SHELLPOT CREEK
FLOOD ABATEMENT STUDY

FINAL REPORT

November 1998

Prepared for:

New Castle Conservation District
6 Peoples Plaza
Newark, Delaware 19702

Prepared by:

Duffield Associates, Inc.
Consultants in the Geosciences
5400 Limestone Road
Wilmington, Delaware 19808-1232

In Association with:

McCrone, Inc.
20 Ridgely Avenue
Annapolis, Maryland 21404

W.O. 3627.CA

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SHELLPOT CREEK FLOOD ABATEMENT STUDY

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SECTION I

INTRODUCTION

I. INTRODUCTION

A. BACKGROUND/PURPOSE

Historically, the Shellpot Creek Watershed has experienced severe flooding and other flood-related problems as a result of increased stream flows during intense rainfall events. To evaluate and begin addressing these problems, Duffield Associates, Inc. in association with McCrone, Inc. (herein referred to as the project team) was contracted by the New Castle Conservation District to perform the Shellpot Creek Flood Abatement Study. The purpose of this study was to identify problems including, but not limited to, flooding, erosion, property damage, poor water quality, increased stream flows resulting from historic development and urbanization, and to recommend improvements that will provide solutions to or mitigate these problems.

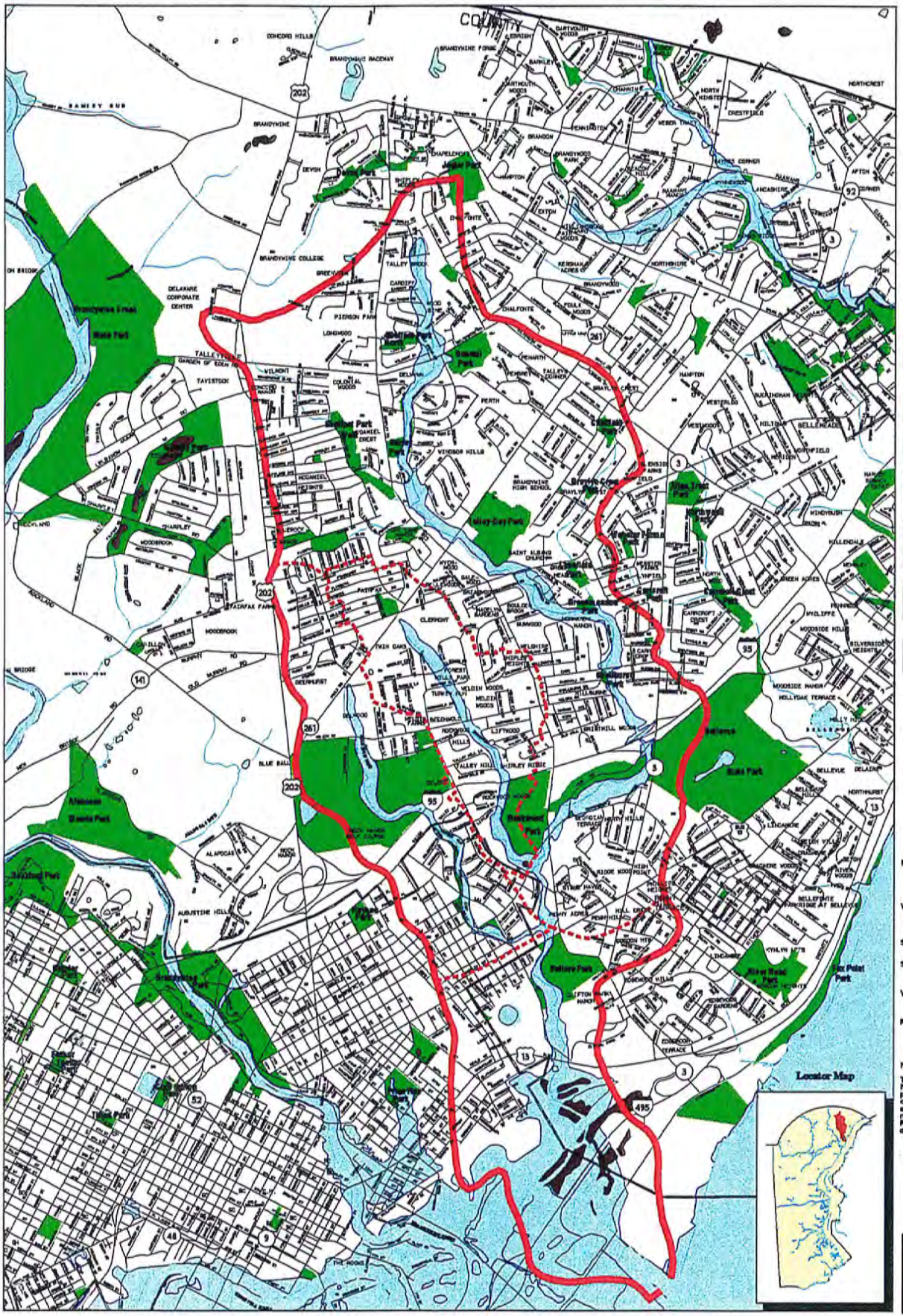
The flood abatement study area includes the entire area draining surface water runoff to Shellpot Creek and its tributaries. The Shellpot Creek Watershed is composed of three principal subwatersheds: 1) Shellpot Creek, 2) Matson Run and 3) Turkey Run (Figure I-1). This combined watershed area encompasses approximately 5,300 acres and is characterized primarily by residential development, parklands, commercial uses, and some industrial uses. Interstate Highway 95 (I-95) bisects the watershed approximately at its north-south midpoint.

As shown in Figure I-2, the Shellpot Creek Watershed is highly developed. Most of the development occurred prior to the 1970's, before New Castle County and the State of Delaware required stormwater management for land development. Consequently, as impervious area increased due to development, unmanaged stormwater runoff flows increased accordingly. Additionally, significant disturbances to the natural stream system (such as stream relocation, stream channelization and lining, and floodplain/riparian buffer encroachment) occurred. The combination of increased flows and stream disturbance eventually caused Shellpot Creek and its tributaries to exceed the capacity of their streambanks and historic floodplains, resulting in severe flooding, erosion and other flood-related problems throughout the watershed.

The following sections of this report describe the process of problem identification, improvement site selection, and assessment that was followed in the study. Also described are the improvement recommendations, costs, and funding alternatives for the selected improvement sites as well as an overall ranking and recommended implementation plan. As a precursor to these sections, the following section (Section II) describes the hydrologic model that served as the basis for much of the evaluation of the sites described in the report.

Shellpot Creek Watershed

Floodplain and Open Space



Floodplains
Floodplain data was extracted (non digital) files supplied by the Federal Emergency Management Agency (FEMA), Washington, D.C., 1993.

Water Resource Protection Areas
Water Resources Agency for New Castle County and the Delaware Geological Survey, 1993.

Stream Network and Roads
Delaware Department of Transportation (1990).

State and county parks digitized by the New Castle County Department of Parks and Recreation, 1992-1993.

Wetlands
U.S. Department of Interior, Fish, and Wildlife Service, 1991.

Representative Districts
Congressional Districts compiled by the Controller General for the State of Delaware and the Board of Elections for New Castle County (1992).

NOTE:
This map is provided by the Water Resources Agency for New Castle County solely for display and reference purposes and is subject to change without notice. No claims, either real or assumed, as to the absolute accuracy or precision of any data contained herein are made by the Water Resources Agency, nor will the Water Resources Agency be held responsible for any use of this document for purposes other than which it was intended.

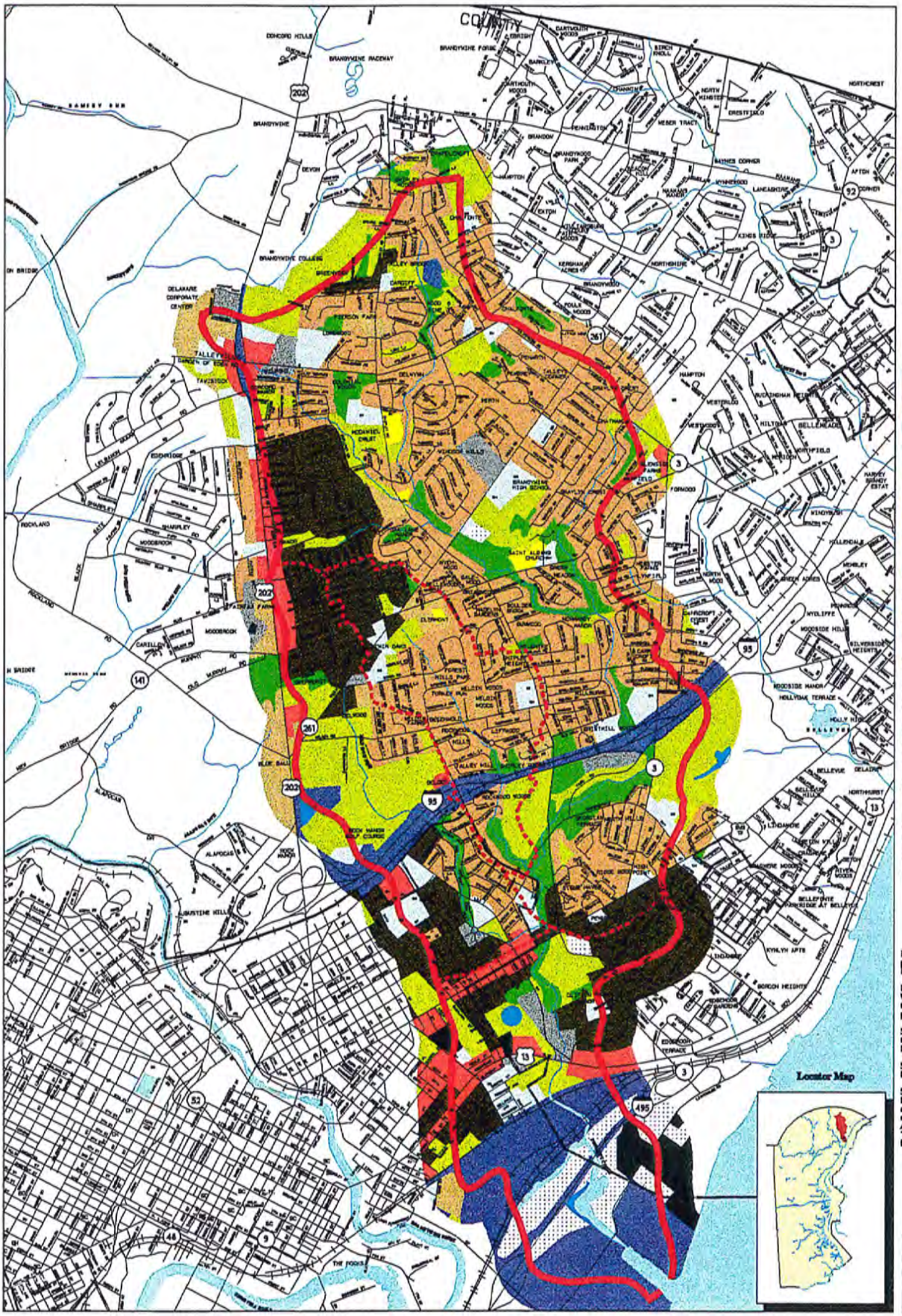
0 0.25 0.5 0.75 Miles
Scale 1:115,000

WRA MAP# 95-025dwf

Figure I - 1

Shellpot Creek Watershed

Land Use



SOURCES OF DATA:

Land Use Inventory for New Castle County, prepared by Environmental Systems Research Institute, 1974.

Land Use Inventory Updating, prepared by the Water Resources Agency using New Castle County Department of Planning aerial photographs (1"=200') from April 1993.

State and county parks, digitized by the New Castle County Department of Parks and Recreation, 1992-1993.

Stream networks and roads, prepared by the Delaware Department of Transportation, 1991.

Sub watershed areas of New Castle County, Delaware, prepared by the Delaware Soil and Water Conservation Commission, in cooperation with the U.S. Department of Agriculture Soil Conservation Service, August 1966. Digitized by the Water Resources Agency for New Castle County, Delaware, March 1992.

0 0.25 0.5 0.75 Miles
Scale 1:13,000

November, 1998

AERI
Advanced Environmental Resource Information System
An Advanced Mapping Facility Management Geographic Information System
WATER RESOURCES AGENCY

WRA MAP# 95-025dul

Figure I - 2

B. SHELLPOT CREEK FLOOD ABATEMENT COMMITTEE

Initial guidance for the Shellpot Creek Flood Abatement Study was provided by a Committee appointed by Governor Thomas Carper, which included elected officials, government agency representatives, members of the State of Delaware Department of Transportation, State of Delaware Department of Natural Resources and Environmental Control, New Castle Conservation District, and private citizens. The Committee was responsible for guiding the direction of the flood study and selecting proposed mitigation alternatives for implementation. Members of the Shellpot Creek Flood Abatement Committee are listed below:

- Representative David H. Ennis, Co-Chairman
- Senator Richard Hauge, Co-Chairman
- Senator Patricia Blevins
- Representative Dennis P. Williams
- Dariel Rakestraw, New Castle Conservation District
- Robert McCleary, Delaware Department of Transportation
- Richard T. Smith, Delaware Department of Natural Resources and Environmental Control
- J. Wayne Merritt, New Castle County, Executive Assistant
- Edith Carlson, Citizen
- Kathleen B. Connolly, Citizen
- Thomas V. Quinn, Citizen

SECTION II

HYDROLOGIC MODEL

II. HYDROLOGIC MODEL

A. GENERAL DESCRIPTION

In order to address flooding and other flood-related problems, it was important to gain an understanding of the hydrologic performance and response of the watershed. This was necessary, not only for the assessment of past flooding events, but also for the evaluation of the efficacy of proposed mitigating measures. For the Shellpot Creek study, a hydrologic model of the watershed was constructed using the Natural Resources Construction Service's (formerly the Soil Conservation Service) computer program Technical Release 20 (TR-20). This model uses hydrologic input data including subwatershed drainage areas, curve numbers, flow concentration times, stream reach routing, and impoundment storage routing to compute runoff flows and durations for specified recurrence interval rainfall events. A more detailed description of these parameters, as well as a general overview of the modeling approach and results, is given in the following subsections. The final TR-20 model developed during this study can be found in Appendix A.

B. WATERSHED AND SUBWATERSHED DELINEATION

A watershed or subwatershed is defined as the land area that will topographically drain to a point of interest. Generally, the point of interest is taken as the confluence of two streams, a road culvert, or some other point along a stream for which it is desired to compute runoff flows. The United States Geological Survey (USGS) 7.5 Minute Quadrangle maps (Wilmington North - DEL - PA - 1993, Wilmington South - DEL - NJ - 1993, and Marcus Hook - PA –NJ - DEL – 1993) were utilized as base maps for topography, stream reach, and roadway locations. The boundaries of the Shellpot Creek Watershed, including Matson Run and Turkey Run, were delineated using these maps and then digitized into CAD format. These primary watersheds were divided into subwatersheds using existing structures with associated significant upstream flood storage (such as bridges and culverts), potential watershed improvement locations, and stream confluences as the points of interest. All watershed and subwatershed boundaries were delineated on digital versions of the USGS maps and placed on appropriate CAD layers for later curve number generation. A map of these delineations is included with the final TR-20 model documentation found in Appendix A.

C. CURVE NUMBER GENERATION

Curve numbers (CNs) describe the portion of the rainfall that will be converted into runoff. CNs are a function of soil type, saturation, ground slope, and land use

cover type. Soil type is based on the United States Department of Agriculture (USDA) Soils Maps for New Castle County and is classified into four hydrologic soil groups (A, B, C and D, with A being the most pervious and D the least pervious). Hydrologic soils groups were interpreted on the soils maps and then electronically digitized into CAD format. Average soil moisture conditions were assumed for the study. Areas of similar land use and ground slope were taken from Water Resource Agency mapping (Shellpot Creek Watershed – Land Use, Water Resources Agency for New Castle County, November 1995) and digitized into CAD format. Mapping showing the soils and land use for the Shellpot Creek Watershed is included in Appendix A.

As defined within the SCS methods, a CN value exists for each unique set of land use and soil conditions. It is, therefore, necessary to subdivide each subwatershed into areas that have a single land use and soil condition and to assign the appropriate CN value. Subwatershed CN values are then computed as an area-weighted composite of these subdivided area CN values. In order to facilitate this calculation, the Geographical Information System (GIS) capability of AutoCAD Map, Release 2 was utilized. Subwatershed, soils, and land use layers were overlaid and "dissolved" into polygons having single values for each parameter (subwatershed ID, soils classification, land use category). CN value was assigned to each polygon and the product of CN times polygon area was calculated for each subwatershed. These products were then divided by the subwatershed areas to compute the composite CN value. Final CN values and associated calculations are presented in the TR-20 model documentation in Appendix A.

D. CALCULATION OF CONCENTRATION TIMES

Concentration time (T_c) is a measure of how quickly overland runoff will reach a point of interest within a given subwatershed. This parameter, in conjunction with the CN value and specified rainfall, is sufficient for the generation of runoff hydrographs for unique drainage areas (subwatersheds) in the TR-20 model. Using SCS methods, T_c values are computed as a function of ground slope and roughness, flow length, and, in cases where flow is concentrated, channel geometry. All T_c calculations and final values are presented in the TR-20 model documentation in Appendix A.

E. STREAM REACH ROUTING

Within the Shellpot Creek Watershed, subwatersheds are connected in a dendridic fashion with upper subwatersheds draining through lower subwatersheds. Stream reaches that convey runoff from upper subwatersheds through lower subwatersheds typically store water and attenuate the flow. This has the effect of reducing peak flows and delaying the time at which the peak occurs at

downstream locations. The TR-20 model accounts for this effect through stream reach routing using the Modified Att-Kin Method. This method requires that tables of area versus flow be specified for stream reaches. These tables were computed for all stream reaches deemed to have significant routing effects. For a given reach, a typical section was chosen and values for flow and area were computed for specified values of flow depth. Manning's formula was utilized for the computation of flow values. All flow versus area tables, associated computations, and stream reach calculations are presented in the TR-20 model documentation in Appendix A.

F. IMPOUNDMENT STORAGE ROUTING

In areas of flow constriction along a stream reach, storage of runoff will occur upstream of the constriction. If the combination of the available storage volume and the constriction is significant, downstream flow attenuation will occur. These situations typically arise at roadway and railroad culverts, stormwater facilities impoundments, and dams. In cases where impoundment storage was deemed to be significant within the Shellpot Creek Watershed, the impoundments were chosen as the points of interest for delineated subwatersheds. Within the TR-20 method, the attenuation effects due to impoundments are accounted for by the performance of level pool flood routing. This method requires values of flow through the constriction and upstream stored volume for each specified value of elevation over which flow may occur at the constriction. Volumes were computed using estimated topographic information from aerial mapping supplied by the New Castle County Conservation District ("Shellpot Creek Floodplain Study, New Castle County, Delaware" prepared by Landmark Engineering, Inc., March 13, 1996). Flow through constrictions was estimated using a variety of methods including FHWA culvert methods, weir flow, the Army Corps of Engineers HEC2 Model, and other methods as appropriate. All volumetric calculations, constriction flow calculations, and flow impoundment calculations are presented in the TR-20 model documentation in Appendix A.

G. MODELING APPROACH AND GENERAL RESULTS

A TR-20 model was developed using the input data for subwatersheds, reaches, and impoundments as described above. In accordance with the method, upper watersheds and reaches were connected to lower reaches, and flows were computed by the program from upstream to downstream. A schematic showing input data and connectivity information for watersheds, reaches, and impoundments is given in the TR-20 model documentation in Appendix A.

The 2-, 10- and 100-year rainfall events (3.3, 5.2 and 7.3 inches, respectively) were used to generate runoff for the study. The 2-year storm was chosen as an indicator of high frequency (more frequent) storm events and the 100-year storm

was chosen as indicator of extreme (less frequent) events. The 10-year storm was computed in order to evaluate intermediate storm events.

The model was used as a tool to address the issues discussed in the remainder of this report. These issues include the evaluation of whether proposed storage of stream flows would be effective in a particular location, whether increasing storage would flood upstream structures, which roads are overtopped in various storm events, and generally, whether cost-effective solutions exist for channel improvements, culvert enlargements, off-stream detention, and other improvements.

SECTION III

PROBLEM SITE IDENTIFICATION

III. PROBLEM IDENTIFICATION

A. GENERAL

A fundamental task of the flood abatement study was to identify existing and historic flooding, water quality, and other flood-related problems in the watershed. The goal was to identify all known problem sites and propose potential improvement measures for each site. In order to identify the improvement sites, the project team conducted the following tasks: collection and review of existing data, review of New Castle County (NCC) and Delaware Department of Transportation (DelDOT) problem areas, coordination of public workshops, analysis of existing studies, and detailed field reconnaissance. As discussed in the following sections, the Shellpot Creek web site was also used as a source of site identification.

B. COLLECTION AND REVIEW OF AVAILABLE DATA

One of the goals of the watershed study was to make maximum use of available data from studies and evaluations that have already been performed in the Shellpot Creek Watershed. This information and other available data gathered from NCC and DelDOT were used to help identify and evaluate potential problem and improvement sites. The following list comprises many of the sources of data that were reviewed for applicability to this project:

- Engineering Study for Storm Drainage, New Castle County, Delaware, July 1968, Edward H. Richardson Associates, Inc.,
- Engineering Update for Storm Drainage, New Castle County, Delaware, 1990 (Landmark Engineering, Inc. in association with Duffield Associates, Inc. and VanDemark & Lynch, Inc., March 1990),
- Open File Report No. 31 - The Storm of July 5, 1989: Hydrologic Conditions, (Delaware Geological Survey, October 1989),
- NCC and DelDOT Complaints, (New Castle County, Department of Special Services, DelDOT),
- FEMA Flood Insurance Rate Maps, New Castle County, Delaware, 1996,
- Orthophoto topography - Shellpot Creek Floodplain Management Study, New Castle County, Delaware, Landmark Engineering, Inc. and Wings Aerial Mapping Company, Inc., March 1996,

- USGS quadrangle maps,
- Shellpot Creek Watershed – Land Use (Water Resources Agency, November 1995), and
- Soil Survey, New Castle, Delaware, October 1970 (USDA, Soil Conservation Service).

During the initial information gathering stage of the project, existing data were reviewed. To develop a list of problem sites that had been previously identified and to locate potential regional stormwater management sites, members of the project team reviewed existing hydrologic and drainage reports, maps, and other existing watershed data. In addition, team members met with representatives of New Castle County's Department of Special Services, DelDOT's Stormwater Management Section, and the New Castle Conservation District.

1. REVIEW OF EXISTING REPORTS

The primary sources of previously identified flood-related issues and proposed solutions used by the project team were "Engineering Study for Storm Drainage, New Castle County, Delaware, 1968," the "Engineering Update For Storm Drainage, New Castle County, Delaware, 1990" and "Open File Report No. 31 - The Storm of July 5, 1989: Hydrologic Conditions, 1989." These reports identified problem/improvement sites for numerous drainage basins in New Castle County, Delaware (including the Shellpot Creek Watershed) and developed preliminary recommendations for the mitigation of flooding conditions. Improvement sites listed in these reports that had not been addressed were evaluated as potential improvement sites for this study.

2. REVIEW OF NCC AND DELDOT PROBLEM/IMPROVEMENT SITES

In addition to the review of existing reports, members of the project team met with representatives from New Castle County's Department of Special Services, Drainage Section group, and DelDOT's Stormwater Management Section. The purpose of these meetings was to discuss and identify historical and existing flooding problem/improvement sites that these agencies had identified in the watershed. Flooding or drainage improvements that had previously been implemented in the watershed were discussed at this time. Sites that were not previously addressed by these agencies were evaluated as potential improvement sites for this study.

3. Review Of Existing Watershed Data

As shown in Figure I-1, the Shellpot Creek Watershed is a highly developed watershed that leaves few available open space sites for regional or semi-regional stormwater management or flood control. Of those open space areas available for stormwater management, potential improvement sites were evaluated based on the presence of flooding and water quality problems, location in the watershed, land use, existing topography, hydrogeologic conditions, and the drainage area to the site. The topography, soils, and land use sources listed previously were used in combination to identify potential stormwater management sites to be used to mitigate flooding conditions in the watershed.

C. PUBLIC WORKSHOPS

Public workshops were conducted on November 19 and 24, 1997 during the data collection phase of the study. The purpose of the workshops was to present an overview of the Shellpot Creek Flood Abatement Study and to solicit input from residents regarding problem areas in the watershed. Prior to the workshops, a project informational bulletin (Appendix B) was developed and mailed to the watershed residents. The bulletin was developed to announce the commencement of the Shellpot Creek Flood Abatement Study, briefly discuss the goals of the study, identify the study area, and invite members of the public to the workshops to discuss and identify problem/improvement sites. The workshops were conducted in the evenings to accommodate the largest number of participants possible. Maps and other study information were provided to aid the residents in identifying problem areas. Senior technical members of the project team led the workshops. Representatives from other agencies and the Flood Abatement Committee were invited to attend the workshops in order to provide information and education.

During the workshops, residents identified problem sites in the watershed by meeting individually with project team members and completing comment/complaint sheets. Copies of the workshop comment sheets are included in Appendix C. These worksheets identified the name, address, and phone number of the complainant, the comment or problem, the magnitude of the problem, and the duration of the problem. These sheets were then used to list potential problem and improvement sites to be evaluated in the field reconnaissance and site assessment phase of the study.

D. WEB SITE

A Shellpot Creek web site located on the World Wide Web at *www.shellpot.com* was developed at the time of project kick-off to inform the public of the problems

being evaluated in the watershed, provide updates of the flood abatement study progress, provide general information about watershed management, enable residents to communicate with the project team, and collect data from members of the public concerning problem areas in the watershed.

Several potential problem/improvement sites were identified from the web site and considered for evaluation in this study. In addition, general watershed information and specific flood-related data were gathered through the site. The web site home page is included in this report in Appendix D.

E. FIELD RECONNAISSANCE

Following the data collection phase of the study, a tabular summary was developed listing problem sites or issues identified during the tasks above. As presented above and as specified in the project scope of work, these sites were primarily identified through the workshops and existing flood reports. Table III-1 summarizes these sixty-one (61) identified sites.

The scope of work for the flood abatement study specified that as part of the design phase, design improvements or preliminary design packages would be developed for up to 30 sites. Initially all sites shown in Table III-1 were evaluated by project team engineers and scientists to determine if they should be carried through to the design phase. A typical improvement site might include stabilization of a streambank that is experiencing severe erosion leading to loss of property or a location where sediment deposition is occurring in the creek.

The project team performed an initial screening to list those sites that were identified that were not directly related to flooding and water quality in the Shellpot Creek. For instance, many individuals were concerned with the location of the Federal Emergency Management Agency's (FEMA) 100-year floodplain boundary in relation to their properties. Because delineation of the 100-year floodplain boundary and evaluation of FEMA flood insurance requirements were not part of the project scope, these sites were dropped from further consideration. During the public workshops, however, members of the project team and DNREC worked with residents to identify flood elevations near individual homes based on the FEMA Flood Insurance Rate Maps. These sites were either referred to FEMA directly or to DNREC's FEMA representative. Also, several identified problem sites were located outside of the Shellpot Creek Watershed and, therefore, were dropped from further consideration.

For the remaining sites that potentially required some form of remediation, the project team performed a field reconnaissance to identify and assess potential improvement measures in the fall of 1997. Field teams initially collected data on each of the sites during a five-day period. To document the information gathered during the site visits, the team utilized field data sheets. These data sheets

TABLE III-1
POTENTIAL IMPROVEMENT SITES

SITE #	*ADDRESS/LOCATION*	*PROBLEM/REVIEW*	*SOURCE*
101	812 Wilson Road	Flooding	Workshop[1]
102	Murphy & Foulk Rd.	Flooding	Workshop[1]
103	Rock Manor Golf Course	Flooding	Workshop[1]
104	Entire Watershed	Water quality	Workshop[1]
106	Webster Farms	Flooding	Workshop[1]
107	1902 Brookside Ln.	Erosion	Workshop[1]
108,109 & 234	Bringhurst Woods	Flooding	Workshop[1]
110,112 - 114,116 & 117	Silverside Rd.	Erosion	Workshop[1]
111	Foulk Manor North	Flooding	Workshop[1]
115	Foulk & Shipley Rd.	Flooding	Workshop[1]
118	3204 Heathwood Rd	Floodplain	Workshop[1]
119	Baynard Blvd.	Flooding	Workshop[1]
120	Stoney Creek Ln.	Flooding	Workshop[1]
121	3024 Maple Shade Ln.	Basement flooding	Workshop[1]
122	2709 Landsdowne Dr.	Floodplain	Workshop[1]
123	2713 Landsdowne Dr.	Floodplain	Workshop[1]
124a	Timber Ln.	Drainage	Workshop[1]
124b	4003 Greenmount Rd	Sink hole	Workshop[1]
125	2711 Landsdowne Dr.	Erosion	Workshop[1]
126	3207 Landsdowne Dr.	Erosion	Workshop[1]
128	Market St.	Debris build-up	Workshop[1]
129	309 Beeson Ave.	Flooding	Workshop[1]
130	309 Beeson Ave.	Erosion	Workshop[1]
131	1200 Hillside Blvd.	Erosion	Workshop[1]
132	107 Rockwood Rd.	Floodplain	Workshop[1]
140	Shipley Rd.	Flooding	Workshop[1]
143	Colony North	Flooding	Workshop[1]
145	Lea Blvd. @ Matson Run	Flooding	1990 Report[2]
146	3206 Tanya Dr.	Erosion	Workshop[1]
148	2824 Kennedy Dr.	Flooding	Workshop[1]
149	Weldin Rd @ Carruthers Ln.	Flooding	1990 Report[2]
150	Edgemoor Industrial Park	Flooding	Workshop[1]
153	2405 Sweetbriar Rd.	Flooding/Erosion	Workshop[1]
154	3215 Cardriff Dr.	Flooding/Erosion	Workshop[1]
160	1012 Sedwick Dr.	Flooding	Workshop[1]
231	Gov. Printz & Lea Blvd.	Flooding	Workshop[1]
232	Market St.	Floodplain	Workshop[1]

TABLE III-1
POTENTIAL IMPROVEMENT SITES
(CONTINUED)

SITE #	*ADDRESS/LOCATION*	*PROBLEM/REVIEW*	*SOURCE*
233	Washington St. Extension	Flooding	1990 Report[2]
234	I-95 & Marsh Rd.	Flooding	1990 Report[2]
236	Tributary Weldin & Foulk Rd.	Flooding	1990 Report[2]
237	Tributary River & Rysing Rd.	Flooding	1990 Report[2]
238	Coachman Rd./Surrey Park	Flooding	1990 Report[2]
239	Edgemoor Terrace & Gardens	Flooding	1990 Report[2]
240 & 301	Carr & Shipley Rds.	Flooding	1990 Report[2]
242	Colony North	Flooding	Workshop[1]
244	Baynard Blvd./Normandy Manor	Flooding	Workshop[1]
245	Weldin Rd. @ Turkey Run	Erosion	1990 Report[2]
302b	Rockwood Museum	Flooding	Committee[3]
304	Rock Manor Golf Course	Flooding	Committee[3]
305	Welding Park	SWM	Reconnaissance[5]
310.5	Tally Day Park @ Shellpot	Flooding	Committee[3]
312	Springer Middle School	Flooding	Reconnaissance[5]
313	WDEL	Erosion	Reconnaissance[5]
325	Shellpot Creek & Amtrak	Flooding	Reconnaissance[5]
401	524 Windley Rd.	Flooding	Workshop[1]
402	126 Homewood Dr.	Flooding	Committee[3]
403	1710 Shady Brook Rd.	Erosion	Workshop[1]
404	Streed Property	SWM	Committee[3]
405	213 Landsdowne Dr.	Erosion	Workshop[1]
406	1698 Shady Brook Dr.	Erosion	Workshop[1]
407	Turkey Run & Washington Street Extension	Erosion	Committee[3]

NOTES:

1. Shellpot Creek Flood Abatement Study workshops held on November 19 and 24, 1997.
2. Engineering Update for the Storm Drainage, New Castle County, Delaware, 1990.
3. Shellpot Creek Flood Abatement Study Committee
4. SWM - Stormwater Management
5. Field reconnaissance and evaluation of potential problem/improvement sites by the project team.

provided the means to obtain consistent data information for all sites. The field data sheets developed during the field reconnaissance phase of the study are provided in Appendix E.

SECTION IV

IMPROVEMENT SITE SELECTION AND ASSESSMENT

IV. IMPROVEMENT SITE SELECTION AND ASSESSMENT

Following the field reconnaissance, the sites for which design packages would be developed were identified. The candidate sites that were dropped from further consideration either after the initial screening or following the field reconnaissance were added to an implementation file that is discussed in Section V. Although these "dropped" sites are not directly addressed in this report, recommendations have been made as to how the problems at these sites can be addressed.

Tasks conducted as described above resulted in the identification of thirty-five (35) potential sites that would benefit from an improvement measure. The sites were presented to the Shellpot Creek Flood Abatement Committee and were approved for consideration under the site assessment/design package phase of the study. As described below, preliminary designs and detailed feasibility assessments were conducted as part of this evaluation.

A. SITE SELECTION

The thirty-five (35) sites that were identified and approved for consideration in the design package development phase of the study are shown in Table IV-1. As indicated in the table, several of the original sites identified in Table III-1 were combined as one improvement design site. This was due to either the proximity of potential improvement sites or identification of a site by more than one individual or report.

Following the combination of sites, twenty-seven (27) sites remained for consideration in the design phase of the project. These sites were chosen based on the overall potential of the site to reduce flooding, restore physical stream conditions, or improve water quality. Following a preliminary analysis, several additional sites were excluded from the design package development phase. Two (2) of the sites (312 and 150) were dropped from consideration after further investigation, due to limited improvement potential. Site 312 (the open space area adjacent to Springer Middle School) was eliminated as a potential stormwater management site due to its ineffectiveness in reducing downstream flood elevations and its proximity to the school and residences. The tide gates on Shellpot Creek (Site 150) were reported during the workshops as being non-functional. However, after meeting with the City of Wilmington's Department of Public Works, it was learned that the gates are operational and on a routine maintenance plan. Sites 111 and 245 were moved to the implementation section of this report as these improvements have already been initiated. Conceptual design, feasibility assessments, and preliminary design packages were then completed for the remaining twenty-three (23) sites. The analyses of these sites are described below.

TABLE IV-1
IMPROVEMENT SITES

SITE	*LOCATION*	*WATER QUALITY/ FLOODING EVALUATION*	*POTENTIAL IMPROVEMENT MEASURES*
FLOW ATTENUATION SITES			
103 & 304	Rock Manor Golf Course, near I-95	Downstream flooding. Possible location for flood storage.	Provide flood storage to reduce downstream flooding. Provide wetland plantings for water quality improvements.
149	Weldin Road at Caruthers Lane (Matson Run upstream of Rock Manor golf course)	Downstream flooding.	Provide flood storage to reduce downstream flooding and improve water quality.
240 & 301	Carr Road at Shellpot Creek; Upstream of Carr Road at Bringhurst Woods	Localized and downstream flooding in location of the Carr Road crossing. Sediment accumulation. Deposition.	Provide flood storage to reduce downstream flooding. Provide wetland plantings for water quality improvements. Remove accumulated sediment.
312	Springer Middle School at Shellpot Creek	Downstream flooding. Possible location for flood storage.	Provide flood storage to reduce downstream flooding. Provide wetland plantings for water quality improvements.
313	WDEL Radio Station (open space in front of building)	Downstream flooding. Possible location for flood storage.	Provide flood storage to reduce downstream flooding. Provide wetland plantings for water quality improvements.
404	Streed Property (upstream of Shellpot Creek at Wilson Road)	Downstream flooding. Possible location for flood storage.	Provide flood storage to reduce downstream flooding. Provide wetland plantings for water quality improvements.
STREAMBANK STABILIZATION SITES			
110, 114, 116, & 117	Silverside Road at Shellpot Creek, and Community immediately upstream	Streambank erosion and undercutting. Localized flooding.	Streambank stabilization.
131	1200 Hillside Boulevard	Erosion on left overbank.	Streambank stabilization.

TABLE IV-1
IMPROVEMENT SITES
(CONTINUED)

SITE	*LOCATION*	*WATER QUALITY/ FLOODING EVALUATION*	*POTENTIAL IMPROVEMENT MEASURES*
238	Coachman Road	Streambank erosion. Sediment accumulation.	Streambank stabilization. Remove accumulated sediment.
245	Weldin Road at Turkey Run	Streambank erosion. Sediment accumulation.	Streambank stabilization. Remove accumulated sediment.
401	524 Windley Road	Streambank erosion.	Streambank stabilization.
403	1710 Shady Brook Road	Streambank erosion. Localized flooding.	Streambank stabilization.
406	1698 Shady Brook Road	Retaining wall failure.	Replace retaining wall.
407	Turkey Run and Washington Street Extension	Streambank Erosion.	Streambank Stabilization.
CHANNEL/CULVERT IMPROVEMENT SITES			
145	Lea Boulevard at Matson Run	Localized flooding.	Increase culvert size. Provide flood storage.
148	2824 Kennedy Road	Streambank erosion. Localized flooding.	Remove debris from stream. Enlarge inlets and/or culvert. Provide auxiliary stormwater channels conveyance. Streambank stabilization.

TABLE IV-1
IMPROVEMENT SITES
(CONTINUED)

SITE	*LOCATION*	*WATER QUALITY/ FLOODING EVALUATION*	*POTENTIAL IMPROVEMENT MEASURES*
160	Tributary to Shellpot Creek at Sedwick Drive	Localized flooding. Flood damage to home at 1012 Sedwick Drive. Streambank erosion.	Increase culvert size. Streambank stabilization. Increase creek conveyance.
233	Washington Street Extension and Shellpot Creek	Localized flooding.	Increase culvert size. Provide flood storage.
242	Matson Run at Washington Street and Park Drive	Localized flooding. Sediment accumulation.	Increase culvert size. Remove accumulated sediment.
325	Shellpot Creek and Amtrak	Flooding upstream of Amtrak creek crossing.	Enlarge bridge culvert.
FLOODPROOFING IMPROVEMENT SITES			
128 & 232	Market Street (Philadelphia Pike) at Shellpot Creek	Localized flooding. Debris accumulation.	Remove walls on downstream side of Market Street. Investigate floodwalls or berms. Remove accumulated debris.
143	Lea Boulevard East at Colony Apartments North	Localized flooding.	Channel modifications. Floodproofing with earth berms.
231	Governor Printz Boulevard at Lea Boulevard (Brooks Armored Car property)	Flooding - Brooks Armored Car Building.	Floodproofing with earth berms. Redesign/Rebuild aerial sewer crossing. Floodproof building. Investigate providing storage or conveyance channel for tributary.

TABLE IV-1
IMPROVEMENT SITES
(CONTINUED)

SITE	*LOCATION*	*WATER QUALITY/ FLOODING EVALUATION*	*POTENTIAL IMPROVEMENT MEASURES*
GENERAL DRAINAGE IMPROVEMENT SITES			
108, 109, & 234	Carr Road crossing of Shellpot Creek	Localized flooding.	Increase road drainage capacity.
111	1212 Foulk Road (Foulk Manor North)	Localized flooding. Sediment accumulation.	Remove accumulated sediment.
124A	Timber Lane, Shellbourne Lane, & Paschall Drive	Entire subdivision drains by swales along sides of roads. Erosion is moderate in one particular area downstream of Timberlane Road. Localized flooding. Drainage swale erosion.	Provide localized drainage improvements. Provide storm sewer. Swale stabilization.
150	Tide Gates - Edgemoor Industrial Park	Flooding - Tide Gates non-functional.	Repair tide gates as necessary. Develop and implement operation and maintenance plan for tide gates.

B. SITE ASSESSMENT

A detailed site assessment, which included a conceptual design and a feasibility assessment, was performed for each of the twenty-three (23) sites. The assessments were performed to: evaluate the feasibility of the proposed improvements; develop proposed design features to be incorporated into the final design; and, eliminate the need for additional planning-level studies. Preliminary design information packages summarizing the analysis for each potential improvement are provided in Appendix F. These packages include a summary of the existing site conditions, analysis of the proposed improvements, and the feasibility assessment. The packages also include a site plan and an estimate of probable cost for each recommended improvement measure.

1. PRELIMINARY DESIGN INFORMATION PACKAGES

Preliminary designs were developed for each of the identified improvement measures. The measures include stormwater management facilities (such as wet ponds and wetland/marsh areas), flood walls/levees, streambank stabilization, and drainage improvements. Standard engineering methodologies were used, as appropriate, for the preliminary designs.

Available data were used to perform the preliminary designs. Most of the topographic information was taken from USGS quadrangle maps or the orthophoto topographic plans identified in Section III provided by the New Castle Conservation District. Supplemental data were obtained for drainage structures, such as culverts, by field survey. The Flood Insurance Rate Maps of New Castle County, Delaware (FEMA, 1996) were also used.

As described in Section II of this report, a hydrologic model for the entire Shellpot Creek Watershed was developed using the SCS TR-20 computer program. As appropriate for the analysis of each recommended improvement measure, the watershed was divided into sub watersheds and curve numbers and times of concentration were generated for each drainage area. Potential flood storage improvement sites were evaluated for their potential to reduce downstream peak flows during rainfall events using the watershed TR-20 model.

Drainage conveyance structure (i.e., culverts and bridges) improvement computations were completed using survey data and other available topographic information. Headwater elevations for the culverts were

computed using the Federal Highway Bureau nomographs and the U.S. Army Corps of Engineers HEC-RAS program.

Storm sewer computations were necessary for two of the recommended improvement measures. Drainage areas were estimated and sizing of the storm drain pipes was completed for the each site. Invert elevations and hydraulic grade lines were not determined for the preliminary analyses.

Streambank stabilization computations were completed using the design parameters set forth by the Pennsylvania S & E Regulations, Chapter 4 - Recommended Engineering Methods & Procedures for Design of Bank Stabilization.

2. Feasibility Assessment

The feasibility of each of the recommended improvement measures was analyzed based on the factors discussed below. A summary of the feasibility analysis for each site is presented in the preliminary design summary packages in Appendix F.

a. Effectiveness

Effectiveness of a proposed improvement measure was defined as the capability to improve water quantity, water quality, and/or reduce flooding/drainage problems. Effectiveness is based on the drainage area, predicted reductions in discharges and water surface elevations, and other assessment factors.

b. Ownership

When possible, a determination was made whether the improvement site is located on public or private property. Facilities located on multiple private properties are likely to be more difficult to implement due to easement and/or right-of-way acquisition considerations.

c. Utility Conflicts

During field visits, the presence and approximate locations of identified utilities and overhead power lines were noted. During final design, more detailed utility types and locations must be determined.

d. Environmental Issues

The assessment of the proposed alternatives considered potential wetland and woodland/habitat impacts. In some cases, wetland plantings are recommended to be incorporated into the proposed remedial design to lessen the impact on stream systems. Improvements which would result in extensive or inappropriate impact to wetlands or woodlands were removed from further consideration before the conceptual design phase.

e. New Castle County Unified Development Code Issues

Implementation of the proposed improvements will need to comply with the provisions of New Castle County, Delaware's Unified Development Code. Issues related to County floodplain, wetland, woodland, and other environmental or construction regulations were considered during the feasibility assessment.

f. Permit Acquisition

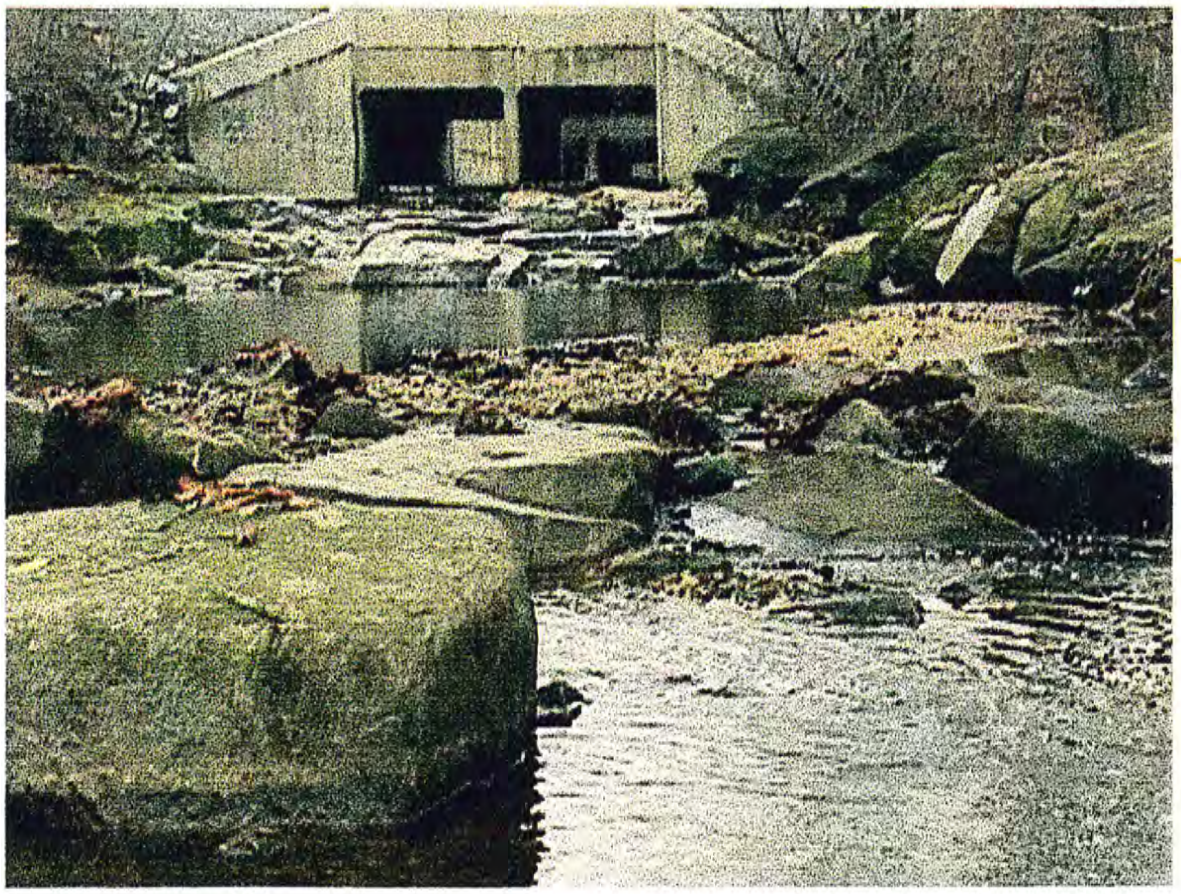
The permits expected to be required for construction of the proposed improvement measures were identified, and anticipated permitting issues were noted in the final design package. Typical potential permits for proposed remedial measures included: Subaqueous Lands (DNREC, Division of Water Resources, Subaqueous Section), Wetlands-Nationwide (U.S. Army Corps of Engineers), Floodplain, Grading and Site Review (NCCDLU) and Sediment and Erosion Control (NCCD).

3. COST ESTIMATES

Estimates of probable design and construction costs were developed for each potential site. Design costs include estimates for engineering, permit processing, and topographic surveys. Estimated construction costs include items such as excavation, sediment and erosion control, structural components, and stabilization/restoration costs. Unit cost data from the Delaware Department of Transportation's Division of Highways and cost estimates developed by the project team were utilized to determine the construction costs. Land acquisition costs are not included in the cost estimates, but the availability of requisite easements and rights-of-way, as well as acquisition or easement costs, should be considered prior to proceeding with final design.

SECTION V

IMPROVEMENT RECOMMENDATIONS



V. IMPROVEMENT RECOMMENDATIONS

This report recommends implementation of both structural and non-structural improvement measures in the Shellpot Creek Watershed. Structural measures generally consist of those constructed at a specific site to enhance stream conditions, reduce flooding typically on a local level or improve water quality. In contrast, non-structural measures typically do not involve construction and are implemented on a watershed-wide or countywide basis. Whereas structural measures generally result in lowering of water surface flood elevations and in improving water quality by a predicted amount, non-structural measures offer results in less quantifiable but often significant improvements. Non-structural measures can be an important tool to enhance the water quality and reduce the effects of future development or redevelopment on flooding in the Shellpot Creek Watershed and other watersheds in the region. Many non-structural measures incorporate public involvement components either directly or indirectly. Public involvement is critical to fostering citizen's and business owner's understanding of the potential impact of human activity on the stream ecosystem and hydrology.

A combination of both structural and non-structural measures is recommended to accomplish the greatest improvement in the Shellpot Creek Watershed. The following sections outline recommendations for structural and non-structural measures.

A. STRUCTURAL

This report recommends implementation of twenty-three (23) site-specific mitigation measures to improve water quality, enhance physical stream condition, and reduce flooding in the Shellpot Creek Watershed. Sites are categorized as follows:

- Flow Attenuation Sites which consist of new stormwater management facilities,
- Bank Stabilization Sites which focus on restoring and protecting eroding stream banks,
- Channel/Culvert Improvements which generally involve enlargement of undersized waterway openings,
- Floodproofing Measures which entail measures to mitigate for high water levels, and
- General Drainage Improvements which relate to storm drain modifications.

The sections below provide an overview of each type of measure and Tables V-1 through V-5 summarize each of the mitigation sites. Additional details are provided in the site-specific preliminary design packages in Appendix F.

1. FLOW ATTENUATION (TABLE V-1)

Five new stormwater management facilities are proposed (Sites 149, 240/301, 103/304, 313, and 404). Four of these sites are recommended to be shallow marsh facilities (Sites 240/301, 103/304, 313 & 404), and Site 149 is recommended to be a wet pond facility. The proposed stormwater management facilities will provide water quality management for drainage areas ranging in size from approximately 95 acres to 582 acres. Sites 313 and 103/304 will also provide water quantity control to reduce downstream flood levels during precipitation events. The stormwater management facilities provide reduction in stormwater discharges, water quality benefits, aquatic habitat enhancement, and aesthetic benefits to the surrounding areas.

2. BANK STABILIZATION (TABLE V-2)

Seven sites (Sites 110/114/116/117, 131, 238, 401, 403, 406 and 407) are proposed for stream bank stabilization improvements. Riprap or rock stabilization is recommended for sites (110/114/116/117, 131, 238, 401, 403 and 407) for stream bank lengths varying from 120 linear feet to 400 linear feet. Although riprap can be less aesthetic than other recently developed biostabilization techniques, this method was selected at these sites due to the existing stream morphology channel dimensions, area constraints and high storm flow velocities. In all cases, the riprap stabilization should be combined with native species plantings above the stream banks to provide additional biohabitat. The riprap stabilization will be placed at bends and other areas where erosion and undercutting of the stream banks has occurred. In conjunction with the riprap placements, the stream will be cleared of debris that is blocking the flow as necessary. A 75-foot long structural retaining wall is recommended at Site 406 because of the proximity of a swimming pool to the creek. At each site, the stream stabilization techniques provide water quality benefits through the reduction of erosion and subsequent downstream sediment deposition. Stabilization will also minimize further loss of property.

3. CHANNEL/CULVERT IMPROVEMENTS (TABLE V-3)

Culvert and channel improvements are recommended for five sites (Sites 145, 233, 242, 160, and 325). The channel/culvert improvements mainly consist of the addition of one or more culverts or enlargement of existing culverts. The culvert improvements sites are recommended to reduce/eliminate the potential of the road crossings at these culverts from being overtopped during large storm events. In general, removal of sediment deposition and regular maintenance (sediment removal) of

TABLE V-1
FLOW ATTENUATION

SITE	*LOCATION*	*WATER QUALITY/ FLOODING EVALUATION*	*RECOMMENDED IMPROVEMENT MEASURES*
103 & 304	Rock Manor Golf Course, near I-95.	Downstream flooding problems. Possible location for flood storage.	Provide flood storage to reduce downstream flooding. Provide wetland plantings for water quality improvements.
149	Weldin Road at Carruthers Lane (Matson Run upstream of the golf course)	Downstream flooding.	Provide offline facility to reduce downstream flooding and improve water quality.
240 & 301	Carr Road at Shellpot Creek; Upstream of Carr Road at Bringhurst Woods.	Localized and downstream flooding in location of the Carr Road crossing. Sediment accumulation. Deposition.	Provide flood storage to reduce downstream flooding. Provide wetland plantings for water quality improvements.
313	WDEL Radio Station (open space in front of building)	Downstream flooding. Possible location for flood storage.	Provide flood storage to reduce downstream flooding. Provide wetland plantings for water quality improvements.
404	Streed Property (upstream of Shellpot Creek at Wilson Road)	Downstream flooding. Possible location for flood storage.	Provide flood storage to reduce downstream flooding. Provide wetland plantings for water quality improvements.

TABLE V-2
STREAMBANK STABILIZATION

SITE	*LOCATION*	*WATER QUALITY/ FLOODING EVALUATION*	*RECOMMENDED IMPROVEMENT MEASURES*
110, 114, 116 & 117	Silverside Road at Shellpot Creek, and Community immediately upstream.	Erosion and undercutting. Localized flooding.	Streambank stabilization.
131	1200 Hillside Boulevard	Erosion on left overbank.	Streambank stabilization.
238	Coachman Road	Streambank erosion. Sediment accumulation.	Streambank stabilization. Clean sediment from channel.
401	524 Windley Road	Streambank erosion.	Streambank stabilization.
403	1710 Shady Brook Road	Streambank erosion. Localized flooding.	Streambank stabilization.
406	1698 Shady Brook Road	Retaining wall failure.	Replace retaining wall.
407	Turkey Run and Washington Street Extension	Streambank erosion.	Streambank stabilization.

TABLE V-3
CHANNEL/CULVERT IMPROVEMENTS

SITE	*LOCATION*	*WATER QUALITY/ FLOODING EVALUATION*	*RECOMMENDED IMPROVEMENT MEASURES*
145	Lea Boulevard at Matson Run	Localized flooding.	Enlarge culvert to provide stormwater management.
160	Tributary to Shellpot Creek at Sedwick Drive	Localized flooding. Flood damage to home at 1012 Sedwick Drive. Streambank erosion.	Enlarge culvert to provide stormwater management. Streambank stabilization. Construct earth berms.
233	Washington Street Extension and Shellpot Creek	Localized flooding.	Increase culvert size.
242	Matson Run at Washington Street and Park Drive	Localized flooding. Sediment accumulation.	Clean sediment from channel to increase conveyance.
325	Shellpot Creek and Amtrak	Flooding upstream of Amtrak creek crossing.	Enlarge culvert to provide stormwater management.

problem areas to prevent further sediment accumulation should reduce flooding potential of roads and surrounding areas.

4. FLOODPROOFING (TABLE V-4)

Three floodproofing sites are recommended for implementation (Sites 128/232, 143 and 231). Site 128/232, which is located at Shellpot Creek and Market Street, experiences flooding (overtopping of the road) during large storms. Although it does not appear to be feasible to construct a floodwall or enlarge the culvert at Sites 128/132, removal of an existing 2-foot high wall which blocks the flow over the road from returning to the stream is proposed. Site 143 is located at Colony North Apartments, where significant flooding has occurred in the first floor of one of the buildings. It is recommended that a floodwall be installed behind the apartments along Shellpot Creek. A one-acre stormwater management pond is proposed to be installed to provide storage of the drainage from areas behind the flood wall. Site 231 is located at the Brooks Armored Car Company, which has experienced flooding of their basement on at least two occasions in the past 20 years. Construction of floodwalls at the two driveway entrances to the basement of the building is recommended. Floodgates are recommended to be installed at both entrances to seal off access to the loading docks when floodwaters threaten the building.

5. GENERAL DRAINAGE IMPROVEMENTS (TABLE V-5)

Storm drainage improvements are recommended for three sites (Sites 108/109/234, 148 and 124A). Site 108/109/234 is located at the Carr Road crossing of Shellpot Creek. This location experiences flooding due to inadequate road drainage. The proposed improvement measure includes the improvement of road drainage by the addition of curb cuts or a catch basin and storm sewer. Site 148, which is located adjacent to a single-family residence at 2824 Kennedy Drive in Talleybrook, is experiencing frequent flooding problems in the side yard of the residence. The proposed improvement measure consists of storm sewer improvements to the system that drains to Shellpot Creek adjacent to the residence. Site 124A, which is located at Timber Lane and Weldin Road, currently experiences flooding during large storm events. Three inlets exist near the intersection, and runoff from 10 acres of single-family development drain along Weldin Road to the inlets. The recommended improvement is to install an additional storm drain system upstream of the existing inlets to intercept the flow from the drainage area and enlarge the existing storm drain system to convey the flow.

TABLE V-4
FLOODPROOFING

SITE	*LOCATION*	*WATER QUALITY/ FLOODING EVALUATION*	*RECOMMENDED IMPROVEMENT MEASURES*
128 & 232	Market Street (Philadelphia Pike) at Shellpot Creek	Localized flooding. Debris accumulation.	Remove walls on downstream side of Market Street to allow conveyance when Market Street overtops. Investigate floodwalls or berms.
143	Lea Boulevard East at Colony Apartments North	Localized flooding.	Increase culvert conveyance by providing a retaining wall on the right channel bank (facing downstream) downstream of the culvert. Install an earth berm to protect the apartment building from flooding.
231	Governor Printz Boulevard at Lea Boulevard (Brooks Armored Car property)	Flooding - Brooks Armored Car Building.	Construct earth berms around entrances to the basement of Brinks building. Redesign/Rebuild aerial sewer crossing to improve stream conveyance. Floodproof building. Investigate providing storage or conveyance channel for tributary.

TABLE V-5
GENERAL DRAINAGE IMPROVEMENTS

SITE	*LOCATION*	*WATER QUALITY/ FLOODING EVALUATION*	*RECOMMENDED IMPROVEMENT MEASURES*
108, 109 & 234	Carr Road crossing of Shellpot Creek	Localized flooding.	Increase road drainage capacity by adding a catch basin & storm sewer.
124A	Timber Lane, Shellbourne Lane, & Paschall Drive	Entire subdivision drains by swales along sides of roads. Erosion is moderate in one particular area downstream of Timberlane Road. Localized flooding. Drainage swale erosion.	Provide localized improvements at the intersection of Weldin and Timberlane Roads. Provide storm drain for community. Provide stabilization for one moderately eroded area.
148	2824 Kennedy Road	Streambank erosion. Localized flooding.	Clean debris from stream. Enlarge inlets and/or culvert. Provide auxiliary channel from uphill (east) on Kennedy Road to reduce drainage to inlets. Provide stream stabilization in eroded areas (riprap).

B. NON-STRUCTURAL

This report recommends implementation of seven (7) types of non-structural measures to ensure both short-term and long-term improvement of water quality and reduction of flooding in the Shellpot Creek Watershed. The non-structural recommendations are categorized as follows: Watershed Coordinator, Riparian Buffer Enhancement, Conservation Design for Stormwater Management, Best Management Practices, Stream Maintenance, Stormwater Management, and Public Education and Awareness. The following sections provide an overview of each of these measures.

1. WATERSHED COORDINATOR

To ensure the implementation of the recommended improvement measures in this report and to maintain long-term interest in management of the Shellpot Creek Watershed, it is recommended that a person or persons be appointed as a Watershed Coordinator. This person could be a representative of New Castle County, the State of Delaware, the New Castle Conservation District, a private firm or organization, or a qualified member of the public who lives within the watershed boundary. The Watershed Coordinator would track the implementation of the structural and non-structural improvements recommended in this report, expand on the non-structural improvements specifically related to public education, coordinate watershed activities with elected officials, and ensure proper management of the watershed.

2. RIPARIAN BUFFER ENHANCEMENT

A riparian buffer is generally a linear corridor adjacent to a water body consisting of dense woody vegetation, such as trees and shrubs, that serves to filter stormwater runoff before entering the water body, provide thermal protection through shading, and provide a natural transition between the aquatic and terrestrial habitat. The creation of new riparian buffers and the enhancement of existing ones will improve water quality in the stream by controlling water temperature, contributing to habitat diversity, maintaining the stream channel's stability, and providing stormwater runoff quality management.

It is recommended that the Watershed Coordinator or other qualified individual work with the State, County, and local governments to identify locations along Shellpot Creek suitable for riparian buffer enhancement and secure funding for the trees and other vegetation to be planted. With the trees and shrubs available, members of the public from civic

organizations in the watershed could participate in the planting effort under the supervision of an expert from the State of Delaware, New Castle County, New Castle Conservation District, or a private organization.

3. Conservation Design for Stormwater Management

Conservation design involves the retention of a site's natural features in its development. This includes leaving portions of the site unaltered, reduction of impervious areas, construction of biofiltration practices, or the creation of natural areas. The creation of natural areas or leaving portions of the site unaltered provides for establishment of new biohabitat or maintenance of the natural habitat that existed before the development. Reduction of impervious area allows for infiltration and reduces the volume of post-development stormwater runoff from the site. Finally, the construction of biofiltration practices provides another level of filtration for stormwater, removes sediment and potentially other contaminants, allows for infiltration, and enhances groundwater recharge.

The State of Delaware's Department of Natural Resources and Environmental Control has developed a manual for the conservation design approach to stormwater management entitled, "Conservation Design for Stormwater Management." It is recommended that conservation design practices be required on all new development or redevelopment sites where feasible. Only when these practices are not physically or geologically possible should other methods of stormwater management be permitted.

4. Best Management Practices

Best management practices (BMPs) are techniques designed to minimize the impacts of development and other anthropogenic practices on surface water quantity and quality. Several structural BMPs have been discussed earlier in this report under the flow attenuation, bank stabilization, and channel/culvert improvement sections. However, this section focuses on non-structural BMPs, most of which are common sense or "good housekeeping" efforts. These efforts are focused primarily on non-point pollution sources. An example of a BMP is covering salt piles used for road deicing or the use of less harmful deicing agents. With the salt piles covered, the chance of salt entering the stream through stormwater runoff is greatly reduced. Some other examples of BMPs involve conservation of stream corridors or preservation of meanders, pools, and riffles, and the preservation of the dendritic drainage networks.

The implementation of the Stormwater National Pollution Discharge Elimination System (NPDES) Program in New Castle County will begin to address many of the stormwater runoff contamination issues in the watershed. This program, in part, requires industries, municipalities, and government agencies (such as New Castle County and DelDOT) to address non-point pollution issues through best management practices. However, some non-point pollution issues covered under this program, such as homeowner fertilizer overuse, among others, should also be addressed by the Watershed Coordinator or civic organizations. These issues can be accomplished through coordination with the New Castle County NDPES program and public education efforts, which will be addressed later in this section.

It is recommended that the Watershed Coordinator, a consulting engineer, or other representative review New Castle County's NPDES program determine what non-point sources are applicable in the watershed. Once the non-point sources have been identified, BMPs should be developed and implemented for these sources.

5. STREAM MAINTENANCE

Many localized flooding problems in the watershed are the result of deposited sediments and other debris, such as tree branches, clogging culverts and stream channels. Currently, both New Castle County and DelDOT have maintenance programs that periodically remove this debris to minimize the potential for clogged culverts. However, based upon comments at the Shellpot Creek workshops, numerous stream sections apparently were not part of these maintenance programs or were not maintained with sufficient frequency. It is recommended that those areas identified during the workshops or during field reconnaissance that are not currently maintained be added to the routine maintenance programs of the appropriate agency. As part of this report, letters have been written to the appropriate agencies recommending this action. It is also recommended that sections of Shellpot Creek that are susceptible to flooding should be periodically walked to identify previously unknown sediment depositions or other blockages in the creek that may contribute to localized flooding. To that end, it is recommended that neighborhood stream watch groups be created to routinely walk Shellpot Creek. Under the guidance of the Watershed Coordinator, these groups could greatly assist New Castle County and DelDOT in identifying problem areas and subsequently reducing localized flooding.

6. STORMWATER MANAGEMENT

Currently in New Castle County, stormwater management regulations address the maintenance of existing peak stormwater runoff rates and quality control. They do not require the reduction of existing peak stormwater runoff rates or volumes. In the Shellpot Creek Watershed and other highly developed watersheds with known flooding problems, it is recommended that regulatory agencies require over management, including detention, where appropriate, or other measures to reduce peak runoff rates for new development or redevelopment projects. This reduction of peak stormwater runoff rates which would occur over time should reduce flood elevations or at a minimum prevent present flood elevations from increasing.

Reduction of existing peak stormwater runoff rates and volumes can be accomplished in several ways. Conservation design, as discussed previously, should be encouraged or even required where feasible to reduce runoff volume. Conservation design techniques enhance stormwater infiltration, thereby reducing the total volume of runoff.

In Maryland, development projects are required to infiltrate a calculated percentage of the total runoff from a development site, again theoretically reducing the total volume of runoff leaving the site. Stormwater infiltration also increases groundwater replenishment, ultimately resulting in baseflow to streams and creeks in a watershed.

In some states such as Pennsylvania, municipalities require the use of the "meadow standard" in stormwater management calculations to reduce existing peak stormwater runoff rates. This standard results in a pre-development stormwater runoff rate that is typically higher than currently would be required in New Castle County, since post-development peak runoff rates can not exceed pre-development peak runoff rates. The result of this requirement is the reduction of post-development runoff rates from new development sites. Finally, New Castle County should require over-detention of stormwater runoff, where appropriate. It should be mentioned that over-detention is not appropriate in all locations in the watershed. Ideally, a stormwater management master plan should be developed and implemented to address future stormwater management issues.

All of the above recommendations would require changes in the current State of Delaware Sediment and Stormwater Management regulations and County codes. For the Shellpot Creek Watershed, it is recommended that a committee consisting of members of New Castle County's Department of Land Use, DNREC, and engineering design professionals be created to provide technical guidance in the determination of what percentage of

stormwater runoff can reasonably be infiltrated or overdetained given specific site conditions such as site size and hydrogeology. These recommendations should then be incorporated into the County and State regulations for the Shellpot Creek Watershed to reduce the overall peak rate and volume of stormwater runoff.

7. PUBLIC EDUCATION/AWARENESS

Educational programs designed to increase overall public awareness often result in the improvement to the water quality of a stream system. Pamphlets, flyers, educational workshops, and school programs are all tools that, when utilized properly, foster a feeling of responsibility among the watershed residents. The focus of educational programs is not only to teach residents about the ecology and function of a watershed and its influence on each individual's quality of life, but also to maintain and protect the watershed after the initial effort of education has been made.

Programs such as the City of Wilmington's Project Turtle are excellent examples of the types of tools that can influence watershed residents and create a valuable legacy. Project Turtle is a public education program in which school children paint turtle symbols on catch basins to remind people of the ultimate destination of pollution: the river and its wildlife.

For the Shellpot Creek Watershed, we recommend implementing a public awareness and education program with components similar to Project Turtle. It is recommended that the program consist of:

- Placement of symbols, such as fish, stenciled or imprinted on all catch basins in the watershed to remind residents that all the water that enters the stormwater collection system eventually makes its way to Shellpot Creek. The paints used for the stenciling should be environmentally safe and free of harmful contaminants

- Placement of signs on major roads at the watershed boundary to inform and remind the public that they are "Entering the Shellpot Creek Watershed"

- "Shellpot Creek" signs at all crossings of the creek, and similar signs for Turkey Run, Matson Run, and other tributaries to Shellpot Creek identifying the watercourse and reminding residents to protect these resources

- Development of interpretive trails or enhancement of existing trails such as greenways along the banks of Shellpot Creek and surrounding park land identifying plant and animal species

- Development and distribution of pamphlets on the care and protection of the Shellpot Creek Watershed. Such a pamphlet might include a list of "Do's and Don'ts" such as:

  - DO keep catch basins and drainage swales free from debris
  - DO maintain a vegetative buffer strip along the banks of the creek
  - DON'T overfertilize your lawn
  - DON'T dump leaves and grass clippings into the creek

Finally, we recommend that an educational and stewardship program be developed for students in the middle schools in the watershed to inform these children about the importance of creating and maintaining a healthy stream network and well-balanced watershed.

The pamphlets and public education program could be developed with the cooperation of New Castle County, DNREC, the Delaware Nature Society, Water Resources Agency, New Castle Conservation District, and other private consultants. The public education program should be coordinated with New Castle County in areas that overlap with the NPDES program.

C. RANKING MATRIX

In order to assist the Shellpot Creek Flood Abatement Committee and subsequent Watershed Coordinators in prioritizing implementation of the potential improvement measures, a qualitative ranking matrix system was developed. Each of the twenty-three (23) sites proposed for improvements was qualitatively ranked based primarily on the feasibility assessment categories. Each of the sites was evaluated with respect to effectiveness, hydraulic impacts, environmental impacts, constructability, permitibility, and costs. Table V-6 presents the ranking of each site for each parameter considered and provides an overall ranking of the sites.

D. IMMEDIATE IMPLEMENTATION

As discussed previously, a list of site specific problems in the Shellpot Creek Watershed was developed from the initial research, comments from committee members, residents attending the public workshops, and e-mail messages sent via the web site. As sites were removed after the initial screening or field review they were placed on an implementation list for immediate action. From the list of implementation sites, letters identifying specific problems and recommending improvement actions will be forwarded to the appropriate agencies. Letters for each of the implementation sites are attached in Appendix G.

TABLE V-6
RANKING MATRIX

Effectiveness:	Hydraulic Impact:	Environmental Impact:	Constructability:	Permit Feasibility:	Probable Cost:	Overall Ranking:
✔ ✔ ✔ Highly Effective	✔ ✔ ✔ High Impact	✔ ✔ ✔ Few Impacts	✔ ✔ ✔ Few Constraints	✔ ✔ ✔ High Feasibility	✔ ✔ ✔ Low Cost	✔ ✔ ✔ Good
✔ ✔ Moderately Effective	✔ ✔ Moderate Impact	✔ ✔ Some Impacts	✔ ✔ Some Constraints	✔ ✔ Moderate Feasibility	✔ ✔ Moderate Cost	✔ ✔ Moderate
✔ Minimally Effective	✔ Low impact	✔ Numerous Impacts	✔ Numerous Constraints	✔ Low Feasibility	✔ High Cost	✔ Poor

Site No.	Location	Type Improvement	Proposed Improvement	Effectiveness	Hydraulic Impacts	Environmental Impact	Constructability	Permit Feasibility	Probable Cost	Rank
103 & 304	Rock Manor Golf Course	Flow Attenuation	New SWM Facility	✔ ✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔	✔	✔ ✔
149	Weldin Road at Carruthers Lane	Flow Attenuation	New SWM Facility	✔	✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔	✔ ✔
240 & 301	Shellpot Creek @ Bringhurst Woods	Flow Attenuation	New SWM Facility	✔ ✔	✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔
313	WDEL Radio Station	Flow Attenuation	New SWM Facility	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔	✔	✔ ✔	✔ ✔
404	Streed Property	Flow Attenuation	New SWM Facility	✔ ✔	✔	✔ ✔ ✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔
110,114, 116 & 117	Shellpot Creek @ Silverside Road	Streambank Stabilization	Streambank Stabilization	✔ ✔ ✔	✔	✔ ✔	✔ ✔ ✔	✔	✔ ✔ ✔	✔ ✔ ✔
131	Hillside Boulevard	Streambank Stabilization	Streambank Stabilization	✔ ✔ ✔	✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔
238	Shellpot Creek @ Coachman Road	Streambank Stabilization	Streambank Stabilization	✔ ✔ ✔	✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔
401	524 Windley Road	Streambank Stabilization	Streambank Stabilization	✔ ✔ ✔	✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔
403	1710 Shady Brook Drive	Streambank Stabilization	Streambank Stabilization	✔ ✔ ✔	✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔
406	1698 Shady Brook Drive	Streambank Stabilization	Streambank Stabilization	✔ ✔ ✔	✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔
407	Turkey Run & Washington Street Extension	Streambank Stabilization	Streambank Stabilization	✔ ✔ ✔	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔

TABLE V-6 (CONTINUED)
RANKING MATRIX

Effectiveness:
✓✓✓ Highly Effective
✓✓ Moderately Effective
✓ Minimally Effective

Hydraulic Impact:
✓✓✓ High Impact
✓✓ Moderate Impact
✓ Low impact

Environmental Impact:
✓✓✓ Few Impacts
✓✓ Some Impacts
✓ Numerous Impacts

Constructability:
✓✓✓ Few Constraints
✓✓ Some Constraints
✓ Numerous Constraints

Permit Feasibility:
✓✓✓ High Feasibility
✓✓ Moderate Feasibility
✓ Low Feasibility

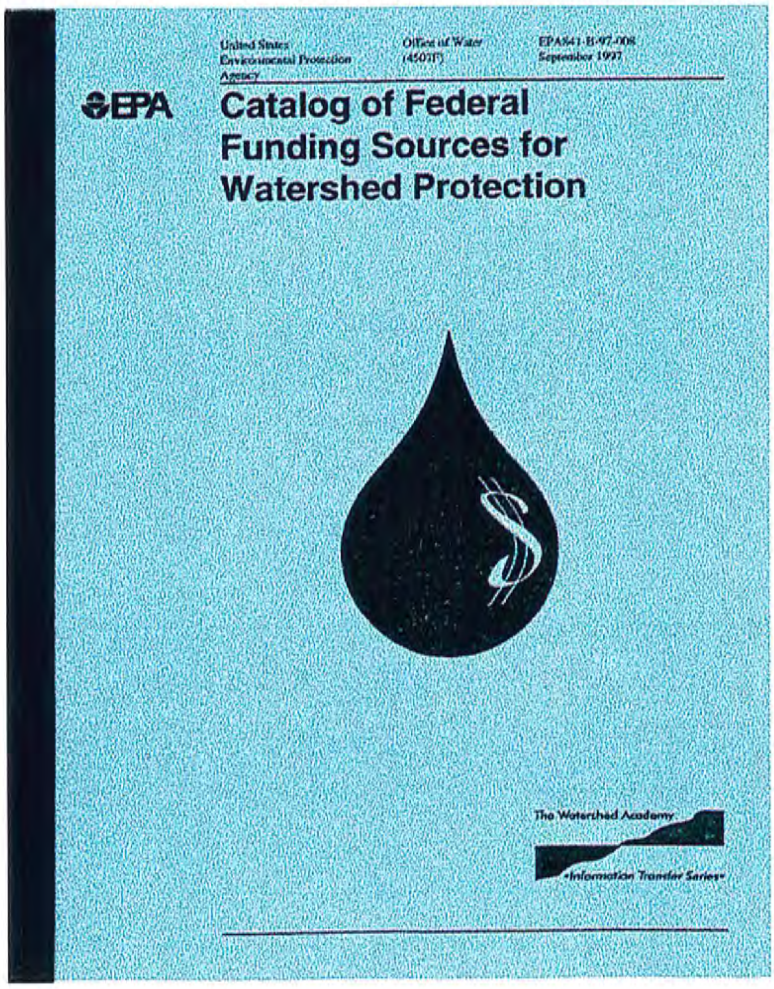
Probable Cost:
✓✓✓ Low Cost
✓✓ Moderate Cost
✓ High Cost

Overall Ranking:
✓✓✓ Good
✓✓ Moderate
✓ Poor

Site No.	Location	Type Improvement	Proposed Improvement	Effectiveness	Hydraulic Impacts	Environmental Impacts	Constructability	Permit Feasibility	Probable Cost	Rank
145	Matson Run @ Lea Boulevard	Culvert/Channel Improvement	Culvert Improvement	✓✓✓	✓✓	✓✓✓	✓✓	✓✓	✓✓	✓✓
160	Trib. to Shellpot Creek @ Sedwick Drive	Culvert/Channel Improvement	Culvert Enlargement	✓✓✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓✓
233	Shellpot Creek @ Washington Street Ext.	Culvert/Channel Improvement	Culvert Improvement	✓✓✓	✓✓	✓✓✓	✓✓	✓✓	✓✓	✓✓
242	Matson Run @ Washington Street Ext.	Culvert/Channel Improvement	Culvert Improvement	✓✓✓	✓✓	✓✓✓	✓✓	✓✓	✓✓	✓✓
325	Shellpot Creek @ Amtrak R.R. Crossing	Culvert/Channel Improvement	Culvert Enlargement	✓	✓	✓✓	✓	✓✓	✓	✓
128 & 232	Shellpot Creek @ Market Street	Flood Proofing	Drainage Improvements	✓✓✓	✓	✓✓✓	✓✓✓	✓✓	✓✓	✓✓✓
143	Shellpot Creek @ Colony North Apts.	Flood Control	Flood Control	✓✓✓	✓	✓✓	✓✓	✓✓	✓✓	✓✓
231	Shellpot Creek @ Lea Boulevard (Brooks Arnored Car)	Flood Proofing	Flood Proofing	✓✓✓	✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
108, 109 & 234	Shellpot Creek @ Carr Road	Flood Control	Storm drain Improvement	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓
124A	Timber Lane, Shellbourne Lane, Paschall Drive	General Drainage	General Drainage	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓
148	2824 Kennedy Road	Flood Control	Storm drain Improvement	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓

SECTION VI

FUNDING ALTERNATIVES



VI. FUNDING ALTERNATIVES

A final task of the watershed study was to research funding sources to be used to fund the improvement measures recommended in this report. The following paragraphs summarize several federal, state, and local funding alternatives.

A. THE WATERSHED PROTECTION AND FLOOD PREVENTION ACT

The Watershed Protection and Flood Prevention Act is a Federal Law (Public Law 83-566) passed by Congress in 1954, in response to the damages sustained to the nation's streams and floodplains from erosion, sedimentation, and flooding. Public Law 83-566, referred to as PL-566, provides a mechanism for local organizations to receive technical and financial assistance from the Department of Agriculture for planning and carrying out watershed projects through cost-sharing. The goal of this program is to integrate conservation efforts by the individual landowner with overall watershed management. The scope of this program is limited to watershed areas of less than 250,000 acres in size. Discussions with personnel at the NRCS have determined that the PL-566 program is applicable to portions of the Shellpot basin outside the incorporated limits of the City of Wilmington.

Typical projects that are eligible for assistance through this program include:

- Projects dealing with preventing damage from erosion, floodwater, and sediment
- Projects that advance the conservation, development, utilization, and disposal of water
- Projects that promote land conservation

These are projects that address water resource problems that transcend the ability of an individual property owner to manage. Organizations eligible for assistance under this program must be legally organized under state law and have the authority to carry out, operate, and maintain the improvements. These projects must be sponsored by groups that collectively or individually have the power of eminent domain and the authority to draw from adequate funding sources to finance their share of the project costs (including all costs of operations and maintenance). Typically, project sponsors are soil and water conservation districts, counties, municipalities, state agencies, or other special purpose districts.

B. FLOOD MITIGATION ASSISTANCE PROGRAM

The Flood Mitigation Assistance Program is a grant program administered by the Federal Emergency Management Agency (FEMA) that obtains project funding as

an extension of their flood insurance program. The total grant program for the State of Delaware is limited to $125,000 per year. Funding for small projects is typically $10,000 to $20,000 per project. Typical projects supported by the grant program are those relating to insurable buildings, which include homes, businesses, and commercial structures.

Eligible projects typically involve insurable buildings that are repeatedly flooded or at high risk for flooding, based on flood history. This grant program will usually pay to elevate or relocate the at-risk structure if suitable property is nearby. The program may also include minor localized structural improvement projects such as erosion control and drainage improvements. Funding from this program may be applicable for smaller individual projects as a component to the overall watershed management strategy.

C. SUBURBAN STREETS PROGRAM

As part of a statewide program, each Delaware legislator receives $300,000 per year to spend in his or her district for a roadway or drainage project identified by the legislator. This money is included in the State's annual budget and is incorporated into the Bond Bill. If accepted, the project is designed and bid by the Delaware Department of Transportation. This is a viable, albeit limited, funding source. Therefore, if implementation of proposed improvements is phased in over several years, funding from this program may provide for construction of smaller individual projects as a component of the overall watershed improvement plan.

D. STORMWATER UTILITIES

Pursuant to Title 7, Chapter 40 of Delaware Code, Erosion and Sedimentation and Stormwater Management, conservation districts, counties, and municipalities have the authority to adopt a fee system to help implement a management program. In lieu of a fee system, conservation districts, counties, and municipalities have the authority to establish a stormwater utility. The utility may be developed for designated watersheds and may fund long-range watershed master planning, watershed retrofitting, and facility maintenance. Financial responsibility to the program must be reasonable and equitable, so that each contributor of runoff within a watershed (including State agencies) pays in accordance with the quantity and quality of runoff that is discharged to the designated watershed.

Furthermore, as established in the Delaware Sediment and Stormwater Regulations Section 7, the following are components required of a local utility ordinance to implement a stormwater utility:

- Financing of the utility with a user charge system. The use of county and municipal taxpayer rolls and accounting systems are allowed for the assessment and collection of fees.

- Clearly defined utility purpose, including programs to be funded by the utility. These include the preparation of long-range watershed master plans, annual inspections of private and public stormwater management facilities, implementing regular maintenance, reviewing stormwater management plans and inspecting sediment controls, and retrofitting designated watersheds to reduce existing flooding problems or to improve water quality.

- Designated utility boundaries, identified by the local governing body, creation of a management entity, method for determining utility charges, procedures for investment and reinvestment of collected funds, and an appeals or petition process.

Additional information is provided in Title 7, Chapter 40 of Delaware Code, Erosion and Sedimentation and Stormwater Management and the Delaware Sediment and Stormwater Regulations Section 7.

E. ARMY CORPS OF ENGINEERS' CHALLENGE 21 PROGRAM

At present, Congress is debating the final form of Challenge 21, a new initiative for stream habitat restoration. It is unlikely that this program will be available to fund proposed improvements in the Shellpot Basin for some time.

F. ARMY CORPS OF ENGINEERS' CONTINUING AUTHORITIES PROGRAM

The Continuing Authority Program establishes a process by which the Corps of Engineers can respond to a variety of water resource problems without the need to obtain specific congressional approval for each project. Under the Continuing Authorities Program, the Corps of Engineers is authorized to construct small projects within specific Federal funding limits, as part of a cost-sharing approach. The Federal cost limit for projects potentially applicable to the Shellpot basin may be as much as $5 million. There are four types of projects pertaining to the Shellpot basin covered by this program. They are:

1. SMALL FLOOD CONTROL PROJECTS (SECTION 205, FLOOD CONTROL ACT OF 1948, AS AMENDED)

Small flood control projects may be constructed, if advisable, as determined by the Chief of Engineers. The project must be a complete

solution to the flood problem involved, and not require subsequent improvements to ensure effective results.

2. EMERGENCY STREAMBANK AND SHORELINE PROTECTION PROJECTS (SECTION 14, FLOOD CONTROL ACT OF 1946, AS AMENDED).

The Corps of Engineers may spend up to $500,000 in one locality in any fiscal year for the construction, repair, restoration, and modification of emergency streambank and shoreline protection works. These projects may be designed to prevent damage to highways, bridge approaches, and public works, as well as churches, hospitals, schools, and other non-profit services endangered by streambank or shoreline erosion.

3. PROJECT MODIFICATIONS FOR THE IMPROVEMENT OF THE ENVIRONMENT (SECTION 1135(B), WATER RESOURCES DEVELOPMENT ACT OF 1986, AS AMENDED).

The Corps of Engineers is authorized to investigate, study, modify, and construct projects for the restoration of fish and wildlife habitats where degradation is attributable to existing Federal water resource projects previously constructed by the Corps of Engineers. Both aquatic and terrestrial habitats can be improved.

4. AQUATIC HABITAT RESTORATION (SECTION 206 OF THE WATER RESOURCES DEVELOPMENT ACT OF 1996).

The Corps of Engineers is authorized to investigate, study, modify, and construct projects for the restoration of aquatic habitats. Degradation does not need to be attributable to a previous Federal water resource project. Terrestrial habitats are not covered.

Projects eligible for assistance must meet the following criteria:

- The project must be complete within itself and not commit the Corps of Engineers to further construction. The project must solve a specific problem and not require a subsequent project to complete the solution.

- The project must be economically justified. The benefits from the project must exceed the cost of the project, including project operation and maintenance costs.

- The project must be environmentally acceptable.
- The project sponsor must be willing to assist with the project.

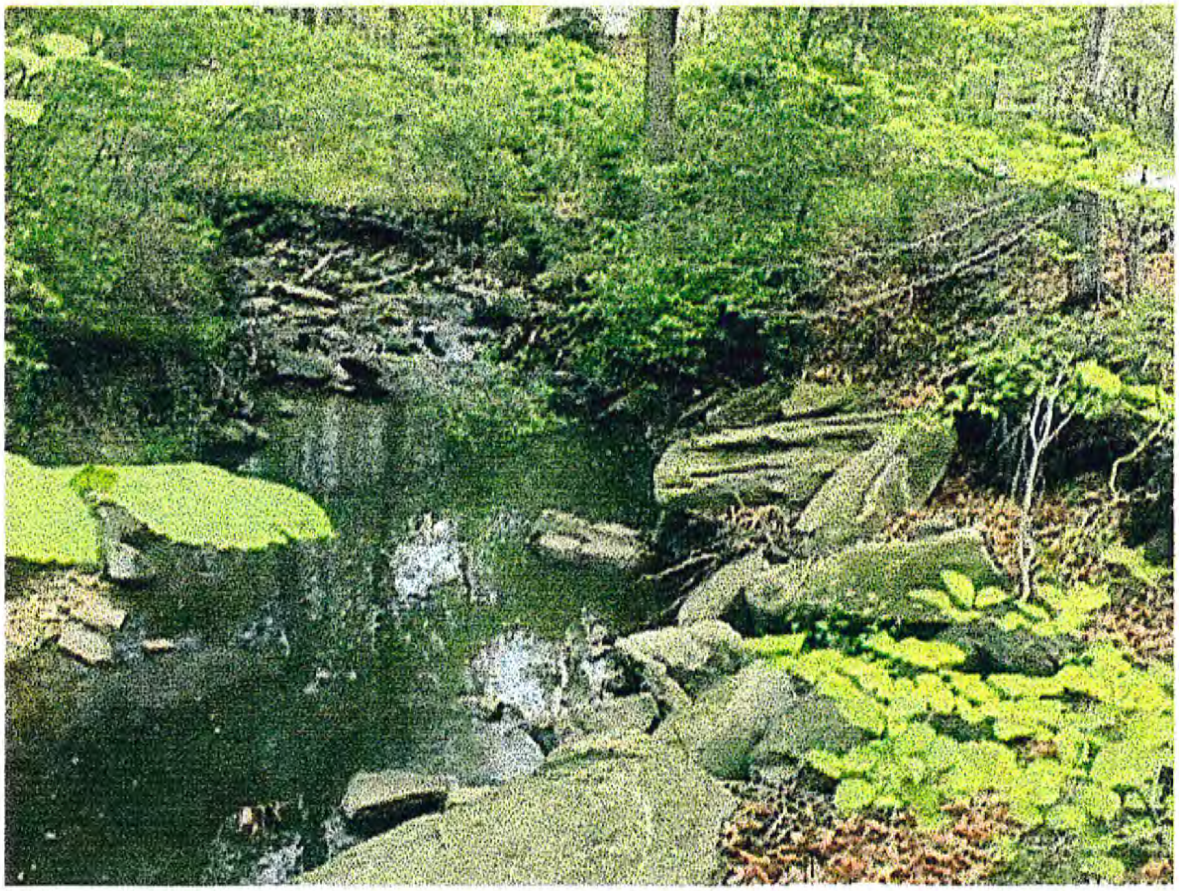
There is some flexibility to the types of projects that can be funded by each form of assistance. Typically, the cost sharing ranges from 65% to 75%.

G. SECTION 319 - WATER QUALITY ENVIRONMENTAL PROTECTION AGENCY

There is a limited amount of funding provided by the U.S. Environmental Protection Agency (EPA) for small projects focused on bioengineering or habitat enhancement projects. These projects usually are demonstration projects.

SECTION VII

SUMMARY AND RECOMMENDED IMPLEMENTATION PLAN



VII. SUMMARY AND RECOMMENDED IMPLEMENTATION PLAN

A. SUMMARY

This report documents the activities, results and recommendations of the flood abatement study conducted on the Shellpot Creek watershed located in New Castle County, Delaware. A Flood Abatement Committee was established and ultimately this study was authorized as a result of frequent and extensive flooding, water quality, and flood-related problems throughout the watershed. The purpose of this study was to evaluate flooding areas within the watershed, evaluate solutions to flooding, water quality, and flood-related problems, identify sites and solutions for the mitigation of those problems, develop a hydrologic model for the assessment of the efficacy of proposed solutions, and develop a ranking of proposed alternatives that considers implementability, cost and funding sources. Each of these topics is covered in this report and the final recommended implementation plan for proposed alternatives is given in Section B below.

B. RECOMMENDED IMPLEMENTATION PLAN

This report provides a tool for the Flood Abatement Committee to use in implementing a number of other stream improvement and bank stabilization projects. A summary of all recommended improvements and their associated rankings and costs is given in Table VII-1. It is recommended that these projects be considered on the basis of the rankings set forth in this table. Once a project has been identified for further consideration, the associated design package in Appendix F can be used for pursuing project funding sources and implementing design construction drawings.

As of the writing of this report, the Flood Abatement Committee has agreed to proceed with detailed design of several projects to implement certain recommendations in this report. These projects include the purchase of land adjacent to the Rock Manor Golf Course to construct a stormwater management facility (site 103 & 304), the construction of a stormwater detention facility on the WDEL property (site 113) and construction of a stormwater management/wetlands water quality control structure on the Streed property (site 404). Implementation of these site improvements is dependent upon adequate funding.

At some future time, it is the recommendation of this report (Section V) that a facilitator such as a watershed coordinator or stormwater utility be developed to carry out these implementations and follow up on funding alternatives. This facilitator will also be able to use this report in conjunction with the assessment of

TABLE VII-1
IMPROVEMENT SITES

SITE	*LOCATION*	*RANKING*	*ESTIMATED COST*
103 & 304	Rock Manor Golf Course, near I-95.	✓✓	$2,297,000
149	Weldin Road at Caruthers Lane (Matson Run upstream of the golf course)	✓✓	$3,920,000
240 & 301	Carr Road at Shellpot Creek; Upstream of Carr Road at Bringhurst Woods.	✓✓	$376,000
313	WDEL Radio Station (open space in front of building)	✓✓	$1,058,000
404	Streed Property (upstream of Shellpot Creek at Wilson Road)	✓✓	$1,100,000
110, 114, 116, & 117	Silverside Road at Shellpot Creek, and Community immediately upstream.	✓✓✓	$110,000
131	1200 Hillside Boulevard	✓✓✓	$75,000
238	Coachman Road	✓✓✓	$95,000
401	524 Windley Road	✓✓✓	$50,000
403	1710 Shady Brook Road	✓✓✓	$68,000
406	1698 Shady Brook Road	✓✓✓	$66,000
407	Turkey Run and Washington Street Extension	✓✓✓	$75,300
145	Lea Boulevard at Matson Run	✓✓✓	(A) $773,000 (B) $372,000
160	Tributary to Shellpot Creek at Sedwick Drive	✓✓✓	$86,000
233	Washington Street Extension and Shellpot Creek	✓✓✓	$380,000
242	Matson Run at Washington Street and Park Drive	✓✓✓	$258,000
325	Shellpot Creek and Amtrak	✓	(A) $2,453,000 (B) $5,874,000
128 & 232	Market Street (Philadelphia Pike) at Shellpot Creek	✓✓✓	$176,000
143	Lea Boulevard East at Colony Apartments North	✓✓	$542,000
231	Governor Printz Boulevard at Lea Boulevard (Brooks Armored Car property)	✓✓✓	(A) $92,000 (B) $165,000
108, 109 & 234	Carr Road	✓✓✓	$58,500
124A	Timber Lane, Shellbourne Lane, & Paschall Drive	✓✓✓	$154,000
148	2824 Kennedy Road	✓✓✓	$80,000

future flooding events to evaluate the best sequence and combination of alternatives to be constructed.