US Army Corps
of Engineers®
Philadelphia District

Section 205
Feasibility Report

TOOKANY CREEK
CHELTENHAM TOWNSHIP
MONTGOMERY COUNTY, PENNSYLVANIA

Flood Risk Management Study and Environmental Assessment

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

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1.0 INTRODUCTION

1.1 STUDY PURPOSE AND SCOPE

The purpose of the feasibility report is to investigate Federal interest in providing flood risk management (FRM) for residential and commercial/industrial structures in Cheltenham Township, Montgomery County, Pennsylvania, due to flooding in the Tookany Creek watershed. The study demonstrates that there is Federal interest in providing FRM for the flooding problems 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). This study of Tookany Creek was initially funded by specific appropriations in the House of Representatives' Energy and Water Development Appropriations Bill, 2005 (H.R. 108-554). Funds were included in the Consolidated Appropriation Act for FY 2005 (Public Law 108-447). Additional Federal funds were made available through appropriations in Fiscal Year 2012 and 2013.

1.3 STUDY AREA LOCATION

The study area includes the portion of the Tookany Creek watershed located within the boundaries of Cheltenham Township, Pennsylvania. Cheltenham Township is 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 County to the southwest, Berks County to the northwest, Lehigh County to the North and Bucks County to the northeast. The county is located in the Piedmont Province of the Appalachian Highlands Division. The Piedmont Province is a gently rolling area that, in general, slopes southeastward.

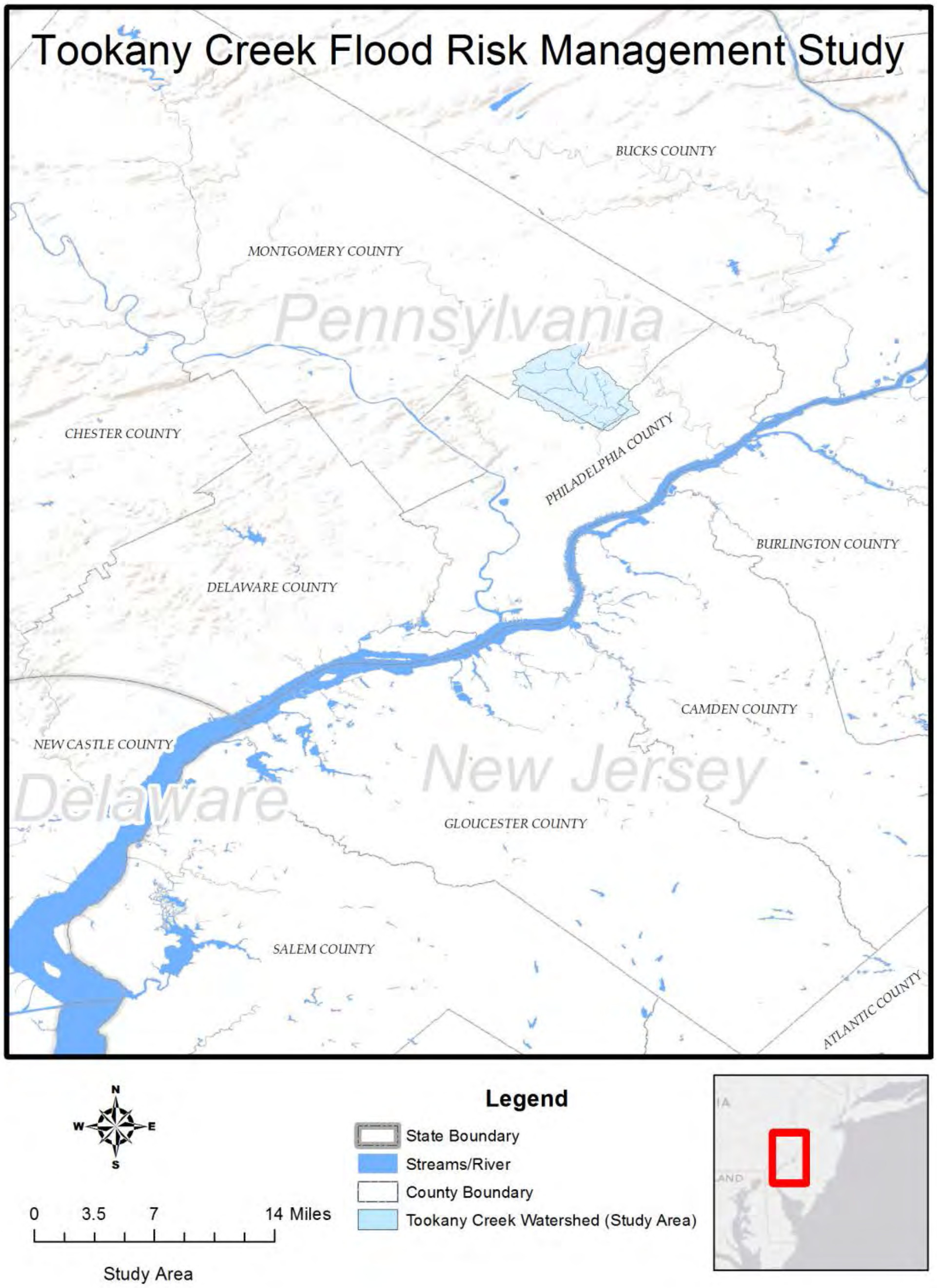

Figure 1
Study Area

1.4 EXISTING WATER RESOURCES PROJECTS AND REFERENCES IN THE TOOKANY CREEK WATERSHED

1.4.1 EXISTING WATER RESOURCES PROJECTS

Depending upon the time of year and the composition of the upstream watershed, streamflow is highly variable within the Tookany Creek watershed. In locations where upstream development is heavy, groundwater infiltration has been largely removed and therefore ephemeral streamflow can exist within historically perennial streams. In other locations that have less upstream development, sources of groundwater flow are available to promote nearly constant streamflow to the existing stream network.

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 study area. 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.

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.

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, flood control 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 up to 5 ft. 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.

Approximately 131 channel obstructions within the Tookany Creek watershed were identified by PWD using in-stream surveys. These obstructions included bridges and culverts on the mainstem Tookany Creek as well as many tributaries. As was previously mentioned, 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.

Federal Emergency Management Agency – “Homeowners Guide to Retrofitting: Six ways to Protect Your House From Flooding,” June 1998.

Philadelphia Water Department-“Tookany/Tacony-Frankford Watershed Comprehensive Characterization Report”

U.S. Army Corps of Engineers – Institute for Water Resources – “National Economic Development Procedures Manual - Urban Flood Damage, Volume 1, IWR 88-R-2,” March 1988

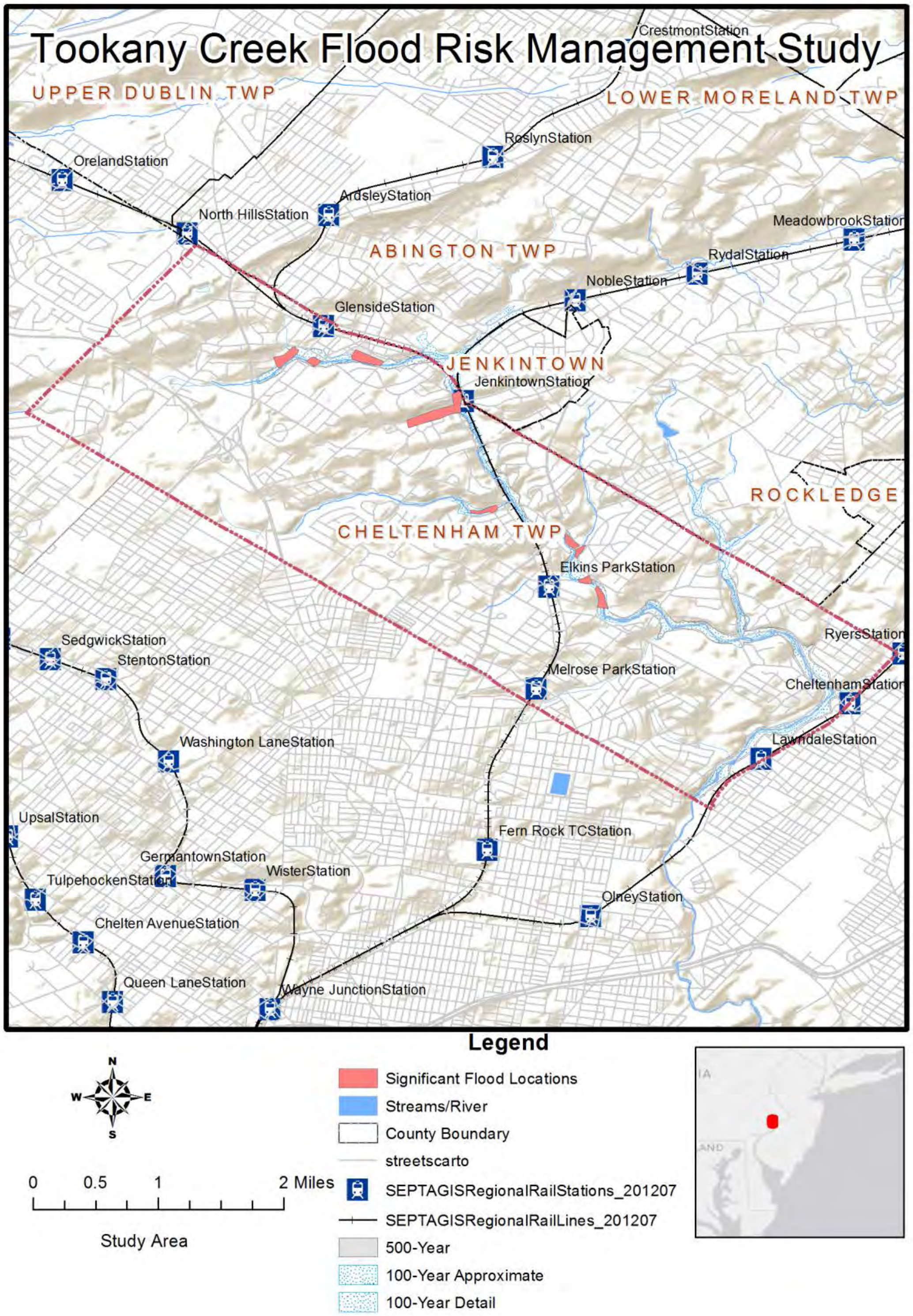

Figure 2
Cheltenham Township Detail and Tookany Creek

2.0 BASELINE CONDITIONS

2.1 EXISTING CONDITIONS

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.

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 probability of 0.500 to 0.002 (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, which is roughly 247% more urban than the average for the remainder of the country.

2.1.1 DESCRIPTION OF THE STUDY AREA

The study area focuses on flood prone areas throughout Cheltenham Township, Montgomery County. Cheltenham is part of the first ring of suburban development outside of the City of Philadelphia and is largely at maximum development capacity. 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.

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 contained 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. Essentially, the latter province is 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 were representative of 2008 conditions.

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 AOI, 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 PWD. Additionally, three non-recording gages are maintained by Cheltenham Township throughout the study area with limited records.

2.1.2 SOCIO-ECONOMIC RESOURCES

The economic modeling was processed using the USACE Hydraulic Engineering Center's Flood Damage Assessment (HEC-FDA) model version 1.4. Use of this model aides in establishing the existing conditions expected annual damages (EAD) along with any damages reduced through planning alternatives. The year 2019 was chosen as the base year for all economic modeling and input requirements. The Philadelphia District hydrologist and hydraulic engineer (H&H) provide inputs for economics in the form of the existing conditions and alternative plan's water-surface profile (WSP) inputs. These include the discharge quantity measured in cubic feet per second (cfs) at each stage height in feet (ft.) indexed at station locations measured in ft. which are assigned to each of eight flood frequencies under analysis. The eight common frequencies chosen for analysis are the 0.5, 0.2, 0.1, 0.04, 0.02, 0.01, 0.004, and 0.002. H&H provides a WSP for each particular project scenario under scrutiny. In tandem, the economic structure inventory was developed which assigned structural and content damages for all structures in the delineated floodplain. These two major model inputs comprise the basis of all model output. Once established, the basic relationships used for analysis are the Discharge-Exceedance Probability, Stage-Discharge, and Stage-Damage, all which combined to form the Damage-Frequency relationship. Mathematical integration of the Damage-Frequency curves output the EAD for existing damages. Uncertainty calculations are output as well using Monte Carlo simulations of probability densities that are assigned to each of these major relationships.

The PDT made a risk-informed decision to ensure that the project benefits were conservatively analyzed. The structure inventory methodology directly correlates to damages estimated and benefits created by project alternatives. While that methodology was employed for this study, a sample of structures was analyzed using a different methodology and a hypothesis test documenting the statistical difference of the two methodologies is described in the Economics Appendix. The hypothesis test describes the significant statistical difference between the two methodologies and the fact that the method employed for this study provides a conservative estimate of project benefits.

2.1.3 ENVIRONMENTAL RESOURCES

The Philadelphia Water Department (PWD) conducted a comprehensive, multi-year assessment of the Tookany/Tacony-Frankford Watershed (TTFW). Results of the watershed-wide assessment suggests 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 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).

VEGETATION - Development within the Tookany Creek floodplain has resulted in recession of the 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).* Land use in the flood areas is primarily residential but also consists of commercial businesses and industrial facilities as well as open space.

AQUATIC RESOURCES – Poor in-stream habitat has been identified as both a problem, as well 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).

Fish – 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).

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).

RARE, THREATENED AND 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 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.

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.

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

The primary water quality concerns were identified as 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

2.1.4 CULTURAL RESOURCES

A Phase I/II cultural resource investigation was conducted in the study area by PennDOT for FEMA for areas that would be impacted by the SR 0309, Section 100 roadway improvement project. As a result of the field investigation, six native American sites were located. Each of these sites is now included in the "Chickees Formation Quartz Procurement Archaeological District".

Listed or potentially eligible resources within the study area include:

- Holy Sepulchre Cemetery
- The Curtis Arboretum
- The Jenkintown Syndicate Historic District
- The Wyncote Historic District
- The Westminster Theological Seminary

There are also approximately 30 historic structures within the potential project area.

2.1.5 HYDROLOGY AND HYDRAULICS

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.

2.1.5.1 Background

The Tookany Creek watershed is part of the larger 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. Therefore, the area of interest (AOI) 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 final study watershed, larger TTFW, major stream systems, roadways and administrative boundaries are shown in Figure 3.

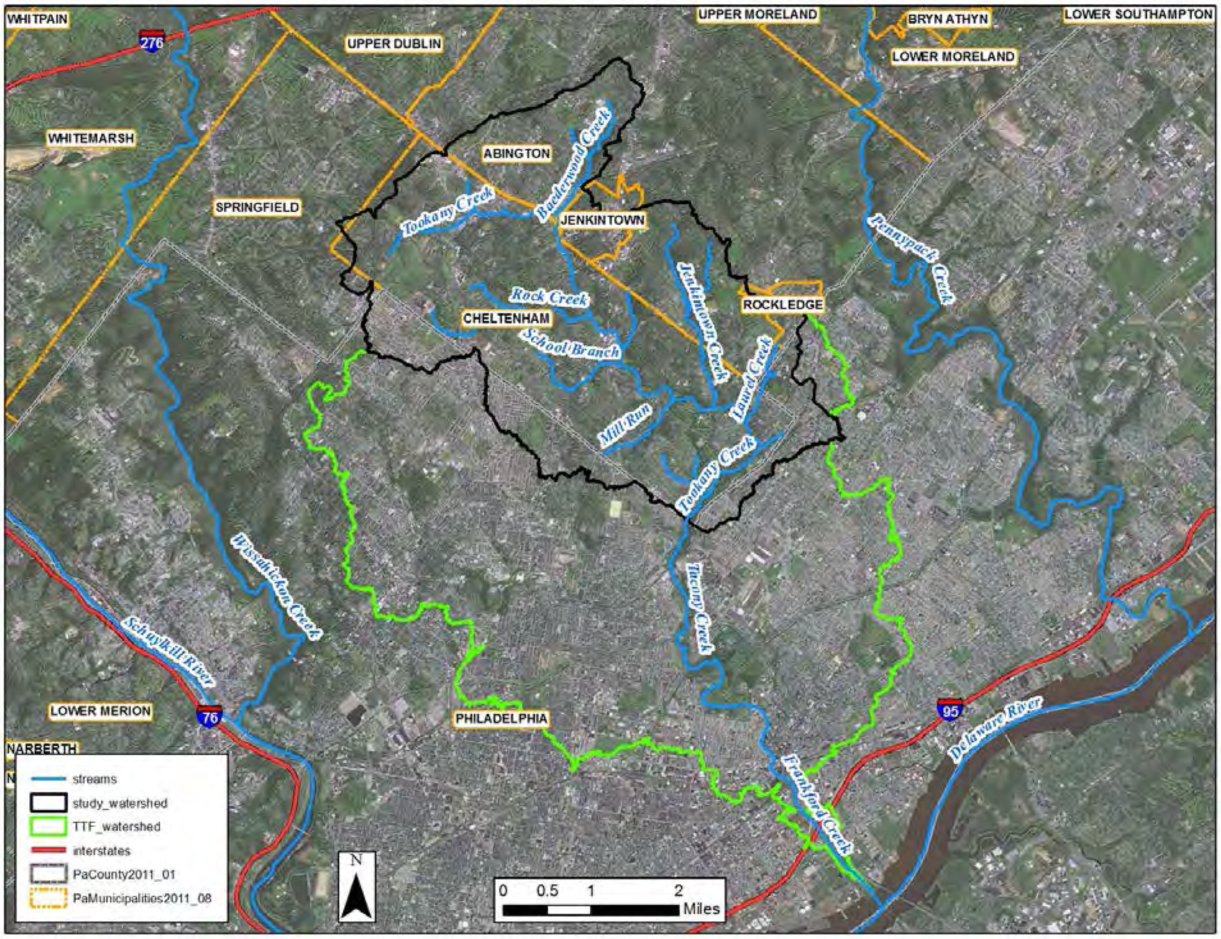

Figure 3 - TTF Watershed and Study Area
ESRI World Imagery

2.1.5.2 Discharge Frequency Analysis

Two United States Geological Survey (USGS) streamflow gauging stations are currently active within the study area. The first gage is located near the Cheltenham/Philadelphia County boundary above Adams Avenue and was used to set the downstream limits of the study watershed. While this gage was installed in 1965, the period of record is not continuous with missing discharge records from 1970 – 1974 as well as 1986 – 2005. However, continuous discharge measurements are available since Oct. 2005.

The second USGS gage is located at Castor Ave (where the "Tacony Creek" transitions to the "Frankford Creek"). This gage was installed in July 1982 with no missing discharge records. Continuous discharge records are available since Oct 1990.

Additional USGS gages have been historically active within the TTFW. These gages were located along tributaries on the Tookany Creek and on the mainstem TTF as well. However, due to their short periods of record and the considerable land use changes since their activity, they were not used as part of this modeling effort. Pertinent data relating to these USGS streamflow gauging stations is detailed in Table 1.

Table 1– USGS Streamflow Gauging Stations near the Study Area

USGS ID	Name	LAT	LONG	Period of Record	Published Drainage Area (mi^2)
01467083	Tacony Creek near Jenkintown, PA	40.09	75.14	10/1973 - 10/1978	5.25
01467084	Rock Creek at Curtis Arboretum near Philadelphia	40.08	75.15	5/1971 - 10/1978	1.15
01467085	Jenkintown Creek at Elkins Park, PA	40.08	75.11	10/1973 - 10/1978	1.17
01467086	Tacony Creek at Adams Avenue, Philadelphia, PA	40.05	75.11	10/1965 - 9/1970, 6/1974 - 9/1986, 10/2005 - current	16.7
01467087	Frankford Creek at Castor Ave, Philadelphia, PA	40.02	75.10	7/1982 - current	30.4
01467089	Frankford Creek at Torresdale Ave, Philadelphia, PA	40.01	75.09	10/1965 - 7/1982	33.8

The frequency discharges for Tookany Creek were based on a statistical analysis of USGS Stream Gage 01467086 (Tacony Creek at Adams Avenue, Philadelphia, PA). An attempt was made to extend the gage record of the Adams Avenue gage with correlation to Gage 01467087 (Frankford Creek at Castor Avenue, Philadelphia, PA) but it was statistically unsuccessful.

Additional information on the statistical gage analysis can be found in Appendix B, Hydrologic and Hydraulic Analysis.

2.1.5.3 Hydrologic Model

The runoff of the Tookany Creek and its tributaries was quantified using the USACE's Gridded Surface Subsurface Hydrologic Analysis Program (GSSHA, version 6.0). GSSHA was selected because it allows the modeler to simulate complex overland and channel flow processes using finite volume approximations. Specifically, GSSHA allows water to flow in different directions over time, which is important in watersheds like Tookany Creek where the overland flow network has been substantially altered by human activities (i.e. runoff flow directions are not necessarily constant through time and change with rainfall magnitude). Also, GSSHA has the ability to model underground pipe routing that interacts with the surface water routing routines on a time-step scale. This is vital due to large-scale storm sewer systems present within the study area. A detailed description of the hydrologic model can be found in Appendix B.

2.1.5.4 Hydraulic Model

The frequency discharges were transformed into frequency water surface elevations (wsel) with the USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 4.1.

Two HEC-RAS models were created within the area of interest. The Tookany Creek model starts at the corporate boundary with Philadelphia and extends to a point 740 feet upstream of Church Road near Arcadia University. The Tookany Creek HEC-RAS model includes 273 cross sections and 29 bridges over a stream length of 8 miles. The first bridge in the model is Levick Road and the last bridge is Church Road upstream of Limekiln Pike.

Figure 4 – Extent of Tookany Creek HEC-RAS Model

The Rock Creek RAS model starts at its confluence with Tookany Creek and extends upstream for 3100 feet. The model includes 32 cross-sections and four bridges. The modeled bridges are: Widener Road, Serpintine Lane, Rock Lane and Dell Lane. The starting water surface elevations for the Rock Creek model were taken from the Tookany model at its junction with Rock Creek. An overview of the Rock Creek Hydraulic Model is provided in Figure 5.

Figure 5 – Extent of Rock Creek HEC-RAS Model

A detailed description of the hydraulic analysis can be found in Appendix B.

2.1.6 EXISTING INSTITUTIONS

An inventory has been made of public and private institutions in the study area which affect or may be affected by the implementation of plans developed as part of this study. The inventory includes Federal, state and local agencies. The primary agencies with interest in the effects of potential projects on the study area include:

- Township of Cheltenham
- U.S. Army Corps of Engineers
- U.S. Department of the Interior, Fish and Wildlife Service
- U.S. Environmental Protection Agency, Region III
- Pennsylvania Department of Environmental Protection
- Pennsylvania Historical and Museum Commission
- Pennsylvania Game Commission
- Pennsylvania Fish & Boat Commission
- Montgomery County Planning Commission

2.2 FUTURE WITHOUT PROJECT CONDITIONS

Given the fact that the developed Tookany Creek floodplain cannot store large quantities of water and ongoing climate change, the magnitude and frequency of flood-related problems will likely increase in the future. In addition, the carrying capacity of Tookany Creek is likely to continue to decrease, thereby increasing the height and destructive capability of floodwaters, floodplain recession and riparian buffer reduction.

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 1% flood frequency 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. USACE evaluated the with-project hydraulic modeling associated with the PADEP plan and determined that it would have little or no impact on potential FRM benefits related to the proposed Federal project in this feasibility study. Further detail of this analysis is included in Section 4.7.

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 in the proposed Federal project area; therefore, the SEPTA project will have little or no impact on potential FRM benefits related to the proposed Federal project in this feasibility study.

Overall analysis of the FRM impacts of these two local projects indicates that a Federal project is still needed to help mitigate the increasing frequency of out of bank flooding in the study area.

3.0 PROBLEM IDENTIFICATION

3.1 INTRODUCTION

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. Of importance to this study are:

- Stream alignment on Tookany Creek upstream of Church Road and Springhouse Lane
- Construction of concrete, stone, masonry, and concrete block channel sections on Tookany Creek upstream of Church Road and Ashmead Road
- Levee construction along Tookany Creek from Rices Mill Road to Brookdale Avenue
- Dredging of Tookany Creek

Despite these improvements, flooding and flood-related damages continue to create problems in the study area. Heavy short duration rainfall events, particularly summer thunderstorms, cause most of the flooding problems by inundating low lying areas. This type of flash flooding is characterized by floodwaters that rise and fall very quickly and usually have high flow velocities.

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 streamflow rates exceeding previous records by approximately 1500 ft3/s at the Adams Avenue gage.

A little over one week later, the remnants of Tropical Storm Lee moved through the northeastern US 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 streamflow rates exceeding the record-setting discharges recorded during Hurricane Irene by approximately 150 ft3/s.

3.2 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.

3.3 MEANS BY WHICH PROBLEMS WERE IDENTIFIED

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 Corps and Cheltenham Township deployed an assessment team to field inspect 9 neighborhood areas over a three day period and gather critical information to calibrate the models. The 9 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.

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 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. The table below summarizes the results of the brainstorming exercise:

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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																					

			Flow Adjustments
14	Retention/Detention	Structural	
15	Dry Dam/Detention	Structural	
16	Wetland Creation/Large Scale Rain Gardens	Structural	
13	Underground Storage	Structural	
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	
			Property Protection
15	Elevation	Non-Structural	
15	Floodplain Evacuation\Acquisition	Non-Structural	
15	Levee/Floodwall	Structural	
5	Floodplain Management	Non-Structural	

Table 2 – Plan Formulation Workshop Summary

4.0 PLAN FORMULATION

4.1 FEDERAL OBJECTIVE

The Principles and Guidelines state 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 define a technically feasible, economically justified and environmentally acceptable solution to the flooding problems in the Tookany Creek watershed in Cheltenham Township. 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.

4.2 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 2019 to 2069.

4.3 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.

4.4 PLANNING CONSIDERATIONS

Study-specific planning considerations include the following:

- There is no known HTRW in the proposed project area; however, HTRW testing will be conducted during the project design phase
- Impacts to cultural resources and historic structures, sites and features will be minimized
- Upstream impacts and actions from neighboring communities will be incorporated into the planning process
- Extensive changes to local land use designations and zoning will be limited

4.5 FORMULATION AND EVALUATION CRITERIA

Water and related land resource project plans are formulated to alleviate problems and take advantage of opportunities in ways that contribute to study planning objectives and, consequently, to the Federal objective. Evaluation of measures and alternative plans considered technical, economic, and environmental criteria.

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. Features are "structural" measures that require construction or assembly on-site, while activities are defined as "nonstructural" actions. Measures are the building blocks of which alternative plans are made.

Management measures developed during the February 2013 Plan Formulation Workshop were carried forward for further analysis in the feasibility study. During the formulation process, structural and nonstructural measures were further subdivided into three categories in order to highlight the hydrologic and hydraulic impacts of the measures:

- Carrying Capacity Modification (CCM) Measures – Improves the creek's conveyance capacity through channel/floodplain modifications without reducing peak volume of water.
    - Inlet Modifications
    - Bridge Modifications
    - Channel Modifications (Levees and Floodwalls)
    - Reconnection of Floodplains and Riparian Buffer
- Flow Adjustment (FA) Measures – Reduces water surface elevations through reductions in the peak volume of water.
    - Aboveground Storage Areas
    - Underground Storage Areas
    - Stormwater Controls
    - Porous Pavement
    - Residential Rain Gardens
    - Rain Barrels
    - Bio-swales
- Property Protection (PP) Measures – Protects property by modifications to the structure or management practices by reducing the impacts of flood water.
    - Flood Proofing
        - Floodplain Evacuation/Acquisition
        - Elevation
    - Floodplain Management
    - Flood Warning

All CCM and FA measures were structural, while all PP measures were nonstructural.

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

<u>Completeness</u> – 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
- Eliminates 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
- Likely to be permitted 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

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

- Inlet Modifications (CCM) – 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 (CCM) – 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 (PP) – 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 (PP) – 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 (FA) – 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 potentially exceed the value of damages avoided.
- Stormwater Controls (FA) – 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 (FA) – 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.

4.6 ADDITIONAL SCREENING OF FLOOD CONTROL MEASURES.

The measures carried forward for more detailed analysis are listed below:

<u>STRUCTURAL MEASURES</u>

- Bridge Modifications – CCM
- Channel Modifications – CCM
- Aboveground Storage Areas – FA

<u>NON STRUCTURAL MEASURES</u>

- No Action
- Flood Proofing (Floodplain Evacuation/Acquisition and Elevation) – PP

4.7 STRUCTURAL MEASURES

BRIDGE MODIFICATIONS (CCM): Multiple existing bridge 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 water surface elevations (WSELs) 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 4.

Figure 6 – Constriction Removal Measures

While alleviating the hydraulic constrictions via bridge modifications could potentially lead to a significant reduction in the upstream water surface elevation, it doesn't reduce the downstream flooding due to prevailing subcritical flow conditions. In fact, it may actually increase downstream flow rates and water surface elevations. In addition, bridge modifications may not only be expensive, but also have acceptability issues related to project approvals from adjacent landowners and transportation authorities. Therefore, bridge modification was not carried forward for further analysis.

CHANNEL MODIFICATIONS (CCM):

- <u>New Levee/Floodwall:</u> Levees and floodwalls are types of flood protection 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 at 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 with an annual cost of approximately $77 per linear foot. 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. To obtain unity or greater, 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 considered not cost effective as more than 3.9 miles of levee would be required to provide protection for the community.

Therefore, this measure has been screened out based on efficiency (not cost effective) and lack of public acceptability.

- 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.

  As referenced in Section 2.2, the project team evaluated a third-party design for a raised levee alternative along Brookdale Ave and determined this alternative was not effective at reducing flood damages within the community. 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 only represents less than 20% of the structures subject to flooding from the 1% chance annual flood (see photo on cover page). Existing condition modeling estimates the levee currently provides protection between a 50 and 100-year level of protection. During peak flood periods, the levee is flanked and the structures the levee is attempting to protect become flooded. As an example, according to PADEP, within a two hour period following Tropical Storm Allison in 2001, approximately 63 acre-feet of water ponded on the Brookdale Ave side of the levee. Therefore, the project team screened out this alternative prior to completing an economic analysis due to its lack of effectiveness demonstrated through engineering analysis. The analysis of the third-party design was completed at the request of the non-Federal sponsor and the results were shared with community officials.

ABOVEGROUND STORAGE AREAS (FA): 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 (acceptability)
- There are potential vector issues associated with standing water in a permanent pool of water (acceptability)

Detention basins or retarding 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 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

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. According to Cheltenham Township officials and residents, these construction impacts are not acceptable at this time. 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 to provide sufficient storage. Not only would this concept have public acceptability challenges, but also such floodwalls would be costly and present potential safety hazards.

Along Rock Creek, the Limekiln-Ogontz and Greenwood storage areas were screened out as well. The Limekiln-Ogontz storage area may not be publicly acceptable because there is a potential development project occurring within the proposed footprint of this basin. Also, there is a PWD CSO outfall that daylights either just adjacent to the proposed Limekiln-Ogontz storage area, which would present potential environmental and construction issues. 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 basins and two of the three dry detention basins along Rock Creek, the remaining 9 basins were carried forward for more detailed analysis. The Upper Tookany System, the Baederwood Creek System and the Rock Creek System (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, as discussed in Section 5 below.

4.8 NON-STRUCTURAL MEASURES

FLOOD PROOFING: Flood proofing measures consist of structural changes and adjustments incorporated into new construction or adopted to existing structures to reduce flood damages. Flood proofing techniques are aimed at reducing damage by several methods: control infiltration of floodwater by raising structures above flood levels (**Elevation**), constructing individual levees around structures, and/or by providing permanent or temporary watertight covers for all openings. Due to the frame construction of many flood prone dwellings in the study area, they are not capable of sustaining the increased hydrostatic pressures when floodwater is prevented from entering the structure.

The Corps quantified the potential benefits and costs associated with elevating the 174 structures within the 1%ACE. Applying a parametric cost for structure elevation/flood-proofing over a 25-year period of analysis (with a 3.125% interest rate), a total cost of \$2,084,858 was computed for this measure. HEC-FDA version 1.4 was used to calculate project benefits (\$1,600,120) for elevating/flood-proofing the 174 structures. Based on these calculations, the BCR for this alternative is 0.77 with -\$484,738 in Annual Net Benefits. Additionally, there are a number of other factors that make this measure impractical and unacceptable:

- Utility lines would have to be removed and their supporting systems relocated in some other part of the structure at a higher elevation
- Utility lines would have to be rerouted and reconnected to relocated support systems
- Basement area would need to be backfilled to create a crawl space
- The structure itself would require raising in placing and the exposed concrete masonry unit walls would need to be reinforced internally with steel or a new reinforced cast-in-place concrete foundation wall
- To raise the structure in place, roof framing that connects the house to the garage would be demolished.

Also, estimated detour and vehicle damage costs would not be substantially reduced by flood proofing techniques.

- **PERMANENT EVACUATION OF THE FLOODPLAIN/ACQUISITION:** Evacuation of the floodplain permanently solves the problem of future flood damages. This type of project involves the acquisition of the land and structure and the subsequent demolition of the structure. The land is then restricted against future development preventing any future flood damage. The community can retain the property for public use, such as a park, or as an environmental sanctuary, such as a wetland. These projects rely on annual estimated flood damages exceeding the market value for an equivalent home not located in the floodplain.

  The industrial structure at 1 North Avenue is owned by Mack Electric Devices, a certified service-disabled veteran owned small business. This structure was identified for a potential non-structural solution. Flood-plain evacuation analysis, commonly referred to as “buy-out” analysis, was conducted in accordance with CECW-PD, and dated 22 January, 2001. The structure was analyzed to understand the benefits of removing the structure from the floodplain relative to the costs incurred to do so.

  As discussed in the Economics Appendix, The floodplain evacuation analysis for 1 North Avenue yields a benefit-to-cost ratio of 0.34. The net benefits are calculated as the difference between the benefits and the flood-free land cost. Table 3 displays the pertinent data under scrutiny. Because the benefits do not exceed the costs, it is not recommended to consider the property for flood-plain evacuation.

Table 3: Floodplain Evacuation – Summary of Benefits and Costs

Benefits	$85,000
Flood-Free Land Cost	$253,000
Net Benefits	-$168,000
BCR	**0.34**

5.0 FEASIBILITY PLAN

After completing the measure screening process, the PDT continued to formulate alternative plans with different combinations of dry detention basin measures. Based on the measure combinations, 4 different action alternatives and 1 no-action alternative were compared and evaluated to determine the recommended plan:

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

Alternative 1: No Action Plan
The No Action alternative excludes measures to provide FRM; this alternative would not check the continuing flood control problems as is applied as baseline information.

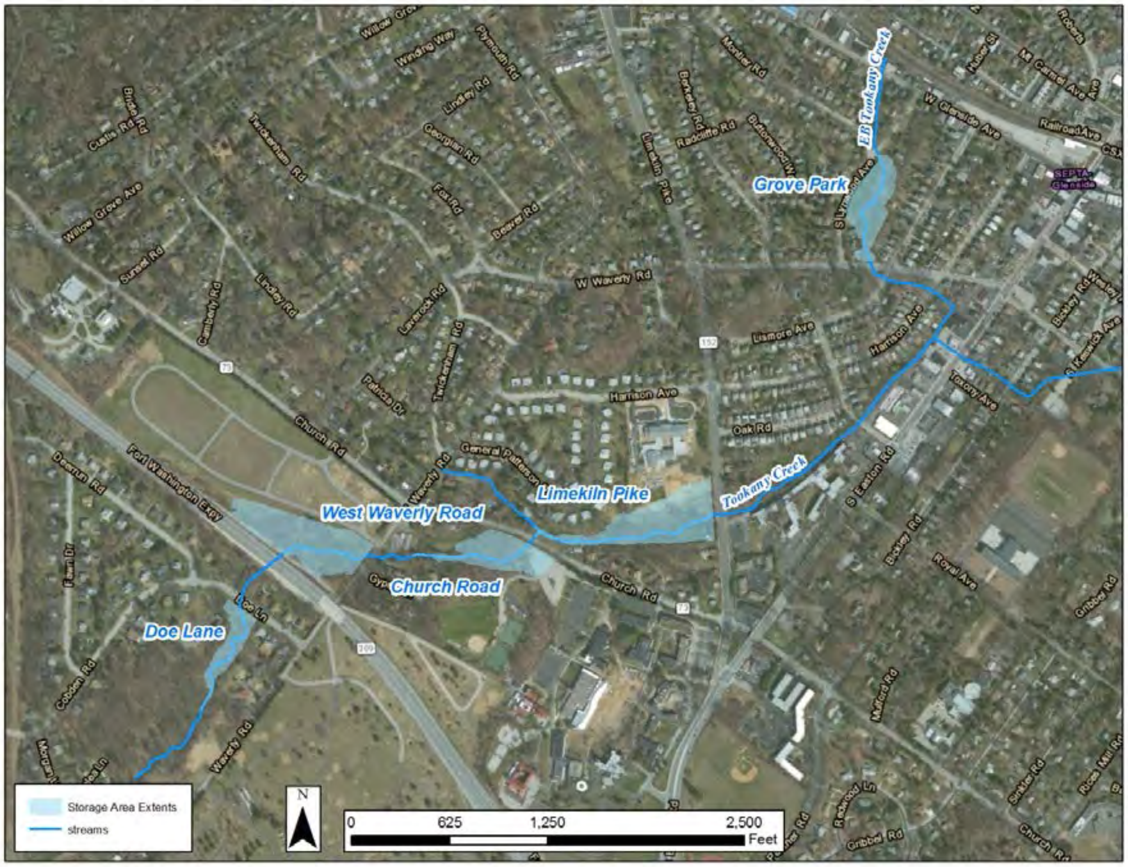
Action Alternatives:
For each of the action alternatives, the proposed dry detention basin locations are low-lying, open-space areas that would require minimal excavation and construction costs to store water. Reduced excavation will not only improve the project economics, but also help to minimize environmental 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. If inflows exceed the storage capacity, the structure can be safely overtopped without failing by "keying" it into a foundation, such as solid rock. 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.

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).

Alternative 2: The Upper Tookany Creek Plan

The Upper Tookany Creek Plan was developed to primarily provide flood risk reduction 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. WSELs for various percent annual chance exceedance (ACE) events were quantified with HEC-RAS for each combination. Based on preliminary costs for each combination and the projected WSEL impacts, benefit-cost ratios (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 7 – Five Basins Considered in Upper Tookany Plan (Alternative 2)

Alternative 3: The Baederwood Creek Plan

The Baederwood Creek Plan was developed to provide flood risk reduction 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.

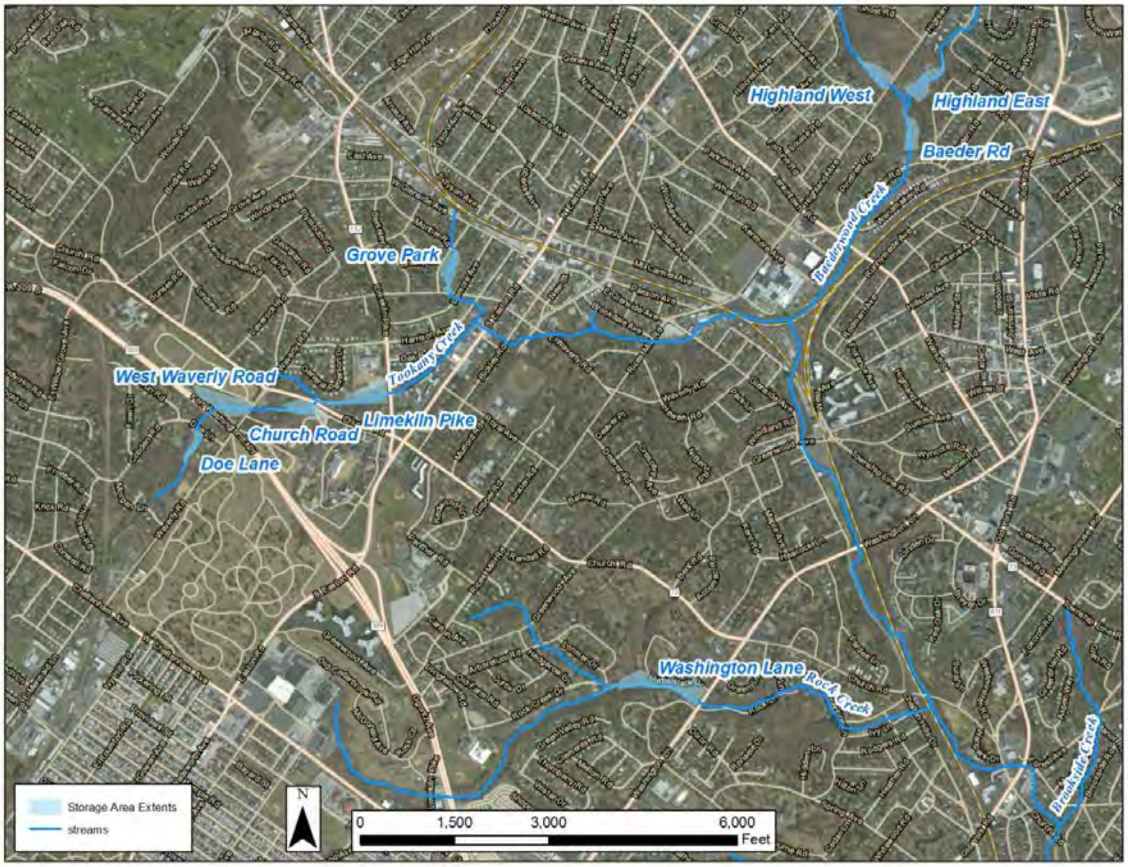
The first combination (D9) included all three basins functioning as a system. The other Baederwood Creek combination (D12) only included the Highland West dry detention basin. Based on the limited extent of the hydraulic and economic models, this storage area group's benefits were not explicitly quantified within Abington Township; however, this storage area group provides flood risk reduction along Baederwood Creek, in addition to communities along Tookany Creek below Baederwood Creek. WSELs for various percent ACE events were quantified with HEC-RAS for each combination. Based on preliminary costs for each combination and the projected WSEL impacts, BCRs and potential net benefits were calculated with HEC-FDA for each combination. Both Baederwood 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 8 – Three Basins Considered in Baederwood Creek Plan (Alternative 3)

Alternative 4: The Comprehensive Plan

The Comprehensive Plan was developed to be an all-encompassing grouping developed to provide flood risk reduction 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 Comprehensive Plan system combination (D30) only included Doe Lane, West Waverly Road, Grove Park, Highland West and Washington Lane. WSELs for various percent ACE events were quantified with HEC-RAS for each combination. Based on preliminary costs for each combination and the projected WSEL impacts, BCRs and potential net benefits were calculated with HEC-FDA for each combination. The 9-basin plan (D27) yielded a BCR greater than 1.0 with positive net benefits, while the other combination (D30) did not yield positive net benefits or a BCR greater than 1.0. Therefore, the 9-basin Comprehensive Plan was carried forward for further analysis.



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

Figure 9 – Nine Basins Considered in Comprehensive Plan (Alternative 4)

Alternative 5: The Rock Creek Plan

The Rock Creek Plan (D15) was developed to provide flood risk reduction 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 WSEL 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 10 – One Basin Considered in Rock Creek Plan (Alternative 5)

5.1 DESCRIPTION OF SELECTED PLAN:

The selected plan, if implemented, is **Alternative 4: The Comprehensive Plan (D27)**. Alternative 4 reduces peak flow rates and flood damages to a greater degree and extent than any other with project condition. Further, Alternative 4 is the selected plan because feasibility-level analysis indicates that it is the alternative plan with the greatest net economic benefits consistent with protecting the nation's environment.

The selected plan and its associated flood risk management structures will consist of an earthen embankment and rock filled gabion basket. 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. An impervious key trench will be located within the embankment. The preliminary key trench dimensions consists of a six foot 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.

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 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.

5.1.1 MITIGATION

For the selected plan, wetlands are found on site of the proposed West Waverly Road Basin. The NWI maps estimate a 4 acre wetland in this area. An official wetland delineation of the site will be completed in the next phase of the project to determine the exact size of the wetland area. The proposed detention structure will impact approximately 0.25 acres of scrub/shrub wetland habitat. It is anticipated that the proposed mitigation for this impact will include an invasive species management plan for the site to control common reed and Japanese knotweed followed by planting of native wetland species {e.g., winterberry (*Ilex verticillata*)} in approximately 1.0 acre of the site to restore the area. During the next phase of the study (PED), a wetland delineation will be completed for all the proposed basin sites and a more detailed mitigation plan will follow.

5.1.2 DESIGN AND CONSTRUCTION CONSIDERATIONS

- Dry detention basins will be constructed using gabion baskets (backside – downstream facing) and earthen embankments (frontside – upstream facing). Conceptual designs for the 9 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 design 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% storm 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 LEERD CONSIDERATIONS

The NFS currently owns in fee approximately 7.08 acres of required projects land within the area required for the channel improvement easement. The additional area required for the channel improvement easement is approximately 22.29 acres of private, commercial and industrial parcels owned by approximately 46 owners. The project may also require a Temporary Work Area Easement for staging areas for a duration of two (2) years.

The minimum estates required for this project are a Permanent Channel Improvement Estate for a permanent right of way on approximately 29.37 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.

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.

5.1.4 OPERATION AND MAINTENANCE

Access to the site and necessary 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 easements will be required for the sponsor to perform future maintenance as required.

5.1.5 SELECTED PLAN ACCOMPLISHMENTS

The selected plan was found to reduce peak flow rates (and in turn WSELs and flooding damages) to greater magnitudes and extents than any other option that was analyzed. 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.

Generally speaking, when simulated individually, all of the embankments were first overtopped during the 2% ACE, 24-hr duration event or the 1% ACE, 24-hr duration event. However, flood waves were still attenuated and translated for events where flood storage was exceeded. Also, when grouped together, the most upstream storage areas in each group may exceed flood storage during a particular event, but this action commonly prevents downstream storage areas from exceeding flood storage, thus greatly reducing peak flow rates at critical damage locations.

5.1.5.1 RESIDUAL RISK

The selected plan does not eliminate the threat of flooding within the community. The selected plan reduces peak flow rates and flood damages to a greater degree and extent than any of the alternatives presented in this report. While the selected plan reduces flood damages in the study area, it was formulated to minimize flood damages associated with the high frequency events. Engineering analyses demonstrates the recommended plan will have positive results for less frequent events, such as experienced with Tropical Storms Irene and Lee, however the community will still remain at risk from future flood events. As discussed in the Economics Appendix (Appendix F), average annual residual damages (average annual damages that remain after a project has been constructed) for the selected plan are $1,008,000 compared to expected annual damages under without-project conditions of $2,092,000. This equates to approximately 52% reduction in damages for the with-project condition.

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5.1.6 SUMMARY OF ECONOMIC, ENVIRONMENTAL & OTHER SOCIAL EFFECTS

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

Table 4 - Tookany Creek Flood Risk Reduction Study: System of Accounts

National Economic Development (NED)

Resource Categories	No Action Plan	Alternative 4 (Tentatively Selected Plan)
Equivalent Annual Damage	2,092,000	1,008,000
Equivalent Annual Benefits	No Impact	1,084,000
Equivalent Annual Interest and Investment Cost	No Impact	359,000
Net Benefits	No Impact	725,000
Benefit-Cost Ratio	No Impact	3.02

Other Social Effects (OSE)

Resource Categories	No Action Plan	Alternative 4 (Tentatively Selected 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 flexible reserves of water supplies, critical power supplies, scarce fuels, evacuation routes and emergency transport to health facilities during and 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 living in poverty.

* Social Vulnerability Index (SVI) is developed by the Agency for Toxic Substances and Disease Registry (ATSDR), a federal public health agency of the U.S. Department of Health and Human Services

Regional Economic Development (RED)

Resource Categories	No Action Plan	Alternative 4 (Tentatively Selected Plan)
Employment distribution	No Impact	Temporary increase in construction-related jobs during construction. Permanent indirect positive impacts on employment opportunities for protected businesses, including opportunities for minority workers.
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 business income and wages as businesses close during and/or after storm events	Permanent increase in real income for below-poverty and near-poverty workers from temporary construction work and permanent wage opportunities from open businesses.

Environmental Quality (EQ)

Resource Categories	No Action Plan	Alternative 4 (Tentatively Selected Plan)
Water Resources	No Impact	There will be minor impacts to wetlands as a result of this proposed project. Approximately 0.25 acres of wetlands will be impacted by construction of the proposed West Waverly basin. Mitigation in the form of wetland restoration of approximately 1.0 acre of the West Waverly property will be completed to compensate for this loss. In addition, the project will comply with Title 25 Pa. Code Chapter 102, Erosion and Sediment Control and Stormwater Management.
Air Quality	No Impact	The 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 PM2.5; and 50 tons of VOC per year. General Conformity under the Clean Air Act, Section 176 has been evaluated for the project according to the requirements of 40 CFR 93, Subpart B. The requirements of this rule are not applicable to this project because the total direct and indirect emissions from the project are below the conformity threshold values established at 40 CFR 93.153 (b) for ozone (NOx and VOC) in a Moderate Nonattainment Area. The project is not considered regionally significant under 40 CFR 93.153 (i).
Biological Resources	No Impact	A Pennsylvania Natural Diversity Inventory (PNDI) search run on the Pennsylvania Natural Heritage Program website indicated that no Federally-listed species are found in the project area and, 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. There will be noise and general disturbances in the stream area as a result of construction activities, but these will be temporary in nature and should not have a long term negative effect on wildlife in the area.
Cultural Resources	No Impact	Based on the results of the Phase IA investigation, additional subsurface archaeological investigations may be required at 8 of the 9 proposed dry detention basins for Alternative 4 to properly assess their potential to contain undocumented prehistoric or historic archaeological sites. The USACE, in consultation with the Pennsylvania State Historic Preservation Officer (SHPO), the Tribes, and other consulting parties will review the results of all investigations and determine any effects to historic properties eligible for or listed on the NRHP, and work to avoid, minimize, or mitigate those effects. In addition, further architectural assessments may be required in order to assess the proposed impacts that Alternative 4 may have on above ground historic properties.
Land Use	No Impact	There will permanent change in the nature of the stream and land use in the proposed basin areas. For the areas proposed for detention basins, some of the basins will go from private property to public property. In addition, the land use will change from its existing use to dentention basins which will hold water during storms. If the funding is available, rain gardens will be planted in the basin areas using native plants to enhance the area for wildlife resources. If this happens, the project will provide a long-term positive impact to the wildlife in the Tookany Creek watershed. Rain gardens would also make for an enhanced public space for passive recreation (i.e., walking).
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 a long term negative effect on the noise level of the neighborhoods.

Table 5 provides a summary and comparison of cost estimates, with project benefits and BCRs associated with each alternative in the final array of alternatives:

Table 5 – Summary of Alternative Costs and Benefits

Alternative	Average Annual Costs	Average Annual Benefits	Annual Net Benefits	BCR
Alternative 1: No Action Plan				
Alternative 2: The Upper Tookany Creek Plan				
a. 5-basin plan (D1)	$225,000	$252,000	$27,000	1.12
b. 3-basin plan (D28)	$155,000	$43,000	-$112,000	0.28
Alternative 3: The Baederwood Creek Plan				
a. 3-basin plan (D9)	$74,000	$104,000	$30,000	1.41
b. 1-basin plan (D12)	$26,000	$70,000	$44,000	2.69
Alternative 4: The Comprehensive Plan				
a. 9-basin plan (D27)*	$359,000	$1,084,000	$725,000	3.02
b. 5-basin plan (D30)	$214,000	$200,000	-$14,000	0.93
Alternative 5: The Rock Creek Plan (D15)	$88,000	$198,000	$110,000	2.25

*Total Cost of Recommended Plan - $9.2 Million

5.2 PLAN IMPLEMENTATION

5.2.1 PLAN IMPLEMENTATION RESPONSIBILITIES

The Tookany Creek Flood Risk Management Feasibility Study was cost-shared 50%-50% between the Federal Government and the Township of Cheltenham. The contributed funds of the NFS demonstrate their intent to support a project for the study area. 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. These events are:

- Technical approval of the selected plan by the North Atlantic Division (NAD) Engineer
- Review of report for policy compliance by NAD and funds for preparation of plans and specifications, if needed
- Authority to implement the project from the NAD Engineer
- Approval to expend funds for construction of the project by the ASA (CW)
- Signing of the Project Partnership Agreement (PPA) by the NFS and the Federal Government
- NFS attainment of all LEERDs necessary for project construction

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 Non-Federal Sponsor (Township of Cheltenham) 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.** Wetlands are found on site of the proposed West Waverly Road Basin. The NWI maps estimate a 4 acre wetland in this area. An official wetland delineation of the site will be completed in the next phase of the project to determine the exact size of the wetland area. The proposed detention structure will impact approximately 0.25 acres of scrub/shrub wetland habitat. It is anticipated that the proposed mitigation for this impact will include an invasive species management plan for the site to control common reed and Japanese knotweed followed by planting of native wetland species {e.g., winterberry (*Ilex verticillata*)} in approximately 1.0 acre of the site to restore the area. During the next phase of the study (PED), a wetland delineation will be completed for all the proposed basin sites and a more detailed mitigation plan will follow.
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

All with-project conditions were analyzed against the existing conditions EAD of approximately $2,092,000. Five alternative plans (with varying scales) were assigned as with-project conditions reducing damages to the existing conditions by varying degrees. NED standards require with-project conditions to be evaluated through a BCR and the net benefits a plan deems to provide the public. The difference in damages reduced per plan to existing damages is the average annual benefits (AAB). Preliminary costs were developed for each alternative plan. Each with-project condition was assigned a project life of fifty years but assumed to have an FY15 federal discount rate of 3.375% per year. After all other cost adjustments, the average annual costs (AAC) were assigned to each plan alternative. The ratio of each project's AAB to AAC result in a simple BCR, while the difference between AAB and AAC are considered to be the net benefits. After all calculations, Alternative 4: The Comprehensive Plan (D27) was tentatively selected with AAB for the public of $1,084,000 per year, AAC of approximately $359,000 and resulting in a BCR of 3.02. Net benefits were calculated to be $725,000 per year.

5.4 RISK & UNCERTAINTY METHODOLOGY

Risk & Uncertainty was considered throughout the formulation, with specific application to the economics and H&H disciplines. For H&H, high and low water surface profiles were calculated based on varying the Manning's "n", expansion and contraction coefficients and pier debris for the recommended plan. The standard deviations were calculated for all economic index stations for all frequencies. The downstream boundary condition was not varied because the structures upstream of the boundary condition are above the best estimate of the 500-year WSE or any reasonable high estimate of the 500-year WSE. There was no economic effect of varying the downstream boundary condition.

For economics, the HEC-FDA Version 1.4 risk analysis model (October 2010) was used to compute expected annual damages for existing conditions and for all future with-project alternatives. Uncertainty parameters used in the HEC-FDA model for this analysis include:

- First floor elevation
- Structure values
- Content to structure ratios
- Percent depth-damage functions; and
- Stage-discharge functions

5.5 CONCLUSIONS

As stated previously, the purpose of this feasibility report is to investigate Federal interest in providing FRM for residential and commercial/industrial structures 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 **Alternative 4: The Comprehensive Plan (D27)** would be the optimal plan for FRM in this study area.

5.6 ENVIRONMENTAL IMPACTS

5.6.1 ENVIRONMENTAL ASSESSMENT CONSIDERATIONS

Initial coordination of the draft Environmental Assessment (EA), including a Pennsylvania Natural Diversity Inventory (PNDI) search indicates that no Federally-listed species are found in the proposed footprint of the recommended plan. Therefore, no impacts to Federally-listed or proposed species would be anticipated from the proposed project. However, the PNDI search did identify a State Special Concern plant (the field dodder) as possibly being in the project area. Additional coordination and field site visits will be conducted to determine if this species is found in the proposed project area. Further, Section 7 consultation with the USFWS, pursuant to the Endangered Species Act of 1973 as amended by P.L. 96-159, will be completed prior to project construction.

There will be minor impacts to wetlands as a result of this proposed project. Specifically at the proposed West Waverly Road dry detention basin, approximately 0.17 acres of wetlands will be impacted by the proposed construction. Mitigation in the form of restoration of approximately 1.0 acre of the West Waverly property will compensate for this loss.

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.

A Phase IA Cultural Resources Investigation indicated that additional subsurface investigations may be required at 8 of the 9 proposed dry detention basins in the recommended plan. The subsurface investigations will properly assess the potential for these proposed basin locations to contain undocumented prehistoric or historic archaeological sites. USACE, in consultation with the SHPO, the Tribes, and other consulting parties will review the results of all investigations and determine any effects to historic properties eligible for or listed on the National Register of Historic Places, and work to avoid, minimize, or mitigate those effects.

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. Public sentiment is generally in support of the recommended plan; however, some folks are concerned about the footprint(s) of the proposed detention basins.

5.7 RECOMMENDATION

Based on preliminary feasibility analysis, I support Alternative 4: The Comprehensive Plan for the Tookany Creek, Cheltenham Township, Montgomery County, Pennsylvania flood risk management in accordance with Section 205 of the Flood Control Act of 1948, as amended.

____
Date

____
Michael A. Bliss
Lieutenant Colonel, Corps of Engineers
District Engineer

APPENDIX A

PERTINENT CORRESPONDENCE

Township of Cheltenham

Montgomery County, Pennsylvania

Administration Building
8230 Old York Road
Elkins Park, PA 19027-1589

Phone: 215 887-1000
FAX: 215 887-1561
Website: cheltenhamtownship.org

July 17, 2003

LTC Thomas C. Chapman
District Engineer
U.S. Army Corps of Engineers, Philadelphia
100 Penn Square East
Philadelphia, PA 19107-3390

Re: Sponsorship Letter for Feasibility Study of Flood Prone Properties

Dear LTC Chapman:

In follow-up to the presentation made by Mr. William Mueller, Planning Division, Civil Engineer of the U. S. Army Corps on June 17, 2003, to the Township's Public Works Committee, and the affirmative action taken by the Board of Commissioners at its June 24, 2003 public meeting, please be advised that the Township hereby requests consideration by the Army Corps to make a feasibility study of four separate areas in Cheltenham Township, Montgomery County, Pennsylvania, in the interest of flood protection along the Tookany Creek. This request is being made in accordance with the provisions of Section 205 of the Flood Control Act of 1948, as amended.

Based on the effects of the two most recent storms, being Hurricane Floyd on September 16, 1999, and Tropical Storm Alison on June 16, 2001, there was significant flood damage to private properties, including single family residences and several commercial properties that abut the Tookany Creek in the Glenside, Wyncote, and Elkins Park neighborhoods of the Township. In particular, there are thirty-eight homes in Glenside, around the Glenside Flood Control structure, and nine residences on Shoemaker Road and one property on Mill Road in the Elkins Park neighborhoods that were directly impacted by way of experiencing floodwaters on their properties. In addition, there were four residences and three commercial properties downstream from the Glenside Pump Station in Wyncote that were impacted as well.

A Home Rule Charter Community

The Township would like the Army Corps to evaluate all of these properties in its feasibility study. In order to expedite this matter, we have enclosed comprehensive address lists, mailing labels for the property names, and parcel maps for all of the properties we are requesting be included in the evaluation.

The Township is aware that this investigation will be conducted in two phases: the first phase is a comprehensive evaluation to consider if buyouts of any of the flood prone properties is something that is worth pursuing further. In doing so, it is the Township's understanding that the Pennsylvania Department of Environmental Protection (PADEP), Bureau of Waterways Engineering, will be consulted to determine what impact, if any, this might have on PADEP's plans for constructing Phase II improvements to the Glenside Flood Control Project currently under engineering design. This information will then be brought back to the Township for detailed analysis.

Depending on the results of the conceptual analysis, should the Township be desirous of entering into the second phase known as the feasibility study, the Township realizes there will be a requirement to have matching costs up to 50% of the total cost for the feasibility study, and all of those costs may consist of in-kind services. Should the Township agree to entertain the second phase and enter into a cooperative agreement with the Army Corps, we understand that local cooperation and participation includes the following:

1. Provide without cost to the Army Corps, all lands, easements, rights-of-way necessary for the construction of the project.

2 Provide without cost to the Army Corps, all necessary relocations and alterations of buildings and utilities, highways and highway bridges, sewers, and special facilities.

3. Hold and save the Army Corps free of claims for damages, which may result from the construction and subsequent maintenance of the project, except damages due to the fault or negligence of the Army Corps or its contractors, and, if applicable, adjust all claims concerning water rights.

4. Maintain and operate the project after completion without cost to the Army Corps in accordance with regulations prescribed by the Secretary of the Army.

5. Prevent future encroachment, which might interfere with proper functioning of the project for flood control.

6. Assume responsibility for all costs in excess of the Federal cost limitation of $7 million.

7. Provide a cash contribution of 5 percent of the project cost. If the value of the Township's contribution above does not exceed 35 percent of the project cost, provide a cash contribution to make the Township's total contributions equal to 35 percent or whatever percentage determined by Congress.

8. Provide guidance and leadership in preventing unwise future development of the flood plain by use of appropriate flood plain management techniques to reduce flood losses.

9. Comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (PL 91-646) and implementing regulations.

10. Comply with Title VI of the Civil Rights Act of 1964 (PL 88-352).

Again, the Township would like to reiterate that at this point in the first part of the conceptual analysis, it is our understanding that this sponsorship letter does not bind the Township in anyway.

We trust this letter will suffice in getting the process underway. In advance, thank you for your consideration of our request. If you have any questions, please do not hesitate to contact me at the Township Administration Building, (215) 887-6200, ext. 110.

Sincerely,

David G. Kraynik
Township Manager

DGK/BTH/kli

xc: Board of Commissioners
Bryan T. Havir, Assistant Township Manager
David M. Lynch, P.E., PLS, Director, Engineering, Zoning & Inspections
Rudy Kastenhuber, Public Works Coordinator
William C. Mueller, Civil Engineer, Army Corps Planning Division
Michael Conway, Project Engineer, PADEP Bureau of Waterways Engineering
Lawrence H. Curry, Pennsylvania Representative, 154th District

APPENDIX B:
HYDROLOGY & HYDRAULICS

APPENDIX C

ENVIRONMENTAL ASSESSMENT INFORMATION

(To be filled)

APPENDIX D:
CIVIL DESIGN

APPENDIX E:
REAL ESTATE

APPENDIX F:
ECONOMICS

APPENDIX G:
COST ENGINEERING