and Gosling 2014).

F. Watershed Restoration Measures to Improve Flood Resiliency

1. General Measures

This section of the report discusses watershed restoration methods that both reduce flood flows and are **environmentally restorative.** They are designed to restore and protect habitat and water quality, while also providing flood water reduction in some flood prone areas. It is understood that these measures alone may not resolve issues related to flooding of human infrastructure, but we recommend that they be fully evaluated along with more traditional flood reduction measures, such as levees and floodwalls, and that their benefits be factored into cost/benefit ratios for various flood control alternatives.

Table 2. Watershed Restoration Flood Reduction Measures *	
Measure	Benefits
Re-forestation Plant trees in urban areas	Canopy intercepts water Greater evaporative loss than grassland Increases roughness Improves habitat
Retain or plant in field buffer strips and hedges	Slows overland runoff Increases infiltration Increases roughness Improves habitat
Use measures such as permeable paving, stormwater retention and storage basins, rain gardens, bioswales, green roofs, filter strips, infiltration basins	Increases water absorption & retention Improves water quality
Restore natural stream channel morphology; reconnect stream to floodplain; online flow storage in lakes and backwaters on course of river; offline flow storage in wetlands	Creates stable streams Reduces sedimentation Improves water quality Improves habitat & biodiversity Slows down water & increases infiltration
Retain or restore riparian buffer strips	Capture pollutants Provide shade – habitat Increases infiltration Increases roughness
Improve soil structure: make more porous, minimize compaction, replenish organic content, plant deeply rooted species	Increases water infiltration Reduces erosion
Plant cover crops	Reduces soil loss Increases organic matter Increases roughness

Avoid unnecessary dredging of water courses	Improves water quality Reduces sedimentation Maintains stable streams Maintains biodiversity
Block or break wetland drainage Protect wetlands	Reduces flow peaks Increases infiltration & water storage
Create woody material and engineered log jams for hydraulic resistance	Increases roughness Increases habitat and biodiversity
Avoid bare fields during rainy season; alternate deep rooted and shallow rooted plants; use no till and low till methods; plant cover crops	Decreases erosion and sedimentation Improves soil structure and fertility Increases roughness
Stream bank fencing of livestock	Reduces erosion, sedimentation, & nutrient input Reduces compaction near water course
Use agricultural practices such as terracing, contour plowing, buffer strips, CRP, EQIP, WRP, appropriate livestock densities	Reduces erosion and sedimentation Improves soil structure and fertility Reduces soil compaction Increases roughness
Enhance roadside ditch design and maintenance	Reduces erosion and sedimentation Improves water quality (nutrients, pollutants) in receiving waters Increases infiltration Reduces stream peak heights Improves habitat
Appropriately size, install, and maintain culverts	Maintains aquatic connectivity Maintains stable stream flow
Create off channel storage (riparian wetlands; side channels)	Increases water storage and infiltration Attenuates flood peaks
Dispersed upland stormwater retention & detention	Increases water storage and infiltration Attenuates flood peaks
* Information sources: Dadson et al. 2017; Environment Agency 2017; Schneider & Boomer 2016; SEPA 2015; STAC 2014; Hey & Philippi 1995; https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/0/5949/files/2016/08/RoadsideDitches-fact-sheet-pdf-2j1nacx.pdf	

2. Application of Watershed Restoration Flood Mitigation Measures

a. Cover Crops

The planting of cover crops increases organic matter and water infiltration and reduces runoff and soil loss. Archuleta (2014) indicated that for every 1% increase in soil organic matter, an additional 17,000 to 25,000 gallons of water per acre infiltrates into the soil. In a hypothetical example modelled for the Upper Cedar River in Iowa, planting winter cover crops on all agricultural areas increased water infiltration by 0.2 to 0.3 inches for four design storms (10, 25, 50, 100 year events). For a storm of 5.89 inches of rain in 24 hours (50 year event), the cover crop scenario predicted peak discharge reductions of 7-10% (IFC 2014).

b. Reconnection of Streams to Floodplains

The East Lents Reach project is an example of how reconnection of a stream to its floodplain can reduce downstream flooding. Johnson Creek is a tributary to the Willamette River near Portland, Oregon. It is a largely urban stream that is known for frequent flooding and that contains sections that do not meet water quality standards under the Clean Water Act (Ahilan et al. 2016). In 2011 and 2012, floodplain restoration (floodplain reconnection, riparian restoration, and wetland restoration) was carried out on approximately 64 acres at the East Lents Reach along Johnson Creek. A hydro-morphodynamic model using simulation scenarios of 10, 50, 100, and 500 year flood events found that the restored floodplain reduces the downstream flood peak by up to 25%. Results also show that approximately 20% - 30% of sediment from upstream is deposited in the East Lents floodplain. Sediment retention at the East Lents floodplain is predicted to reduce the annual sediment loading of Johnson Creek to the Willamette River by 1%. The East Lents floodplain restoration provides flood storage, improves fish and wildlife habitat, affords recreational opportunities, and provides flood resilience downstream (Ahilan et al. 2016). Other stream restoration techniques, such as restoring stream morphology (e.g., recreating natural stream meander patterns), will also achieve flood control benefits by slowing water down.

c. Wetlands, Bioswales, Detention Basins

Habitat features such as wetlands, bioswales, and detention basins all serve to mitigate flooding by storing and slowing floodwater so that it moves downstream more slowly. Smith et al. (2015) modelled a system of detention basins in the 14 km^2 urban Dead Run watershed in Maryland. The entire modelled detention basin network in Dead Run decreased peak discharges by a median of 11% for the flood events included in the study. Watson et al. (2016) estimated the economic value of floodplains and wetlands to the Town of Middlebury, Vermont. They determined that wetlands and floodplains along Otter Creek reduced flood-related damages associated with 10 storm events[4] by 54 - 78%.

d. Improve Soil Structure

A study in the Upper Cedar Creek watershed in Iowa evaluated the benefits to soil structure that can be achieved by converting row crops to native tall grass prairie feet (IFC 2014). Prairie grass species are deeply rooted and associated with deep, loosely packed soils. Modelling conducted for the Upper Cedar Creek watershed in Iowa predicted that changes from an agricultural to native tall grass prairie landscape would increase water infiltration by 0.8 inches for a 10 year event and 1.8 inches for a 100 year event, thereby reducing runoff. Peak discharges at the seven modelled index locations were reduced by 18-25%; flood stages were reduced by up to 2.5 inches. These authors did caveat that while the restored tall grass prairie landscape would significantly reduce flood severity and frequency, there may be substantial flooding with extreme rainfall events (such as in 2008) because of saturated initial conditions and persistent rainfall.

e. Re-forestation

The Center for Watershed Protection in Maryland evaluated the effectiveness of urban tree planting for reducing runoff, nutrients, and sediment and developed a tool to estimate stormwater reduction "credits" for tree planting (CWP 2017). Using this tool, the planting of 1,000 broad-leaved deciduous trees in the Syracuse, New York, area would achieve a runoff reduction of

[4] 10 storm events included Tropical Storm Irene and nine historic flooding events

29,000 cubic feet from a 0.9 inch rainfall event (https://owl.cwp.org/mdocs-posts/stormwater-performance-based-credit-calculator/).

We recommend that the USACE conceptually evaluate the watershed restoration measures discussed in this section of the report as part of a comprehensive flood regulation strategy.

3. Example of a Comprehensive Watershed Restoration Flood Control Project

Sidney, New York

> *"Sidney accepts that flooding is inevitable, but devastation is not. This plan works with nature, giving the river and streams space to spread out into areas where people, infrastructure, and community investments are not in danger and giving residents new choices"*
> NY Rising Community Reconstruction Plan for Sidney, March 2014

The New York Rising Community Reconstruction (NYRCR) program was developed in 2013 by New York State to provide rebuilding and resiliency assistance to communities severely damaged by hurricanes Irene, Lee, and Sandy. Delaware County, in conjunction with the Villages of Sidney and Sidney Center, is proposing a flood management program under NYRCR called "Sidney GreenPlain" that would include the elevation or acquisition and demolition of 136 structures in flood hazard areas, in conjunction with environmentally restorative non-structural flood control measures. Areas in which structures are removed would be graded, seeded, and maintained as open space. Approximately 140 acres of floodplain would be turned into a wetland, stream, and pond complex for flood storage and water quality improvement. The GreenPlain area is predicted to provide an additional 22.8 million cubic feet of flood storage, which would reduce or slow downstream flows. The estimated cost for full implementation is approximately $22 million (NYRCR 2014).

The GreenPlain proposal was developed in response to severe floods in 2006 and 2011, as an alternative to a 2006 USACE flood control proposal for Sidney that included construction of a levee/floodwall system, flap gates on Weir Creek, river dredging, pumping stations, and acquisition of about 20 properties (Corps 2010). Although the USACE proposal was predicted to eliminate flooding during a 100 year storm event for much of the Village of Sidney, it was considered expensive to construct ($35 - $50 million), with high operating and maintenance costs, and adverse environmental impacts due to tree removal and wetland impacts. It also would have contributed to a slight increase in flooding in Unadilla Township (FEMA & GOSR 2016).

The GreenPlain is predicted to reduce flooding in downstream areas[5], restore water quality, increase health and wellness, attract visitors, and expand jobs at half the cost of the 2006 USACE flood control proposal (NYRCR 2014).

---

[5] The GreenPlain project would provide an additional 22.8 million cubic feet of flood storage and would be expected to reduce flooding downstream

G. PILOT WATERSHEDS FOR APPLICATION OF WATERSHED RESTORATION FLOOD CONTROL MEASURES

The USFWS has identified four pilot watersheds in the Upper Susquehanna Watershed in which we recommend consideration of the watershed restoration-based flood mitigation measures discussed above. The identification of these pilot watersheds is the first step at developing watershed restoration flood mitigation measures for the Susquehanna watershed. We recommend that, as part of this study, the USACE conceptually evaluate these pilot watersheds as areas in which a suite of landscape actions may be considered and implemented as part of a comprehensive flood regulation strategy. As suggested by the USACE, investigation of the pilot watersheds could potentially be explored further by USACE through the Chesapeake Bay Comprehensive Plan currently being developed and by other stakeholders. https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/initiatives/?cid=stelprdb1047323

These pilot watersheds were selected using the following criteria:

- **Target areas upstream of flood-prone areas, as shown in Figure 11.**

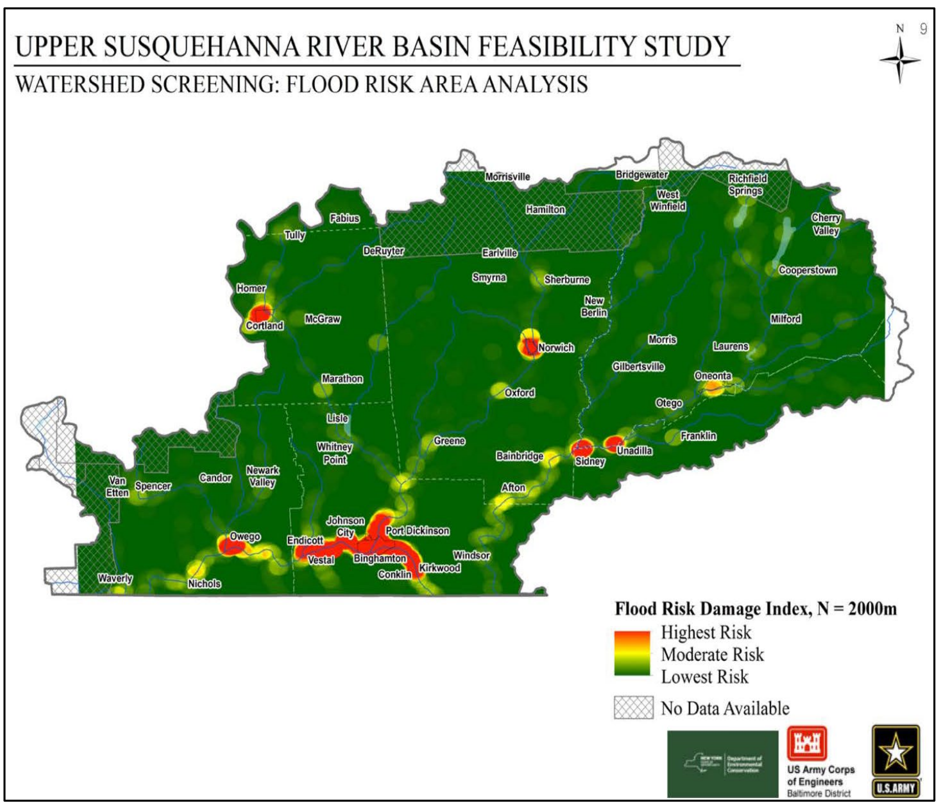


Figure 11. USACE Flood Risk Map

➢ **Identify locations in the Upper Susquehanna watershed with environmentally sensitive species – brook trout, eastern hellbender, and brook floater (Figure 12).**

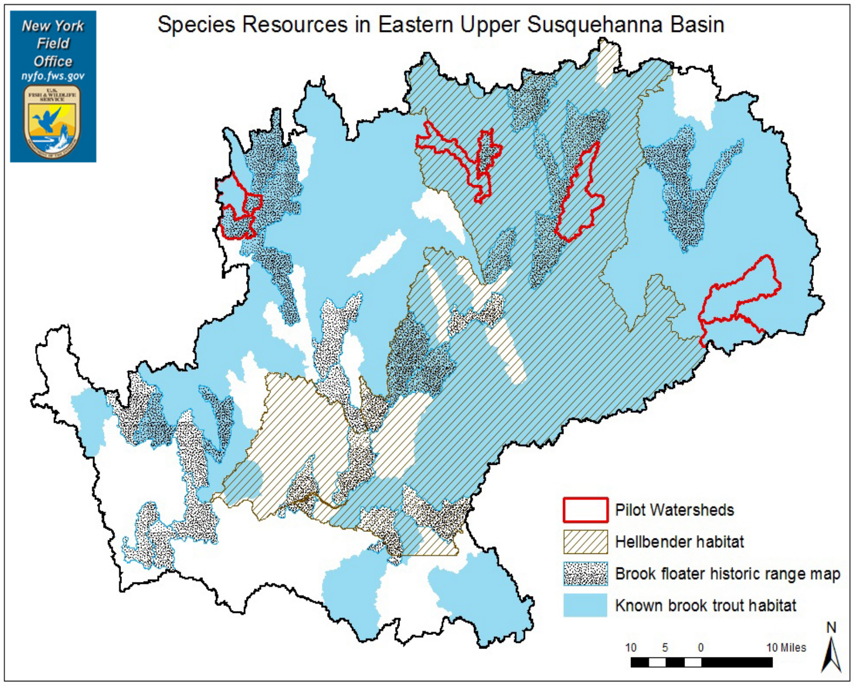


Figure 12. Environmentally Sensitive Resources

➢ **Identify low slope watersheds with high levels of agriculture and/or hydric soils in riparian areas. The assumption is that these areas may afford opportunities for restorative measures such as reconnecting streams to floodplains, wetland restoration, and reforestation (Figure 13, 14).**

The pilot watersheds illustrated in red in Figure 13 and at a greater resolution in Figure 14 are:

- Wharton Creek
- Upper Chenango River
- Charlotte Creek
- West Branch Tioughnioga River

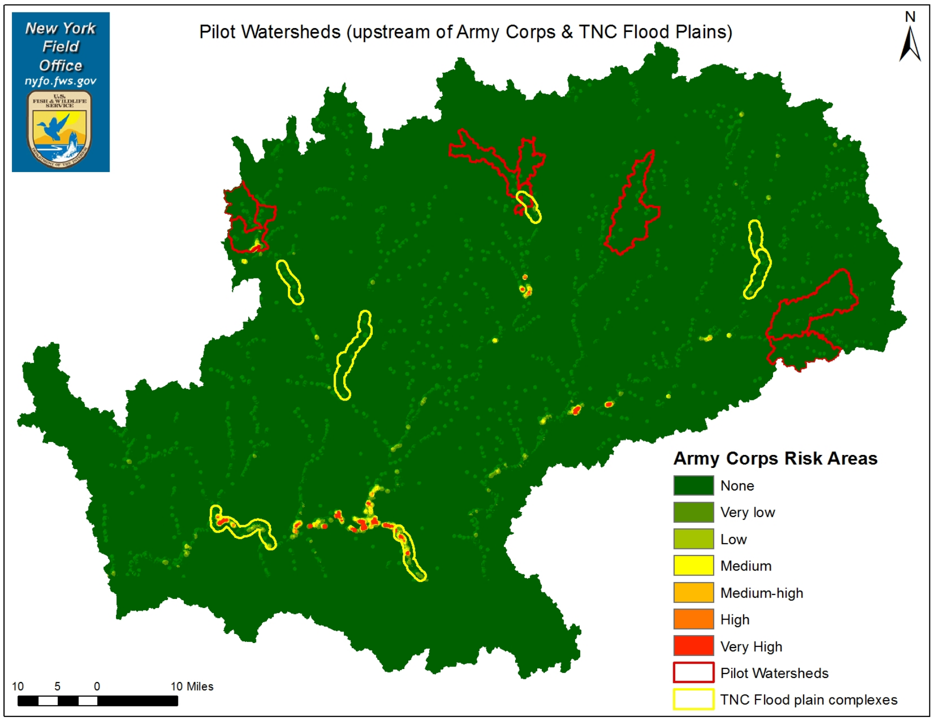


Figure 13. Pilot Watersheds

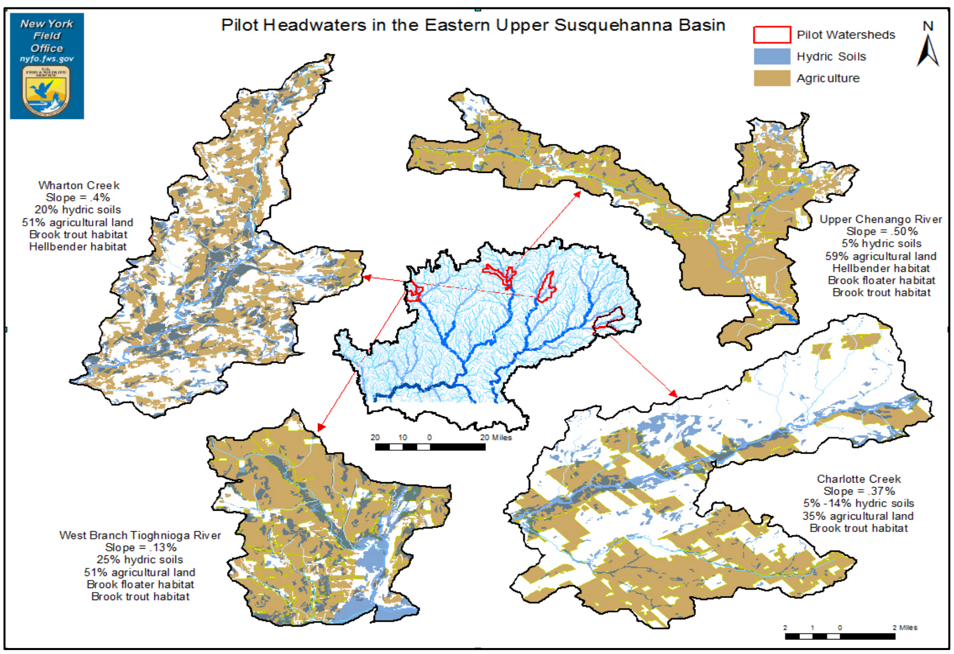


Figure 14. Pilot Watersheds

- **Consider the application of a suite of environmentally restorative flood mitigation strategies, in conjunction with other non-structural measures such as acquisition and structure elevation, to assess potential flood benefits achievable.**

H. U.S. Fish and Wildlife Service Recommendations

1. Alternatives

We recommend that the following be considered in the development of alternatives for flood reduction management.

- Fully develop a watershed restoration flood control alternative. Include environmentally restorative measures as a separate fully vetted alternative or within project alternatives that may be used to further mitigate flood damage by keeping rain closer to where it falls, encouraging water infiltration into soils, enhancing stormwater detention, and slowing downstream flows. Consider evaluating the use of these methods in the pilot watersheds as proposed in Section G of this report (Figures 13 and 14).

- Select alternatives and design options that minimize the footprint of levees and minimize snagging, clearing, shoal removal, and dredging of rivers and streams.

- Provide the costs of non-structural infrastructure improvements (acquisition, flood proofing, etc.) to enable a cost/benefit comparison with structural alternatives.

- In addition, any future alternatives evaluation should quantify the ecological benefits along with the ecosystems services (e.g., carbon and nutrient removal or sequestration; reduced flood risk) that connected and reconnected floodplains provide to society in order to fully assess the costs and benefits of flood-control projects.

- Any future alternative should also determine the valuation of human-use services such as angling, boating, or hiking, that may be adversely impacted by proposed structural projects.

2. Minimization and Mitigation Measures

In order to minimize impacts to fish and wildlife and mitigate for unavoidable impacts, we recommend that the USACE:

- Evaluate and quantify habitat lost as part of levee construction. This includes riparian habitat and floodplain wetlands that may be adversely impacted by levee construction. Mitigation should be provided for these losses.

- Consider vegetative options for levees other than maintained grass in order to provide greater habitat value (Shields 2016; PCPW 2016).

- Remove woody material from rivers and streams only if it is demonstrated that it will achieve measurable flood benefits. Provide mitigation for adverse environmental effects.

- Excavate river shoals only if it is demonstrated that it will achieve measurable flood benefits that will persist over time. Provide mitigation for adverse environmental effects. The USACE should evaluate the causes and the likelihood of shoal re-development in the future and assess options to address the cause. Addressing the cause will minimize the need for repetitive shoal removal costs, especially to local communities.

- Seek to improve fish passage wherever possible when it can be accomplished in conjunction with flood reduction measures.

- Avoid and minimize impacts to the federally listed, threatened Northern long-eared bat by leaving suitable trees on the landscape if feasible, or if not, conduct tree removal during the winter while bats are hibernating (October 31 and March 31).

- Avoid removing wetlands and floodplains from the landscape as they are ecologically beneficial and can store floodwater and provide wildlife habitat. Consider restoring wetlands and floodplains that have been impacted in the past to build resiliency and provide recreational space for communities.

- Identify alternate authorities to address recommendations that do not fall within the current authority for this project.

I. Literature Cited

Ahilan, S., M. Guan, A. Sleigh, N. Wright, and H. Chang. 2016. The influence of floodplain restoration on flow and sediment dynamics in an urban river. Journal of Flood Risk Management 11:S986-S1001.

Archuleta, R. 2014. Cedar River Watershed Coalition Meeting – Cover Crops and Other Conservation practices – personal interview, as cited in IFC 2014.

Arnell, N.W. and S.N. Gosling. 2014. The impacts of climate change on river flood risk at the global scale. Climatic Change 134: 387 – 401.

Arnold, J.L. 1986. The evolution of the 1936 Flood Control Act. Office of History, United States Army Corps of Engineers, Fort Belvoir, Virginia. http://www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_870-1-29.pdf

CWP. Center for Watershed Protection. 2017. Documentation for stormwater performance-based credit. Crediting framework product #7 for the project, *Making urban trees count: A project to demonstrate the role of urban trees in achieving regulatory compliance for clean water*. Center for Watershed Protection, Ellicott City, MD.

Corps (U.S. Army Corps of Engineers) 2010 . Flood risk management analysis, Village of Sidney, Delaware County. Prepared by U.S. Army Corps of Engineers, Baltimore District, August 2010.

Cowin, M.W. and G.B. Bardini. 2012. Central Valley flood protection plan. A path for improving public safety, environmental stewardship and long-term economic stability. https://www.water.ca.gov/LegacyFiles/floodsafe/fessro/docs/flood_tab_cvfpp.pdf

Dadson, S.J., J.W. Hall, A. Murgatroyd, M. Acreman, P. Bates, K. Beven, L. Heathwaite, J. Holden, I.P. Holman, S.N. Lane, E. O'Connell, E. Penning-Rowsell, N. Reynard, D. Sear, C. Thorne, and R. Wilby. 2017. A restatement of the natural science evidence concerning catchment-based 'natural' flood management in the U.K. Proc R Soc A 473: 20160706. http://dx.doi.org/10.1098/rspa.2016.0706

Environment Agency (U.K.). 2017. Natural Flood Management Toolbox. Guidance for working with natural processes in flood management schemes. https://www.catchmentbasedapproach.org/images/PDFS/NFM/EA-NFM-Toolbox-Final-Draft.pdf

FEMA and GOSR (Federal Emergency Management Agency and Governor's Office of Storm Recovery). 2016. Draft Environmental Assessment, Community Development Block Grant – Disaster Recovery, Hazard Mitigation Grant Program Global Match and Acquisition & Elevation. Village of Sidney and Sidney Center, Delaware County, New York. FEMA-4020-DR-NY.

FLLT (Finger Lakes Land Trust). 2012. Conservation focus areas of the Upper Susquehanna watershed within the Finger Lakes Land Trust's service area. http://www.fllt.org/content/uploads/2015/02/Conservation-Plan-Upper-Susquehanna.pdf

Franklin, S.B., J.A. Kupfer, S.R. Pzeshki, R. Gentry, and R.D. Smith. 2009. Complex effects of channelization and levee construction on western Tennessee floodplain forest function. Wetlands 29(2):451-464.

Garner, JT and SW McGregor. 2001. Current status of freshwater mussels (Unionidae, Margaritiferidae) in the Muscle Shoals area of Tennessee River in Alabama (Muscle Shoals revisited again). American Malacological Bulletin 16(1/2): 155-170.

Hey, D.L. and N.S. Philippi. 1995. Flood reduction through wetland restoration: the upper Mississippi River basin as a case history. Restoration Ecology 3 (1): 4-17.

Hynicka, J. and D. Caraco. 2017. Relative and absolute reductions in annual water yield and non-point source pollutant loads of urban trees. Crediting framework Product #2 for the project Making Urban Trees Count: A Project to Demonstrate the Role of Urban Trees in Achieving Regulatory Compliance for Clean Water. Center for Watershed Protection, Ellicott City, MD.

IFC (Iowa Flood Center). 2014. Hydrologic assessment of the Upper Cedar River watershed. Iowa Flood Center and IIHR- Hydroscience and Engineering, University of Iowa. IIHR Technical Report No. 489.

IRMRC (Interagency Floodplain Management Review Committee). 1994. Sharing the Challenge: Floodplain Management into the 21st Century. Prepared for Administration Floodplain Management Task Force. Washington. D.C. 1994. "The Galloway Report"

Lane, J.A., C.B. Portt, and C.K. Minns. 1996. Spawning habitat characteristics of Great Lakes fishes. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2368.

Lassettre, N.S. and G.M. Kondolf. 2012. Large woody debris in urban stream channels: redefining the problem. River Research and Applications 28:1477-1487.

MacGregor, R., J.M. Casselman, W.A. Allen, T. Haxton, J.M. Dettmers, A. Mathers, S. LaPan, T.C. Pratt, P. Thompson, M. Stanfield, L. Marcogliese, and J-D Dutil. 2009. Natural heritage, anthropogenic impacts, and biopolitical issues related to the status and sustainable management of American eel: A retrospective analysis and management perspective at the population level. Am. Fisheries Society Symposium 69:713-740.

Makhdoom, M.T. 2013. Impacts of levees on floodplain ecosystems. Online presentation. https://vaflood.files.wordpress.com/2012/09/levee-impacts-on-floodplain-ecosystems.pdf

Mallakpour, I. and G. Villarini. 2015. The changing nature of flooding across the central United States. Nature Climate change 5: 250 - 254.

Marcinek, P.A., M.C. Freeman, and B.J. Freeman. 2003. Distribution and abundance of three endemic fishes in shoals of the upper Flint River system. Proceedings of the 2003 Georgia Water Resources Conference, April 23-24, 2003, University of Georgia.

Mayasich, J., D. Grandmaison, and C. Phillips. 2003. Eastern hellbender status assessment. U.S. Fish and Wildlife Service.

Miller, AC and BS Payne. 2004. Reducing risks of maintenance dredging on freshwater mussels (Unionidae) in the Big Sunflower River, Mississippi. J Environ Manage 73(2): 147-154.

Ning, L., E.E. Riddle, and R.S. Bradley. 2015. Projected changes in climate extremes over the Northeastern United States. American Meteorological Society, April 2015. https://doi.org/10.1175/JCLI-D-14-00150.1

NYRCR (New York Rising and Community Reconstruction Program). 2014. NYRCR Sidney. https://stormrecovery.ny.gov/sites/default/files/crp/community/documents/sidney_nyrcr_plan.pdf

PCPW (Pierce County Public Works). 2016. Levee vegetation management – strategy. https://www.co.pierce.wa.us/ArchiveCenter/ViewFile/Item/4622

Pugh, W.W., M. Hutchins, M. Madritch, L. Siefferman, and M.M. Gangloff. 2015. Land-use and local physical and chemical habitat parameters predict site occupancy by hellbender salamanders. Hydrobiologia: DOI 10.1007/s10750-015-2570-0.

Richter, B.D., D.P. Braun, M.A. Mendelson, and L.L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology 11(5): 1081-1093.

Saldi-Caromile, K., K. Bates, P. Skidmore, J. Barenti, D. Pineo. 2004. Stream Habitat Restoration Guidelines: Final Draft. Co-published by the Washington Departments of Fish and Wildlife and Ecology and the U.S. Fish and Wildlife Service. Olympia, Washington. Washington State Aquatic Habitat Guidelines Program.

Schneider, R. and K. Boomer. 2016. Re-plumbing the Chesapeake Watershed: Improving roadside ditch management to meet TMDL water quality goals. STAC Publication Number 16-001, Edgewater, MD. 43 pp.

SEPA (Scottish Environment Protection Agency). 2015. Natural Flood Management Handbook. https://www.sepa.org.uk/media/163560/sepa-natural-flood-management-handbook1.pdf

SEPA. 2012. Supporting guidance (WAT-SG-78). Sediment management authorization. https://www.sepa.org.uk/media/151062/wat-sg-78.pdf

Sherer, D. 2011. Mussels important in birth of Shoals. Times Daily, November 13, 2011. Florence, Alabama.

Shields D.F. 2016. Synthesis of levee vegetation research results (2007-2014). Prepared for California Levee Vegetation Research Program. https://www.water.ca.gov/LegacyFiles/floodsafe/leveeveg/levee_documents/2016-0127-Levee-Veg-Synthesis-Report-FINAL.pdf

Smith, B.K., J.A. Smith, M.L. Baeck, and A.J. Miller. 2015. Exploring storage and runoff generation processes for urban flooding through a physically based watershed model. Water Resources Research 51, 1552-1569, doi:10.1002/2014WR016085.

SRAFRC (Susquehanna River Anadromous Fish Restoration Cooperative). 2010. https://www.dec.ny.gov/docs/fish_marine_pdf/r7fsrafcfinal.pdf

STAC (Scientific and Technical Advisory Committee). 2014. Re-plumbing the Chesapeake watershed: improving roadside ditch management to meet TMDL water quality goals. STAC Workshop Report October 9-10, 2014. STAC Publication 16-001.

Strayer, D.L. and A.R. Fetterman. 1999. Changes in the distribution of freshwater mussels (Unionidae) in the Upper Susquehanna River basin, 1955-1965 to 1996-1997. American Midland Naturalist 142(2):328-339.

Strayer, D. and H. Malcom. 2012. Causes of recruitment failure in freshwater mussel populations in southeastern New York. Ecological Applications 22(6):1780-1790.

Thibeault, J.M. and A. Seth. 2014. Changing climate extremes in the Northeastern United States: observations and projections from CMIP5. Climatic Change 127:273-287.

Tuel, A.L.B.. 2017. Levee vegetation management in California: An overview of law, policy and science, and recommendations for addressing vegetation management challenges. http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Sacramento%20River/levee_vegetation_management_in_california.pdf

UNECE (United Nations Economic and Social Council). 2000. Sustainable Flood Prevention. http://www.unece.org/fileadmin/DAM/env/water/publications/documents/guidelinesfloode.pdf

Watson, K.B., T. Ricketts, G. Galford, S. Polasky, and J. O'Niel-Dunne. 2016. Quantifying flood mitigation services: the economic value of Otter Creek wetlands and floodplains to Middlebury, VT Ecological Economics 130:16-24.

Young, W.J. 1991. Flume study of the hydraulic effects of large woody debris in lowland rivers. River Research and Applications 6(3): 203-211