US Army Corps
of Engineers
Philadelphia District

Section 205
Feasibility Report

TOOKANY CREEK
CHELTENHAM TOWNSHIP
MONTGOMERY COUNTY, PENNSYLVANIA
Flood Risk Management Feasibility Study

Lead Federal Agency – U.S. Army Corps of Engineers
Non-Federal Sponsor – Township of Cheltenham, Montgomery County, PA

U.S. ARMY CORPS OF ENGINEERS
PHILADELPHIA DISTRICT
WANAMAKER BUILDING
100 PENN SQUARE EAST
PHILADELPHIA, PA 19107

JULY 2022

Executive Summary

The U.S. Army Corps of Engineers, Philadelphia District (USACE) Tookany Creek Final Feasibility Report evaluates the impacts of constructing dry detention basins within the Tookany Creek watershed for flood risk management (FRM) in the Township of Cheltenham, Montgomery County, Pennsylvania.

The Recommended Plan for this study (Alternative 6: The Tookany/Rock Creek Plan) consists of six dry detention basins located within Cheltenham Township (Doe Lane, West Waverly Road, Church Road (Arcadia University), Limekiln Pike, Grove Park and Washington Lane).

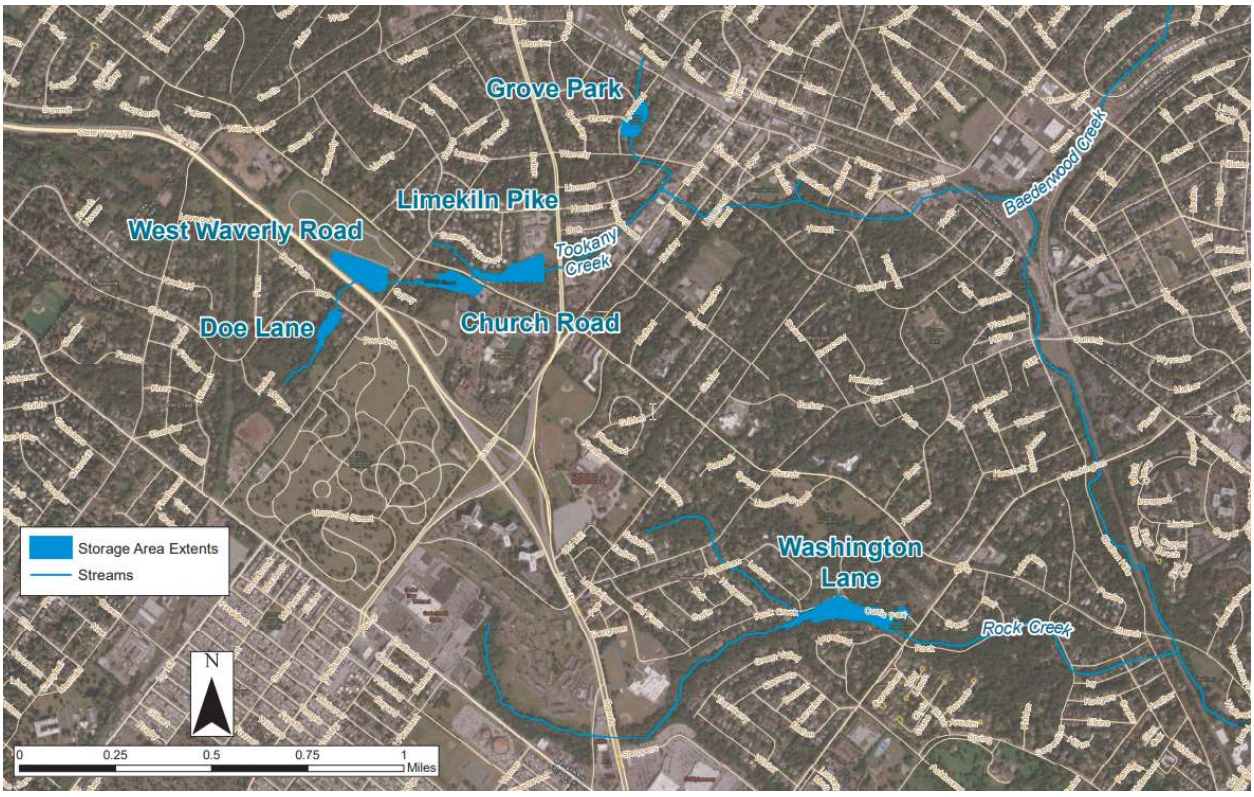

Figure ES- 1: Recommended Plan

The detention basins are proposed for construction in low-lying, open-space areas that would require minimal excavation and construction costs to store water. Instead of large-scale excavation, an earthen embankment will be constructed on the downstream end of each detention basin to capture and control flows. The earthen embankments have been designed with an outlet structure channeling flow to a concrete box culvert (conduit) that conveys the water through the embankment and outfalls to the existing stream channel (See Appendix D – Civil Design). Such a structure will include interlocked gabion baskets and earthen material that allow flows up to a non-damaging level to pass unimpeded. As the inflow rate increases, flow through the gabion basket conduit structure will be "choked" and a pool will start to form behind the embankment. The earthen embankment and a compacted clay trench will be designed to prevent flow from passing through them. The box culvert is intended to allow flow until the capacity is exceeded and

the embankment serves as an overflow weir when the impoundment fills up to overflowing. If inflows exceed the storage capacity, the embankment structure design proposes to key it into a foundation, such as solid rock, to prevent seepage and, at a minimum, provide a longer seepage path for any water that will pass along the perimeter of the key. Once the downstream flows have returned to a low level and inflows have dropped, the stored water will be slowly released through the conduit and everything will be returned to pre-storm conditions.

Based on the 50-year period of analysis with the FY21 Project Evaluation and Formulation Rate (Federal Discount Rate) of 2.5%, the Recommended Plan is the National Economic Development (NED Plan) that reasonably maximizes net economic development benefits consistent with the Federal objective. The Recommended Plan provides $38,000 (rounded) in Average Annual Net Benefits (AANB) with a 1.1 Benefit-Cost Ratio (BCR) and a 78% probability of positive economic viability, as summarized on Table ES-1.

Table ES- 1: Recommended Plan Cost/Benefit Summary

Item	NED Plan
First Construction Cost	$7,893,000
Interest During Construction	$148,000
Subtotal Construction Cost	$8,040,000
Subtotal Average Annual Cost	$283,000
Annual OMRR&R	$39,000
Average Annual Cost	**$323,000**
Without Project EAD	$2,291,000
With Project EAD	$1,933,000
Average Annual Benefits	$359,000
Average Annual Net Benefits	**$38,000**
Benefit-Cost Ratio	**1.1**

The initial project cost of the CAP Section 205 Tookany Creek Project will be cost shared, with 65 percent of initial cost paid by the Federal Government and 35 percent paid by the non-federal sponsor. A Project Partnership Agreement (PPA) package will be coordinated and executed subsequent to the feasibility phase. The PPA reflects the recommendations of this Feasibility Report.

Cost Apportionment

The total project cost would be shared between the USACE and the Township of Cheltenham, Montgomery County, PA with 65 percent of the cost from Federal funds and 35 percent non-Federal. Section 205 projects have a federal expenditure limit of $10,000,000. Table ES-2 presents the fully funded cost estimate for the proposed project which includes the Federal and non-Federal cost shares. Feasibility costs include those costs spent to date on the study. It should be noted that

the first $100,000 of the project study costs are 100 percent Federally funded and not included in the estimated Total Project Cost shown in Table ES-2.

Table ES- 2: Project Cost Apportionment

	Total Project Costs
Feasibility Study Costs	**$845,000**
FED Share	$472,500
Non-FED	$372,500
Design and Implementation Costs	**7,893,000**
Monitoring[1]	$36,000
LERRDs[3]	$713,000
FED Share	$5,130,450
Non-FED Share	$2,762,550
Non-FED Cash	$2,049,550
Non-FED LERRD credit	$713,000
TOTAL PROJECT COST[2]	**$8,738,000**
FED Share	$5,602,950
Non-FED	$3,135,050

Notes:

1 Monitoring Costs are incurred after the project is constructed.
2 Total Project Costs do not include operations and maintenance costs.
3 LERRDs are a 100% non-Federal responsibility for which the sponsor gets cost sharing credit.

Based on the data presented and continuing coordination with State and Federal resource agencies, no significant adverse environmental impacts are expected to occur as a result of the proposed action.

There are approximately 0.25 acres of wetlands within the potential footprint of the proposed West Waverly Basin. During design and implementation, the embankment and associated dry detention basin footprint will be designed to avoid impacts to the existing wetlands to the greatest extent possible. If wetland impacts are determined to be unavoidable as the plan design progresses, coordination with the USFWS will be updated and potential mitigation in the form of wetland restoration within the West Waverly Basin will be completed to compensate for this loss. At this point in the feasibility-level analysis, no compensatory mitigation is required as part of the recommended plan.

Pursuant to Section 106 of the National Historic Preservation Act of 1966, as amended, USACE has determined that the recommended plan has a moderate potential to affect both above-ground and below-ground historic properties. Additional investigations will need to be conducted to fully assess potential impacts, in consultation with the Pennsylvania State Historic Preservation Office, the Tribes, and other consulting parties. Based on the findings in the Phase IA Cultural Resources Investigation, USACE has initiated negotiation of a programmatic agreement (PA). All terms and

conditions resulting from the PA shall be implemented in order to minimize adverse impacts to historic properties.

The minimum estates required for this project are a Permanent Channel Improvement Estate for a permanent right of way on approximately 20.617 acres of land (Estate No. 8) and a Temporary Work Area Easement in which acreage will be determined in the future for staging, work and disposal areas (Estate No. 15). There are no Non-Standard Estates necessary for this project. The non-Federal sponsor (NFS) currently owns in fee approximately 7.08 acres of required land within the area required for the channel improvement easement. The additional area required for the channel improvement easement is approximately 13.53 acres of private, commercial and industrial parcels owned by approximately 39 owners. The project may also require a Temporary Work Area Easement for staging areas for a duration of two (2) years.

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1.0 INTRODUCTION

1.1 STUDY PURPOSE AND SCOPE

The purpose of the feasibility study is to identify, evaluate and recommend to decision makers an appropriate, coordinated and implementable solution to the identified water resources problems and opportunities in Cheltenham Township, Montgomery County, Pennsylvania, due to flooding in the Tookany Creek watershed. This feasibility study has identified a recommended plan that reasonably maximizes net National Economic Development (NED) benefits consistent with protecting the nation's environment by reducing peak flow rates and associated flood inundation levels that contribute to flooding damages in the Tookany Creek watershed in Cheltenham Township, Pennsylvania.

1.2 STUDY AUTHORITY AND APPROPRIATIONS

This study and report were completed under the authority of Section 205 of the Flood Control Act of 1948, as amended. Under this authority, the Secretary of the Army, acting through the Chief of Engineers, is authorized to plan, design, and construct small flood control projects with and without specific Congressional authorization.

An initial request for assistance to investigate the flood-related problems was made by the Township of Cheltenham, Montgomery County, Pennsylvania (the non-Federal sponsor) in correspondence dated July 17, 2003 (Appendix A).

1.3 STUDY AREA LOCATION

The study area (Figure 1) includes flood prone areas throughout Cheltenham Township, Montgomery County, PA within the Tookany Creek watershed. Cheltenham Township is a densely developed suburban community located just north of Philadelphia within the Philadelphia Consolidated Metropolitan Statistical Area, on the southeastern edge of Montgomery County in southeastern Pennsylvania. The county is bordered by the City of Philadelphia to the southeast, Chester and Delaware Counties to the southwest, Berks County to the northwest, Lehigh County to the North and Bucks County to the northeast.

Tookany Creek itself is an urbanized tributary of Tacony Creek in the Tacony-Frankford Creek watershed and ultimately part of the Delaware River drainage system. In Cheltenham Township, Tookany Creek is 98% open channel flowing through residential and parklands for more than 95% of its length.

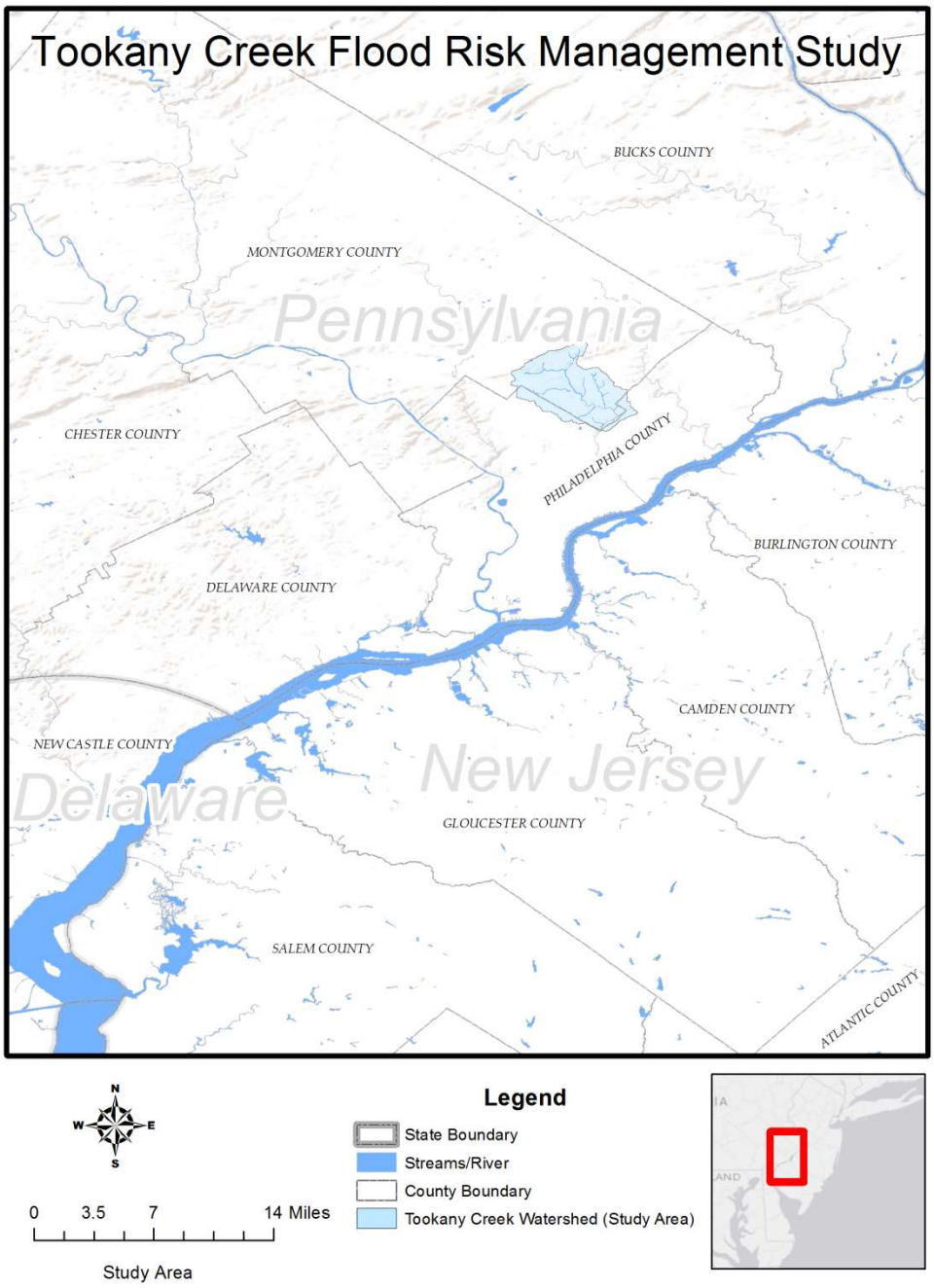

Figure 1 - Study Area

1.4 PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

1.4.1 EXISTING WATER PROJECTS

Man-made infrastructure within the Tookany Creek watershed plays a large role in both the occurrence of flooding and the severity of flooding. Man-made infrastructure includes projects built to reduce flooding risks as well as those that disregarded flooding risks when they were constructed. Approximately 131 channel obstructions within the Tookany Creek watershed were identified by the Philadelphia Water Department (PWD) using in-stream surveys. These obstructions included bridges and culverts on the mainstem Tookany Creek as well as many tributaries. An extremely large-scale storm sewer system exists within the study area. Major stormwater systems include those along Cheltenham Ave, Cottman Ave, Keswick Ave, and Limekiln Pike.

1.4.2 ADDITIONAL WATER RESOURCES STUDIES

Studies of water resources in the Tacony Creek watershed referenced in this evaluation are as follows:

Cheltenham Township, Heritage Conservancy-"Tookany Creek Watershed Management Plan, September 2003."

Federal Emergency Management Agency – "Flood Insurance Study – Montgomery County," Revised October 19, 2001.

Philadelphia Water Department – "Tookany/Tacony-Frankford Watershed Comprehensive Characterization Report."

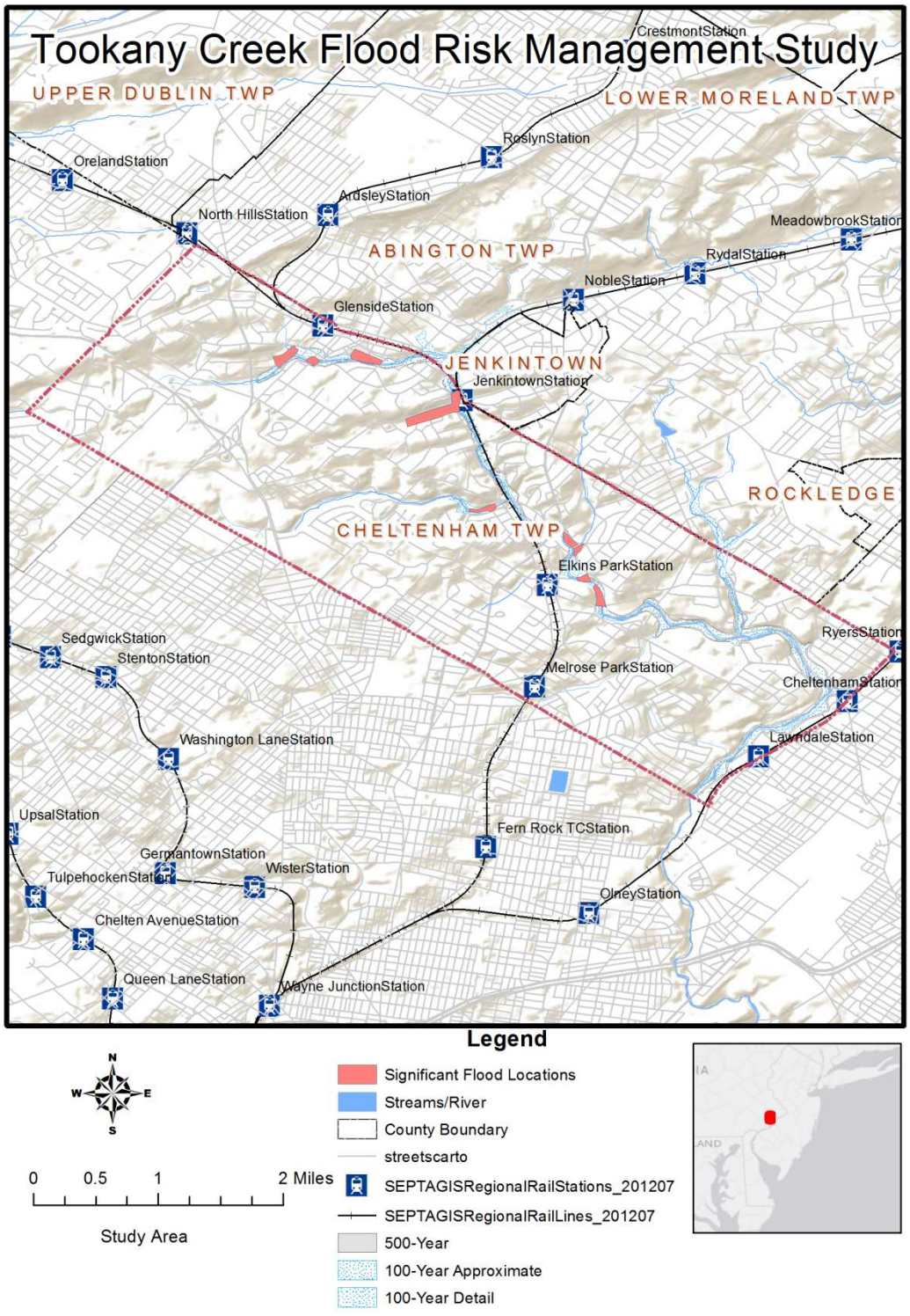

Figure 2 - Cheltenham Township Detail & Tookany Creek

2.0 EXISTING CONDITIONS

2.1 TOPOGRAPHY

Pennsylvania can be divided into several distinct physiographic provinces that are themselves comprised of coastal plains, mountainous sections, glaciated plateaus, etc. The study area is located within two provinces separated by a vague fall line escarpment: the Piedmont and Atlantic Coastal Plain. The Piedmont province is characterized by flat-topped hills and shallow valleys while the Atlantic Coastal Plain is comprised of flat terraces and shallow valleys. The latter province is located in the Delaware River floodplain.

Elevations within the study area range from approximately 60 ft near the Cheltenham/Philadelphia County boundary to nearly 430 ft in the northwestern portions of the Tookany Creek watershed. These elevations were sourced from the Pennsylvania Department of Conservation and Natural Resources (DCNR) PAMAP LIDAR elevation coverages, which are representative of 2008 conditions.

2.2 EXISTING FLOOD RISK MANAGEMENT

As a result of serious flooding in 1955 and in 1967, the Township of Cheltenham undertook a large number of stream improvements along Tookany Creek and its tributaries. These improvements were based on recommendations in a report prepared by a joint venture of George B. Mebus, Inc. Engineers (Glenside, Pennsylvania) and Metcalf and Eddy Engineers (Boston, Massachusetts). Several segments of Tookany Creek have been altered to increase flow capacity. These segments include both concrete lined portions and earthen channels with varying cross-sectional shapes including vertical walls and trapezoidal shapes. In addition, FRM projects exist within the Tookany Creek watershed, including: storm sewers, channel modifications (channelization), levees, pumping stations, and scattered small scale detention basins.

Specifically, the Brookdale Avenue levee was constructed in 1952 to provide improved FRM for the low-lying Brookdale Avenue neighborhood in the Glenside area of Cheltenham Township. Located along the downstream left side of the channel, the alignment stretches approximately 1000 linear feet in length with varying heights. The top width along the levee crest is approximately 10 ft while side slopes are approximately 1:2 (H:V) on both the stream and landward sides. An accompanying pumping station completed in 1978 consists of three pumps, trash racks, and a diesel backup generator. The location of the pumping station requires interior drainage to move past many homes, thereby raising flooding risks to the protected side of the levee. Historically, the trash racks have also become clogged with trash and debris which prevents the effective operation of the pumping station. Clear flow to the pump station is necessary to allow effective operation of the pumping station.

2.3 GENERAL OVERVIEW OF HYDROLOGY/HYDRAULICS & STORMS/ FLOODING

The Tookany Creek watershed is part of the larger Tookany/Tacony-Frankford Watershed (TTFW). The TTFW drains approximately 36 square miles from two counties (Philadelphia and Montgomery) and six municipalities (Cheltenham, Springfield, Abington, Jenkintown, Rockledge, and Philadelphia). The stream is termed “Tookany Creek” above the Cheltenham Township/Philadelphia County boundary, “Tacony Creek” above Castor Avenue, and “Frankford

Creek" below Castor Avenue until it empties into the Delaware River near the Betsy Ross Bridge. Major stream systems bordering the TTFW include the Pennypack Creek to the east, Delaware River to the south, Wissahickon Creek to the west, and Schuylkill River to the southwest.

Tookany Creek drains the majority of Cheltenham Township (a small portion of western Cheltenham Township drains to the Wissahickon Creek watershed). Since Cheltenham Township is the non-Federal sponsor, the PDT focused its analysis on maximizing flood risk reduction activities within the Cheltenham Township boundary of the Tookany Creek watershed. Therefore, the modeled hydraulic area for this study was delimited above the Cheltenham Township/Philadelphia County boundary near Adams Avenue. The drainage area of Tookany Creek at Adams Avenue is approximately 15.6 square miles.

The modeled hydraulic area for this study (final study watershed), larger TTFW, major stream systems, roadways and administrative boundaries are shown in Figure 3.

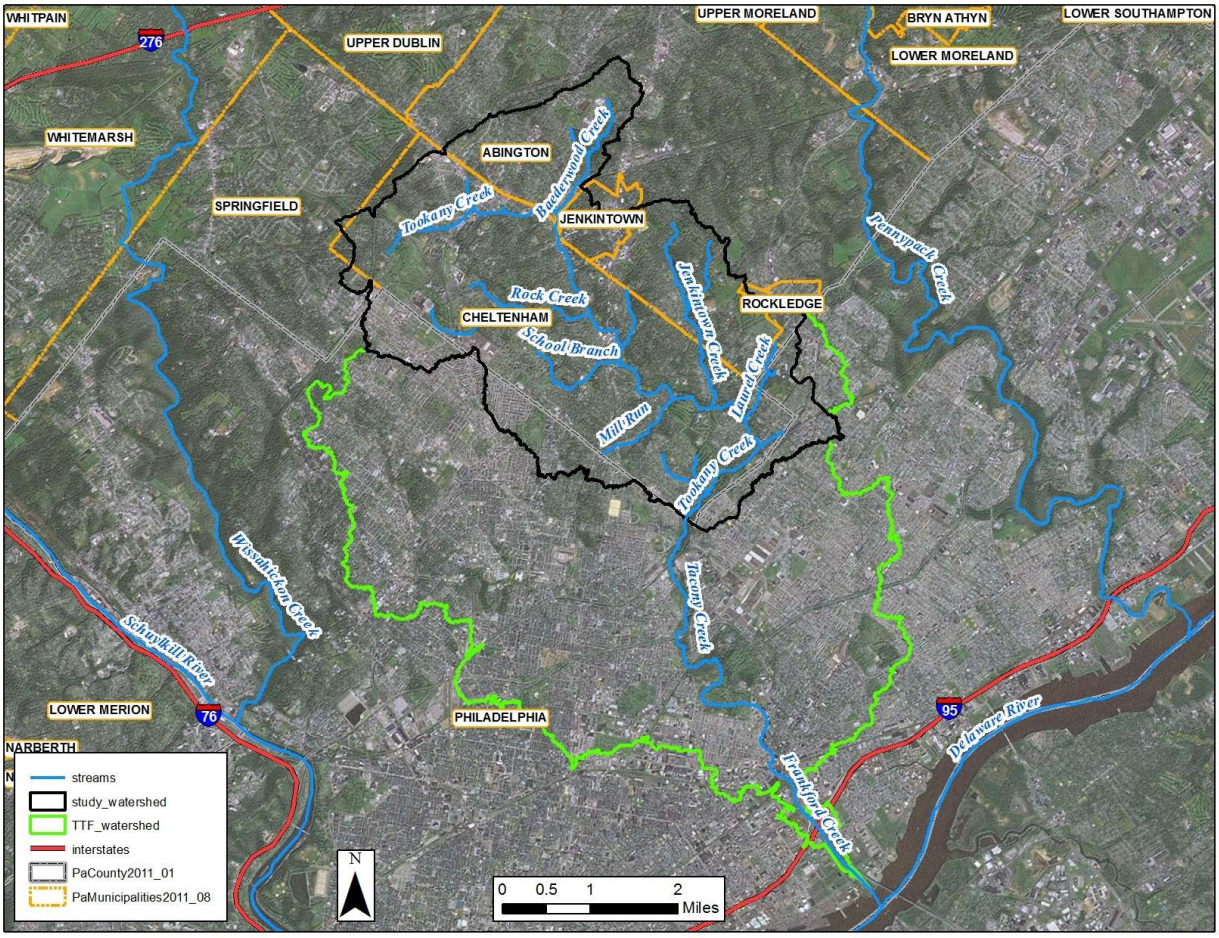

Figure 3 - TTF Watershed and Study Area

Major flooding in this area may occur during any season of the year. During the summer and fall, floods are usually the result of widespread heavy rainfall often associated with tropical storms moving up the Atlantic coastline. Spring floods are generally the result of a combination of heavy rains on frozen ground augmented by melting snow.

In order to accurately identify and evaluate flooding problems, hydrologic and hydraulic models were developed for Tookany Creek and Rock Creek within the study area using the latest existing data which was supplemented and updated as necessary. This analysis reflects the existing conditions. These models were then used to recreate and understand different flooding events and to assess the effectiveness of various flood reduction alternatives. Based on the hydrologic and hydraulic analyses, floods that cause widespread damage are likely to result from the occurrence of various events ranging from an annual exceedance probability AEP) of 50% (2-year storm equivalent) to 0.2% (500-year storm equivalent), depending on the location within the flood plain. The highly urbanized nature of the study area (98% built-up) increases the likelihood for significant flood-related damage. There are approximately 4,088 persons per square mile in Cheltenham Township, PA.

2.4 FLOODING HISTORY

Despite the Townships efforts to reduce flood impacts, flooding and flood-related damages have continued to create problems in the study area. In August 2011, Hurricane Irene caused significant flood-related damages in the study area. Twenty-four hour rainfall accumulations in excess of 7 inches were recorded at the Brookdale Avenue pumping station. This rainfall resulted in peak stream flow rates exceeding previous records by approximately 1500 ft^3/s at the Adams Avenue gage. A little over one week later, the remnants of Tropical Storm Lee moved through the northeastern U.S. resulting in even more disastrous flooding within the Delaware River watershed. Cheltenham Township was again hard hit, receiving between 9 and 12 inches of precipitation from September 6–8, 2011. This extreme rainfall resulted in peak stream flow rates exceeding the record-setting discharges recorded during Hurricane Irene by approximately 150 ft^3/s.

3.0 EXISTING ENVIRONMENT

3.1 INTRODUCTON

The PWD conducted a comprehensive, multi-year assessment of the TTFW. Results of the watershed-wide assessment suggest that sometimes during dry weather periods, bacterial contamination of the TTFW's waters prevents the achievement of water quality standards that would support swimming or other forms of primary contact recreation in the creek. Stream aesthetics, accessibility, and safety are compromised due to a number of factors, including litter and illegal dumping, trash from stormwater discharges, channelization of portions of the stream, and bank deterioration along stream corridors. The existing aquatic and riparian habitats have been degraded by urban runoff, limiting the diversity of fish and other aquatic life and preventing the development of healthy living resource conditions necessary to support recreational activities such as fishing. Wet weather water quality is limited by bacteria discharged from combined and separate storm sewers. High rates of urban runoff cause flooding during larger storms, and flood flows that erode the stream banks and bottoms and have subsequently exposed and compromised utility infrastructure (PWD 2005).

3.2 LAND USE

Land use in the study area is primarily residential but also consists of commercial businesses and industrial facilities as well as open space.

3.3 CLIMATE AND PRECIPITATION

The Tookany Creek watershed has a climate that is typical of the Piedmont and Coastal Plain provinces. This includes warm and humid summers with wet and variable winters. Residing in a northeastern state, the study area is exposed to occasional tropical storms (hurricanes) and extra-tropical storms ("northeasters"). However, thunderstorms, which normally occur during the summer months, are the predominant storm type.

Air temperatures within the study area, as recorded at two United States Air Force 14th Weather Squadron (USAF – 14WS) hydro-meteorological stations that are near the modeled hydraulic area, vary from near zero (Fahrenheit) temperatures during the winter months to near 100-degree temperatures during the summer months.

Average annual point rainfall within and around the Tookany Creek watershed, as derived from nearby precipitation gauging stations, usually varies between approximately 30 to 60 inches. Average annual point snowfall within the study area can also vary between 10 and 30 inches. These variations are also supplemented by temporal and spatial distributions due to topographic relief (orographic effects) and effective weather patterns.

The previously mentioned precipitation gauging stations near the study area are maintained by the National Oceanic and Atmospheric Administration (NOAA) National Climactic Data Center (NCDC) in addition to several gages maintained by Philadelphia Water Department PWD. Additionally, three non-recording gages are maintained by Cheltenham Township throughout the study area with limited records.

3.4 VEGETATION

Development within the Tookany Creek floodplain has resulted in the loss of the natural floodplain, thereby diminishing the riparian buffer. The area along Church and Shoemaker Road in Elkins Park and Brookdale and Glenside Avenues in Cheltenham are particularly affected by degraded stream banks. The riparian buffer contains invasive species such as Japanese Knotweed (*Reynoutria japonica).*

3.5 AQUATIC RESOURCES

Poor in-stream habitat has been identified as the cause of biological impairment found throughout the watershed. Stream channels in the TTFW exhibit many effects of urbanization, including over-widening, erosion, loss of sinuosity, loss of the floodplain, loss of stream connection, channel modification, and loss/degradation of aquatic habitat. Biological monitoring indicates that the whole watershed suffers from impaired aquatic habitat and does not meet its designated use as a warm water fishery. As a result, the whole length of the non-tidal Tookany/Tacony-Frankford Creek and its tributaries were listed in PADEP's 303d list of impaired waters in 1999. This impairment is due to severe water flow fluctuations, habitat alteration, point and non-point source pollution from urban development, hydro-modification, and combined sewer overflows. The biological community of the watershed is heavily impacted by its urban surroundings (PWD 2005).

<u>*Fish*</u> – During the 2004 watershed fish assessment, PWD collected over 9,000 individuals representing 17 species in 7 families. Blacknose dace (*Rhinichthys atratulus*) and mummichog (*Fundulus heteroclitus*), two taxa extremely tolerant of poor stream conditions, were most

abundant and comprised over half (56%) of all fish collected. Other common species included white sucker (*Catostomus commersoni*), satinfin shiner (*Cyprinella analostana*), banded killifish (*Fundulus diaphanus*), and swallowtail shiner (*Notropis procne*). Five species made up greater than 80% of the total fish biomass, with redbreast sunfish (*Lepomis auritus*) and American eel (*Anguilla rostrata*) contributing 42% of the biomass. Though community composition varied between sites, the fish assemblage in TTFW was highly skewed towards a pollution tolerant, generalist feeding community (PWD 2005).

Benthic Macroinvertebrates – Benthic macroinvertebrate monitoring occurred at 12 sites in the watershed during 2004 and benthic impairment was omnipresent. With the exception of Jenkintown Creek, all stream segments were designated "severely impaired" (PWD 2005). Benthic macroinvertebrates rely heavily on stream riffles for at least part of their life cycle. Clinging to life in a riffle requires various adaptations, and most macroinvertebrates are not prepared for the extreme hydrologic fluctuations that can occur in a channelized creek such as the Tookany/Tacony-Frankford. Increased stream velocities and sediment loads from eroding stream banks are disrupting the benthic environment by scouring the stream bottom of appropriately sized substrates. The cobble substrate has limited interstitial space, often filled by finer materials, for benthic macroinvertebrates to thrive. In addition, storm events lead to decreased species richness and evenness, which in turn changes the dynamics of feeding groups within the communities. Specialized feeders are greatly diminished, and generalists such as gatherer/collectors dominate the feeding community (PWD 2005).

3.6 WILDLIFE RESOURCES

With very limited open space and riparian areas still intact in the watershed, there is limited habitat for wildlife resources. The white-tailed deer, chipmunk, woodchuck (groundhog), opossum, skunk, red fox, eastern cottontail, raccoon, big brown bat, little brown bat, muskrat, eastern mole, rat, field mouse, and the gray squirrel are common mammalian species that occur throughout the TTFW. These species are also known throughout the rest of the State. The watershed generally lacks species diversity as a direct result of the elimination of habitat. Few animals, other than those listed above, are able to co-exist with the level of human activity within most of the watershed.

The watershed study completed by PWD in 2005 evaluated the riparian habitat at various locations in the watershed. PWD surveyed habitat at 12 sites throughout the watershed. Monitoring locations along the mainstem of Tookany Creek (Montgomery County) received uniform scores of "Non-Supporting," indicating a region of severe habitat degradation. In general, upstream reaches in Tookany Creek lacked habitat heterogeneity, possessed poor riparian zones, and experienced high levels of channelization. Moreover, poor bank stability and exaggerated levels of sediment deposition also contributed to the poor aquatic habitat in the upper portions of the watershed. Rock Creek and Jenkintown Creek sites, the two surveyed upstream tributaries, both were rated as partially supporting, indicating slightly better habitat conditions relative to the mainstem (PWD 2005).

3.7 RARE, THREATENED & ENDANGERED SPECIES

Conducting a Pennsylvania Natural Diversity Inventory (PNDI) search (run by the Pennsylvania Natural Heritage Program) resulted in one species of potential concern listed for the Pennsylvania

Department of Conservation and Natural Resources. The species was the Field dodder (Cuscuta pentagona), a State Special Concern plant, which is found in old fields and prairies, sandstone ledges, and coastal plain marshes. Blooming occurs from July through October. Additional coordination and field site visits will have to be conducted to determine if this species is found in the proposed project area.

Additionally, the PNDI search indicated that no Federally-listed species are found in the project area and that no impacts to Federally-listed or proposed species would be anticipated with the proposed project.

3.8 WETLANDS

According to the U.S. Fish & Wildlife Service's National Wetlands Inventory (NWI), there is one wetland (West Waverly Road site) found within the project area. A field visit also confirmed the presence of the wetland at this location. The NWI maps categorize the wetland as PSS1/EM5C or a palustrine scrub shrub/common reed (*Phragmites australis*) dominated emergent wetland of approximately 4 acres. The field visit also confirmed this categorical information, as well as documenting the large presence of another invasive species, Japanese knotweed (*Fallopia japonica*). No other wetlands were identified in the project area.

3.9 WATER QUALITY

In an effort to promote public health as well as increase available real estate for development, several streams (both perennial and ephemeral) have been paved over and confined to sewer systems within the Tookany Creek watershed. This practice was used by all of the municipalities within the TTFW. The most extensive use of this practice was within Philadelphia County, where an extensive combined sanitary and storm sewer system exists. This arrangement can severely degrade water quality during times of heavy rainfall when the system capacity is exceeded and combined sewer overflows (CSOs) occur. Several portions of the historic Tookany Creek watershed have been diverted to flow to the Pennypack Creek through storm sewer systems.

Tookany Creek is characteristically a suburban stream; however, the Tookany Creek sub-basin suffers from urbanization resulting in point and non-point source pollution from urban/stormwater runoff, hydrologic modification, illicit connections, sanitary laterals hooked into storm sewers, heavy industry, and commercial and residential development.

The primary water quality concerns identified were elevated concentrations of some metals and Total Suspended Solids (TSS) (particularly during wet weather events), high fecal coliform counts (particularly in wet weather), and low dissolved oxygen (DO) in downstream areas of the creek. Additional water quality issues identified in the Tookany/Tacony-Frankford Integrated Watershed Management Plan (2005) included:

- High fecal coliform during dry weather
- Potential dry weather sewage flows in separate sewered areas
- Trash
- Degraded aquatic and riparian habitats
- Loss of wetlands
- Limited diversity of fish and other aquatic life

- Wide diurnal swings in DO

3.10 CULTURAL RESOURCES

A Phase IA Cultural Resources Investigation was completed by the USACE in November 2014 and it indicated potential for the select basin locations in the proposed plan project area to exhibit high archaeological sensitivity for the presence of undocumented cultural resources; therefore, Phase IB shovel testing may be required during the Design & Implementation (D&I) phase.

3.11 SOCIO-ECONOMIC RESOURCES

The Township of Cheltenham was founded in 1683 and incorporated as a municipal government in 1900. Located at the eastern extent of Montgomery County and bordering Philadelphia County, Cheltenham encompasses an area of 9.06 square miles and, according to the 2018 American Community Survey (ACS) 5-year Estimates, has a population of 37,149. Figure 3 below shows the location of Cheltenham Township within Montgomery County and the location of Montgomery County within the state of Pennsylvania.

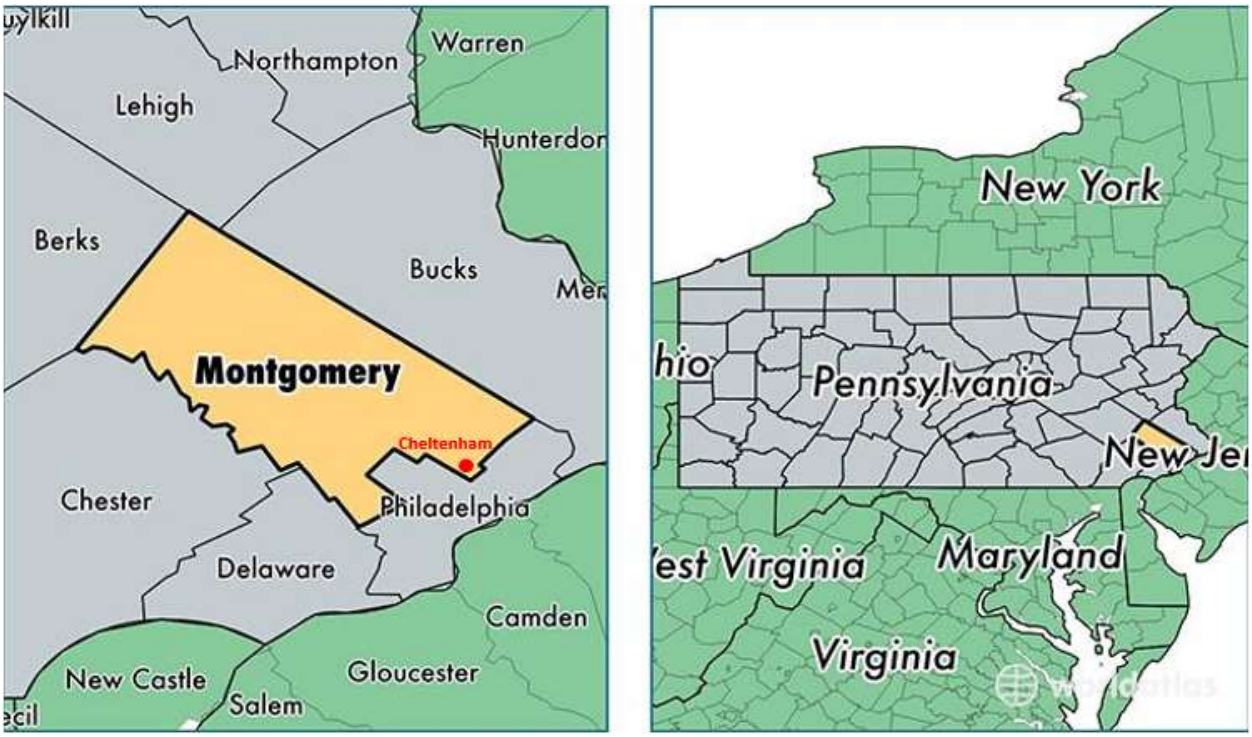

Figure 4 - Cheltenham Township and Montgomery County

Population and Demographics

All socioeconomic data provided in this section is provided by the 2018 ACS 5-year Estimates. Cheltenham Township's 37,149 residents represent 4.5% of the total population of Montgomery County, PA. Cheltenham has experienced a steady population level with only a 1.0% increase in population since 2010.

Table 1 below provides the demographics data for Cheltenham Township in comparison with Montgomery County and the state of Pennsylvania.

Table 1 - Population Demographics

Demographic	Cheltenham	Montgomery County	Pennsylvania
White, not Hispanic or Latino	51.5%	75.0%	75.7%
Black or African American	32.6%	10.0%	12.0%
American Indian and Alaska Native	0.7%	0.2%	0.4%
Asian	7.0%	8.1%	3.8%
Native Hawaiian and Other Pacific Islander	0.1%	0.1%	0.1%
Two or More Races	4.0%	2.3%	2.1%
Hispanic or Latino	5.2%	5.4%	7.8%

Cheltenham Township is more racially diverse than both Montgomery County and the state of Pennsylvania, particularly among residents that identify as Black or African American. Table 2 below shows additional demographics data including income, poverty, and educational attainment.

Table 2 - Income, Poverty, and Education

Category	Cheltenham	Montgomery County	Pennsylvania
Median Household Income	$80,174	$88,166	$59,445
Per Capita Income	$44,202	$46,776	$32,889
Persons in Poverty	9.1%	5.9%	12.0%
High School Graduate or Higher	96.4%	94.2%	90.2%
Bachelor's Degree or Higher	53.0%	48.7%	30.8%

Cheltenham lags behind the rest of Montgomery County in Median Household Income, Per Capita Income, and Poverty rate, but does claim better scores than Pennsylvania as a whole. For educational attainment, Cheltenham exceeds both Montgomery County and the state of Pennsylvania.

4.0 PLAN FORMULATION

4.1 PROBLEMS AND OPPORTUNITIES

PROBLEM STATEMENT

Urbanization has resulted in increased stormwater runoff and floodplain recession leading to reduced carrying capacity for Tookany Creek, increased height and destructive capability of floodwaters in Tookany Creek and a floodplain that cannot store large quantities of water in the Tookany Creek watershed.

OPPORTUNITY STATEMENT
Manage the risk of flooding and flood-related damages in the Tookany Creek watershed.

PROBLEM DEFINITION
The data collection and problem identification phases of this study involved several steps. Prior reports were reviewed for information on flooding in the area and to scope out the extent of current problems. The project team conducted numerous site visits with local officials and residents to identify flooding problems and formulate options. In September 2012, the USACE and Cheltenham Township deployed an assessment team to field inspect nine neighborhood areas over a three-day period and gather critical information to calibrate the models. The nine neighborhood areas included: Brookdale Avenue, Brookside Road, Harrison Avenue, Rock Lane/Widener Road, Bickley Road, Cliff Terrace, High School Road, Shoemaker Road and Mill Road.

4.2 FUTURE WITHOUT PROJECT CONDITIONS
Given the fact that the developed Tookany Creek floodplain cannot store large quantities of water and due to ongoing climate change, the magnitude and frequency of flood-related problems will likely increase in the future. Specifically, modeling indicates the potential for $2,291,000 in total damages during the period of analysis (2024 to 2073) in the absence of a Federal project.

Within the 50-year Federal project horizon, USACE is aware of two local projects likely to be constructed within the Federal project footprint. One project (Glenside Area Flood Protection, Unit II, Tacony Creek, Cheltenham & Abington Townships, Montgomery County) is a collaboration between the Pennsylvania Department of Environmental Protection (PADEP) and Cheltenham Township. The project begins at Brookdale Avenue (along the Keswick Avenue drainage channel) and continues downstream along Tookany Creek to a point approximately 150-feet downstream of the first SEPTA railway bridge at Standard Press Steel. It is intended to manage flood risk associated with the 100-year (1% AEP) event for homes and businesses in the Glenside area, from the Brookdale Avenue area to SEPTA Bridge #11.22. Some of the major features in the project include channel modifications downstream of Brookside Avenue, levee modifications, floodwall construction, channel modifications upstream of the Glenside Avenue Bridge, etc. At this point in time, USACE does not expect the PADEP plan to impact the recommended plan proposed herein; however, USACE will continue to coordinate with PADEP as the project design progresses.

In addition, SEPTA is planning infrastructure flood protection at the Jenkintown Regional Rail Station. Coordination between SEPTA and USACE indicates that the proposed infrastructure improvements will not impact water surface elevations (WSEs) in the proposed Federal project area; therefore, the SEPTA project is not expected to impact this study's recommended plan.

4.3 PLANNING GOALS AND OBJECTIVES

FEDERAL OBJECTIVE
The P&G states that the Federal objective of water and related land resources planning is to contribute to national economic development (NED) consistent with protecting the Nation's

environment, in accordance with national environmental statutes, applicable executive orders, and other Federal Planning requirements (USACE Planning Guidance Notebook: ER 1105-2-100).

The objective for plan formulation in this feasibility report is to identify a technically feasible, economically justified and environmentally acceptable solution to the flooding problems in the Tookany Creek watershed in Cheltenham Township, PA. The formulation process involves establishing plan formulation rationale, identification and screening of alternatives, and assessment and evaluation of plans responsive to identified problems and needs.

PLANNING OBJECTIVES
The primary planning objective is to reduce flood hazards, including risks to life safety and damages to private and public infrastructure, in the Tookany Creek watershed in Cheltenham Township, PA from 2024 to 2073.

4.4 PLANNING CONSTRAINTS
Study-specific planning constraints include the following:

- Avoid inducing flood damages.
- Avoid and minimize adverse impacts to in-stream or adjacent native habitat.
- Avoid degradation to water quality.
- Minimize impacts to cultural resources and historic structures, sites and features.

4.5 PLANNING CONSIDERATIONS
Study-specific planning considerations include the following:

- Upstream impacts and actions from neighboring communities will be incorporated into the planning process.
- Limit changes to local land use designations and zoning.

4.6 MANAGEMENT MEASURES
Measures are defined as features or activities that can be implemented to address one or more planning objective. Measures can either be structural or nonstructural and are the building blocks of which alternative plans are made.

In February 2013, the project team sponsored a Plan Formulation Workshop involving a total of 30 participants representing 13 different agencies and organizations and serving multiple disciplines and programs. During the workshop, participants were assigned to "Breakout Groups" in order to brainstorm specific FRM problem areas and propose potential measures and alternatives to address these problems. Attendees spent approximately 30 minutes brainstorming various structural and non-structural FRM measures and subsequently evaluated the measures based on the Principles and Guidelines' (P&G) four evaluation criteria (completeness, effectiveness, efficiency and acceptability). If a specific measure provided a positive answer to the sub-questions under the P&G criteria, a value of "1" was scored for the measure for that specific question. The table below summarizes the results of the brainstorming exercise. The green boxes represent positive answers and the sum of positive

answers is summed on the left side of the following table. The purple boxes represent negative answers in which no value was added to the measure's score. Management measures developed during the February 2013 Plan Formulation Workshop were carried forward for further analysis in the feasibility study.

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Resulting Rank/Score			Completeness				Effectiveness						Efficiency					Acceptability					
			Minimizes Risk to the Community	Minimizes Impacts of Flooding	Incorporates upstream future actions	Eliminates Potential for Residual Risk	Reduces Flooding Greater than 0.2% Annual Probability Event	Reduces Flooding Greater than 1% Annual Probability Event	Reduces Flooding Greater than 10% Annual Probability Event	Reduces Flooding Greater than 50% Annual Probability Event	Project Does not Induce Unmitigated Flooding Upstream or Downstream of Project	Passive System (does not require human intervention outside of normal operation and maintenance)	Potential Damages Avoided exceed Implementation Cost	Provides Benefits to the General Public	Directly Reduces Community's Financial Response to Flooding	Improves conditions at multiple areas	Provides Benefits other than FRM (ecosystem)	No Adverse Environmental Impacts	Likely to be Permitable based on existing Laws	Acceptable to Community Officials	Meets USACE Definition for FRM (versus Stormwater Management	Enhances Community Recreational Opportunities	Limited Time Until Benefits Realized
			Carrying Capacity Modification																				
15	Inlet Modifications	Structural																					
13	Bridge Modifications	Structural																					
14	Channel Modifications	Structural																					
8	Reconnection of Floodplains	Structural																					
8	Riparian Buffer	Green Infrastructure																					

Resulting Rank/Score			Completeness				Effectiveness						Efficiency					Acceptability					
			Minimizes Risk to the Community	Minimizes Impacts of Flooding	Incorporates upstream future actions	Eliminates Potential for Residual Risk	Reduces Flooding Greater than 0.2% Annual Probability Event	Reduces Flooding Greater than 1% Annual Probability Event	Reduces Flooding Greater than 10% Annual Probability Event	Reduces Flooding Greater than 50% Annual Probability Event	Project Does not Induce Unmitigated Flooding Upstream or Downstream of Project	Passive System (does not require human intervention outside of normal operation and maintenance)	Potential Damages Avoided exceed Implementation Cost	Provides Benefits to the General Public	Directly Reduces Community's Financial Response to Flooding	Improves conditions at multiple areas	Provides Benefits other than FRM (ecosystem)	No Adverse Environmental Impacts	Likely to be Permitable based on existing Laws	Acceptable to Community Officials	Meets USACE Definition for FRM (versus Stormwater Management	Enhances Community Recreational Opportunities	Limited Time Until Benefits Realized
			Carrying Capacity Modification																				
			Flow Adjustments																				
14	Retention/Detention	Structural																					
15	Dry Dam/Detention	Structural																					
16	Wetland Creation/Large Scale Rain Gardens	Structural																					
13	Underground Storage	Structural																					

Resulting Rank/Score			Completeness				Effectiveness						Efficiency					Acceptability					
			Minimizes Risk to the Community	Minimizes Impacts of Flooding	Incorporates upstream future actions	Eliminates Potential for Residual Risk	Reduces Flooding Greater than 0.2% Annual Probability Event	Reduces Flooding Greater than 1% Annual Probability Event	Reduces Flooding Greater than 10% Annual Probability Event	Reduces Flooding Greater than 50% Annual Probability Event	Project Does not Induce Unmitigated Flooding Upstream or Downstream of Project	Passive System (does not require human intervention outside of normal operation and maintenance)	Potential Damages Avoided exceed Implementation Cost	Provides Benefits to the General Public	Directly Reduces Community's Financial Response to Flooding	Improves conditions at multiple areas	Provides Benefits other than FRM (ecosystem)	No Adverse Environmental Impacts	Likely to be Permitable based on existing Laws	Acceptable to Community Officials	Meets USACE Definition for FRM (versus Stormwater Management	Enhances Community Recreational Opportunities	Limited Time Until Benefits Realized
		Carrying Capacity Modification																					
10	Stormwater Controls	Non Structural																					
3	Porous Pavement	Green Infrastructure																					
2	Residential Rain Gardens	Green Infrastructure																					
2	Rain Barrel	Green Infrastructure																					
4	Bio-swale	Green Infrastructure																					

Resulting Rank/Score			Completeness				Effectiveness						Efficiency					Acceptability					
			Minimizes Risk to the Community	Minimizes Impacts of Flooding	Incorporates upstream future actions	Eliminates Potential for Residual Risk	Reduces Flooding Greater than 0.2% Annual Probability Event	Reduces Flooding Greater than 1% Annual Probability Event	Reduces Flooding Greater than 10% Annual Probability Event	Reduces Flooding Greater than 50% Annual Probability Event	Project Does not Induce Unmitigated Flooding Upstream or Downstream of Project	Passive System (does not require human intervention outside of normal operation and maintenance)	Potential Damages Avoided exceed Implementation Cost	Provides Benefits to the General Public	Directly Reduces Community's Financial Response to Flooding	Improves conditions at multiple areas	Provides Benefits other than FRM (ecosystem)	No Adverse Environmental Impacts	Likely to be Permitable based on existing Laws	Acceptable to Community Officials	Meets USACE Definition for FRM (versus Stormwater Management	Enhances Community Recreational Opportunities	Limited Time Until Benefits Realized
			Carrying Capacity Modification																				
			Property Protection																				
15	Elevation	Non-Structural																					
15	Floodplain Evacuation\Acquisition	Non-Structural																					
15	Levee/Floodwall	Structural																					

Resulting Rank/Score			Completeness				Effectiveness						Efficiency					Acceptability					
			Minimizes Risk to the Community	Minimizes Impacts of Flooding	Incorporates upstream future actions	Eliminates Potential for Residual Risk	Reduces Flooding Greater than 0.2% Annual Probability Event	Reduces Flooding Greater than 1% Annual Probability Event	Reduces Flooding Greater than 10% Annual Probability Event	Reduces Flooding Greater than 50% Annual Probability Event	Project Does not Induce Unmitigated Flooding Upstream or Downstream of Project	Passive System (does not require human intervention outside of normal operation and maintenance)	Potential Damages Avoided exceed Implementation Cost	Provides Benefits to the General Public	Directly Reduces Community's Financial Response to Flooding	Improves conditions at multiple areas	Provides Benefits other than FRM (ecosystem)	No Adverse Environmental Impacts	Likely to be Permitable based on existing Laws	Acceptable to Community Officials	Meets USACE Definition for FRM (versus Stormwater Management	Enhances Community Recreational Opportunities	Limited Time Until Benefits Realized
			Carrying Capacity Modification																				
5	Floodplain Management	Non-Structural																					

Table 3 - Plan Formulation Workshop Summary

4.7 MANAGEMENT MEASURE SCREENING

The four primary criteria used to screen the measures included completeness, effectiveness, efficiency and acceptability, as described below.

Completeness – Completeness is defined as the extent to which an alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of all planned effects. The measures' completeness was evaluated based on the following criteria:

- Minimizes Risk to the Community
- Minimizes Impacts of Flooding
- Incorporates Future Local Actions
- Reduces Potential for Residual Risk

Effectiveness – Effectiveness is defined as the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities, as established in the planning objectives. The measures' effectiveness was evaluated based on the following criteria:

- Reduces flooding in the project area for various flood frequencies
- Does not induce unmitigated flooding upstream or downstream of the project
- Does not require human intervention outside of normal operation and maintenance

Efficiency – Efficiency is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities as established in the planning objectives, consistent with protecting the nation's environment. The measures' efficiency was evaluated based on the following criteria:

- Potential damages avoided exceed implementation cost
- Provides benefits to the general public
- Directly reduces communities' financial response to flooding
- Improves conditions at multiple areas

Acceptability – Acceptability is the workability and viability of the alternative plan with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies. The measures' acceptability was evaluated based on the following criteria:

- No adverse environmental impacts, or if necessary, minimal impacts
- Likely to be permitted based on existing laws
- Plan feasibility, related to technical, economic, financial, environmental, social, political, legal and institutional factors
- Meets USACE definition for FRM (versus stormwater management)
- Limited time until benefits realized

Based on initial measure screening, the following measures were not carried forward for detailed analysis:

- Inlet Modifications – This measure was not carried forward based on a lack of acceptability because inlet modifications are considered to be stormwater management for local stormwater systems, which does not meet the USACE definition for FRM.
- Reconnection of Floodplains & Riparian Buffer – This measure was eliminated based on its limited effectiveness. Given the highly urbanized/developed nature of the watershed, there was very little land available to implement such a measure for effective FRM.
- Floodplain Management – Floodplain management seeks to regulate floodplain uses to minimize current and future damages by controlling construction activities and land use. Based on the highly urbanized nature of the floodplain, it would not be an effective measure due to the limited opportunity for floodplain management to effectively address the existing flood inundation problems.
- Flood Warning – The fundamental objective of a flood warning and preparedness program is to alert residents and thereby save lives and reduce property damages by allowing the removal of items from the floodplain. In this case, drainage area characteristics result in a rapid rise of Tookany Creek waters and thereby there would be little time for homeowners to take effective protective action.
- Underground Storage Areas – Underground storage was not carried forward based on a lack of efficiency or cost effectiveness. Based on the anticipated construction costs for underground storage areas, it was determined that the potential implementation cost would exceed the value of damages avoided.
- Stormwater Controls – This measure was not carried forward based on a lack of acceptability because it is considered an administrative and maintenance program that would fall outside of the USACE definition for FRM.
- Porous Pavement, Residential Rain Gardens, Rain Barrels & Bio-swales – While these are great measures to increase infiltration, improve water quality and capture the "first flush" from frequent storm events, they lack the completeness and effectiveness necessary to provide a large volume or peak flow rate reduction. These particular measures do not typically store large volumes of runoff for less frequently occurring events.

4.8 ADDITIONAL SCREENING OF FLOOD CONTROL MEASURES

The measures carried forward for more detailed analysis included: bridge modifications (structural), channel modifications (structural), aboveground storage areas (structural), flood proofing (non-structural), floodplain evacuation/acquisition (non-structural), and elevation (non-structural).

4.8.1 STRUCTURAL MEASURES

BRIDGE MODIFICATIONS: Multiple existing bridges and culverts span Tookany Creek throughout Cheltenham Township. The vast majority of these crossings affect the movement of water by constricting flows at the crossing, resulting in elevated WSEs upstream of the bridge that can negatively impact infrastructure, residences and various properties. Bridge

modifications to alleviate the constricted flows were evaluated and compared against the without project conditions.

Bridge modifications consist of raising, removing, or replacing existing bridges in order to alleviate backwater effects. Three bridges/culverts were removed from the GSSHA model geometry and compared against the without project conditions to determine their potential consequences. These included the Easton Road culvert, the SEPTA 11.22 culvert, and the Rock Creek culvert at Widener Road, as shown on Figure 7.

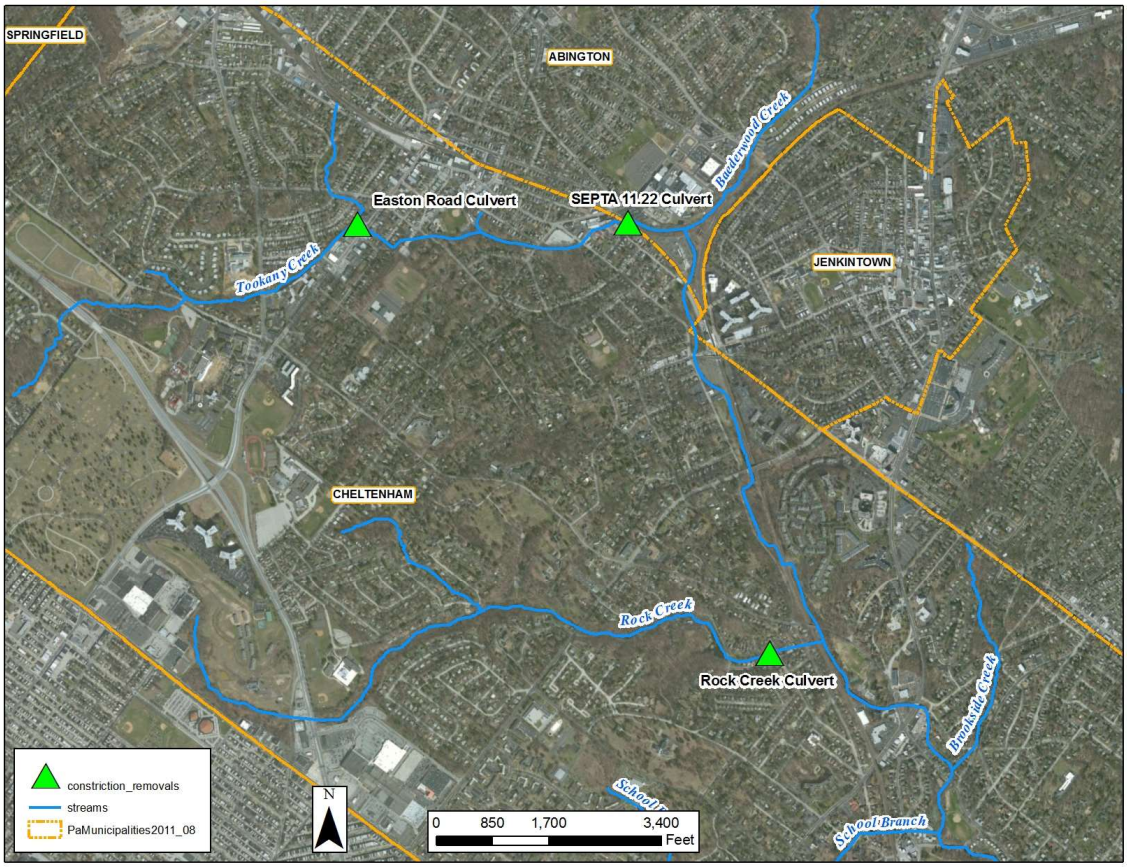


Figure 5 - Constriction Removal Measures

While alleviating the hydraulic constrictions via bridge modifications could potentially lead to a significant reduction in the upstream WSE, it doesn't reduce the downstream flooding due to prevailing subcritical flow conditions. In fact, it may actually increase downstream flow rates and WSEs. Given the potential cost of bridge modification and the potential to induce downstream flooding, bridge modification was not carried forward for further analysis.

CHANNEL MODIFICATIONS:

- New Levee/Floodwall: Levees and floodwalls are types of FRM barriers. A levee is typically a compacted earthen structure; a floodwall is an engineered structure usually built of concrete, masonry, or a combination of both.

Land requirements necessary to construct floodwalls or levees around each structure, or multiple structures, are greater than what is available. Additionally, the need for human intervention to close any openings such as a driveway makes this alternative less desirable. Furthermore, one of the planning constraints in this study is to avoid and minimize adverse impacts to in-stream or adjacent native habitat; however, levees create adverse environmental impacts by disconnecting the stream from the adjacent floodplain.

Additional consideration was given in terms of evaluating potential new levee construction based on parametric cost estimates contained in the North Atlantic Coast Comprehensive Study (NACCS). The NACCS estimated a total first construction cost of $8,333,329 per mile of levee construction. This assumes levees of 6 to 16 feet high, which is consistent with the existing levee along Brookdale Avenue. The mainstem of Tookany Creek within the study area is in excess of 6 miles in length (12 miles assuming levee construction on both sides of the creek). Assuming 1% ACE protection, the projected annual benefit is $1,600,120. In order to have positive net benefits, the recommended plan would need to include approximately 3.9 miles or less of levee construction. Considering the existing conditions within the community, levee construction was not considered cost effective as more than 3.9 miles of levee would be required to provide protection for the community.

Therefore, this measure was screened out based on efficiency (not cost effective).

- Raise Levee(s): As part of the alternative evaluations, consideration is often given to the applicability of increasing the height of existing levees and floodwalls as this typically has the least impact on existing real estate and minimal adverse environmental impact.

  Raising a levee could also require raising several downstream bridges adding greatly to the complexity of the design and construction of the project, and significantly increase the cost. Another consideration is that this would simply move the flooding downstream causing damage in areas that currently do not experience problems. In addition, as the height of a levee or floodwall increases, so does the depth of water that can build up behind it. Greater depths result in greater water pressures, so taller levees and floodwalls must be designed and constructed to withstand the increased pressures. Meeting this need for additional strength greatly increases the cost of the levee or floodwall.

  The project team evaluated a third-party design for a raised levee alternative along Brookdale Ave and determined this alternative was not cost effective from a Federal benefit-cost basis. As way of background, there is one existing levee in this study area. The approximately 1,000-ft long levee protects a single neighborhood within the community and represents less than 20% of the structures subject to flooding from the 1% AEP. Existing condition modeling estimates the levee currently manages flood risk associated with storms varying between a 50-year (2% AEP) and 100-year (1% AEP) event. The project team screened out this alternative prior to completing a

detailed economic analysis due to the limited additional FRM benefits that could be provided in a small subset of the study area.

ABOVEGROUND STORAGE AREAS: The storage areas considered during the plan formulation process included surface water detention and retention basins. Each type of basin is intended to allow large surface water flows to enter, while limiting and controlling the rate of release to downstream receiving waters. Essentially, the basins function to temporarily hold back the peak flow during storm events and slowly release the ponded water to the downstream receiving waters.

The primary difference between detention and retention basins is that retention basins have a permanent pool of water, while detention basins only contain standing water during flood events. For the purposes of this study, retention basins were eliminated from further consideration based on the following:

- A permanent pool of water reduces the flood storage capacity of the basin (effectiveness)
- There are potential public safety issues with a permanent pool of water
- There are potential vector issues associated with standing water in a permanent pool of water (acceptability)

Detention basins are areas installed on or adjacent to tributaries of rivers, streams, lakes or bays to provide FRM and in some cases protect against downstream erosion by storing water for a limited period of time. These basins are often called "dry ponds," "holding ponds" or "dry detention basins" since no permanent pool of water exists.

During site visits and subsequent review of aerial imagery, thirteen (13) potential dry detention basins locations were initially identified. Potential basin locations were identified based on their potential to provide beneficial flow reductions while also minimizing required excavation or construction. In addition, these locations had an added environmental benefit because the poorly draining and hydric soil in these areas provided excellent places for potential wetlands. The 13 basins were divided into four major groups based on their location within the watershed:

- Upper Tookany Creek Basins – Doe Lane, West Waverly Road, Church Road, Limekiln Pike and Grove Park
- Middle Tookany Creek Basins – George Perley Bird Sanctuary and Highland/Mt. Carmel
- Baederwood Creek Basins – Baeder Road, Highland East and Highland West
- Rock Creek Basins – Washington Lane, Greenwood and Limekiln/Ogontz

Based on the potential for dry detention basins to effectively and efficiently reduce storm damages by temporarily hold back the peak flow during storm events and slowly release the ponded water to the downstream receiving waters, they were retained for additional formulation and screening.

4.8.2 NON-STRUCTURAL MEASURES

Preliminary nonstructural measures were considered in the study area. Specifically, floodplain evacuation or buy-out analysis was undertaken for the structures that were surveyed as most probable to meet the USACE requirements as outlined in IWR Report 2013-R-5, Flood Risk Management. Floodproofing and structure elevations were also considered but were screened out using semi-quantitative analysis.

For floodproofing, as the majority of structures are residential with a high variability in structure construction and probability of effective maintenance, it was considered unlikely that wet- or dry-floodproofing could consistently provide FRM benefits to the study area. Specifically, it was considered unlikely that the majority of residential structures could implement an effective dry-floodproofing solution that would withstand the increase in hydrostatic pressure when flood waters are prevented from entering the structure. Wet-floodproofing for these same structures was expensive and not expected to greatly reduce inundation damages, suggesting it is highly cost inefficient. Dry- or wet-floodproofing non-residential structures is more likely to result in an effective reduction of inundation damages, but individually floodproofing each non-residential structure was not cost efficient compared to a more comprehensive structural FRM approach. Given the significant cost of the measures and unlikelihood of defensible FRM benefits, the measures were screened from further consideration.

Structure elevations for residential buildings is an effective method of reducing inundation damages, but the high cost per structure compared against the average depreciated replacement value (DRV) per structure suggested implementation of the measure to have a low probability of economics viability. The average residential DRV (FY21 Price Level) in the study area is $188,000 and the approximate average elevation cost for residential structures (according to the North Atlantic Coast Comprehensive Study (NACCS)) is $219,000. As the implementation cost would likely be greater than the entire value of the residential inventory, the measure was screened out as cost inefficient. It is likely that some residential structures within the inventory have positive net benefits when evaluating elevations, but only elevating these structures, and not mitigating flood risk for the other residential structures in the inventory, would result in significant residual damages in the FWP condition. When compared to a more comprehensive structural measure that has a similar unit cost but greatly reduced residual damages, nonstructural elevations are shown not to be a viable alternative in this area.

For commercial structures, the average DRV is higher than their residential counterparts, but the anticipated elevation cost, and associated difficulties, also increase. Commercial structures in the study area are, on average, larger and taller than residential counterparts. Increasing costs and introducing new difficulties such as maintaining American with Disabilities Act (ADA) compliance or replacing existing utility infrastructure when the structure is no longer near ground elevation.

Floodplain evacuation, or acquisition, is a measure that involves permanently removing (buying out) structures from the floodplain and restricting future development on the land. As with floodproofing and elevations, this measure is typically prohibitively expensive for densely populated neighborhoods (such as the study area) as smaller structural measures on the source of inundation are typically more cost efficient. With an average DRV of $188,000, the market

value (including land value) would approach $400,000 per structure. That means acquiring the 203 residential structures would cost an estimated $80,000,000. While focusing acquisition on only the high-risk structures would drive down the cost, it also significantly raises residual damages compared to the comprehensive acquisition plan. Any structures not deemed eligible for acquisition would continue to receive damage and inundation would continue to affect the roads and neighborhoods in the study area. As non-residential structures are estimated at even higher average market values than compared to residential structures, the estimated measure cost would rise significantly above $80 million.

For both residential and non-residential structures, nonstructural measures (elevation / floodproofing / acquisition) are not effective nor efficient alternatives for managing flood risk in this study area.

5.0 ALTERNATIVE ANALYSIS

After completing the measure screening process, it was determined that dry detention basins would offer the best reduction in storm damages for the study area and the PDT continued to formulate alternative plans with different combinations of dry detention basin measures.

As referenced above, 13 potential basins were divided into four major groups based on their location within the watershed:

- Upper Tookany Creek Basin Group – Doe Lane, West Waverly Road, Church Road, Limekiln Pike and Grove Park
- Middle Tookany Creek Basin Group – George Perley Bird Sanctuary and Highland/Mt. Carmel
- Baederwood Creek Basin Group – Baeder Road, Highland East and Highland West
- Rock Creek Basin Group – Washington Lane, Greenwood and Limekiln/Ogontz

The dry detention basin groups were screened by the project team to determine what basins or combination of basins would provide the greatest FRM benefits. Initially, the basins in the Middle Tookany Group were screened out based on limited effectiveness, efficiency and acceptability. Specifically, hydrologic results from the GSSHA model indicated that the George Perley Bird Sanctuary basin location had a relatively small storage capacity versus the upstream drainage area. This basin would have minimal effectiveness because it would likely fill up prior to the arrival of the peak flow; therefore, the peak flow would simply pass over/through the storage area with little or no attenuation. At the Highland-Mt. Carmel basin location, basin construction may necessitate the removal of a large portion of the adjacent park and the SPS parking lot. In addition, to provide sufficient storage relative to the upstream drainage area, substantially tall and long floodwalls would need to be placed along numerous bordering properties. Not only would this concept have public acceptability challenges, but also such floodwalls would be costly and present potential safety hazards.

Within the Rock Creek basin group, the Limekiln-Ogontz and Greenwood storage areas were screened out as well. The Limekiln-Ogontz storage area may not be acceptable because there is a potential development project occurring within the proposed footprint of this basin. Initially, the PDT did not screen the Limekiln-Ogontz storage area out based on the

acceptability/development issue; however, there is a PWD CSO outfall that daylights adjacent to the proposed Limekiln-Ogontz storage area, which would present potential environmental and construction issues and ultimately resulted in the PDT screening out this storage area. The Greenwood storage area would not be efficient or effective because it not only has a small footprint, but also it receives water from a very small drainage area.

After initially screening out the Middle Tookany Creek Basin Group and two of the three dry detention basins in the Rock Creek Basin Group, the remaining nine basins were carried forward for more detailed analysis. The Upper Tookany Basin Group, the Baederwood Creek Basin Group and the Rock Creek Basin Group (Washington Lane only) were each evaluated as individual systems by routing water through the basins and examining the flow reduction at their outlet and further downstream. In addition, the basin systems were evaluated in series through various basin system combinations.

Based on the measure combinations, 5 different action alternatives and 1 no-action alternative were compared and evaluated to determine the National Economic Development (NED) plan:

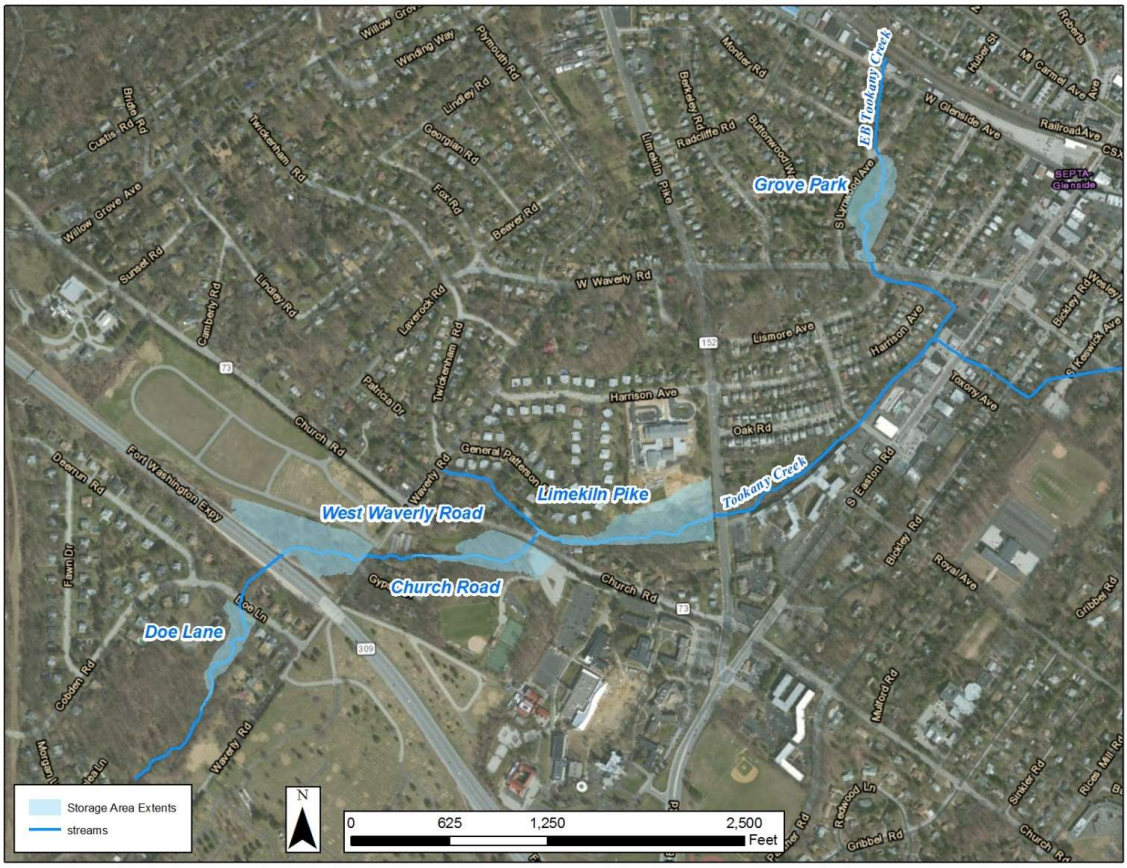
- Alternative 1: No Action Plan
- Alternative 2: The Upper Tookany Creek Plan
- Alternative 3: The Tookany/Baederwood/Rock Creek Plan
- Alternative 4: The Baederwood Creek Plan
- Alternative 5: The Rock Creek Plan
- Alternative 6: The Tookany/Rock Creek Plan

Alternative 1: No Action Plan
The No Action Plan excludes measures to provide FRM; this alternative would not check the continuing FRM problems in the study area. With no action, the study area would continue to see without project damages of $2,291,000 for the economic period of analysis between 2024-2073.

Action Alternatives:
Each action alternative includes dry detention basin locations. These basins are low-lying, open-space areas that would require minimal excavation and construction costs to store water; therefore, the reduced excavation will not only improve the project economics, but also help to minimize environmental and cultural impacts. Instead of large-scale excavation, an embankment will be constructed on the downstream end of the dry detention basin to capture and control flows. Such a structure will include interlocked gabion baskets and earthen material that allow flows up to a non-damaging level to pass unimpeded. As the inflow rate increases, flow through the gabion basket conduit structure will be "choked" and a pool will start to form behind the embankment. Once the downstream flows have returned to a low level and inflows have dropped, the stored water will be slowly released through the conduit and everything will return back to pre-storm conditions.

Alternative 2: The Upper Tookany Creek Plan

The Upper Tookany Creek Plan was developed to primarily provide FRM benefits to neighborhoods in Glenside (i.e. Harrison Ave, Bickley Road, Brookdale Ave). Five potential storage basins were evaluated at different scales/combinations: Doe Lane, West Waverly Road, Church Road (Arcadia University), Limekiln Pike and Grove Park. The first combination (D1) included all five basins functioning as a system. The other Upper Tookany system combination (D28) only included Doe Lane, West Waverly Road and Grove Park. WSEs for various storm events were quantified with HEC-RAS for each combination. Based on preliminary costs for each combination and the projected WSE impacts, BCRs and potential net benefits were calculated with HEC-FDA for each combination. Both Upper Tookany Creek combinations were screened out because they did not yield positive net benefits or a BCR greater than 1.0.



***Note: Basin Footprints Subject to Modification, pursuant to Real Estate Considerations and Additional Design**

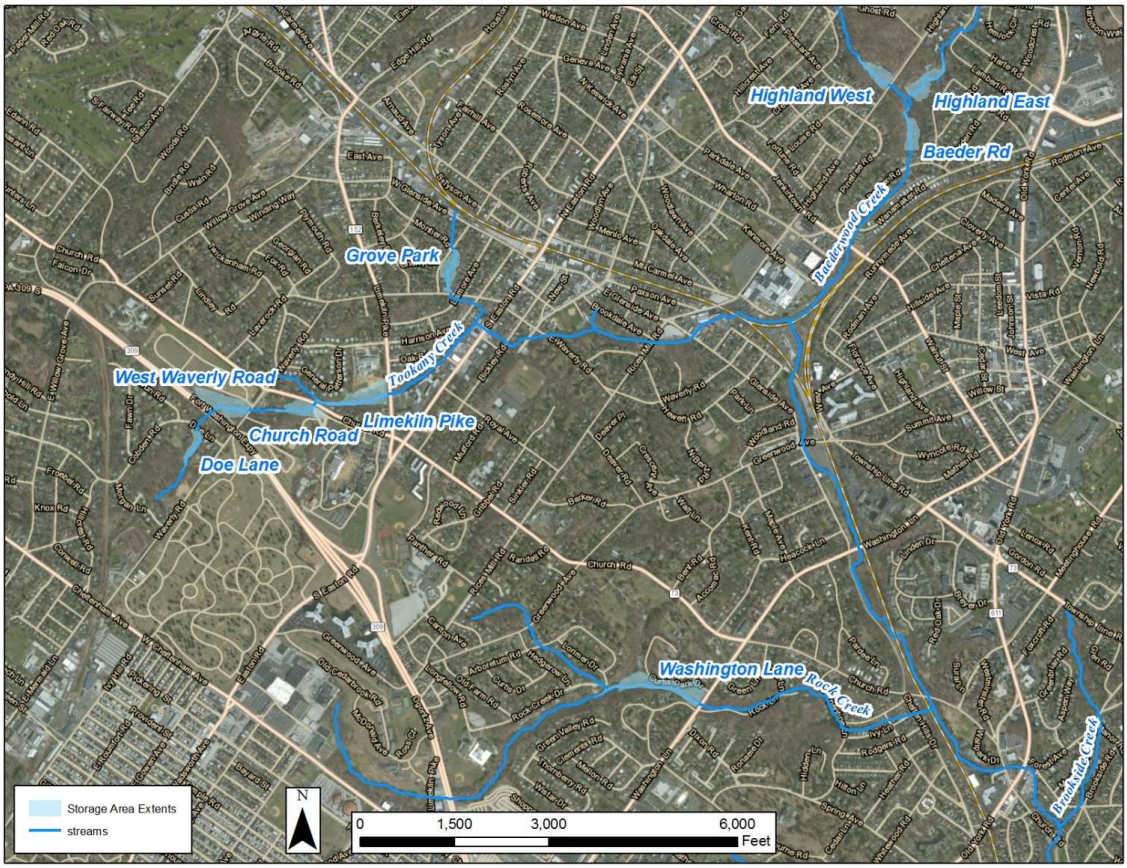
Figure 6 - Five Basins Considered in Upper Tookany Plan (Alternative 2)

Alternative 3: The Tookany/Baederwood/Rock Creek Plan

The Tookany/Baederwood/Rock Creek Plan was intended to be an all-encompassing grouping developed to provide FRM benefits to a greater degree as well as to a greater extent (further downstream) than individual basins or smaller sub-group storage areas. Nine potential storage areas were evaluated at different scales/combinations: Doe Lane, West Waverly Road, Church Road (Arcadia University), Limekiln Pike, Grove Park, Highland West, Highland East, Baeder

Road and Washington Lane. The first combination (D27) included all nine basins functioning as a system. The other combination (D30) only included Doe Lane, West Waverly Road, Grove Park, Highland West and Washington Lane.

Per ER 1105-2-100, the Tookany/Baederwood/Rock Creek Plan(s) were screened out based on the acceptability criteria, as it relates to the plan implementability. Specifically, the proposed plans include detention basins located on Baederwood Creek in the neighboring Township of Abington. The non-Federal sponsor for this FRM study is the Township of Cheltenham. As the non-Federal sponsor is responsible for all real estate requirements, necessitating that the non-Federal sponsor acquire real estate outside of its legal jurisdiction is not an implementable alternative. As the alternative plans are not implementable, they cannot be deemed acceptable and are therefore infeasible. As infeasible plans should not be carried forward for further consideration, any alternative plans that require detention basins in Abington Township were removed from further investigation.



***Note: Basin Footprints Subject to Modification, pursuant to Real Estate Considerations and Additional Design**

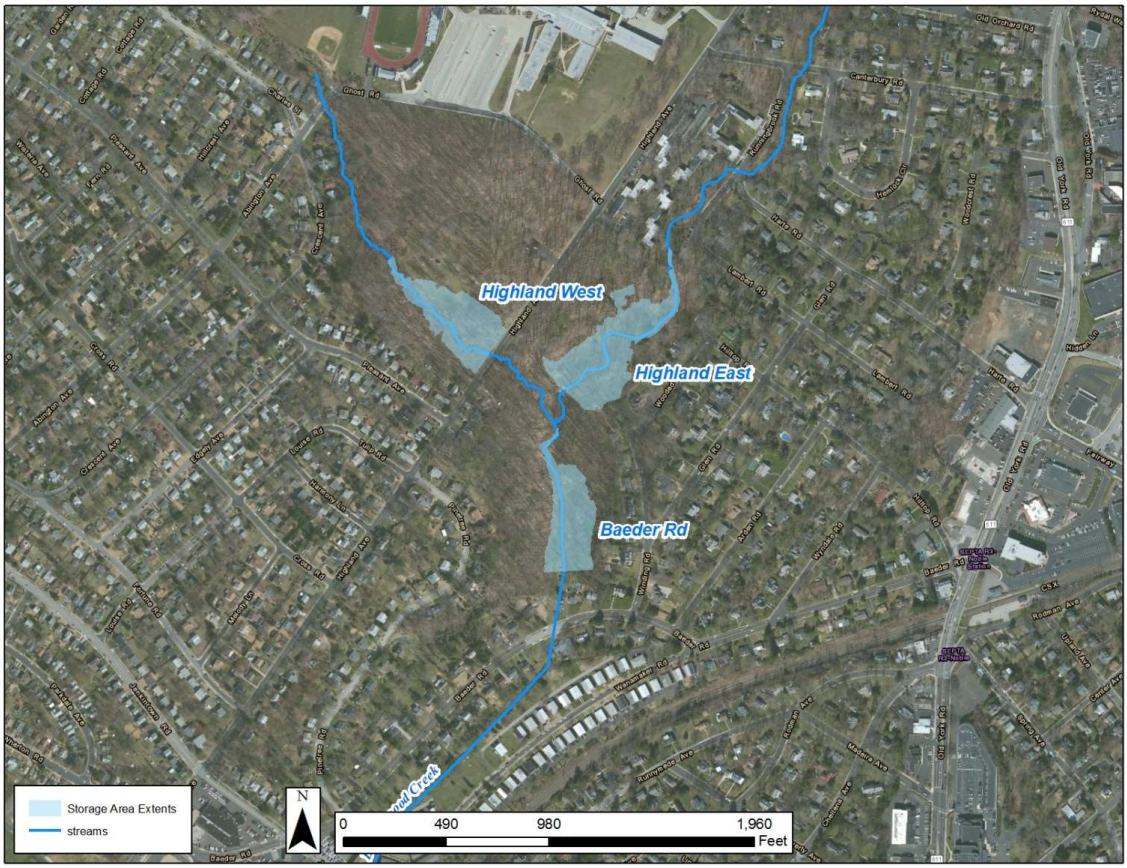
Figure 7 - Nine Basins Considered in Tookany/Baederwood/Rock Creek Plan (Alternative 3)

Alternative 4: The Baederwood Creek Plan

The Baederwood Creek Plan was developed to provide FRM benefits to neighborhoods along Tookany Creek below the Baederwood Creek confluence (i.e. Cliff Terrace neighborhood). Three potential storage basins were evaluated at different scales/combinations: Highland

West, Highland East and Baeder Road. Each storage area in this group is entirely located within Abington Township.

The first combination (D9) included all three basins functioning as a system. The other Baederwood Creek combination (D12) only included the Highland West dry detention basin. As was the case with the Tookany/Baederwood/Rock Creek Plan(s), the proposed Baederwood Creek Plans included detention basins located on Baederwood Creek in the neighboring Township of Abington. Therefore, these plans were also deemed infeasible, based on the acceptability criteria in ER 1105-2-100 and were not carried forward for further consideration.

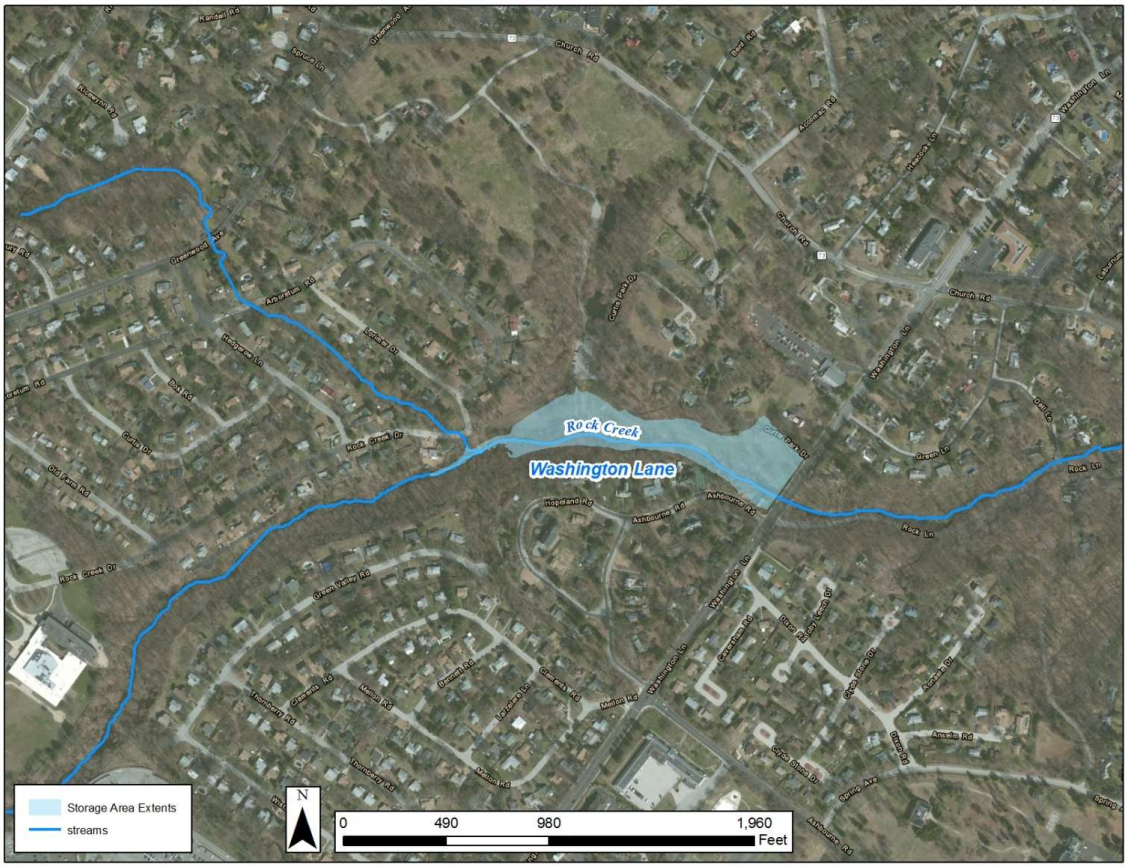


***Note: Basin Footprints Subject to Modification, pursuant to Real Estate Considerations and Additional Design**

Figure 8 - Three Basins Considered in Baederwood Creek Plan (Alternative 4)

Alternative 5: The Rock Creek Plan

The Rock Creek Plan (Alternative 5) was developed to provide FRM benefits to neighborhoods along Rock Creek and Tookany Creek below the Rock Creek confluence (i.e. Rock Lane, Shoemaker Road, Brookside Road, High School Road, Mill Road). Alternative 5 consists of one dry detention basin along Rock Creek (a tributary to Tookany Creek): Washington Lane. Based on preliminary costs for Alternative 5 and the projected WSE impacts, BCRs and potential net benefits were calculated with HEC-FDA. The Rock Creek Plan yielded a BCR greater than 1.0 with positive net benefits; therefore, it was carried forward for further analysis.

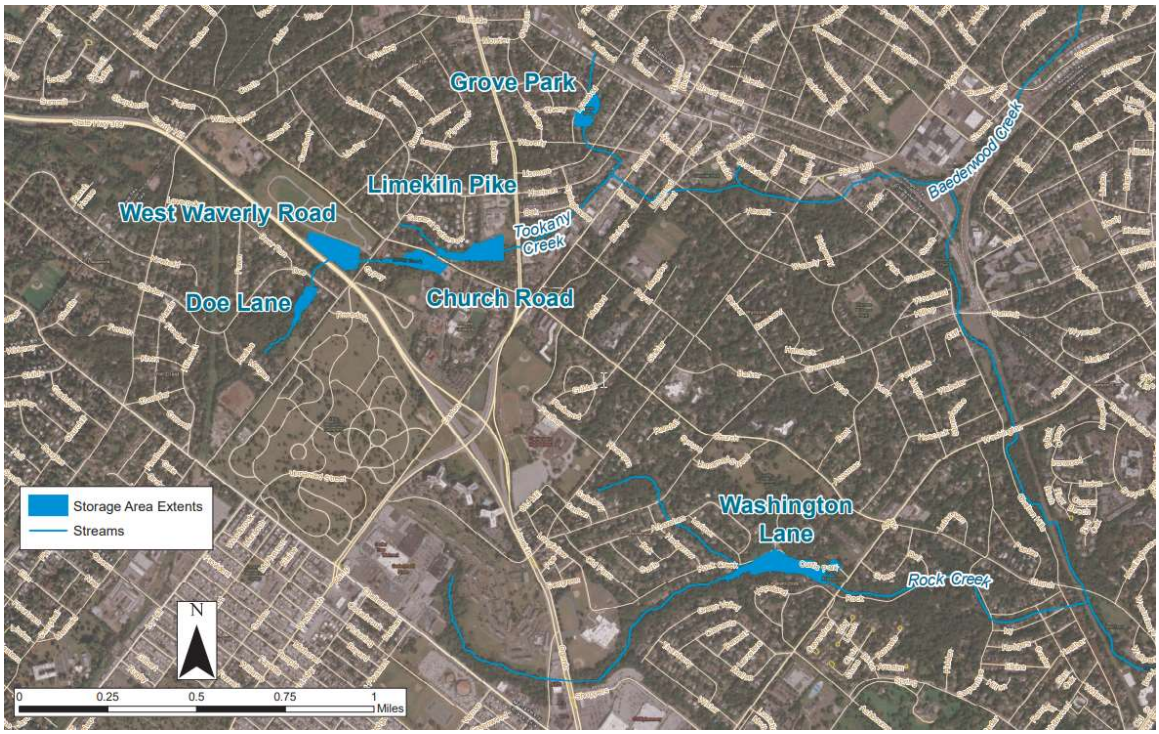


***Note: Basin Footprints Subject to Modification, pursuant to Real Estate Considerations and Additional Design**

Figure 9 - One Basin Considered in Rock Creek Plan (Alternative 5)

Alternative 6: The Tookany/Rock Creek Plan

The Tookany/Rock Creek Plan (Alternative 6) was developed to provide FRM benefits to neighborhoods in Glenside (i.e. Harrison Ave, Bickley Road, Brookdale Ave) and neighborhoods along Rock Creek and Tookany Creek below the Rock Creek confluence (i.e. Rock Lane, Shoemaker Road, Brookside Road, High School Road, Mill Road). It consists of 6 basins located within Cheltenham Township, PA (Doe Lane, West Waverly Road, Church Road (Arcadia University), Limekiln Pike, Grove Park and Washington Lane). Based on preliminary costs for each combination and the projected WSE impacts, BCRs and potential net benefits were calculated with HEC-FDA. The Tookany/Rock Creek Plan yielded a BCR greater than 1.0 with positive net benefits; therefore, it was carried forward for further analysis.



***Note: Basin Footprints Subject to Modification, pursuant to Real Estate Considerations and Additional Design**

Figure 10 - Six Basins Considered in the Tookany/Rock Creek Plan (Alternative 6)

Based on the aforementioned preliminary screening results, Alternative 5 and the Alternative 6 were carried forward for detailed economic analysis via HEC-FDA 1.4.2. As discussed in the economics appendix, twelve separate economic reaches were delineated for Tookany Creek and one reach was delineated for Rock Creek to evaluate plan FRM performance. Reaches were delineated based on economic and hydraulic & hydrologic criteria. All thirteen reaches were analyzed using both left and right bank orientation. The projected performance of each plan is summarized on the table below.

Table 4 - Comparison of Alternative Performance

Reach	Description	Without Project Damages	With Project Damages (Alternative 5)	With Project Damages (Alternative 6)
TC-1	Country Club	$0	$0	$0
TC-2	Cheltenham SEPTA Station	$36,000	$36,000	$33,000
TC-3	Cheltenham & Tennis Courts	$258,000	$258,000	$255,000
TC-4	Cheltenham High School	$227,000	$227,000	$216,000
TC-5	Harrison Ave Baseball Fields	$34,000	$34,000	$33,000
TC-6	Ogontz Field	$268,000	$268,000	$252,000
TC-7	Elkins Park Free Library	$743,000	$743,000	$728,000
TC-8	Wall Park & Beth Sholom Congregation	$7,000	$7,000	$6,000
TC-9	Glenside US Post Office	$12,000	$12,000	$10,000
TC-10	Wyncote	$136,000	$136,000	$91,000
TC-11	Harry Renninger Park	$125,000	$125,000	$77,000
TC-12	Easton Rd	$236,000	$236,000	$131,000
RC-1	Chelten Hills	$209,000	$140,000	$100,000
TOTAL	**-**	**$2,291,000**	**$2,222,000**	**$1,933,000**
REDUCED	**-**	**$0**	**$69,000**	**$359,000**

All reaches on Tookany Creek in Alternative 5 (TC-8 through TC-12) are identical to the future without project condition (i.e., no reduction in damages). Total average annual benefits for the Alternative 5 are approximately $69,000, while average annual benefits for Alternative 6 are approximately $359,000. The average annual net benefits for Alternative 6 are approximately $38,000.

Alternative 6 experiences significant inundation damage reduction in Reach RC-1 as well as the northern Tookany reaches of TC-10, TC-11, and TC-12, with total average annual benefits of approximately $359,000. Alternative 5 has just one basin on Rock Creek and experiences all modeled inundation damage reduction in Reach RC-1. Also, there is no damage reduction

in the Tookany Creek reaches in Alternative 5 and less damage reduction than Alternative 6 on the Rock Creek Reach.

5.1 DESCRIPTION OF SELECTED PLAN

Alternative 6 (The Tookany/Rock Creek Plan) reasonably maximizes net national economic development (NED) benefits among the alternatives and is the selected NED Plan. This plan reduces peak flow rates and flood damages to a greater degree and extent than any other with project condition and has the greatest net economic benefits consistent with protecting the nation's environment.

The selected plan and its associated FRM structures will consist of an earthen embankment and rock filled gabion basket structure at each of the six proposed detention basins. The typical structure section consists of an upstream earthen embankment having a slope of three horizontal to one vertical, a 15-foot top width, and a terraced gabion basket wall along the downstream face. The box culvert passes flow until the capacity is exceeded and the embankment serves as an overflow weir when the impoundment fills up to overflowing. The earthen/gabion embankment is designed to be overtopped. For each site, the crest is proposed at a consistent elevation to allow the entire length of the embankment to act as a spillway. This maximizes storage capacity within the area behind the embankment while keeping water velocities over the structure as low as possible.

The structure is keyed into a foundation, such as solid rock, to prevent seepage and, as a minimum, provide a longer seepage path for any water that will pass along the perimeter of the key. The preliminary key trench dimensions consist of a six feet deep key with side slopes of one horizontal to two vertical. The key will have a width of five feet at the base, and an eleven-foot width at its widest point. The depth of the key trench was assumed to be six feet, however the actual depth will vary from site to site and will be based on depths to rock or depths to suitable sub-base material.

Dry detention basins may also include rain gardens within their footprint to provide ancillary ecosystem restoration benefits in addition to FRM. A rain garden is an excavated shallow surface depression planted with specially selected native vegetation to treat and capture runoff. Rain gardens can improve FRM through water quantity reduction (via evapo-transpiration and/or ground infiltration), while providing ancillary water quality benefits. Rain gardens also provide ecosystem restoration benefits by mimicking native ecosystems through species diversity, density and distribution of vegetation, and the use of native species, resulting in a system that is resistant to insects, disease, pollution and climatic stresses, while improving the basin aesthetics for the local community. It is important to note that rain gardens are not to be confused with constructed wetlands or wet ponds which permanently pond water. Rain gardens are best suited for areas with at least moderate infiltration rates (more than 0.1 inches per hour).

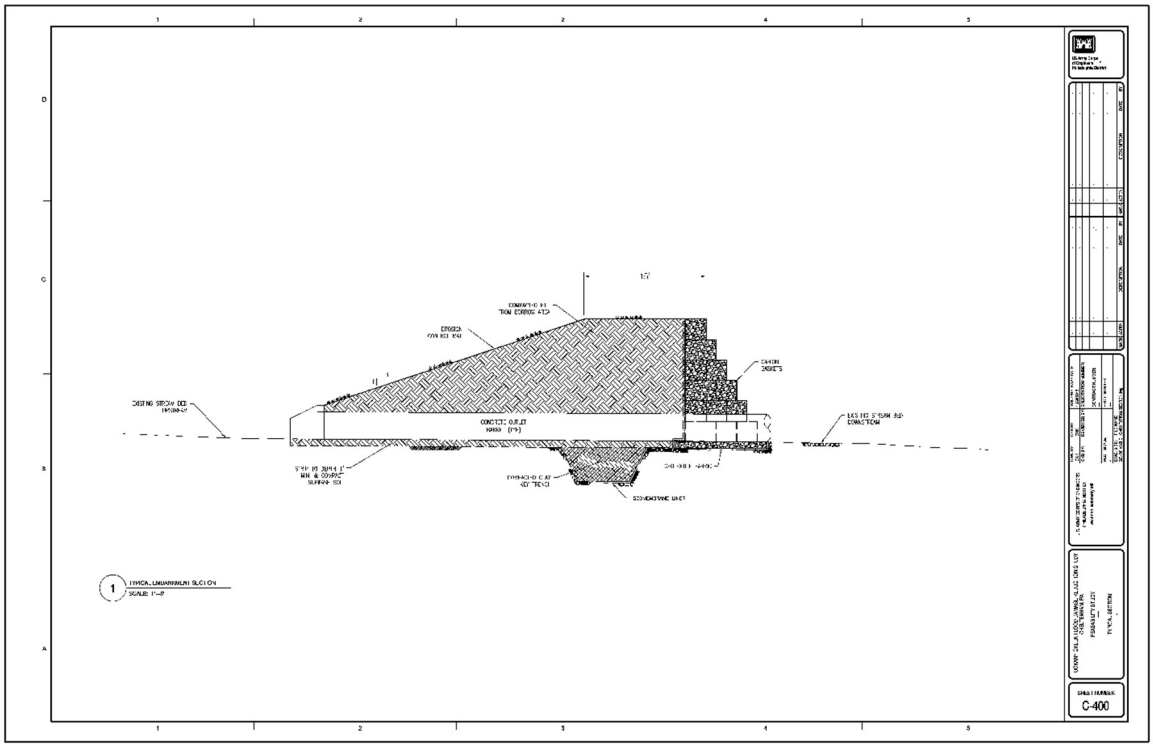


Figure 11 - Typical Dry Detention Embankment Cross Section

5.1.1 MITIGATION

There are approximately 0.25 acres of wetlands within the potential footprint of the proposed West Waverly Basin. During design and implementation, the embankment and associated dry detention basin footprint will be designed to avoid impacts to the existing wetlands to the greatest extent possible. If wetland impacts are determined to be unavoidable as the plan design progresses, coordination with the USFWS will be updated and potential mitigation in the form of wetland restoration within the West Waverly Basin will be completed to compensate for this loss. At this point in the feasibility-level analysis, no compensatory mitigation is required as part of the recommended plan.

5.1.2 DESIGN AND CONSTRUCTION CONSIDERATIONS

USACE recognizes that the non-Federal sponsor (Cheltenham Township) is committed to comprehensive flood mitigation and stormwater management as an essential public investment to provide critical FRM to the community including, but not limited to residential, commercial and non-taxable properties. This is an ongoing Township-wide effort that includes recognition of the Township's flood mitigation needs as well as identification of the most vulnerable/exposed areas (~36 locations) across the municipality. While this feasibility analysis has identified a plan to reduce flood-related damages in Cheltenham Township, it is only part of the Township's overall plan(s) for flood mitigation; therefore, continuous outreach/coordination between USACE and the Township is necessary to better inform the post-feasibility (D&I) plans and specifications (P&S) and associated implementation. Other design considerations to be monitored in the D&I phase include the following:

- Dry detention basins will be constructed using gabion baskets (backside – downstream facing) and earthen embankments (frontside – upstream facing). Conceptual designs for the 6 basins can be found in Appendix D.
- All excavated material will stay onsite and be used in construction of the embankments.
- An Environmental Data Resources (EDR) data search identified no known sources of HTRW for the proposed basin locations. Future testing will be conducted during the geotechnical subsurface investigation during the D&I phase.
- Additional clean material will need to be brought in for specific basins.
- Embankments will be planted with native grasses and shrubs for wildlife habitat and aesthetics.
- Dry detention basins will hold water for approximately 24 hrs (1% AEP or 100 year storm) before draining and the basin area returning to the normal creek width.
- Dry detention basins may also include rain gardens planted with native species within their footprint to provide ancillary ecosystem restoration benefits, as well as to improve the aesthetics of the basins to the local community. This additional work will be dependent on Federal and non-federal funding availability for the project.
- Box culverts used for each basin structure will be set at a low enough elevation that they will not impede fish and other aquatic species movement within the creek. In addition, bottomless or natural bottom culverts may be used within the detention structures. The applicability of "bottomless" culverts to the project will be determined in the next phase of the project design.
- All basins will have an appropriately sized low flow channel that mimics the natural stream channel as much as possible.
- The size of the basin will be site specific and each basin will be different in size.

5.1.3 LIFE SAFETY ANALYSIS

Feasibility studies that include existing and proposed levee systems and dams must take special care in evaluating the risk imposed by the infrastructure on the population downstream or in the leveed area, per Planning Bulleting PB 2019-04 (Incorporating Life Safety into Flood and Coastal Storm Risk Management Studies – June 2019). As referenced above, the recommended plan for this feasibility study includes a series of dry detention basins, which meet the criteria for the definition of a dam, as outlined in Chapter 1, Section 1.6 of ER 1110-2-1156. Therefore, USACE Philadelphia District (NAP) in coordination with the USACE Risk Management Center (RMC) conducted a risk assessment focusing on life safety and feasibility-level design considerations for the recommended plan (Appendix H).

A Tolerability of Risk Framework focusing on life safety and feasibility-level design considerations was established for the recommended plan. The Framework applied Tolerable Risk Guidelines (TRGs), as defined by PB 2019-04, to inform the degree and priority of federal investments and actions; to make recommendations on non-federal investment to others on the same basis; and to determine if the risk is tolerable. The TRGs included the following:

1. TRG 1 – Understanding the Risk
2. TRG 2 – Building Risk Awareness
3. TRG 3 – Fulfilling Daily Responsibilities
4. TRG 4 – Actions to Reduce Risk

In order to apply the above-referenced TRGs, NAP in coordination with the USACE Modeling Mapping Consequences (MMC) Production Center conducted a screening level consequence analysis to estimate the potential consequences of dam breaches associated with the recommended plan. Incremental consequences showed that while structures inundated, population at risk, and total damages increase slightly in a breach scenario, incremental median life loss for a failure during both day and night scenarios remains at zero. While a potential failure mode analysis was not conducted at this point in the study, NAP identified feasibility-level design considerations (dam stability, scour and seepage/piping) to be further evaluated during Design & Implementation and determined that the potential risk of higher construction costs (still below the CAP limit) is a more acceptable risk than terminating the project based on the current risk assessment on a feasibility-level design, which would result in no protection for the public in this area.

5.1.4 LERRD CONSIDERATIONS

The minimum estates required for this project are a Permanent Channel Improvement Estate for a permanent right of way on approximately 20.617 acres of land (Estate No. 8) and a Temporary Work Area Easement for a duration of two (2) years, the acreage of which will be determined in the future for staging, work and disposal areas (Estate No. 15). The NFS currently owns in fee approximately 7.08 acres of required land within the area required for the channel improvement easement. The additional area required for the channel improvement easement is approximately 13.53 acres of private, commercial and industrial parcels owned by approximately 39 owners. There are no Non-Standard Estates necessary for this project.

CHANNEL IMPROVEMENT EASEMENT (Estate No. 8)

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over, and across (that land described in Schedule A) (Tract Nos. _____) for the purposes as authorized by the Act of Congress approved _____, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions there from; to excavate, dredge, cut away and remove any or all said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT (Estate No.15)

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract Nos. ____), for a period not to exceed one (1) year, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a work area, including the right to move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the

construction of the Tookany Creek Flood Risk Reduction Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however to existing easements for public roads and highways, public utilities, railroads and pipelines.

5.1.5 OPERATION AND MAINTENANCE

Access to the site and necessary channel improvement easements will be required for maintenance. Comprehensive surveys are recommended to help determine access road placement and easement acquisitions. The project sites are located within Cheltenham Township, Montgomery County, PA and existing public city streets will be utilized for transportation of miscellaneous construction equipment and materials. The project site will require temporary construction easements within 15' of the earthen embankment/gabion structure. Permanent channel improvement easements will be required for the sponsor to perform future maintenance as required.

5.1.6 SELECTED PLAN ACCOMPLISHMENTS

At each dry detention basin location, the existing stream invert was designated as the invert of the regulating outlet. The regulating outlets were conceptualized to be of such a size to allow the maximum non-damaging discharge to pass through the embankment unimpeded. Once stream flows exceed the maximum non-damaging discharge, additional excess flows should be stored. This maximized the amount of flood control storage space available above each embankment during a large runoff event.

The recommended plan has Average Annual Benefits of $359,000 with the majority of benefits accrued in the Upper Tookany reaches (Reaches TC-10 to TC-12) and Reach RC-1 on Rock Creek.

5.1.6.1 RESIDUAL RISK

Damages reduced from high frequency storm events provide most of the NED benefits while low frequency storm event impacts constitute the majority of residual damages. The basins in the recommended plan are not designed to significantly minimize the damages of these low frequency, high impact events. Deeper or wider basins, designed for larger storm events, could not feasibly be constructed due to constraints on available footprints and significantly greater construction costs. As the six detention basins are not expected to have a large impact on flood risk reduction in the Lower Tookany reaches, residual damages for those areas remain high. These residual damages range from 98.8% in Reach TC-3 to 83.7% in Reach TC-8 (see Table 5 and figure below). As all six detention basins are located on the Upper Tookany and Rock Creek, reaches in these areas experience the least residual risk. Reaches farther downstream from the detention basins experience little flood risk damage reduction.

Table 5 - Summary of Residual Risk

Stream	Reach	Without-Project	With-Project	Reduced	Residual Risk
Rock	RC-1	$209,000	$100,000	$109,000	47.8%
Tookany	TC-1	$0	$0	$0	0.0%
	TC-2	$36,000	$33,000	$3,000	91.7%
	TC-3	$258,000	$255,000	$3,000	98.8%
	TC-4	$227,000	$216,000	$11,000	95.3%
	TC-5	$34,000	$33,000	$1,000	95.6%
	TC-6	$268,000	$252,000	$16,000	94.1%
	TC-7	$743,000	$728,000	$14,000	98.1%
	TC-8	$7,000	$6,000	$1,000	83.7%
	TC-9	$12,000	$10,000	$1,000	87.7%
	TC-10	$136,000	$91,000	$45,000	67.1%
	TC-11	$125,000	$77,000	$48,000	61.3%
	TC-12	$236,000	$131,000	$105,000	55.4%
Total	**-**	**$2,291,000**	**$1,933,000**	**$359,000**	**84.3%**

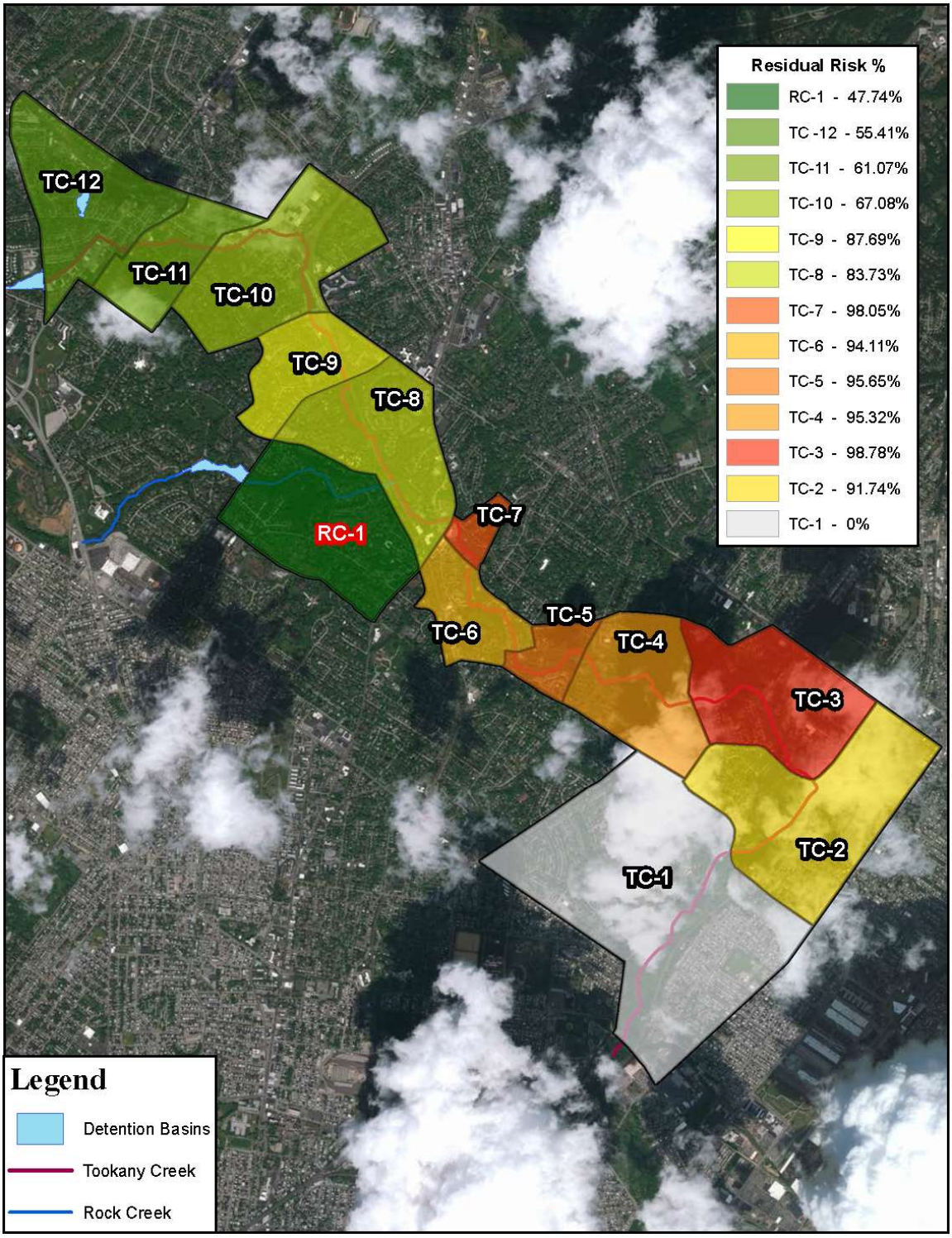


Figure 12 - Residual Risk by Reach

5.1.7 SUMMARY OF REGIONAL ECONOMIC, ENVIRONMENTAL & OTHER SOCIAL EFFECTS

The following table provides a narrative documenting how the Regional Economic Development, Environmental Quality and Other Social Effects were applied for the evaluation and display of effects of alternative plans.

Table 6 - Summary of System of Accounts

Other Social Effects (OSE)		
Resource Categories	**No Action Plan**	**Recommended Plan**
Aesthetics	No Impact	Temporary adverse impacts on sight and smell due to construction activities (equipment, earth moving) would disappear upon end of construction period
Displacement Effects	No Impact	No permanent displacement of people, businesses, or farms
Educational, Cultural, and Recreational Opportunities	No Impact	Permanent increase in availability of transportation routes during and after severe storm events. Increased level of protection prevents disruption of community services such as schools, hospitals, and utilities
Emergency Preparedness	No Impact	Permanent increase in access to reserves of water supplies, critical power supplies, scarce fuels, evacuation routes, and emergency transport to health facilities during/after storm events
Long-Term Productivity	No Impact	Negligible impact on long-term productivity of resources
Security of Life, Health, and Safety	No Impact	Significant mitigation of related health risks, such as loss of life, trauma, hypothermia, water & air pollution, water-borne diseases, vector-borne diseases (through ephemeral water bodies), and food & water supply disruption
Social Vulnerability	No Impact	Permanent reduction in flood hazard exposure for highly vulnerable populations identified in the Social Vulnerability Index*, including senior citizens, minorities, and persons in poverty
Regional Economic Development (RED)		
Employment Distribution	No Impact	Temporary increase in construction-related jobs during construction.
Fiscal Condition of State and Local Sponsor	No Impact	Permanent reduction in clean-up, emergency response, resource allocation, and other flood-related costs. Permanent increase in tax base of workers and businesses
Population Distribution and Composition	No Impact	Minimal temporary impact on population distribution or composition

Real Income	Loss of income and wages	Permanent increase in real income for below-poverty and near-poverty workers from temporary construction work.

Environmental Quality (EQ)		
Water Resources	No Impact	There are approximately 0.25 acres of wetlands within the potential footprint of the proposed West Waverly Basin. During design and implementation, the embankment and associated dry detention basin footprint will be designed to avoid impacts to the existing wetlands to the greatest extent possible. If wetland impacts are determined to be unavoidable as the plan design progresses, coordination with the USFWS will be updated and potential mitigation in the form of wetland restoration within the West Waverly Basin will be completed to compensate for this loss. At this point in the feasibility-level analysis, no compensatory mitigation is required as part of the recommended plan.
Air Quality	No Impact	Total estimated emissions that would result from construction of the Tookany Creek Flood Damage Reduction Project is 3.89 tons of NOx, 1.67 tons of VOC, and 0.34 tons of PM 2.5. These emissions are well below the General Conformity trigger levels of 100 tons of NOx and PM 2.5 and 50 tons of VOC per year, as confirmed in the Record of Non-Applicability (RONA).
Biological Resources	No Impact	A PNDI search run on the Pennsylvania Natural Heritage Program website indicated that no Federally-listed species are found in the project area; hence, no impacts to Federally listed or proposed species would be anticipated from the proposed project. No long-term impacts to the fish and wildlife resources in the Tookany Creek watershed are anticipated as a result of this project.
Cultural Resources	No Impact	Pursuant to Section 106 of the National Historic Preservation Act of 1966, as amended, the US Army Corps of Engineers has determined that there is a moderate potential to effect both above-ground and below-ground historic properties by the recommended plan. Additional investigations will need to be conducted to fully assess potential

		impacts, in consultation with the Pennsylvania State Historic Preservation Office, the Tribes, and other consulting parties. Based on the findings in the Phase IA Cultural Resources Investigation, USACE has initiated negotiation of a programmatic agreement (PA). All terms and conditions resulting from the PA shall be implemented in order to minimize adverse impacts to historic properties.
Land Use	No Impact	Permanent change in the nature of the stream and land use in the proposed basin areas. Some of the basins will go from private property to public property. If funding is available, rain gardens will be planted in the basin areas using native plants to enhance the area for wildlife resources.
Hazardous, Toxic and Radioactive Waste (HTRW)	No Impact	Based on the best available information at this time in the Planning process, it does not appear that there are any HTRW concerns for the project; however, additional investigations on this issue will occur during the D&I phase of the project.
Noise	No Impact	There will be noise and general disturbances in the project area as a result of construction activities, but these will be temporary in nature and should not have long term negative effects

5.2 PLAN IMPLEMENTATION

The Tookany Creek FRM Feasibility Study was cost-shared 50%-50% between the Federal Government (USACE) and the Township of Cheltenham. The deliverable for this study will be a feasibility report and a NEPA compliant Environmental Assessment. Submission of this report by the District Engineer would constitute the first step in a series of events which must take place before the project is constructed. It may be modified at any stage of review, and only if it successfully passes all stages of review would it ultimately be constructed. The project will proceed into the Design and Implementation Phase pending execution of a Project Partnership Agreement (PPA) with the non-Federal sponsor.

5.2.1 PLAN IMPLEMENTATION RESPONSIBILITIES

The initial project cost of the CAP Section 205 Tookany Creek FRM Project will be cost shared, with 65 percent of initial cost paid by the Federal Government and 35 percent paid by the non-federal sponsor. A PPA package will be coordinated and executed subsequent to the feasibility phase. The PPA will reflect the recommendations of this Feasibility Report.

Cost Apportionment

The total project cost would be shared between the USACE and the Township of Cheltenham, with 65 percent of the cost from Federal funds and 35 percent non-Federal. Section 205 projects have a federal expenditure limit of $10,000,000. Table 7 presents the fully funded cost estimate for the proposed project which includes the Federal and non-Federal cost shares. The fully funded cost estimate assumes a single construction season in fiscal year 2023. Feasibility costs include those costs spent to date on the study. It should be noted that the first $100,000 of the project study costs are 100 percent Federally funded and not included in the estimated Total Project Cost shown in Table 7.

Table 7 – Project Cost Apportionment Table

	Total Project Costs
Feasibility Study Costs	**$845,000**
FED Share	$472,500
Non-FED	$372,500
Design and Implementation Costs	**7,893,000**
Monitoring[1]	$36,000
LERRDs[3]	$713,000
FED Share	$5,130,450
Non-FED Share	$2,762,550
Non-FED Cash	$2,049,550
Non-FED LERRD credit	$713,000
TOTAL PROJECT COST[2]	**$8,738,000**
FED Share	$5,602,950
Non-FED	$3,135,050

Notes:

1 Monitoring Costs are incurred after the project is constructed.
2 Total Project Costs do not include operations and maintenance costs.
3 LERRDs are a 100% non-Federal responsibility for which the sponsor gets cost sharing credit.

As the non-Federal project partner, the Township of Cheltenham must comply with all applicable Federal laws and policies and other requirements, including but not limited to:

1 Provide all lands, easements, rights-of-way and relocations (LERRD) necessary for the construction, operation and maintenance of the proposed project, and perform or ensure performance of any relocations determined by the Federal Government to be necessary for the initial construction, operation, and maintenance of this project.

2 Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law (PL) 96-510, as amended, 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the construction, operation, and maintenance of the Project. However, for lands that the Federal Government determines to be subject to the navigational servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal project partner with prior specific written direction, in which case the non-Federal project partner shall perform such investigations in accordance with such written direction.

3 Coordinate all necessary cleanup and response costs of any CERCLA-regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the Project.

5.2.2 VIEWS OF NON-FEDERAL SPONSOR

A fully coordinated PPA will be prepared subsequent to approval of the feasibility study and will reflect final recommendations of this feasibility study. The NFS has indicated support of the recommended plan and desire to execute a PPA.

5.2.3 EXECUTIVE ORDER 11988

The development of the selected plan was in compliance with Executive Order 11988 (EO 11988), which requires Federal agencies avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. An eight-step process was employed to comply with EO 11988:

1. **Determine if a proposed action is in the base floodplain (that area which has a one percent or greater chance of flooding in any given year).** The proposed project is within the base floodplain; however, it is designed to reduce flood hazards, including risks to life safety and damages to private and public infrastructure.
2. **If the action is in the base floodplain, identify and evaluate practicable alternatives to the action or to location of the action in the base floodplain.** Practicable measures and alternatives were formulated and evaluated, including non-structural measures such as Flood Proofing, Floodplain Evacuation and Floodplain Management.
3. **If the action must be in the floodplain, advise the general public in the affected area and obtain their views and comments.** Public meetings were held throughout the feasibility study process (January 2013, February 2014 and May 2015). The meetings were well attended and a rich diversity of views were expressed in multiple formats.
4. **Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial floodplain values. Where actions proposed to be located outside the base floodplain will affect the base floodplain, impacts resulting from these actions should also be identified.** The project would not alter or impact the natural or beneficial floodplain values.
5. **If the action is likely to induce development in the base floodplain, determine if a practicable non-floodplain alternative for the development exists.** The Tookany Creek watershed is densely developed and highly urbanized. This project provides benefits for existing development, but will not encourage additional development in the floodplain.
6. **As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial floodplain values. This should include reevaluation of the "no action" alternative.** There are approximately 0.25 acres of wetlands within the potential footprint of the proposed West Waverly Basin.

During design and implementation, the embankment and associated dry detention basin footprint will be designed to avoid impacts to the existing wetlands to the greatest extent possible. If wetland impacts are determined to be unavoidable as the plan design progresses, coordination with the USFWS will be updated and potential mitigation in the form of wetland restoration within the West Waverly Basin will be completed to compensate for this loss. At this point in the feasibility-level analysis, no compensatory mitigation is required as part of the recommended plan.

7. **If the final determination is made that no practicable alternative exists to locating the action in the floodplain, advise the general public in the affected area of the findings.** Public meetings were held throughout the feasibility study process and the EA will be provided for public review.
8. **Recommend the plan most responsive to planning objectives established by the study and consistent with the requirements of the EO.** The Recommended Plan is the most responsive to the study objective and it is consistent with the requirements of EO 11988.

5.3 BENEFIT/COST ANALYSIS

Based on the 50-year period of analysis with the FY21 Project Evaluation and Formulation Rate (Federal Discount Rate) of 2.5%, the recommended plan is the NED Plan. The NED Plan provides $38,000 (rounded) in Average Annual Net Benefits (AANB) with a 1.1 Benefit-Cost Ratio (BCR) and a 78% probability of positive economic viability, as summarized on Table 8.

Table 8 - Economic Summary

Item	NED Plan
First Construction Cost	$7,893,000
Interest During Construction	$148,000
Subtotal Construction Cost	$8,040,000
Subtotal Average Annual Cost	$283,000
Annual OMRR&R	$39,000
Average Annual Cost	**$323,000**
Without Project EAD	$2,291,000
With Project EAD	$1,933,000
Average Annual Benefits	$359,000
Average Annual Net Benefits	**$38,000**
Benefit-Cost Ratio	**1.1**

5.4 RISK & UNCERTAINTY METHODOLOGY

As required in ER 1105-2-101 *Risk Assessment for Flood Risk Management Studies*, the performance of the plan is presented to explicitly assess the effectiveness of the proposed plan in reducing flood risk. The complete breakdown of risk assessment decision metrics is found in Appendix I.

Risk & Uncertainty was considered throughout the formulation, with specific application to the economics and hydraulics and hydrology disciplines. As described earlier, HEC-FDA version 1.4.2 employs a Monte Carlo simulation to account for uncertainty and allow for risk informed decision making. Distributions are applied to both economic and H&H inputs. With a mean of $359,000 and a median of $353,000, the results suggest a slight right-tail skew in the distribution. The probabilities below show there is a 75% probability that damages reduced exceed $272,000 and a 25% probability that damages reduced exceed $426,000.

Given the difficulty in quantitatively assigning project performance for each reach of the study area, Reach TC-7 was used as a representative location to present the performance of the NED Plan.

The AEP of the project is the likelihood that the proposed feature target elevation may be exceeded by flood waters in any given year considering the full range of possible values. The expected AEP for Reach TC-7 was calculated using the future year (2073) water surface profiles. The expected value of 5.9% AEP is computed from the results of the Monte Carlo simulations which considers uncertainty in hydrologic/hydraulic functions and project features. With an expected AEP of 5.9%, or 17-year event, the Recommended Plan is sufficient to provide FRM for high-frequency, lower stage events, but will not be effective in managing risk for serious, low-frequency storm events.

The Long-Term Exceedance Probability (LTEP) is the probability that the target stage will be exceeded at least once in the specified durations of 10, 30, and 50 years. This accounts for the repeated annual exposure to flood risk over time. For the Recommended Plan, there is a 95.2% probability that the feature will be overtopped at least once during over a 50-year period at the Year 2073 water levels.

Assurance measures the probability that the project will not be exceeded by a specified hydrologic event considering the full range of uncertainties. This is a measure of how reliable the plan is in providing the intended levels of risk reduction. For this analysis the future year, Assurance has been computed for each scenario for the 10%, 4%, 2%, 1%, 0.4% and 0.2% AEP events. There is only a 12.1% probability of overtopping at the 10% AEP event, but a 92.9% probability of overtopping at the 1% AEP event.

This analysis does not consider potential failure modes nor life safety risk. This analysis also does not capture the potential risk for transformed or transferred flood risk. Appendix H details the risk analysis for those aspects of the Recommended Plan.

5.5 CONCLUSIONS

As stated previously, the purpose of this feasibility study was to identify, evaluate and recommend to decision makers an appropriate, coordinated, implementable solution to the identified water resources problems and opportunities in Cheltenham Township, Montgomery County, Pennsylvania due to flooding from Tookany Creek. The development and evaluation of alternative plans and the selection of the recommended plan were guided by the objective of reducing flood hazards (including risks to life safety and damages to private and public infrastructure) to Tookany Creek in Cheltenham Township, PA.

A full range of potential solutions to the flooding problems were investigated including both structural and non-structural solutions. Through the process of plan formulation, it was determined that the NED Plan is the Tookany/Rock Creek Plan because it reasonably maximizes net NED benefits consistent with protecting the nation's environment by reducing peak flow rates and flood damages to a greater degree and extent than any other with project condition.

5.6 ENVIRONMENTAL IMPACTS

5.6.1 ENVIRONMENTAL ASSESSMENT CONSIDERATIONS

A web-based PNDI search identified the potential of field dodder (*Cuscuta pentagona*), a State Special Concern plant, which is found in old fields and prairies, sandstone ledges and coastal plain marshes to be found in the project area. Field surveys during the next phase of the project will confirm or refute this finding. We do not anticipate an impact on these species as a result of the project; however, additional coordination will occur with PADEP to insure this is the case prior to project construction. Additionally, the PNDI search indicated that no Federally-listed species are found in the project area and that no impacts to Federally-listed or proposed species would be anticipated with the proposed project.

There are approximately 0.25 acres of wetlands within the potential footprint of the proposed West Waverly Basin. During design and implementation, the embankment and associated dry detention basin footprint will be designed to avoid impacts to the existing wetlands to the greatest extent possible. If wetland impacts are determined to be unavoidable as the plan design progresses, coordination with the USFWS will be updated and potential mitigation in the form of wetland restoration within the West Waverly Basin will be completed to compensate for this loss. At this point in the feasibility-level analysis, no compensatory mitigation is required as part of the recommended plan.

The draft EA indicates that this proposed project is not located in the area defined under the Coastal Zone Management Act of 1972. Therefore, the proposed project will not require a Federal consistency determination in regards to the Coastal Zone Management Program of Pennsylvania.

Pursuant to Section 106 of the National Historic Preservation Act of 1966, as amended, the US Army Corps of Engineers has determined that there is a moderate potential to affect both above-ground and below-ground historic properties by the recommended plan. Additional investigations will need to be conducted to fully assess potential impacts, in consultation with the Pennsylvania State Historic Preservation Office, the Tribes, and other consulting parties.

Based on the findings in the Phase IA Cultural Resources Investigation, USACE has initiated negotiation of a programmatic agreement (PA). All terms and conditions resulting from the PA shall be implemented in order to minimize adverse impacts to historic properties.

5.6.2 COORDINATION

The draft EA for the project was forwarded to the U.S. Environmental Protection Agency (EPA), Region III, the U.S. Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), Pennsylvania Department of Environmental Protection (PADEP), Pennsylvania State Historic Preservation Officer (SHPO), Pennsylvania Game Commission (PGC), Pennsylvania Fish and Boat Commission (PFBC), and all other known interested parties. In addition, a public notice discussing this project was emailed to members of the public who have signed up to receive copies of Philadelphia District public notices. Currently, there are approximately 350 parties registered on our public notice review email list.

Public meetings were conducted in January 2013, February 2014 and May 2015 to provide public outreach regarding the study progress and plan development. Comment letters as well as a tabulated summary of all public and agency comments (including proposed USACE responses) is included as a sub-appendix to the Environmental Assessment.

5.7 RECOMMENDATION

This Final Feasibility Report and Environmental Assessment have given consideration to aspects in the overall public interest, including environmental, social, and economic impacts; feasibility; and the ability and interests of the non-Federal sponsor. The sponsor, the Township of Cheltenham, Montgomery County, PA, will enter into a PPA to perform the required items of cooperation, including provision of all needed real estate interests, provision of cash as needed beyond real estate values to constitute 35 percent of total costs, and postconstruction operation and maintenance of the project. I recommend that the proposed plan for flood risk management be approved and implemented for Tookany Creek, Cheltenham Township, Montgomery County, Pennsylvania in accordance with Section 205 of the Flood Control Act of 1948, as amended. This recommendation reflects the information available at this time and with respect to current departmental policies.

_____ _____

Date

Ramon Brigantti
Lieutenant Colonel, Corps of Engineers
District Engineer

APPENDIX A
PERTINENT CORRESPONDENCE

APPENDIX B:
HYDROLOGY & HYDRAULICS

APPENDIX C
ENVIRONMENTAL ASSESSMENT

APPENDIX D:
CIVIL DESIGN

APPENDIX E:
REAL ESTATE

APPENDIX F:
ECONOMICS

APPENDIX G:
COST ENGINEERING

APPENDIX H:
LIFE SAFETY ANALYSIS

APPENDIX I:
PROJECT RISK&PERFORMANCE METRICS