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COMPREHENSIVE DRAINAGE STUDY
STORMWATER MANAGEMENT MASTER PLAN
DARBY/LITTLE DARBY CREEK, ITHAN CREEK,
GULPH CREEK AND MEADOWBROOK RUN WATERSHEDS
RADNOR TOWNSHIP, DELAWARE COUNTY, PA

Owner:

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**RADNOR TOWNSHIP
STORMWATER MANAGEMENT MASTER PLAN
YEAR 2000**

TABLE OF CONTENTS

I.	SUMMARY	
A.	Recommendations	1
B.	Improvement Schedule.....	3
II.	INTRODUCTION	
A.	Purpose.....	6
B.	Scope.....	6
C.	Overall Problem Areas.....	7
	Darby/Little Darby Creek Watershed (Area 1).....	7
	Ithan Creek Watershed (Area 2).....	7
	Gulph Creek Watershed (Area 3).....	8
	Meadowbrook Run Watershed (Area 4)	8
III.	DARBY/LITTLE DARBY CREEK WATERSHED (AREA 1)	
A.	Physical Characteristics.....	10
B.	Review of Previous Recommendations.....	10
C.	Other Township Stormwater Management Projects	13
D.	Detailed Study Locations	13
E.	Conclusions and Recommendations.....	13
F.	Opinions of Probable Construction Costs	17
G.	Schedule/Sequence of Recommended Improvements	18
IV.	ITHAN CREEK WATERSHED (AREA 2)	
A.	Physical Characteristics.....	19
B.	Review of Previous Recommendations.....	19
C.	Other Township Stormwater Management Projects	21

D.	Detailed Study Locations	22
E.	Conclusions and Recommendations.....	22
F.	Opinions of Probable Construction Costs	26
G.	Schedule/Sequence of Recommended Improvements	26
V.	GULPH CREEK WATERSHED (AREA 3)	
A.	Physical Characteristics.....	27
B.	Review of Previous Recommendations.....	27
C.	Other Township Stormwater Management Projects	29
D.	Detailed Study Locations	30
E.	Conclusions and Recommendations.....	30
F.	Opinions of Probable Construction Costs	34
G.	Schedule/Sequence of Recommended Improvements	35
VI.	MEADOWBROOK RUN WATERSHED (AREA 4)	
A.	Physical Characteristics.....	36
B.	Review of Previous Recommendations.....	36
C.	Other Township Stormwater Management Projects	36
D.	Detailed Study Locations	38
E.	Conclusions and Recommendations.....	38
F.	Opinions of Probable Construction Costs	41
G.	Schedule/Sequence of Recommended Improvements	41
VII.	PENNSYLVANIA ACT 167 STORMWATER MANAGEMENT STUDY	
A.	Status	43
B.	Goals and Objectives.....	43

VIII. TOWNSHIP ORDINANCE RECOMMENDATIONS

A.	Chapter 280, Zoning.....	44
B.	Various Sections.....	44
C.	Chapter 245, Stormwater Management.....	44
D.	Chapter 255, Subdivision of Land.....	45

LIST OF APPENDICIES

Appendix A - Public Input

Darby/Little Darby Creek Watershed	A-1
Ithan Creek Watershed.....	A-1
Meadowbrook Creek Watershed.....	A-2
Gulph Creek Watershed.....	A-3

LIST OF FIGURES

Figure 1:	Darby/Little Darby Creek Watershed Map.....	11
Figure 2:	Ithan Creek Watershed Map.....	20
Figure 3:	Gulph Creek Watershed Map.....	28
Figure 4:	Meadowbrook Run Watershed Map	37

**RADNOR TOWNSHIP
STORMWATER MANAGEMENT MASTER PLAN
YEAR 2000**

I. SUMMARY

A. RECOMMENDATIONS

This Comprehensive Drainage Study updates the previous studies performed for Radnor Township in 1973, 1975, 1980, and 1992, and revises or augments the recommendations that were included in those reports. This study also focuses on specific areas of concern within each watershed and provides specific recommendations for improvements that would improve drainage conditions within those areas.

The four (4) main watersheds in Radnor Township include the Darby/Little Darby Creek Watershed (Area 1), the Ithan Creek Watershed (Area 2), the Gulph Creek Watershed (Area 3) and the Meadowbrook Run Watershed (Area 4). Each of the main watersheds was reviewed with the focus of identifying areas of flooding concerns and developing both structural and non-structural solutions to reduce the frequency and magnitude of the flooding within each watershed.

“Structural” solutions are unique to the specific watersheds, in the location within the watershed and the type of development in the area that contributes runoff to the proposed area for the structural solution. Structural solutions include stormwater management basins, increased stormwater collection systems, diversion systems, and other improvements that are constructed within the watershed.

“Non-structural” solutions are more general in nature and can be applied to all watersheds. These solutions include policies and procedures that result in a reduction of runoff and perform in conjunction with the existing stormwater infrastructure.

STRUCTURAL SOLUTIONS

DARBY/LITTLE DARBY CREEK WATERSHED

1. Construct a surface detention basin on the Levin Tract at Conestoga Road and S. Devon Avenue. This detention basin should be designed to provide the maximum storage and flow reduction that is practical.
2. Construct a surface detention basin within the S. Devon and Filipone Parks, immediately upstream of S. Devon Avenue. This detention basin should be designed to provide the maximum storage and flow reduction that is practical.
3. Reconstruct storm drainage system along intermittent tributary that flows from Overbrook Golf Club in a southeasterly direction towards Roberts Road. Coordinate possible stormwater management with the Golf Club.

4. Provide streambank stabilization designed to meet the unique requirements of each repair area. Maintain channel conveyance capacities during repair. Stabilization methods could include vegetated, bioengineered and structural elements, including reed berms, fiber rolls, willow cuttings, gabions, piling, cribbing, pavers, rip rap, and reinforced earth.

ITHAN CREEK WATERSHED

1. Construct stormwater collection system at the intersection of S. Wayne Avenue and Runnymede Avenue to collect the accumulated surface runoff that ponds at the low point. System would convey runoff around the existing school building.
2. Construct underground detention basin in the field areas to the east of the existing Middle School buildings and along Louella Avenue.
3. Construct, or require private developers to construct, underground detention basins in the parking lot areas of the commercial and retail development within Wayne.
4. Provide streambank stabilization designed to meet the unique requirements of each repair area. Maintain channel conveyance capacities during repair.

GULPH CREEK WATERSHED

1. Initiate discussions with the Church of Our Savior and expand the stormwater detention basin located northwest of the rear parking lot at the Church of Our Savior located in Tredyffrin Township. This basin should be expanded to provide the maximum storage and flow reduction that is practical.
2. Acquire and remove principal structures located within the flood plain and subject to frequent flood damage.
3. Provide streambank stabilization designed to meet the unique requirements of each repair area. Maintain channel conveyance capacities during repair.

MEADOWBROOK RUN WATERSHED

1. Expand stormwater management basin located on the campus of Villanova University in the area of Brooklea Road and Meadowood Road. This basin should be expanded to provide the maximum storage and flow reduction that is practical.
2. Request the Pennsylvania Department of Transportation (PennDOT) to reconstruct curbing and sidewalk along Lancaster Avenue in the area of Barley Cone Lane to provide gutter control of surface runoff.
3. Request the Southeastern Pennsylvania Transportation Authority (SEPTA) to reconstruct and/or repair the existing culvert under the rail embankment located between Buckingham Road and Fairfax Road to reduce the flooding on Buckingham Road.

4. Convert existing infiltration basin at Rosemont Office Building to a regulated underground detention basin by constructing a multi-stage outlet structure. Infiltration should be allowed to continue but should not be the primary discharge mode.
5. Provide a defined and stable channel along the toe of slope of the rock embankment along Conestoga Road near the SEPTA overpass. Provide landscape screening along Conestoga Road and tree plantings on the slope of the embankment.
6. Provide streambank stabilization designed to meet the unique requirements of each repair area. Maintain channel conveyance capacities during repair.

NONSTRUCTURAL SOLUTIONS

1. The Township should fully participate in the preparation of the Act 167 Stormwater Management Plan for Darby Creek that is currently being managed by Delaware County. It should be noted that the goals of the Act 167 Plan do not include the remediation of existing drainage problems within each drainage area but are to serve as the guidelines for stormwater management for future development in a manner that does not aggravate existing conditions.
2. Semi-regional watershed associations should be formed with Tredyffrin, Easttown and Newtown Townships in order to develop cooperation from the upper reaches of the watersheds that drain into Radnor Township. These associations should focus on the development of plans and procedures that would coordinate the efforts to improve existing drainage problems and provide information on flood plains, flood insurance, and care of channels and waterways.
3. Routine inspection and maintenance programs must be implemented to provide reasonable assurance that the channels and culverts do not become blocked by debris or ineffective due to deteriorated conditions; and that inlets and storm collection systems are clear and capable of receiving and conveying runoff.
4. Current zoning, land development and stormwater management ordinances must be modified to include additional provisions for controlling activities within the flood plains and additional provisions for stormwater management controls.

B. IMPROVEMENT SCHEDULE AND COST

With the exception of the recommended action in the Ithan Creek Watershed at the Radnor Middle School, development of a proposed implementation schedule would be an arbitrary schedule. The proposed recommendations do not require a specific sequence of implementation.

The exception is the recommendations at the Radnor Middle School should be designed in conjunction with the preparation of the plans for the site that are under consideration by the School District. The design of the drainage and stormwater management facilities should be coordinated with the design of the site; and the construction of the designed facilities should be coordinated with the construction of the improvements proposed by the School District.

The following represents an opinion of probable construction costs for the structural recommendations made within each watershed. All costs are presented in current (2000) dollars.

DARBY/LITTLE DARBY CREEK WATERSHED

- | | |
|--|------------|
| 1. Levin Tract Detention Basin | \$ 250,000 |
| 2. Underground Detention
Per acre of Commercial/Retail Site | \$ 150,000 |
| 3. South Devon/Filipone Park Detention Basin | \$ 800,000 |

ITHAN CREEK WATERSHED

- | | |
|---|--------------|
| 1. South Wayne/Runnymede Intersection
Drainage Improvements | \$ 200,000 |
| Middle School Underground Detention | \$ 3,000,000 |
| 2. Underground Detention
Per acre of Commercial/Retail Site | \$ 150,000 |
| 3. Streambank Stabilization
Per square foot of exposed wall area | \$ 50/SF |

GULPH CREEK WATERSHED

- | | |
|---|------------|
| 1. Underground Detention
Per acre of Commercial/Retail Site | \$ 150,000 |
| 2. Streambank Stabilization
Per square foot of exposed wall area | \$ 50/SF |
| 3. Church of Our Savior (Tredyffrin Twp.)
Detention Basin | \$ 300,000 |

MEADOWBROOK RUN

- | | |
|---|------------------|
| 1. Expand Villanova University Detention Basin | \$ 220,000 |
| 2. Lancaster Avenue at Barley Cone Lane | No Township Cost |
| 3. SEPTA Culvert near Buckingham Road | No Township Cost |
| 4. Rosemont Office Building
Modify Underground Detention Basin | \$ 50,000 |
| 5. Conestoga Road/SEPTA Slope | \$ 200,000 |

- | | |
|--------------------------------------|------------|
| 6. Streambank Stabilization | |
| Per square foot of exposed wall area | \$ 50/SF |
| 7. Underground Detention | |
| Per acre of Commercial/Retail Site | \$ 150,000 |

**RADNOR TOWNSHIP
STORMWATER MANAGEMENT MASTER PLAN
YEAR 2000**

II. INTRODUCTION

A. PURPOSE

This study supplements and updates the 1992 Stormwater Management Study prepared for Radnor Township by Pennoni Associates and augments the original recommendations within the Darby/Little Darby Creek Watershed (Area 1), Ithan Creek Watershed (Area 2), and Gulph Creek Watershed (Area 3). This study update also includes a review of the Meadowbrook Run Watershed (Area 4) that was not included in the scope of the previous study. (See Watershed Maps, figures 1 through 4.)

The hydrologic model that was applied for analyses of runoff was based upon the Soil Conservation Service methodology (Technical Release 55) with base data information developed for the previous studies. The estimates of the volume of storage required and the approximate detained release rates are based upon the procedures within TR-55. Actual computations were performed with the application of the PondPack® Urban Stormwater Management Program by Haestad Methods, Inc.

The 1992 study of three watersheds, Areas 1 through 3, were reviewed with respect to the recommendations for actions. Previous recommendations were placed in categories of implemented recommendations, recommendations in the planning and/or design stage, recommendations that are still appropriate but with no action to date, and recommendations that are no longer deemed appropriate.

Public participation in this study was encouraged by both the Township's staff and governing commissioners. Public meetings were held on February 23, 2000 and on March 1, 2000 to obtain information and input from residents within each watershed. This information is summarized in Appendix "A" of this report.

The detailed information contained within this report and appendices is not intended as final engineering but rather as information to define possible and feasible methods of improvement.

B. SCOPE

This study reviewed the three (3) watersheds covered in the previous studies, Darby/Little Darby, Ithan Creek and Gulph Creek watersheds, and added a review of the Meadowbrook Run watershed. This update consists of the following:

1. A review of the U.S. Geological Survey Maps; Valley Forge, Norristown, Lansdowne and Media quadrangles

2. A review of the Federal Emergency Management Agency Flood Insurance Rate Maps
3. Public meetings where specific areas of concern were identified within each watershed by the public and township officials. Appendix “A” includes the listing of identified locations and the specific problem(s) described. The following Section C describes the general types of problems identified in each watershed.
4. Field observations of major problem areas
5. Field observations of potential locations for stormwater management facilities
6. Technical analyses of portions of the various watersheds to estimate peak rates and volumes of runoff using the SCS TR-55 methodology
7. Recommendations for consideration by township officials

C. OVERALL PROBLEM AREAS

1. Darby/Little Darby Creek Watershed
 - a. Surface runoff flowing down South Devon Avenue from railroad overpass toward Little Darby Creek
 - b. Side and rear yard flooding along Arbordale Road near Oakford Road with garage and basement flooding in major storms
 - c. Rear yard flooding and loss of wooden bridge behind Oakford Circle with basement flooding through walk-out portal in major storms
 - d. Damage to storm drain and streambank erosion along tributary flowing southeast near Clyde Circle
2. Ithan Creek Watershed
 - a. Roadway flooding at the intersection of South Wayne Avenue and Runnymede Avenue (Radnor Middle School)
 - b. Periodic flooding in the vicinity of 215 through 219 Midland due to runoff from Lancaster Avenue
 - c. Periodic flooding over existing arch culvert between South Aberdeen Avenue and Pembroke Avenue with flooding of garages; occasional flooding of basements
 - d. Streambank erosion along various sections

- e. Periodic flooding of basement in the vicinity of Pembroke Avenue due to groundwater intrusion
 - f. Damage to culvert and streambank in the vicinity of Orchard Way
 - g. Damage to streambank walls in the vicinity of Meadowbrook Avenue
 - h. Periodic flooding of garage and front yard and damage to streambank walls in the vicinity of Brookside Avenue
 - i. Periodic flooding of rear yard and damage to streambank walls in the vicinity of Meadowbrook Circle
 - j. Periodic flooding of roadway, driveway, water in basement and culvert damage in the vicinity of Roberts Road
3. Gulph Creek Watershed
- a. Flooding of basement during hurricane events in the vicinity of West Beechtree Lane
 - b. Periodic flooding of rear yards and streambank erosion in the vicinity of Forrest Road
 - c. Flooding of basement during hurricane events and periodic flooding of rear yards and streambank erosion in the vicinity of North Wayne Avenue
 - d. Periodic flooding of rear yard and streambank erosion in the vicinity of Poplar Avenue
 - e. Periodic flooding of basements and rear yards with streambank erosion in the vicinity of Willow Avenue; high groundwater problems
 - f. Streambank erosion and wall damage in the vicinities of Trout Run and Cowan Field
4. Meadowbrook Run Watershed
- a. Periodic flooding of yard from Lancaster Avenue runoff and intrusion of groundwater into basement in the vicinity of Barley Cone Lane
 - b. Periodic flooding of yards and roadways with sewage backup due to stormwater inflow in the vicinity of Buckingham Road
 - c. Periodic flooding of Conestoga Road and slope erosion in the vicinity of the SEPTA overpass

- d. Streambank erosion and wall damage along Valley Run (tributary) in the vicinity of Fairfax Road
- e. Streambank erosion in the vicinity of South Roberts Road
- f. Periodic garage and house flooding with streambank erosion in the vicinity of Castlefinn Lane
- g. Periodic yard flooding and streambank erosion in the vicinity of Meadowbrook Run and Conestoga Road
- h. Periodic yard flooding, loss of wooden bridge, basement flooding and paving damage due to high groundwater in the vicinity of Meadowbrook Run and Conestoga Road

The overall flooding characteristics with the individual watersheds are reviewed within the following sections, with consideration given to the specific areas noted above. Each watershed is described in detail in Sections III through VI.

III. DARBY/LITTLE DARBY CREEK WATERSHED (AREA 1)

A. Physical Characteristics

The headwaters of Darby Creek and its major branch, Little Darby Creek, originate in both Easttown Township and Tredyffrin Township, Chester County. The main branch of Darby Creek enters Radnor Township along its westerly boundary with Newtown Township, Delaware County, approximately ¼ mile from Saw Mill Road in Skunk Hollow Park. The Little Darby Creek branch enters Radnor Township along its northerly boundary with Tredyffrin Township just north of Sugartown Road. The watershed area to the Little Darby Creek is approximately 355 acres as it enters Radnor Township.

Little Darby Creek and Darby Creek flow generally in southeasterly direction in the western portion of Radnor Township. Tributaries enter the main watercourse along its path through the Township. These tributaries drain not only the area within Radnor Township, but also receive runoff from Easttown Township, Chester County, and Newtown Township, Delaware County.

Darby Creek leaves Radnor Township along its southerly boundary with Marple and Haverford Townships at a location east of Fawnhill Road. The total drainage area at the exit from township is 15.0 sq. mi. (9600 Acres). Approximately 2800 acres of Radnor Township drain into the Darby/Little Darby Creek. Radnor Township represents approximately 29% of the drainage area at the creeks discharge location from the township. The estimated flow in the creek at this location is approximately 8100 cubic feet per second (cfs) during the standard 100-year storm based on Flood Insurance Study.

With the exception of the area along Lancaster Avenue (Route 30) known as West Wayne, the general land use within Radnor Township is low-density residential development. The West Wayne section of the watershed is highly urban development with commercial/retail uses along with medium to high-density residential development.

B. Review of Previous Recommendations

To date, none of the structural recommendations presented in the 1992 study have been implemented.

Two of the recommendations are in the planning and design stages of development. Those recommendations include the construction of surface a stormwater management basin at the Levin Tract (Conestoga Road and South Devon Avenue) and construction of a stormwater management basin within South Devon and Filipone Parks in the area upstream of South Devon Avenue.

The following non-structural recommendations were presented in the 1992 study and continue to be recommended for implementation within the watershed:

INSERT FIGURE 1 HERE

1. Establish and fund a regular channel maintenance program to include removal of trash, rubbish, debris and accumulated silt deposits in the watercourses that are in close proximity to structures. Natural blockages in undeveloped flood plain areas and other areas where the ponding upstream of a restriction are not damaging should be allowed to remain to provide natural detention.
2. Revise fence regulations in floodplain areas to eliminate the fences that become traps for floating debris and ultimately reduce the capacity of the channel in areas where ponding upstream damages property.
3. Establish and fund a regular inlet cleaning program to maintain effective capture of runoff along roads and properties.
4. Verify the effective permanent seeding/stabilization of D'Antonio construction yard on Liberty Lane.
5. Establish a Watershed Association and develop watershed hydrology and hydraulics model to evaluate proposed development alternatives and estimate the effectiveness of proposed stormwater management facilities within the watershed.
6. Establish and fund a program for the acquisition of flood damaged property in the delineated floodplain associated with the watercourses, the removal of those structures and the development of buffers and floodplain storage.

The following structural recommendations were presented in the 1992 study and continue to be recommended for implementation within the watershed:

1. Construct a surface detention basin on the Levin Tract at Conestoga Road and South Devon Avenue. This detention basin should be designed to provide the maximum storage and flow reduction that is practical.
2. Construct a surface detention basin within the South Devon and Filipone Parks, immediately upstream of South Devon Avenue. This detention basin should be designed to provide the maximum storage and flow reduction that is practical.

The following structural recommendations were presented in the 1992 study and are considered to be no longer appropriate for implementation within the watershed:

1. Expansion of the Liberty Lane detention basin. The probable amount of additional storage volume that is available would not be sufficient to provide an appreciable amount of flow reduction during the standard design storms.
2. Construct Gallagher Road detention facility. The probable drainage area to a basin on the former railroad bed is approximately 16 acres, and the probable amount of storage that could be developed is approximately 0.83 acre-feet with a conventional surface detention basin. A basin of this nature would have no measurable impact on the 50-year and 100-year peak flows and would have only a minimal (25 to 45 percent) reduction in the 10-year and 25-year peak flows at the basin. The basin would provide a reasonable reduction (60 to 80 percent) of the 2-year and 5-year peak flows for the area draining from the basin location to the intersection of South Devon and Gallagher. The additional acreage that flows to the intersection of South Devon Avenue and Gallagher Road would quickly negate the magnitude of flow reduction from a basin at this location.
3. Culvert replacements at locations where roads cross the main channels are no longer recommended. This change in approach is based upon the limited area

immediately upstream of the culvert that would have a reduced level of inundation. The existing channels, both upstream and downstream of the culverts, would quickly become the controlling feature for maintaining current levels of inundation. A second disadvantage is that larger culverts would convey a higher rate of flow downstream and increase the potential for additional flooding. The following culverts were previously recommended to be replaced:

- a. South Devon Avenue
- b. Oakford Road
- c. West Wayne Avenue

C. Other Township Stormwater Management Projects

The major project within the Darby/Little Darby Creek watershed that included stormwater management facilities was the redevelopment at Forbes Field. Observations by Township officials during and immediately following recent rainfall events have been that the underground detention basin is functioning as expected.

D. Detailed Study Locations

The following specific areas were identified as study locations or locations of reported problems and concerns within the watershed.

1. The Levin Tract at the intersection of South Devon Avenue and Conestoga Road.
2. Gallagher Road for a possible detention basin in the former railroad bed.
3. Expansion of Liberty Lane Detention Basin to provide additional reduction of discharge.
4. Underground detention in commercial/retail parking areas in the highly developed sections of the watershed.
5. Areas identified at public meeting (February 23, 2000)
 - a. 308 S. Devon – overflow from Levin Tract flowing down S. Devon
 - b. 516 Arbordale – rear yard flooding along unnamed tributary from Levin Tract
 - c. 113 Oakford Circle – rear yard flooding along Little Darby, loss of wooden bridge across creek, basement flooding (walkout basement)

E. Conclusions and Recommendations

1. The Levin Tract

The Levin Tract Detention Basin would provide a significant reduction in flow due to the amount of storage possible on the site. This detention basin would provide flow reductions for the reach of the unnamed tributary to Little Darby Creek that flows along the rear properties on South Devon Avenue. The basin would also significantly reduce the amount of surface runoff that bypasses the Levin Tract in its current condition and flows under the overpass and down South Devon Avenue.

**THE LEVIN TRACT
CONCEPTUAL DETENTION BASIN**

Contributing Drainage Area: 29.4 Acres
CN = 76 and Tc = 0.24 hrs (from 1992 report)

Approximate Storage Volume Available = 380x80x7 = 4.9 ac-ft

DESIGN STORM	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Rainfall (in)	3.3	4.2	5.0	5.7	6.4	7.3
Runoff Depth (in)	1.22	1.89	2.54	3.12	3.73	4.53
Runoff Volume (ac-ft)	2.99	4.64	6.21	7.65	9.13	11.09
Peak Runoff (cfs)	43.4	68.4	92.1	113.5	135.2	163.6
Estimate Flow Reduction due to 4.9 ac-ft of storage $V_s/V_r = 4.9/11.09 = 0.44$ $Q_o/Q_i = 0.22$ $Q_o = 0.22 \times Q_i$						
Probable Release from Basin (cfs)	9.5	15.0	20.3	25.0	29.7	36.0
Probable Runoff Reduction (cfs)	33.9	53.4	71.8	88.5	105.5	127.6
Probable Runoff Reduction (%)	78	78	78	78	78	78

PERCENTAGE OF FLOW REDUCTION DOWNSTREAM OF BASIN

Oakford Rd.	0%	0%	0%	0%	0%	0%
W. Wayne Ave.	8%	8%	8%	8%	nc	8%
Maplewood Rd.	6%	6%	6%	6%	nc	6%
Darby Paoli Rd.	5%	nc	nc	5%	nc	5%
Bryn Mawr Ave.	3%	2%	2%	2%	nc	2%

nc - Not Calculated in previous analyses

**GALLAGHER ROAD/RAILROAD BED
CONCEPTUAL DETENTION BASIN**

Contributing Drainage Area: 16 Acres
Assume runoff volume per acre is same as Levin Tract

Approximate Storage Volume Available = $450 \times 20 \times 4 = 0.83$ ac-ft

DESIGN STORM	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Rainfall (in)	3.3	4.2	5.0	5.7	6.4	7.3
Runoff Depth (in)	1.22	1.89	2.54	3.12	3.73	4.53
Runoff Volume (ac-ft)	1.63	2.53	3.38	4.16	4.97	6.04
Peak Runoff (cfs)	23.6	37.2	50.1	61.8	73.6	89.0
Estimate the probable release rates based upon SCS TR-55 methodology						
Vs/Vr	0.51	0.33	0.25	0.20	0.17	0.14
Qo/Qi	0.14	0.38	0.57	0.73	*	*
Probable Release from Basin (cfs)	3.3	14.1	28.6	45.1	*	*
Probable Runoff Reduction (cfs)	20.3	23.1	21.5	16.7	*	*
Probable Runoff Reduction (%)	86	62	43	27	*	*

NOTES:

* Storage outside of estimating range, no calculation made

- No reduction of flow during the 50-year and 100-year rainfall events
- Minimal reduction of flow if basin is designed to handle either the 10-year or the 25-year rainfall event
- Reasonable control of 2-year or 5-year rainfall events for the area draining to the upper portion of Gallagher Road with discharge to the intersection of Gallagher and S. Devon
- Balance of undetained watershed draining to that intersection (approx. 16 acres) would significantly reduce the effectiveness of the basin

The Levin Tract Detention Basin would not be expected to provide a significant reduction in runoff downstream of the confluence with the main branch of the Little Darby Creek. This confluence is located in the vicinity of Arbordale Road near Oakford Road.

It is recommended that the Township continue with the design and permitting of the Levin Tract Detention Basin to provide the maximum storage possible and subsequent reduction of peak runoff that is practical.

2. Gallagher Road Detention Basin

A detention basin in the former railroad bed along Gallagher Road would not be able to generate a significant amount of storage due to the configuration and physical grading of the land. The amount of volume that could be reasonably developed would not have any impact on the less frequent, but more intense rainfall events, and would have limited impact on the more frequent events. The basin would be able to control approximately half of the area draining to South Devon Avenue from the northwest, but would rapidly lose impact in the areas downstream along South Devon Avenue.

It is recommended that the Township not consider a detention basin adjacent to Gallagher Road. The basin would not be of significant benefit during the rainfall events that generate the by-pass flows of the Levin Tract and subsequent flooding of South Devon Road.

3. Expansion of the Liberty Lane Detention Basin

Expansion of the existing Liberty Lane Detention Basin would not generate sufficient additional storage to effectively detain any additional area of the watershed. The limitations are due to the configuration and physical grading of the remaining yard area available.

It is recommended that the Township not consider expanding the existing Liberty Lane Detention Basin due to its limited performance capabilities during moderate to large rainfall events.

4. Underground Detention in Commercial/Retail Developments

Much of the area in the upper portions of the watershed along Lancaster Avenue is highly developed with commercial and retail establishments. This type of development generally produces high percentages of impervious cover due to the buildings and required parking areas. Attenuation of peak runoff in commercial and retail parking areas can be provided by the installation of underground detention basins with controlled discharge elements similar to conventional above ground basins. It is estimated that approximately 10,800 cubic feet of storage would be required to reduce the peak runoff from one acre of land with ninety percent (90%) impervious cover to a condition similar to “meadow” land use during a standard 100-year design storm.

It is recommended that the Township encourage existing commercial and retail developments to provide underground detention under the parking lots; to require that detention be provided when substantial repairs and/or remodeling is proposed; and to approach owners of major parking areas to allow installation of underground detention facilities by the Township, if warranted.

5. Detention Basin in South Devon and Filipone Parks

This location provides the possibility of controlling flows that are already collected in the main channel of the Little Darby Creek. Reduction in flows within the main channel would have some level of benefit to the full length of the watercourse downstream, and benefit the most residents and property along its path. As demonstrated with the analysis of the Levin Tract, the percentage of flow reduction is greatest immediately downstream of the basin and becomes smaller as additional uncontrolled areas are collected in the stream.

The proposed detention basin at the Levin Tract will provide limited benefit to the residents along Arbordale and Oakford Circle since they are adjacent to the main branch of the Little Darby Creek. The detention basin located in South Devon and Filipone Parks could provide a significant reduction of peak flows in the watercourse.

It is recommended that the Township continue with the design and permitting of the South Devon and Filipone Parks Detention Basin to provide the most storage and subsequent reduction of peak runoff that is practical. It is acknowledged that the permitting process for this location will be lengthy due to the presence of wetlands along the banks of the stream. The Township should evaluate the project costs and prognosis of obtaining the permit at frequent milestones to reduce expenditures.

F. Opinions of Probable Construction Costs

The following opinions of probable construction costs were developed for the structural recommendations made within the watershed. The values are based upon current (year 2000) construction costs.

1.	Levin Tract Detention Basin	\$ 250,000
2.	Gallagher Road Detention Basin	No Action/No Cost
3.	Liberty Lane Detention Basin Expansion	No Action/No Cost
4.	Underground Detention in Commercial/Retail Areas Cost per acre of site	\$ 150,000 per acre

5. South Devon/Filipone Park Detention Basin \$ 800,000

G. Schedule/Sequence of Recommended Improvements

The proposed structural improvements are based upon the detention of runoff and the reduction of peak flows to the major watercourses. The recommendations are not interrelated and do not have a technical need to be implemented in a specific sequence.

Two (2) of the recommended projects are in the design stages. Those projects include the Levin Tract Detention Basin and the South Devon/Filipone Parks Detention Basin. Those projects should continue as scheduled. Coordination with owners of commercial and retail parking areas for underground detention should be initiated and should continue as an on-going process.

Non-structural recommendations should be implemented as soon as practical.

IV. ITHAN CREEK WATERSHED (AREA 2)

A. Physical Characteristics

The headwaters of Ithan Creek originate in Radnor Township in the area of Windsor Avenue and Lancaster Avenue. This area is within the highly urban development known as West Wayne. Runoff is collected in a conventional inlet and storm drainage system within the upper reaches and via overland flow to a natural low area at intersection of South Wayne Avenue and Runnymede Avenue in front of the Radnor Middle School. From this intersection the watercourse flows through large culverts and open channel sections through the township and discharges into Haverford Township near the Blue Route.

Ithan Creek flows generally in a southeasterly direction in the central portion of Radnor Township. With the exception of a very small portion of the watershed that is in Lower Merion Township, the entire drainage area at the township boundary is within Radnor Township. The drainage area at this point is 5.0 sq. mi. (3200 Acres).

The upper reaches of the watershed are highly urbanized and include the area known as West Wayne. This high level of development continues along the Lancaster Avenue corridor. The existing development makes a transition to generally low density residential development in the lower reaches of the watershed.

B. Review of Previous Recommendations

To date, none of the structural recommendations presented in the 1992 study have been implemented.

Two of the recommendations have been reviewed at the conceptual level of planning. Those recommendations include the construction of an underground stormwater management basin at the Radnor Middle School, and removal or reconstruction of the existing brick culvert between South Aberdeen and Pembroke Avenues. The underground detention basin at the Radnor Middle School is still a viable alternative; however, the alternative to remove the brick culvert has been eliminated due to the resident's opposition to the project.

The following non-structural recommendations were presented in the 1992 study and continue to be recommended for implementation within the watershed:

1. Establish and fund a regular channel maintenance program to include removal of trash, rubbish, debris and accumulated silt deposits in the watercourses that are in close proximity to structures. Natural blockages in undeveloped flood plain areas and other areas where the ponding upstream of a restriction are not damaging should be allowed to remain to provide natural detention.
2. Revise fence regulations in floodplain areas to eliminate the fences that become traps for floating debris and ultimately reduce the capacity of the channel in areas where ponding upstream damages property.

INSERT FIGURE 2 HERE

3. Establish and fund a regular inlet cleaning program to maintain effective capture of runoff along roads and properties.
4. Establish a Watershed Association and develop watershed hydrology and hydraulics model to evaluate proposed development alternatives and estimate the effectiveness of proposed stormwater management facilities within the watershed.
5. Establish and fund a program for the acquisition of flood damaged property in the delineated floodplain associated with the watercourses, the removal of those structures and the development of buffers and floodplain storage.

The following structural recommendations were presented in the 1992 study and continue to be recommended for implementation within the watershed:

1. Construction of an enlarged storm drainage collection system on South Wayne Avenue and Runnymede Avenue in the vicinity of the Radnor Middle School.
2. Driveway modifications at the Radnor Middle School to provide overland relief of surface waters that accumulate in the roadway intersection at South Wayne and Runnymede Avenues.
3. Investigate the Middle School Gym roof drains and provide backflow preventors as necessary to reduce the inflow of stormwater from the culvert system into the building's drainage system.

The following structural recommendations were presented in the 1992 study and are considered to be no longer appropriate for implementation within the watershed:

1. Culvert replacements at locations where roads cross the main channels are no longer recommended. This change in approach is based upon the limited area immediately upstream of the culvert that could have a reduced level of inundation. The existing channels, both upstream and downstream of the culverts, would quickly become the controlling feature for maintaining current levels of inundation. A second disadvantage is that larger culverts would convey a higher rate of flow to the downstream and increase the potential for additional flooding. The following culverts were previously recommended to be replaced:
 - a. Creek Drive
 - b. Iven Avenue
 - c. Orchard Way
 - d. Meadowbrook Avenue
 - e. Radnor-Chester Road
2. Removal of brick culvert from South Aberdeen to Pembroke Avenues. This project was in the conceptual design process and cancelled due to resident opposition to the loss of rear yards to an open channel.
3. Construction of a Lancaster Pike drainage system that would divert flows from the existing brick arch culvert system is no longer recommended for consideration due to the high probability that this system would decrease the flow time in that portion of the watershed and increase peak flows downstream of the terminus of the drainage system.

C. Other Township Stormwater Management Projects

Stormwater management systems and drainage improvement projects have been constructed at the following locations within the Ithan Creek watershed:

1. Detention at Banbury and Francis (underground system)
2. Channel and headwall improvements at South Aberdeen Avenue
3. Detention at Fire Station on South Wayne Avenue (underground system)
4. Detention at Township garage on Lancaster Avenue (underground system)

D. Detailed Study Locations

The following specific areas were identified as study locations or locations of reported problems and concerns within the watershed.

1. Radnor Middle School detention basin
2. South Wayne and Runnymede Avenue flooding
3. Underground detention in commercial/retail parking areas in the highly developed sections of the watershed.
4. Areas identified at public meeting (February 23, 2000)
 - a. Radnor Middle School – intersection flooding and groundwater control
 - b. 219 Midland – flooding of garage and yard from Lancaster Avenue runoff
 - c. 318 Midland – flooding of garage and yard; settlement of garage and water in basement
 - d. 323 & 327 Midland – flooding of yards and groundwater inflow in basements
 - e. 300 Block (odd side) of St. Davids – flooding of garage and yard; several with water in basements
 - f. 254 Pembroke – water in basement (groundwater)
 - g. 309 Orchard – existing culvert damage and streambank wall damage
 - h. 410 Meadowbrook Ave. – roadway flooding; streambank wall damage
 - i. 515 Brookside – flooding of garage and yard; streambank wall damage
 - j. 524 Meadowbrook Circle – flooding of rear yard; streambank erosion and wall damage
 - j. 550 Roberts – flooding of roadway and driveway; water in basement; storm drain and culvert

E. Conclusions and Recommendations

1. Radnor Middle School and intersection of South Wayne and Runnymede

The intersection of South Wayne and Runnymede Avenues is the point of collection of the runoff from the upper reaches of the watershed. Based upon the general topography, this would be the area where a stream would have developed. The school property is located in a position of being in the upper portion of the watershed where the contributing area, approximately 181 acres, generates a reasonable but manageable amount of runoff.

**THE RADNOR MIDDLE SCHOOL
CONCEPTUAL DETENTION BASIN**

ESTIMATED VOLUME REQUIRED FOR 50 CFS TO 200 CFS FLOW REDUCTION

Contributing Drainage Area: 180.9 Acres (to S. Wayne and Runnymede)
CN = 76 and Tc = 0.53 hrs (from 1992 report)

DESIGN STORM	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Rainfall (in)	3.3	4.2	5.0	5.7	6.4	7.3
Runoff Depth (in)	1.22	1.89	2.54	3.12	3.73	4.53
Runoff Volume (ac-ft)	18.42	28.54	38.22	47.08	56.20	68.22
Peak Runoff (cfs)	174.2	276.8	373.9	461.7	551.3	668.2
Estimate Volume of Storage Required for Selected Flow Reductions (ac-ft)						
50 cfs Reduction	3.9	*	*	*	*	*
100 cfs Reduction	5.7	6.6	7.7	8.5	*	*
150 cfs Reduction	9.4	8.6	9.2	10.4	11.2	12.3
200 cfs Reduction	*	11.1	11.1	11.8	12.9	14.3

* Storage outside of estimating range, no calculation made

**THE RADNOR MIDDLE SCHOOL
CONCEPTUAL DETENTION BASIN**

VOLUME REQUIRED FOR 20% FLOW REDUCTION

DESIGN STORM	RUNOFF (cfs)	20% REDUCTION	STORAGE VOLUME REQUIRED			
			AC-FT	LENGTH OF 48" DIA. PIPE (FT)	LENGTH OF 48" DIA. PIPE (MI)	NUMBER OF FIELDS
2 YR	174	34	3.3	11,550	2.2	1.5
5 YR	277	55	5.2	18,200	3.5	2.3
10 YR	374	75	6.9	23,900	4.5	3.1
25 YR	462	92	8.5	29,400	5.6	3.8
50 YR	551	110	10.1	35,000	6.6	4.5
100 YR	668	134	12.3	42,625	8.1	5.5

Number of Fields is based on placing 48" diameter pipes under the playing area of a football field.

**PERCENTAGE OF FLOW REDUCTION DOWNSTREAM OF BASIN
(based on a 20% flow reduction at the basin)**

DESIGN STORM	Louella & Midland		Aberdeen		Pembroke		Orchard Way	
	(cfs)	(%)	(cfs)	(%)	(cfs)	(%)	(cfs)	(%)
2 YR	198→164	17%	241→207	14%	343→309	10%	392→358	8%
5 YR	315→260	17%	384→329	14%	546→491	10%	624→569	8%
10 YR	425→350	17%	518→443	14%	737→662	10%	846→768	8%
25 YR	525→433	17%	640→548	14%	910→818	10%	1041→949	8%
50 YR	627→517	17%	764→654	14%	1085→975	10%	1242→1132	8%
100 YR	760→626	17%	926→792	14%	1316→1182	10%	1505→1371	8%

NOTE: BASED ON RECOMMENDED 7 AC-FT OF STORAGE, NO FLOW REDUCTIONS WILL BE PROVIDED DURING THE 25, 50 AND 100-YEAR RAINFALL EVENTS.

The storage volume that could be potentially developed at the Radnor Middle School property is controlled by the development plans that are being considered for the site by the School Board. At this time, it is assumed that approximately seven (7) acre-feet of storage could be developed in conjunction with the design plans for the property.

Based upon the anticipated storage that would be provided, the basin could control runoff to provide a twenty percent (20%) reduction in flows up to the 10-year design storm. This would provide a reduction in the frequency of flooding for the area immediately downstream of the school property, but would provide no reduction of peak flows during the larger storm events (those greater than the 10-year event).

It is recommended that the Township continue to develop schematic and preliminary designs for detention facilities at the Radnor Middle School in conjunction with the design plans being considered by the School District.

It is further recommended that a storm drainage system be provided at South Wayne Avenue and Runnymede Avenue that would collect and convey runoff to the proposed detention facility.

2. Underground Detention in Commercial/Retail Developments

Much of the area in the upper portions of the watershed along Lancaster Avenue is highly developed with commercial and retail establishments. This type of development generally produces high percentages of impervious cover due to the buildings and required parking areas. Attenuation of peak runoff in commercial and retail parking areas can be provided by the installation of underground detention basins with controlled discharge elements similar to conventional above ground basins. It is estimated that approximately 10,800 cubic feet of storage would be required to reduce the peak runoff from one acre of land with ninety percent (90%) impervious cover to a condition similar to “meadow” land use during a standard 100-year design storm.

It is recommended that the Township encourage existing commercial and retail developments to provide underground detention under the parking lots; to require that detention be provided when substantial repairs and/or remodeling is proposed; and to approach owners of major parking areas to allow installation of underground detention facilities by the Township, if warranted.

3. Streambank and Stream Wall Rehabilitation

Erosion of stream banks is a natural action of the stream changing its characteristics to balance with its surroundings. This action is acceptable in open and undeveloped portions of the Township. However, in the developed portions of the Township, the erosion of the banks tends to damage man-made improvements and structures.

It is recommended that each case of streambank erosion and/or stream wall damage be reviewed based upon its unique situation. In general, any bank rehabilitation project must maintain the hydraulic capacity of the watercourse to prevent the aggravation of flooding upstream of the project without causing increased velocities and flows downstream of the project. All bank rehabilitation projects must be completed in accordance with the rules and regulations of the Pennsylvania Department of Environmental Protection, Title 25, Chapter 105.

F. Opinions of Probable Construction Costs

The following opinions of probable construction costs were developed for the structural recommendations made within the watershed. The values are based upon current (year 2000) construction costs.

- | | | |
|----|---|---------------------|
| 1. | South Wayne & Runnymede Intersection Improvements | \$ 200,000 |
| | Middle School Underground Detention Basin | \$ 3,000,000 |
| 2. | Underground Detention in Commercial/Retail Areas | |
| | Cost per acre of site | \$ 150,000 per acre |
| 3. | Streambank & Stream Wall Rehabilitation | |
| | Cost per square foot of exposed wall surface | \$ 50 per sf |

G. Schedule/Sequence of Recommended Improvements

The proposed structural improvements are based upon the detention of runoff and the reduction of peak flows to the major watercourses. The recommendations are not interrelated and do not have a technical need to be implemented in a specific sequence.

Coordination with owners of commercial and retail parking areas for underground detention should be initiated and should continue as an on-going process.

Non-structural recommendations should be implemented as soon as practical.

V. GULPH CREEK WATERSHED (AREA 3)

A. Physical Characteristics

The headwaters of Gulph Creek originate in Tredyffrin Township, Chester County. Flows enter Radnor Township along its northerly boundary at two (2) general locations. The main branch of Gulph Creek enters the Township near West Beechtree Lane and Forrest Road. A second branch enters the Township east of Radnor Street Road within the campus of the Valley Forge Military Academy. When these areas are combined, approximately 560 acres of drainage area enter Radnor Township from Tredyffrin Township. The two (2) watercourses converge in Radnor Township near Chamounix Road.

Gulph Creek flows generally in easterly direction in the northeast quadrant of the Township. There are few defined tributaries to the main branch within Radnor Township. Gulph Creek leaves the Township at County Line Road near Gulph Creek Road. The drainage area at the exit from Radnor Township into Upper Merion Township is 3.13 sq. mi. (2004 Acres). Approximately 1440 acres of Radnor Township drain into Gulph Creek. This represents approximately 72% of the drainage area at the point of exit. The estimated flow in the creek at this location is approximately 2150 cubic feet per second during the standard 100-year storm based upon a proration of flows based upon the areas in the Flood Insurance Study.

The upper portion of the watershed within the township (west of Radnor Street Road) is mostly urban development. The lower portion is generally rural or very low density residential. The lower portion includes the campuses of Cabrini College and Eastern College.

B. Review of Previous Recommendations

To date, none of the structural recommendations presented in the 1992 study have been implemented.

The following non-structural recommendations were presented in the 1992 study and continue to be recommended for implementation within the watershed:

1. Establish and fund a regular channel maintenance program to include removal of trash, rubbish, debris and accumulated silt deposits in the watercourses that are in close proximity to structures. Natural blockages in undeveloped flood plain areas and other areas where the ponding upstream of a restriction are not damaging should be allowed to remain to provide natural detention.
2. Revise fence regulations in floodplain areas to eliminate the fences that become traps for floating debris and ultimately reduce the capacity of the channel in areas where ponding upstream damages property.
3. Establish and fund a regular inlet cleaning program to maintain effective capture of runoff along roads and properties.

INSERT FIGURE 3 HERE

4. Encourage providing groundwater recharge provisions in stormwater management and drainage systems. Recharge should not be part of the design discharge from detention basins, but the basin should allow recharge to occur.
5. Establish a Watershed Association and develop watershed hydrology and hydraulics model to evaluate proposed development alternatives and estimate the effectiveness of proposed stormwater management facilities within the watershed.
6. Establish and fund a program for the acquisition of flood damaged property in the delineated floodplain associated with the watercourses, the removal of those structures and the development of buffers and floodplain storage.

The following structural recommendations were presented in the 1992 study and continue to be recommended for implementation within the watershed:

1. Modify inlets to allow recharge by providing holes in the bottom of the inlet boxes.
2. Eliminate roof drains that connect to the gutter or directly to storm drains. Allow the runoff to travel over vegetation to encourage infiltration and filtration.

The following structural recommendations were presented in the 1992 study and are considered to be no longer appropriate for implementation within the watershed:

1. Excavation of the floodplain with the private property north of Eagle Road at North Wayne Avenue. The available depth to the existing channel bed does not allow for the development of sufficient storage to be effective. Depth to the channel bottom is approximately 18 inches.
2. Modification of the existing basin near Plant Avenue (PECo building). The physical constraints of the site do not allow for the development of sufficient additional storage to be effective during moderate to heavy rainfall events
3. Culvert replacements at locations where roads cross the main channels are no longer recommended. This change in approach is based upon the limited area immediately upstream of the culvert that could have a reduced level of inundation. The existing channels, both upstream and downstream of the culverts, would quickly become the controlling feature for maintaining current levels of inundation. A second disadvantage is that larger culverts would convey a higher rate of flow to the downstream and increase the potential for additional flooding. The following culverts were previously recommended to be replaced:
 - a. Chamounix Road
 - b. Poplar Avenue
 - c. Walnut Avenue
 - d. Beechtree Lane
 - e. North Wayne Avenue
 - f. Eagle Road
 - g. Forest Road (east)
 - h. Forest Road (north)

C. Other Township Stormwater Management Projects

The stormwater management project at North Wayne Avenue Park included an expansion

of the existing detention basin to provide additional capacity and flow reduction into the Township drainage system. The project included both enlarging the surface volume and introducing underground storage below the bottom of the surface basin. Constraints from the use of the park restricted the design storm of the basin to approximately the 25-year event.

D. Detailed Study Locations

The following specific areas were identified as study locations or locations of reported problems and concerns within the watershed.

1. Private property at Eagle and Wayne
2. Underground detention in commercial/retail parking areas
3. Areas identified at public meeting (March 1, 2000)
 - a. 532 W. Beechtree – flooding of basement (Hurricane Floyd); implement plan and maintenance program
 - b. 12 Forrest – flooding of rear yard; streambank erosion
 - c. 8 Forrest – flooding of basement (Hurricane Floyd); frequent rear yard flooding; sink holes (settlement) of yard areas
 - d. 415 N. Wayne – flooding of basement (groundwater and inflow during Hurricane Floyd), flooding of front side and rear yards; streambank erosion
 - e. 409 N. Wayne – flooding of stream due to lack of maintenance, pipe crossing catches debris, N. Wayne Ave. bridge foundation, backwater from Beechtree bridge
 - f. 201 N. Wayne – flooding of yards and streets (Hurricane Floyd); no overall planning or policies
 - g. 111 Poplar – flooding of rear yard and basement due to groundwater; stream cresting 3 times during last year; streambank erosion
 - h. 242 Willow – flooding of basement due to high groundwater; streambank erosion
 - i. 252 Willow –flooding of basement and floor cracking due to high groundwater pressure; streambank erosion
 - j. 256 Willow - flooding of basement due to high groundwater and inflow through windows and entrance; persistent high groundwater in yard; horizontal cracking of foundation; streambank erosion
 - k. 257 Willow – apparent haphazard selection of properties that have had rip-rap wall installations
 - l. Trout Run – streambank and wall damage
 - m. Cowan Field – streambank erosion
4. Rear parking lot of Church of Our Savior in Tredyffrin Township

E. Conclusions and Recommendations

1. Private property at Eagle Road and Wayne Avenue

The private property located on the northwest corner of Eagle Road and North Wayne Avenue has a relatively large portion of the lot adjacent to the Gulph

Creek channel undeveloped. It is currently flat wooded floodplain area. This area was initially identified as a potential candidate for a detention basin. However, the physical relationship between the land and the depth to the channel does not provide sufficient depth to develop enough storage required to be effective.

It is recommended that the Township not consider a detention basin adjacent to Eagle Road. The basin would not be of significant benefit.

2. Underground Detention in Commercial/Retail Developments

Much of the area in the upper portions of the watershed along Lancaster Avenue is highly developed with commercial and retail establishments. This type of development generally produces high percentages of impervious cover due to the buildings and required parking areas. Attenuation of peak runoff in commercial and retail parking areas can be provided by the installation of underground detention basins with controlled discharge elements similar to conventional above ground basins. It is estimated that approximately 10,800 cubic feet of storage would be required to reduce the peak runoff from one acre of land with ninety percent (90%) impervious cover to a condition similar to “meadow” land use during a standard 100-year design storm.

It is recommended that the Township encourage existing commercial and retail developments to provide underground detention under the parking lots; to require that detention be provided when substantial repairs and/or remodeling is proposed; and to approach owners of major parking areas to allow installation of underground detention facilities by the Township, if warranted.

**EAGLE ROAD AND WAYNE AVENUE/PRIVATE PROPERTY
CONCEPTUAL DETENTION BASIN**

Contributing Drainage Area: 258 Acres

Assume runoff volume per acre is similar to Ithan Creek watershed

Approximate Storage Volume Available = 2 ac x 1.5 ft deep = 3.0 ac-ft

DESIGN STORM	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Rainfall (in)	3.3	4.2	5.0	5.7	6.4	7.3
Runoff Depth (in)	1.22	1.89	2.54	3.12	3.73	4.53
Runoff Volume (ac-ft)	25.8	40.8	53.8	66.7	79.6	96.8
Peak Runoff (cfs)	nc	nc	nc	nc	nc	nc
Estimate the probable release rates based upon SCS TR-55 methodology						
Vs/Vr	0.12	0.07	0.06	0.04	0.04	0.03
Qo/Qi	*	*	*	*	*	*
Probable Release from Basin (cfs)	*	*	*	*	*	*
Probable Runoff Reduction (cfs)	*	*	*	*	*	*
Probable Runoff Reduction (%)	*	*	*	*	*	*

nc - Not Calculated for this analysis

* Storage outside of estimating range, no calculation made

NOTES:

- The available storage, 3.0 ac-ft, is not effective for peak flow reduction even at the 2-year design event
- Minimum storage of 18% of runoff volume is required to provide 20% reduction in peak runoff flow

**THE CHURCH OF OUR SAVIOR
CONCEPTUAL DETENTION BASIN
(Rear Parking Lot)**

Contributing Drainage Area: 10.1 Acres
 Estimate Peak Runoff based upon Rational Method ($Q=ciA$)
 $C = 0.70$ (60% impervious 40% lawn)
 $T_c = 20$ minutes (assumed for 10 acre site)

DESIGN STORM	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Rainfall Intensity (in/hr)	2.6	3.0	3.5	4.0	4.6	5.4
Peak Runoff (cfs)	18.4	21.2	24.7	28.3	32.5	38.2
Assume high, but reasonable, reduction in peak flow of 80%						
Probable Release from Basin (cfs)	3.7	4.2	4.9	5.7	6.5	7.6
Probable Runoff Reduction (cfs)	14.7	17.0	19.8	22.6	26.0	30.6
Probable Runoff Reduction (%)	80	80	80	80	80	80

PERCENTAGE OF FLOW REDUCTION DOWNSTREAM OF BASIN

Eagle Rd.	12%	7%	6%	5%	nc	4%
N. Wayne Ave.	11%	7%	6%	5%	nc	4%
Beechtree La.	11%	7%	nc	nc	nc	4%
Poplar Ave.	9%	6%	4%	4%	nc	3%
Radnor Street Rd.	9%	nc	nc	nc	nc	3%

nc - Not Calculated in previous analyses

Estimated Volume Required for 80% reduction of 100-year storm = 2.0 ac-ft

3. Streambank and Stream Wall Rehabilitation

Erosion of stream banks is a natural action of the stream changing its characteristics to balance with its surroundings. This action is acceptable in open and undeveloped portions of the Township. However, in the developed portions of the Township, the erosion of the banks tends to damage man-made improvements and structures.

It is recommended that each case of streambank erosion and/or stream wall damage be reviewed based upon its unique situation. In general, any bank rehabilitation project must maintain the hydraulic capacity of the watercourse to prevent the aggravation of flooding upstream of the project without causing increased velocities and flows downstream of the project. All bank rehabilitation projects must be completed in accordance with the rules and regulations of the Pennsylvania Department of Environmental Protection, Title 25, Chapter 105.

4. Rear parking lot of Church of Our Savior in Tredyffrin Township

Because of the limited area of open space to construct a stormwater management facility in Radnor Township for this watershed, we have investigated alternatives upstream in Tredyffrin Township.

Runoff from the Church of Our Savior property enters Radnor Township along the northerly boundary of the township and contributes flow to the main branch of Gulph Creek. This site was identified as a possible source of additional runoff and also a potential location for controlling that runoff. It is estimated that providing a high level of detention in the rear of the property would be of benefit to the upper reaches of Gulph Creek. The benefit does attenuate down the watercourse.

It is recommended that the Township initiate discussions with Tredyffrin Township and the Church of Our Savior for an agreement to design and construct an enlarged detention basin on the property of the Church. The detention basin should be designed to provide the maximum level of flow reduction and the greatest volume that is practical to meet the restraints of the site.

F. Opinions of Probable Construction Costs

- | | | |
|----|---|---------------------|
| 1. | Private Property at Eagle Road & Wayne Avenue | No Action/No Cost |
| 2. | Underground Detention in Commercial/Retail Areas
Cost per acre of site | \$ 150,000 per acre |
| 3. | Streambank & Stream Wall Rehabilitation
Cost per square foot of exposed wall surface | \$ 50 per sf |

4. Church of Our Savior Detention Basin \$ 300,000

G. Schedule/Sequence of Recommended Improvements

The proposed structural improvements are based upon the detention of runoff and the reduction of peak flows to the major watercourses. The recommendations are not interrelated and do not have a technical need to be implemented in a specific sequence.

Coordination with owners of commercial and retail parking areas for underground detention should be initiated and should continue as an on-going process.

Non-structural recommendations should be implemented as soon as practical.

VI. MEADOWBROOK RUN WATERSHED (AREA 4)

A. Physical Characteristics

The headwaters of Meadowbrook Run and its major tributary, Valley Run, originate generally within Radnor Township in the area of the Villanova campus with a small contributing area east of Lancaster Avenue in Lower Merion Township. The watercourse flows generally in southwesterly direction in the southeast quadrant of the township. Tributaries from the east also drain portions of Haverford Township.

Meadowbrook Run leaves Radnor Township at the Blue Route (I-476) to the west of Ramblewood Drive. At this point, the drainage area is 2.39 sq. mi. (1530 acres). Approximately 1300 acres of Radnor Township drain into Meadowbrook Run. Radnor Township represents approximately 85% of the drainage area at the discharge location. The estimated flow in the creek at this location is approximately 1300 cubic feet per second during the standard 100-year storm based upon a proration of flows based upon the areas in the Flood Insurance Study.

The upper portion of the watershed is mostly urban residential and retail development along both Lancaster Avenue and along Conestoga Road. The lower portion is generally rural or very low density residential development.

B. Review of Previous Recommendations

This watershed was not included in the detailed studies performed for previous reports. There are, therefore, no previous recommendations to review.

C. Other Township Stormwater Management Projects

The township has replaced the Yorkshire Road culvert for Valley Run due to its deteriorated condition. The culvert was replaced at the same size as existed.

The replacement of the Robinhood Road culvert is in the design and permitting stages. This culvert is to be replaced with the same size as currently exists. The project also includes streambank stabilization and repair of a utility crossing immediately downstream of the culvert.

INSERT FIGURE 4 HERE

D. Detailed Study Locations

The following specific areas were identified as study locations or locations of reported problems and concerns within the watershed:

1. Areas identified at a public meeting (February 23, 2000):
 - a. 1 Barley Cone – flooding of yard from Lancaster Ave; groundwater entering basement walls and floor
 - b. 120 Buckingham – sewage backup due to stormwater inflow
 - c. 121 Buckingham – flooding in yard
 - d. 123 Buckingham – roadway flooding due to debris in inlets; basement flooding due to groundwater pressure
 - e. 126 Buckingham – flooding of basement due to groundwater and flooding of channel along railroad embankment
 - f. 101 Locust Grove – erosion along SEPTA embankment on Conestoga
 - g. 104 Locust Grove – flooding on Conestoga at SEPTA overpass
 - h. 107 Locust Grove – erosion along SEPTA embankment on Conestoga
 - i. 129 Locust Grove – flooding on Conestoga due to lack of gutter (near Bywood fish store)
 - j. 121 Fairfax – streambank wall damage and siltation of streambed
 - k. 123 Fairfax – streambank erosion
 - l. 125 Fairfax – streambank erosion along Valley Run
 - m. 284 S. Roberts – streambank erosion approx. 300' long
 - n. 831 Castlefinn – flooding of house and garage; streambank erosion
 - o. 767 Conestoga – flooding of yard due to Conestoga Rd culvert; streambank erosion
 - p. 954 Conestoga – driveway damage due to high groundwater pressure
 - q. 964 Conestoga – Flooding of stream; loss of wooden bridge; basement flooding

E. Conclusions and Recommendations

1. Expand Villanova University Detention Basin

The existing stormwater management basin located on the Villanova Campus has the potential for controlling runoff from approximately 51 acres of land in the upper reaches of the Meadowbrook Run watershed. The existing basin is in the area of Brooklea Road and Meadowood Road.

The contributing drainage area of the watershed at Roberts Road is approximately 350 acres. Expanding the existing detention basin could control up to 14 percent of the drainage contributing runoff at the Roberts Road crossing. The expansion should be designed to provide maximum storage attainable to provide the greatest level of benefit to the downstream reaches.

It is recommended that the Township enter into discussions with Villanova University to allow detailed design of an expanded stormwater management basin and, if the site constraints permit a sufficient amount of additional

detention, permit the construction of an expanded basin.

2. Runoff from Lancaster Avenue at Barley Cone

Surface runoff from Lancaster Avenue is no longer being controlled along the gutter line in the area of Barley Cone Lane. The curb reveal has been greatly reduced or eliminated due to pavement overlays of the roadway.

It is recommended that the Township correspond with the Pennsylvania Department of Transportation regarding the reconstruction of the curb and sidewalk along portions of Lancaster Avenue.

3. Culvert under SEPTA Rail Embankment near Buckingham

The existing culvert and channels within the SEPTA rail right-of-way appear to be in a deteriorated condition. The restrictions are causing a backwater effect into the Township drainage system in Buckingham Road.

It is recommended that the Township correspond with SEPTA regarding repair and/or reconstruction of the culvert, headwalls and channels within the SEPTA right-of-way. The culvert should not be enlarged to the point that additional peak flows are permitted to be discharged to the immediate downstream properties.

4. Villanova Field

The athletic field on the south side of Lancaster Avenue was recently regraded to provide a more level playing field than had previously existed. The peak runoff from a site increases with an increase in the steepness of the slope of the land surface. The flatter slopes generate a longer flow time and also increase the possibility of infiltration. With all other variables (land cover and flow length) being constant, peak runoff from a flatter slope would be less than the peak runoff from a steeper slope. The reconstruction of the athletic field would have no significant impact on the downstream runoff.

The field improvements include a collection berm and swale around the easterly perimeter. Inlets that exist along the rear property line appear to require periodic cleaning of debris to allow the surface runoff into the storm collection system. If surface runoff does not enter the inlets and pipes, it will flow across the surface and appear to be more runoff than has been previously experienced.

It is recommended that the inlets be periodically inspected and cleaned as necessary in accordance with the “non-structural” recommendations presented in this report.

5. Rosemont Office Building – Conestoga Road

Runoff from the office building and parking lot is controlled by an underground

recharge basin that is provided with an emergency outlet. It has been reported that the emergency outlet discharges periodically. Discharges occur even during moderate rainfall events. This is common for recharge basins and indicates a lack of maintenance and cleaning of the recharge system.

The discharges from the emergency outlet flow onto the SEPTA embankment and further aggravate the flooding conditions that periodically occur along Conestoga Road at the SEPTA overpass.

It is recommended that the recharge basin be converted to an underground detention basin with conventional control of the releases. This would provide reasonable control of the standard rainfall design storms, and would reduce the periodic uncontrolled or undercontrolled releases from the emergency outlet. The recharge nature of the basin should continue, but should not be the primary control feature for stormwater management.

6. SEPTA Rock Slope – Conestoga Road

The existing rock covered slope between Conestoga Road and the SEPTA rails is not only an eyesore but is also a source of rocks being washed onto the roadway during moderate to heavy rainfall events. This area is also a probable release location for the basin outlet recommended in item 5 above.

It is recommended that the existing slope be improved with the addition of screening planting along the roadway with an engineered drainage swale behind the screening. Tree planting should continue up the slope to provide additional stabilization and appearance enhancement.

The Township should contact both the owner of the office building and SEPTA to begin the process of design and implementation of the recommended improvements. Permission and/or legal ability to perform the work should be obtained prior to a major expenditure on behalf of the Township.

7. Streambank and Stream Wall Rehabilitation

Erosion of stream banks is a natural action of the stream changing its characteristics to balance with its surroundings. This action is acceptable in open and undeveloped portions of the Township. However, in the developed portions of the Township, the erosion of the banks tends to damage man-made improvements and structures.

It is recommended that each case of streambank erosion and/or stream wall damage be reviewed based upon its unique situation. In general, any bank rehabilitation project must maintain the hydraulic capacity of the watercourse to prevent the aggravation of flooding upstream of the project without causing increased velocities and flows downstream of the project. All bank rehabilitation projects must be completed in accordance with the

rules and regulations of the Pennsylvania Department of Environmental Protection, Title 25, Chapter 105.

8. Underground Detention in Commercial/Retail Developments

Much of the area in the upper portions of the watershed along Lancaster Avenue is highly developed with commercial and retail establishments. This type of development generally produces high percentages of impervious cover due to the buildings and required parking areas. Attenuation of peak runoff in commercial and retail parking areas can be provided by the installation of underground detention basins with controlled discharge elements similar to conventional above ground basins. It is estimated that approximately 10,800 cubic feet of storage would be required to reduce the peak runoff from one acre of land with ninety percent (90%) impervious cover to a condition similar to “meadow” land use during a standard 100-year design storm.

It is recommended that the Township encourage existing commercial and retail developments to provide underground detention under the parking lots; to require that detention be provided when substantial repairs and/or remodeling is proposed; and to approach owners of major parking areas to allow installation of underground detention facilities by the Township, if warranted.

F. Opinions of Probable Construction Costs

1.	Expand Villanova University Detention Basin	\$ 220,000
2.	Lancaster Avenue Runoff at Barley Cone Lane	No Cost to Township
3.	SEPTA Culvert Replacement near Buckingham	No Cost to Township
4.	Villanova Field Inlet Cleaning	Include in Maintenance Program
5.	Rosemont Office Building Basin Modification	\$ 50,000
6.	Conestoga Road/SEPTA Slope	\$ 200,000
7.	Streambank & Stream Wall Rehabilitation Cost per square foot of exposed wall surface	\$ 50 per sf
8.	Underground Detention in Commercial/Retail Areas Cost per acre of site	\$ 150,000 per acre

G. Schedule/Sequence of Recommended Improvements

The proposed structural improvements are based upon the detention of runoff and the reduction of peak flows to the major watercourses. The recommendations are not interrelated and do not have a technical need to be implemented in a specific sequence.

Coordination with owners of commercial and retail parking areas for underground detention should be initiated and should continue as an on-going process.

Non-structural recommendations should be implemented as soon as practical.

VII. PENNSYLVANIA ACT 167 STORMWATER MANAGEMENT STUDY – Darby Creek Watershed

A. Status

Phase I of the Darby Creek Stormwater Management Plan is currently under contract with Delaware County Planning Commission. The County's engineering consultant on the project is Borton Lawson Engineering.

B. Goals and Objectives (Phase I and Phase II)

The following are the general goals and objectives defined for the Stormwater Management Studies prepared under Act 167

1. Provide base information for stormwater management at the watershed level
2. Identification of existing areas of flooding and erosion
3. Obtain public participation and input for the management plan
4. Review existing stormwater management and drainage ordinances of the municipalities within the watershed
5. Development of hydrologic and hydraulic model for the watershed based upon existing land cover and on projected land cover in ten (10) years
6. Perform modeling to determine allowable peak release rates from future development within sections of the watershed.
7. Prepare model stormwater management ordinance for use by all municipalities that are located within the watershed.

VIII. TOWNSHIP ORDINANCE RECOMMENDATIONS

Based upon a review of the Zoning, Subdivision of Land, and Stormwater Management ordinances of Radnor Township, the following additions indicated as underlined are recommended. In addition to those specific recommendations, it is also recommended that verbiage be included in the identified sections to strengthen the stormwater management requirements for development and redevelopment or renovation.

A. Chapter 280, Zoning

The following recommended additions are underlined:

1. 280-75
 - a. ...effective September 30, 1993 or as later amended, as prepared by ...
 - b. A.(1) FW (Floodway Area): ... Within fifty (50) feet of the top of bank of any watercourse as defined by Title 25, Chapter 105 of the Pennsylvania Department of Environmental Protection.
2. 280-76
 - a. Emphasize that the restrictions pertain to both floodway and floodplain areas within the Floodplain Conservation District.
 - b. Eliminate parking as a permitted use. Where driveways are required by the regulations for the underlying district and where no alternative alignment outside the Floodplain Conservation District is reasonably available. In such case the driveway within the Floodplain Conservation District shall be of a stable and pervious construction. The Township Engineer shall evaluate the reasonableness of alternative driveway locations.
 - c. No existing structure located within the Floodplain Conservation District shall be expanded, remodeled, or reconstructed and/or repaired when substantially damaged.
3. 280-78
 - a. No storage of any material that may be subject to floatation or transport by flowing waters shall be permitted within the Floodplain Conservation District.

B. Various sections of the Zoning Ordinance

1. Area and height limitations should include limitations on total impervious area. Current limitations are only for building area in most districts.

C. Chapter 245, Stormwater Management

1. 245-1
 - a. The exclusion for requiring stormwater management for impervious area increases of 1,500 square feet or less should be reconsidered.
 - b. In densely developed areas with lots of ¼ acre, 1,500 square feet is approximately 14% of the lot area
 - c. In areas with 1 acre lots, the increase is approximately 3%

- d. Exclusions should be limited in the frequency or total number of exclusions per lot. The ordinance does not specifically prohibit paving 1,500 square feet of lot several times.
2. 245-3
- a. Stormwater management should be designed in accordance with the method set forth as currently required, but with the following assumptions:
 - 1) Predevelopment condition for all storms should be based upon a “meadow” condition
 - 2) The postdevelopment 10-year storm should be detained to the peak runoff generated by the predevelopment 2-year storm in a “meadow” condition; the 25, 50 and 100 year storms should be detained to the corresponding “meadow” condition for those design storms
 - b. Stormwater management should be required for all redevelopment and substantial renovation and/or repair activities within the township.
 - c. Stormwater management basins should be designed to permit recharge through the use of perforated pipes and gravel; however, the recharge rate should not be used in the routing calculations for the regulating structure(s) that provide a positive discharge.

D. Chapter 255, Subdivision of Land

- 1. 255-31, Grading and drainage
 - a. Design storms should be included, for example
 - 1) 25-year for general drainage with overland relief
 - 2) 50-year for low points
 - 3) 100-year for culverts, swales, open channels and watercourses
 - b. Design method should be included – Rational Method with minimum time of concentration of five (5) minutes with PennDOT Region 5 IDF curves

PUBLIC INPUT
MEETING HELD ON 02/23/00
RADNOR TOWNSHIP MUNICIPAL BUILDING

The following represents comments made by residents concerning flooding and/or erosion problems.

DARBY/LITTLE DARBY CREEK WATERSHED

ADDRESS	COMMENTS
308 S. Devon Ave.	Existing "natural" detention at Levin Tract is exceeded and runs down South Devon Avenue during heavy rainfall
516 Arbordale Rd.	Flooding of garage (1 ½-2') and basement; rear yard flooding during moderate rainfall (8/99); yard drain pipe apparently clogged/broken.
517 Arbordale Rd.	Side and rear yard flooding (Hurricane Floyd entered basement); streambank erosion
113 Oakford Circle	Rear yard flooding; loss of wooden bridge; basement flooding through walkout portal
700 & 710 Sproul Rd.	Damaged storm drain and streambank erosion

ITHAN CREEK WATERSHED

ADDRESS	COMMENTS
Radnor Middle School	Intersection flooding at S. Wayne and Runnymede; continuous dry-weather pumping of groundwater in basements; fields are saturated for extended periods
219 Midland Ave	Flooding of garage (1') and rear yard from Lancaster Ave; flooding starts at 215 Midland and includes 217 & 219
318 Midland Ave	Flooding of garage and rear yard (1'-2'); water in basement (1''-2''); settlement of garage
301 St. Davids Rd.	Flooding of rear yard and overtopping of existing headwall; water enters basement through block wall
305 St. Davids Rd.	Flooding of garage (2'), basement, and yard
313 St. Davids Rd.	Flooding of garage (3'), basement, and yard; flow from roadways down side yards and into rear yard
319 St. Davids Rd.	Flooding of garage (2'), basement, and yard
321 St. Davids Rd.	Flooding of garage (2') and basement (2''-3'') several times annually over passed 16 years
323 St. Davids Rd.	Flooding of basement (1'-2') if electrical failure occurs, and rear yard; streambank erosion approx. 40' long, 12' channel depth and 15' width
254 Pembroke Ave	Water in basement from groundwater pressure; stream in front yard
309 Orchard Way	Damage to culvert and streambank walls
410 Meadowbrook Ave	Flooding in basement (Hurricane Floyd); roadway flooding; streambank wall damage, 3'-4' high, 1'-2' wide
515 Brookside Ave	Flooding of garage and front yard; damage to streambank walls
524 Meadowbrook Circle	Flooding of rear yard during moderate and heavy rainfall; streambank erosion approx 250-300' long, damage to streambank stone wall
550 Roberts Rd.	Flooding of roadway and driveway, water in basement; storm drain and culvert problems

PUBLIC INPUT
MEETING HELD ON 02/23/00
RADNOR TOWNSHIP MUNICIPAL BUILDING

The following represents comments made by residents concerning flooding and/or erosion problems.

MEADOWBROOK RUN WATERSHED

1 Barley Cone La.	Runoff from Lancaster Ave flooding yard, groundwater entering basement walls and floor
120 Buckingham Rd.	Sewage backup due to stormwater inflow
121 Buckingham Rd.	Flooding in yard
123 Buckingham Rd.	Flooding of basement due to groundwater pressure, of roadway (8/99) due to clogged inlets
126 Buckingham Rd.	Flooding of basement due to groundwater; channel flows along railroad embankment to existing culvert
101 Locust Grove Rd.	Erosion along SEPTA slope on Conestoga Rd
104 Locust Grove Rd.	Flooding on Conestoga Rd at the SEPTA overpass
107 Locust Grove Rd.	Erosion along SEPTA slope on Conestoga Rd
129 Locust Grove Rd.	Flooding on Conestoga Rd (near Bywood fish store) due to lack of gutter
121 Fairfax Rd.	Streambank wall damage and siltation of bed
123 Fairfax Rd.	Streambank erosion
125 Fairfax Rd.	Streambank erosion along Valley Run
284 S. Roberts Rd.	Streambank erosion approx. 300' long
831 Castlefinn Lane	Flooding of garage and house; streambank erosion
767 Conestoga Rd.	Flooding of yard due to Conestoga Rd culvert; streambank erosion
954 Conestoga Rd.	Driveway damage due to high groundwater table
964 Conestoga Rd.	Flooding of stream, loss of wooden bridge; basement flooding

PUBLIC INPUT
MEETING HELD ON 03/01/00
RADNOR TOWNSHIP MUNICIPAL BUILDING

The following represents comments made by residents concerning flooding and/or erosion problems.

GULPH CREEK WATERSHED

ADDRESS	
532 W. Beechtree La.	Flooding of basement (Hurricane Floyd); implementation of plan and maintenance program for system
12 Forrest Rd.	Flooding of rear yard; streambank erosion on #14, approx. 40' long
8 Forrest Rd.	Flooding of basement (Hurricane Floyd), frequent rear yard (1' deep) and occasional front yard flooding; minor sinking in yard
415 N. Wayne Ave.	Flooding of basement by groundwater and inflow (Hurricane Floyd), front side and rear yard flooding; streambank erosion approx. 50' long, 4' high bank or wall and 3' wide erosion
409 N. Wayne Ave.	Flooding of stream due to lack of maintenance, pipe crossing catching debris, bridge foundation of N. Wayne Ave., and backwater from Beechtree bridge
201 N. Wayne Ave.	Flooding of yards and streets (Hurricane Floyd); no overall planning or policies
111 Poplar	Flooding of rear yard and basement through foundation; general flooding (1'-3' during Hurricane Floyd) and stream cresting 3 times during last year; streambank erosion approx. 200' long, 6"-2' high and 1' wide.
242 Willow Ave.	Flooding of basement due to groundwater, high groundwater and saturation levels; streambank erosion approx. 30' long, 12' high and 2' wide in last 2 years
252 Willow Ave.	Flooding of basement and cracking of floor due to groundwater pressure; streambank erosion approx. 28' long, 3' high and 3' wide. Clearing and widening of channel helped in the past, recent gabion baskets restrict width in some areas and have created problems.
256 Willow Ave.	Flooding of basement due to groundwater and inflow through windows and entrance, persistent high groundwater and yard saturation; horizontal cracks in foundation; streambank erosion approx. 47' long, 5'-6' high and 3'-4' wide.
257 Willow Ave.	Some properties have streambank protection (gabions) while others do not
Trout Run	Streambank and wall damage.
Cowan Field	Streambank erosion