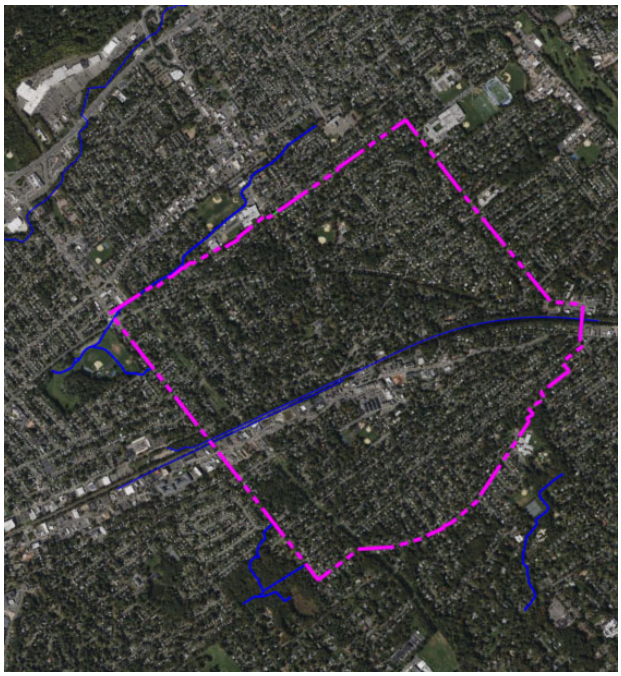
FNWD-00479 **October 2023**

FANWOOD DRAINAGE SYSTEMS STUDY

PRELIMINARY ANALYSIS

BOROUGH OF FANWOOD
UNION COUNTY, NEW JERSEY



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APPENDICES

I. PROJECT DESCRIPTION

The Borough has historically experienced serious flooding problems at several locations as the result of intense rainfall events. These flooding events create significant negative impacts to Fanwood residents, commuters, and businesses. These locations are provided in a memorandum from the Borough of Fanwood Police Department, entitled Affected Roadways – July 3, 2023, dated July 6, 2023, and the table below. The memorandum is provided in Appendix A.

Street	Affected Area	Length Of Shutdown
Westfield Road	Pleasant – Birchwood	3+ Hours
North Avenue	Tillotson (intersection)	3 Hours
Westfield Road	Birchwood – North	2 Hours
Midway Avenue	North Avenue (intersection)	2 Hours
South Martine Avenue	South - LaGrande	1 Hours
Forest Road	Midway Avenue (intersection)	1 Hours
Pleasant Avenue	Martine Avenue (intersection)	1 Hours
Hunter Avenue	Midway Avenue (intersection)	1 Hours
MacLennan Place	Entire length of street	1 Hours
Farley Avenue	Midway Avenue (intersection)	1 Hours
Poplar Ave	Clement Pl	1 Hours
Tillotson (Dead End)		1 Hours
Glenwood (60's)		1 Hours

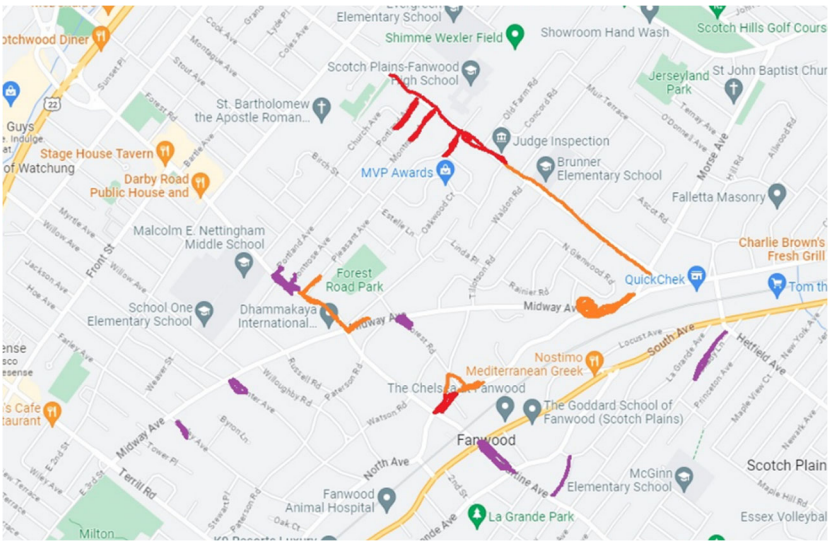

Figure 1

Red: Severe Flooding (3+ hours), **Orange**: Moderate Flooding (1-3 hours), **Purple**: Light Flooding (0-1 hour)
Note that some flooding locations are shown in figure 1.

Note that this report provides a preliminary pipe analysis and a potential basins routing calculations for 3+ hours flooding and 2+ hours flooding locations. Preliminary Construction cost estimates for each area are provided. The proposed concept plans for both 3+ hours & 2+ hours flooding will be provided in the next phase. All work for 1 hour flooding will also be perform in next phase.

In order to evaluate the flooding problems in these locations, the Borough of Fanwood has requested that T&M Associates perform the preliminary existing drainage systems study, as prioritized by the Borough. As part of this analysis, T&M performed existing analysis and concept analysis to minimize flooding. Moreover, T&M explored the effectiveness of four (4) potential flood attenuation basins located at various locations throughout the Borough.

In 2007, the Borough of Fanwood retained T&M to study the locations:

- Glenwood/North Glenwood/Tillotson Roads
- Midway Avenue at Terrill Road
- Shady Lane/Clement Place/Birch Place/Beech Avenue/Mac Lennan Place

The proposed basins in Glenwood/North Glenwood/Tillotson Roads and drainage pipes improvement were constructed in 2014. The study reports prepared in 2007 and in 2014 are not included in this report.

II. GEOGRAPHIC & WATERSHED INFORMATION

The Borough is situated on a ridgeline that separates the Raritan River Basin from the Rahway River Basin. Drainage patterns are such that flows from the northwest portion of Fanwood drain to the Cedar Brook in the Township of Scotch Plains and the City of Plainsfield. Flows from the southeast of the drain to the Robinson's Branch of the Rahway River in the City of Plainsfield.

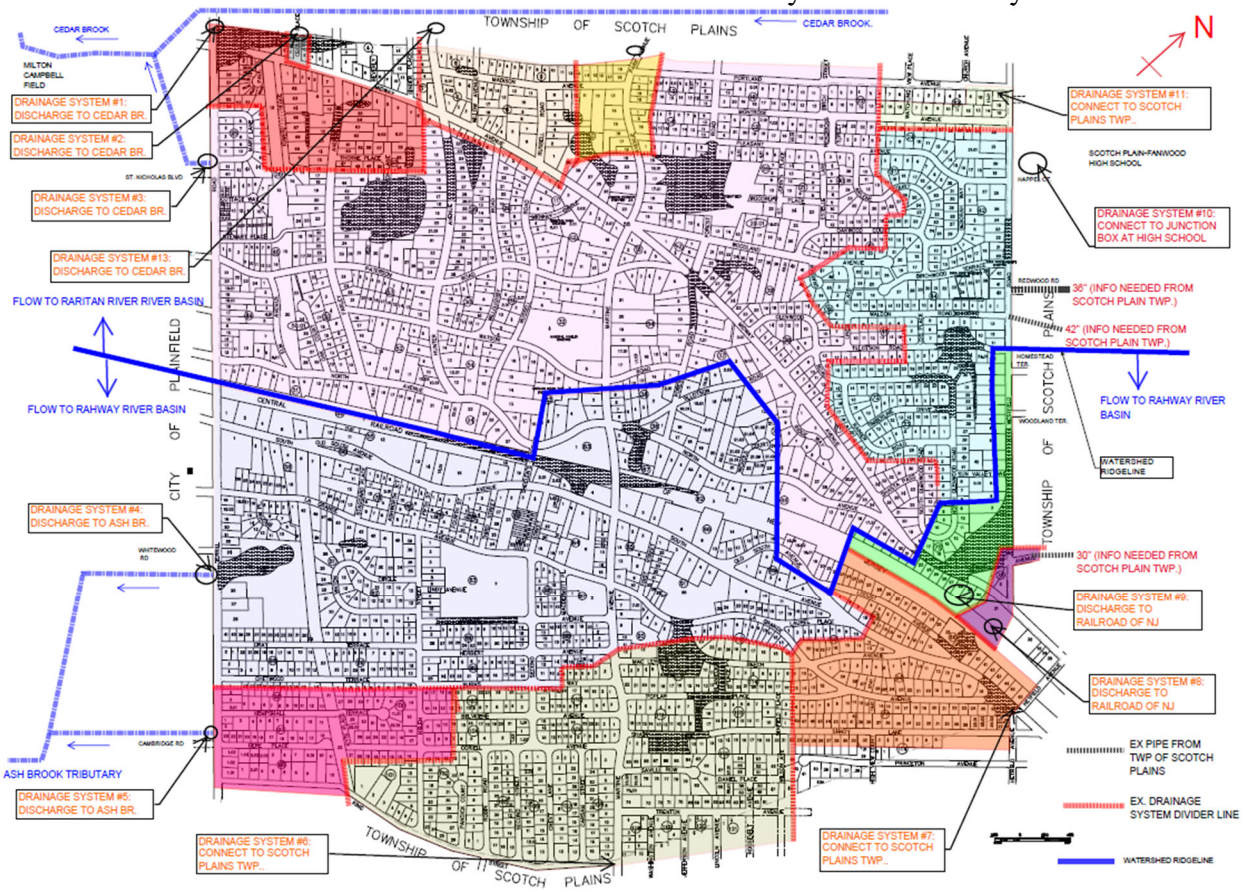

Figure 2

Most of the Borough is outside the FEMA 100 year floodplains. However, a FEMA study indicated there is a portion of the floodplains associated with Cedar Brook at the intersection of Midway Avenue and Terrill Road.

Full versions of Figure 1, 2 and 3 are provided in Appendix A. Other detail Maps are also provided in Appendix A.

Figure 3

III. DRAINAGE SYSTEMS ANALYSIS CRITERIA & METHODOLOGY

The drainage systems were analyzed for a 2, 10 and 25-year storm frequency based on the principles of the Rational Method, utilizing using the Autodesk® Storm and Sanitary Analysis 2022 software (hereinafter referred to as SSA).

Times of concentration and travel time used in the analysis were based on estimates of the watershed slope, surface roughness, overland flow paths, and flow patterns determined based on the best available data obtained from field survey, Soil Survey Maps, Topographic Maps and USGS Maps and Lidar. Note that a minimum 10-minute time of concentration has been used for most of the inlets which have small drainage areas.

Weighted runoff coefficient (Cw) was calculated for the sub-watersheds based on existing soil conditions for the tributary area, as indicated in the Soil Survey of Union County, and current land use. The manning's roughness "n" for pipe chosen based on the existing pipe material.

Additionally, the input was supplemented where appropriate from the following sources:

- The Borough's Storm Sewer Map, dated 12/12/94, prepared by JEM Engineering Incorporated.
- The site survey prepared by T&M Associates in 2007 and 2012.
- The Glenwood Road Area Drainage Improvement Plans, prepared by T&M Associates, revision dated September 23, 2014.
- The Gere Place & Morse Avenue Improvements Plans, prepared by T&M Associates, revision dated July 21, 2021.

Pipe Capacity Analysis – Pipe capacity is design for 25-year storm events.

Gutter Spread Analysis – Gutter spread is design for 10-year storm events. All existing inlets have been assumed to be at the low point and to not bypass runoff to the downstream inlet. It will provide a worst ponding scenario and maximize the widest gutter spread width.

Hydraulic Grade Line Analysis – Determined the pipe system surcharge elevations and inlets overtopped in 25-year storm events.

Tailwater elevation – tailwater elevations depends on the outfall locations and downstream conditions. 1/5 of the pipe height was used as tailwater elevations if the outfall is not free discharge condition.

Based on the result of the existing analyses, T&M develop proposed concepts to minimize ponding locations and the spread where it exceeds the allowable limit. The proposed pipe was sized to provide for the design storm event, where existing utilities and downstream/ offsite systems, tailwaters and other constraints allow.

IV. PIPE ANALYSES

Existing Condition: Area-1

Area-1 (See Fig. 4) is a drainage area to the drainage structure located near the Scotch Plains – Fanwood High School east driveway entrance (See Fig. 6). There are two locations which were flooded in Area-1 (See Fig. 5), as follows:

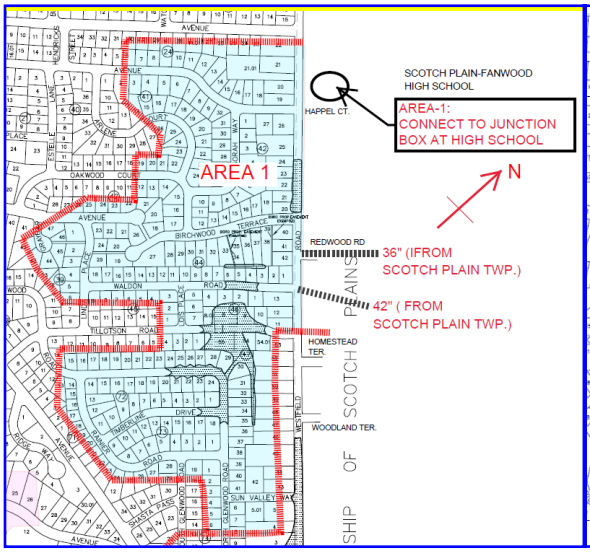

Figure 4

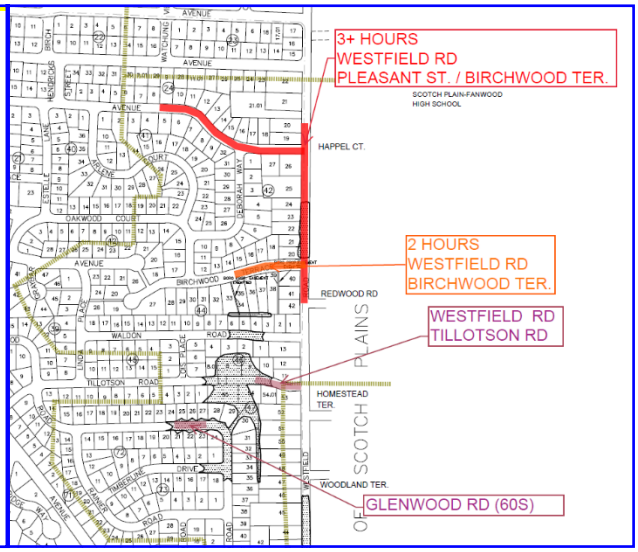

Figure 5

Figure 6

Location 1: Westfield Rd & Pleasant St. (3h+)

Location 2: Westfield Rd & Birchwood Ter. (2h)

According to the memorandum from the Police Dept., 3 of 4 locations in Area-1 are related to the Westfield Road. In facts, the drainage system along the Westfield Road is a major storm drain that conveys runoff to the downstream pipe systems, which is owned by Scotch Plains

Township, and it likely discharges to Cedar Brook. Muti-drainage systems with flow diversion / bypass function from the Fanwood Borough side street are tied into the it. There is also a 36" RCP and 42" RCP from Scotch Plains Township tied into it at Redwood Rd. and Howard B. Brunner Elementary School.

Location 1: Westfield Rd & Pleasant St. & Location 2: Westfield Rd & Birchwood Terrace.
The Westfield Rd. pipe capacity analysis included in Appendix B shows that flooding in this area is the result of inadequate capacity in the existing drainage system. This condition is caused by undersized pipes with shallow slopes, in some cases as little as 0.1%. Analysis has determined that the existing drainage system is presently handling flows up to 200% of the system's capacity in the 25- year storm event, as shown on Pipe Analysis Plans in Appendix B. The undersized pipes and shallow slopes cause a severe surcharge and overtopping in upstream pipe. The overtopping runoff ponds along the roadway and increases the width of gutter spread. The surcharged condition from the Westfield Rd drainage pipe become a tailwater to the pipe system at Pleasant St. & Birchwood St. In fact, some pipes are undersized in both streets. A 0.73-ft (0.2 x pipe height) tailwater has been added to the analysis due to the pipe with shallow slope.

Existing Condition: Area-2
Area-2 (See Fig. 7) is a drainage area that discharges to the drainage structure located at the Fanwood Place and is tied into the 24-inches downstream drainage pipe along the railroad. However, the pipe out from the drainage structure connects to a downstream drainage pipe that is downsized and creates a bottleneck situation. The location was flooded in Area-2 (See Fig. 8) and location is as follows:

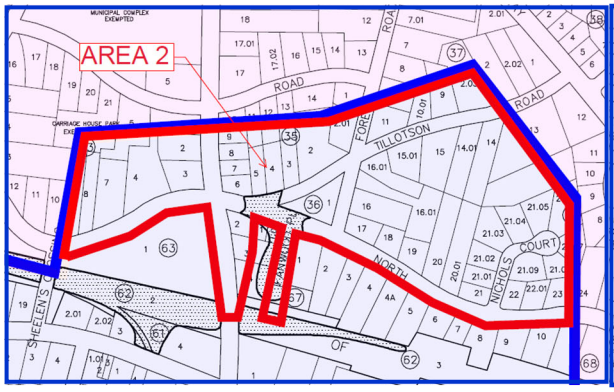

Figure 7

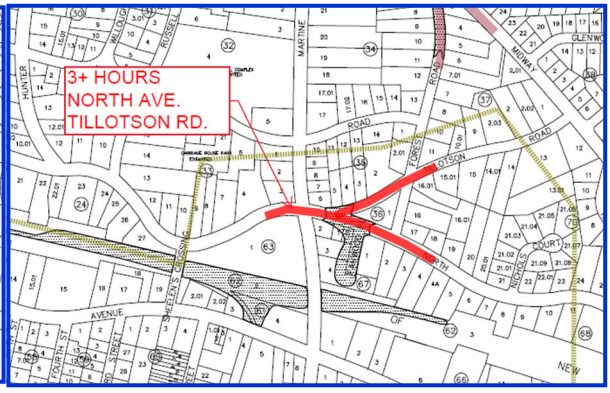

Figure 8

Location: North Avenue & Tillotson Rd. (3h+)
The Area-2 pipe capacity analysis included in Appendix C shows that flooding in this area is the result of inadequate capacity of downstream pipes in this existing drainage system. This condition is caused by undersized pipe sizes, most of which are 12-inches. The analysis has determined that the existing drainage system is presently handling flows up to 371% of the system's capacity in the 25- year storm event, as shown on the Pipe Analysis Plans in Appendix C. The severe surcharge from the downstream pipe results in overtopping of the upstream pipe. The overtopping runoff ponds along the roadway and

increases the width of gutter spread. A normal tailwater boundary has been added to the analysis as it is tied into the downstream pipe.

Existing Condition: Area-3

Area-3 (See Fig. 9) is a drainage area to the headwall located at the railroad behind the Block 68, Lot 27. The location was flooded in Area-3 (See Fig. 10) as follows:

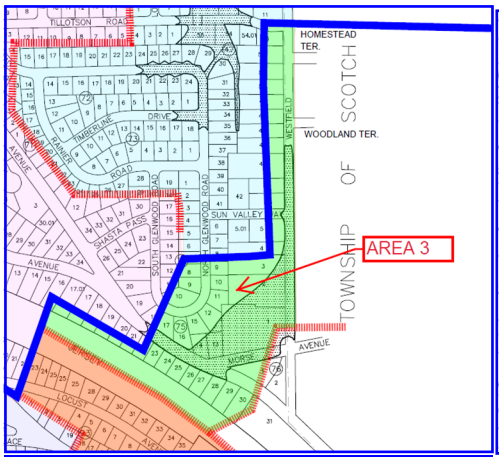

Figure 9

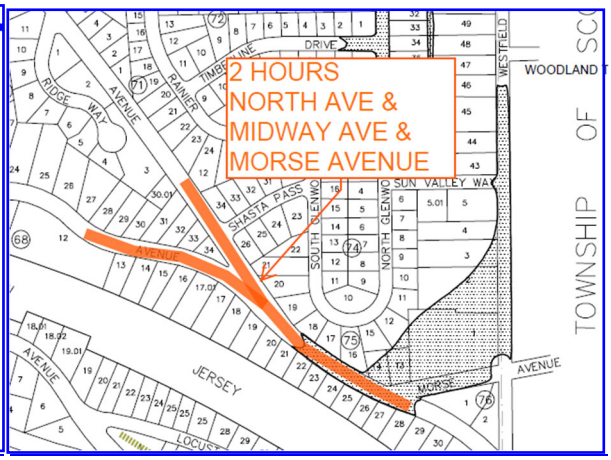

Figure 10

Location: North Avenue, Midway Avenue & Morse Avenue (2h)

The Area-3 pipe capacity analysis included in Appendix D shows that flooding in this area is the result of lack of inlets around low point area. The inadequate capacity of drainage pipes in this existing drainage system is caused by shallow pipe slopes. The analysis has determined that the existing drainage system is presently handling flows up to 176% of the system's capacity in 25- year storm events, as shown on Pipe Analysis Plans in Appendix D. The severe surcharge from the downstream pipe causes overtopping in the upstream pipe system. The overtopping runoff ponds along the roadway and increases the width of gutter spread. A free discharge boundary has been used for the analysis.

Proposed Condition:

According to the results of the pipe analysis and gutter spread analysis, T&M developed a proposed concept to address flooding in these locations of concern. The concept was designed based on the follow,

For the pipe capacity:

- No proposed basin detains and attenuates the runoff
- Pipe capacity designed for 25 year storm if possible
- Tailwater elevation or outfall boundary applied

For the gutter spread:

- Additional inlets to be installed as required.
- Double B inlets to be strategically placed to reduce surface ponding.

Note that some existing pipes are under capacity but not to be replaced due to the following

reasons:

- Limited pipe cover
- Existing outfalls/downstream invert elevation.

The results indicate that improvements can be made to the existing drainage system, however these improvements will provide some reduction of existing flooding. The results are included in Appendices B, C, and D.

V. HYDRAULICS / HYDROLOGY

The basins analyzed were selected based on their location within the various watersheds, and their potential for providing an effective degree of stormwater storage and peak flow rate attenuation.

Preliminary hydrologic analyses of the sub-drainage area to each of the potential basin locations were developed, along with hydraulic routing analysis of each conceptual basin, in order to gauge the effectiveness of each basin. Estimated input parameters, based on aerial photography and LIDAR topography, were used in preliminary existing and proposed condition models in order to develop an initial understanding of each site's potential effectiveness, pending guidance from the Borough on the feasibility of acquiring the identified parcels. Once direction is provided on the availability of basin sites, those with the potential to be effective will be analyzed using more detailed input parameters. The current calculations are based on the following assumptions:

- CN values and times of concentration were estimated based on observation topography and aerial mapping
- No downstream tailwaters were applied to the routing calculations

Preliminary land use/ soil type summary tables, maps, curve number calculations are included in in this stage of the study, but will be finalized in future revisions for potentially viable basins that can be acquired and utilized by the Borough.

The peak flows for the basins were generated for the 2-year, 10-year and 25-year storm events using current Rainfall Depth with the HydroCAD hydrologic model, using the NRCS TR-20 methodology. The data for all propose basins, such as the length, invert and storage, used in the hydrologic analysis is estimated, based on the best available information obtained from existing survey in 2007 and 2014, USGS and LiDAR topography.

STORM OF FREQUENCY	CURRENT RAINFALL DEPTH
(YR.)	(inches)
2	**3.42**
10	**5.33**
25	**6.81**

VI. PRELIMINARY BASIN ANALYSES

T&M analyzed four municipal or privately owned parcels that could potentially accommodate future basins, to determine if any of those sites are suitable to reduce the flood impacts.

Area 1 – Basin A1

Proposed Basin A1 is a proposed underground R-Tank (SD) basin is located within the Scotch Plains – Fanwood High School, at the southeast corner of Scotch Plains Township Block 6501, Lot 1. The underground R-Tank basin bottom is at elevation 165.25 within a lawn footprint of 0.145 Ac. The basin contains 26 rows of R-tank and each row has 60 units. The height of the R-tanks is 5.65-ft. The preliminary storage volume from the existing and proposed scenarios are provided below.

The storage of the existing 150-ft L, 71"W X 47"H CMP with 0.3% slope = **0.063 ac-ft**

The storage of the proposed underground R-Tank Basin = **0.46 ac-ft**

The proposed underground R-Tank Basin provide more than 7-time storage volume than the existing single pipe. The basin will store the runoff from the Westfield Road during the downstream pipe system surcharge. It will also reduce the flood volume at the intersection of Westfield Road / Happel Ct. / Pleasant Avenue.

Area 1 – Basin A2

Proposed Basin A2 is a proposed underground R-Tank (SD) basin located within the Howard B. Brunner Elementary School, at the frontage along Westfield Road in Scotch Plains Township Block 7001, Lot 12. The underground R-Tank basin bottom is at elevation 173.50 within an open space footprint of 0.233 Ac. The basin contains 40 rows of R-

tank and each row has 75 units. The height of the R-tanks is 6.37-ft. The storage of the proposed underground R-Tank Basin A2 = **1.031 ac-ft.** The basin will store the overland and upstream Westfield Road runoff. It will also reduce the flood volume at the intersection of Westfield Road/Tillotson Road and downstream of Westfield Road. The preliminary discharge rates from the existing and proposed scenarios are provided in **Table 1,** below.

TABLE 1 – BASIN A2 RESULTS

STORM FREQUENCY	PRE-DEVELOPED PEAK DISCHARGE RATE (1)	POST-DEVELOPED PEAK BASIN DISCHARGE RATE (2)	POST-DEVELOPED PEAK BASIN ELEVATION (3)	CHANGE IN PEAK DISCHARGE RATE (2) – (1)	PERCENTAGE PER REDUCTION
(YR.)	(CFS)	(CFS)	(FT)	(CFS)	%
2	**10.56**	**0.83**	**175.99**	**-9.73**	**92.2**
10	**17.93**	**1.76**	**177.52**	**-16.17**	**90.2**
25	**23.79**	**7.08**	**178.11**	**-16.71**	**70.2**

The preliminary construction cost for Area 1 drainage improvement is approximately 2.5 million dollars.

Area 2 - Basin 2

Basin 2 is a proposed above ground basin located on Block 63, Lot 1in Fanwood Borough. The lot is described as owned by the Borough on the Fanwood Borough tax map. The basin bottom was assumed to be at elevation 159.50 with a footprint of 0.51 Ac. The preliminary discharge rates from the existing and proposed scenarios are provided in **Table 2,** below.

TABLE 2 – BASIN 2 RESULTS

STORM FREQUENCY	PRE-DEVELOPED PEAK DISCHARGE RATE (1)	POST-DEVELOPED PEAK BASIN DISCHARGE RATE (2)	POST-DEVELOPED PEAK BASIN ELEVATION (3)	CHANGE IN PEAK DISCHARGE RATE (2) – (1)	PERCENTAGE PER REDUCTION
(YR.)	(CFS)	(CFS)	(FT)	(CFS)	%
2	**11.05**	**0.56**	**160.60**	**-10.49**	**94.9**
10	**20.06**	**4.09**	**160.97**	**-15.97**	**79.6**

The storage of the proposed aboveground basin 2 = **0.818 ac-ft.** The basin will store the runoff from North Avenue. It will also reduce the flood volume at the intersection of North Avenue/Tillotson Road. The preliminary construction cost for Area 2 drainage improvement is approximately 1.9 million dollars.

Area 3 - Basin 3

Proposed Basin 3 is a proposed underground R-Tank (UD) basin located underneath the Woodside Chapel parking lot, Fanwood Borough Block 75, Lot 1. The underground R-Tank basin bottom is at elevation 174.25 within a footprint of 0.545 Ac. The basin contains 40 rows of R-Tank and each row has 143 units. The height of the R-tanks is 4.60-ft. The storage of the proposed underground R-Tank Basin 3 = 1.618 ac-ft. The basin will store the overland and upstream Westfield Road runoff. It will also reduce the flood volume at the intersection of North Avenue, Midway Avenue, Morse Avenue and Westfield Road. The preliminary discharge rates from the existing and proposed scenarios are provided in **Table 3,** below.

TABLE 3 – BASIN 3 RESULTS

STORM FREQUENCY	PRE-DEVELOPED PEAK DISCHARGE RATE (1)	POST-DEVELOPED PEAK BASIN DISCHARGE RATE (2)	POST-DEVELOPED PEAK BASIN ELEVATION (3)	CHANGE IN PEAK DISCHARGE RATE (2) – (1)	PERCENTAGE PER REDUCTION
(YR.)	(CFS)	(CFS)	(FT)	(CFS)	%
2	**23.26**	**3.42**	**176.79**	**-19.84**	**71.5**
10	**39.50**	**18.26**	**177.58**	**-21.24**	**39.0**

The preliminary construction cost for Area 2 drainage improvement is approximately 3.1 million dollars.

VII. SUMMARY

The results of the preliminary hydrologic analyses of the four (4) flood control basins indicate that they all have the potential to provide a degree of flood storage and downstream attenuation, proportionate with their size. However, please note that the various input coefficients and results associated with the current analyses are preliminary, pending guidance from the Borough

regarding the feasibility of acquiring and utilizing these locations for flood control facilities, as well as assessing more site-specific topography to evaluate each site's ability to collect, store and discharge floodwaters via gravity.

Upon receiving guidance from the Borough regarding which lots can be realistically acquired, preliminary on-site survey will be performed. Should the topography prove favorable, more detailed input will be developed, and the hydrologic and hydraulic analyses will be re-calculated, in order to provide an indication of which basins would potentially be feasible for final design and permitting phases.