TOM'S CREEK FLOOD STUDY

Preliminary Hydrologic Report

FOR

THE TOWN OF CARRBORO
PUBLIC WORKS DEPARTMENT
May 16, 2016

Rainbow Drive on June 30, 2013

PREPARED BY:

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5/16/16

TOM'S CREEK FLOOD STUDY

I. Project Background

On June 30, 2013 heavy rainfall caused significant flooding in many areas of Carrboro, including along Tom's Creek. In response to this and other historical flooding events, the Carrboro Public Works Department commissioned Sungate Design Group (Sungate) to initiate Preliminary Hydrologic Studies to investigate this and other sites to determine potential causes of flooding and available mitigation measures for inclusion in the Town of Carrboro's CIP Budget. This included Hydrologic / Hydraulic analyses, interviews with affected property owners, possible mitigation efforts and associated costs. This information was presented to the Town of Carrboro BOA in May 2015 and January 2016. The BOA expressed concern that mitigating flooding problems at one specific location in the stream could cause flooding problems elsewhere downstream since the storage created by the flooding problem would be effectively removed. It was recommended that a Preliminary Hydrologic analysis be undertaken so that the Town could review and address potential downstream flooding issues prior to authorizing design of flood mitigation projects.

Therefore, the purpose of this Report is to evaluate alternatives that may eliminate or mitigate further flood damage to insurable structures along Tom's Creek between W. Main Street and just upstream of Rainbow Drive while investigating the impact these alternatives may have to downstream structures.

The total drainage area to West Main Street is 0.44 Sq. Mi. (284 Acres) (See Appendix A). Based on GIS mapping for the Town and the Preliminary FEMA Floodplain Mapping (DFIRM), which is currently under review by FEMA and is expected to become the Effective Mapping sometime during this coming year, there appear to be 21 dwellings and 1 detached garage/dwelling that are wholly or partially in the 100-year floodplain of Tom's Creek within the study area (See Appendix E). Following is a list of properties with dwellings in the floodplain of Tom's Creek:

302 Simpson St	208 James St	118 Carol St
100 James St	300 James St	200 Rainbow Dr
102 James St	404 James St	201 Rainbow Dr
104 James St	400 Lorraine St	101 Dove St
106 James St	401 Lorraine St	
200 James St	403 Lorraine St	
202 James St	105 Melba Cr	
204 James St	115 Carol St	
206 James St	116 Carol St	

II. Preliminary Data Gathering

Sungate obtained available Town of Carrboro GIS, zoning and contour data to use in creating a base map and information to be used in the analysis. The NRCS Soil Survey for Orange County was referenced to determine the hydrologic soil types for the watershed area. The stream location, FEMA cross-sections and the Preliminary FEMA 100 Year Floodplain boundary were downloaded from the NC Floodplain Mapping Program (NCFMP) website along with the Preliminary FEMA Hec-Ras Hydraulic model. As stated above, the Preliminary FEMA Flood Insurance Study (FIS) is currently under review by FEMA and is expected to become the Effective FIS sometime during the coming year.

III. Field Reconnaissance and Survey

Sungate visited the existing crossings along Tom's Creek in the study area to visually observe the site and to gather detailed field surveys of the existing cross-pipes, stream cross-sections and roadway profiles for overtopping.

The following are the size of the existing cross-pipes found during the course of the Sungate surveys.

W. Main Street:	1 @ 6' x 6' Box Culvert
Lorraine Street:	1 @ 66" Corrugated Pipe
Carol Street:	2 @ 36" Concrete Pipes
Rainbow Drive:	2 @ 30" Concrete Pipes

The cross-pipes at Carol Street were found to be in poor condition. In one of the barrels, there is a major separation in the last joint of the pipe on the downstream side of the culvert. It appears that the last joint of the pipe has completely separated from the rest of the culvert due to failure of the supporting bed material under the pipe. The separation may be large enough to allow stormwater to flow out into the surrounding soil and further erode the bedding around the pipe. Over time, this could cause the last joint of the pipe to collapse into the outlet stream channel, which would lead to failure of the fill slope of the road and compromise the integrity of the roadbed. In the other barrel, it appears that there is joint separation occurring; however, not as severe.

The cross-pipe at Lorraine Street was found to be in poor condition with a corroded invert and sectional deformity likely caused by structural overload.

Sungate participated in the stream property owner survey undertaken by the Town after the June 30, 2013 flood event. This survey consisted of interviewing property owners affected by the flooding of Tom's Creek and observing the affected properties. There were five separate meetings during July and August, 2013 where property owners provided information regarding the elevation of the flooding and showed damage caused by the flooding. Based on the results of the survey, there were six of the twenty-one

dwellings shown to be in the 100-year floodplain on the Preliminary DFIRM that suffered flood related damage during the storm event. Below is a list of these properties:

100 James Street
115 Carol Street
400 Lorraine Street
116 Carol Street
118 Carol Street
200 Rainbow Drive

IV. Preliminary Engineering Evaluation

Hydrologic Study:

The drainage area for the study area was delineated at each of the crossings using available contour data and information from the Carrboro stormwater inventory. The delineated area was then field verified. The drainage area was subdivided into smaller sub-basins and the soil types were found for each sub-basin using the NRCS Soil Survey for Orange County (See Appendix B). The existing land use data such as residential lot size, commercial, street area and open space were found using the Carrboro GIS data. For areas that have not been fully developed, the Carrboro Zoning Map was used (See Appendix C).

A hydrologic model of the drainage basin was completed using HydroCAD. HydroCAD is a computer aided design system used to model hydrology and hydraulics of stormwater runoff. The program is based on hydrology techniques developed by the SCS (NRCS) and models complex watersheds to determine peak flows for a given rainfall event. These techniques are used to generate hydrographs throughout the watershed.

Initially, the peak discharge rates for the existing conditions were determined using the SCS Method for several 24-hour storm recurrence intervals based on rainfall data for Orange County from NRCS. The resulting peak discharge rates were much larger than anticipated and produced flood elevations much higher than any historically documented flood levels in the drainage basin. Based on numerous discussions with residents in the drainage basin, the storm event on June 30, 2013 was the highest documented event in the past 30-years more so than Hurricane Fran, Hurricane Floyd, or Tropical Storm Jerry. The HydroCAD model was then calibrated to closely approximate the peak discharge rates and corresponding documented flood elevations for the June 30, 2013 storm event.

Below are the peak discharge rates from the HydroCAD model for the calibrated historical June 30, 2013 storm event and the 2-inch total rainfall 24-hour storm event. The 2-inch rainfall event was chosen to demonstrate the impact a more common storm event would have on the dwellings within the floodplain.

Street	Drainage Area (acres)	Calibrated Existing HydroCAD 6-30-2013 Storm (cfs)	Existing HydroCAD 2-inch 24-Hour Storm (cfs)
Rainbow Dr	126 acres	218	37
Carol St	145 acres	195	42
Lorraine St	227 acres	280	67
W. Main St	284 acres	266	77

Based on field survey of the existing cross-pipes and the visual observation of the surrounding area, Sungate determined that there were several locations where there is significant passive detention within the watershed due to undersized cross-pipes. These include the cross-pipes at Lorraine Street, Carol Street, Rainbow Drive and Quail Roost. The existing detention basins located in the southeast corner of the McDougle Middle School and within the school parking lot were also included in the model. The information used to describe the available volume at these locations was found using available contour data and the stage storage computations from the original stormwater design for the school. The data used for the McDougle Middle School existing detention basins assumed that they had been properly maintained.

Hydraulic Study:

The FEMA HEC-RAS model for the Preliminary FIS was obtained from NCFMP and used as the starting basis for the hydraulic analysis. Additional cross-sections were added to the HEC-RAS model. The field survey data for the W. Main Street, Lorraine Street, Coral Street and Rainbow Drive was used to update or verify the cross-pipes and roadway profile at each of these locations. The peak discharges found using the HydroCAD models were placed in the HEC-RAS model for the existing condition and each of the Alternatives.

It should be noted, that in the previous Preliminary Engineering Report that investigated possible causes of flooding and mitigation for Tom's Creek, the Effective FEMA HEC-RAS model was used for the analysis. At the time that the Preliminary Engineering Report was begun, the Preliminary FEMA HEC-RAS model for the updated study was not available.

The discharges found from the HydroCAD model for the June 30, 2013 and 2-inch total rainfall Storms were placed in the updated HEC-RAS model. Sungate then ran the HEC-RAS model for the existing conditions to produce the water surface elevations for each of these storms and thus create a base line for comparison with alternative cross-pipe sizes at the Lorraine Street, Carol Street and Rainbow Drive crossings.

V. Results of Hydraulic Analysis

Sungate's study of the impacts from the water surface elevations were confined to dwellings and garages. We did not investigate whether other insurable structures such as sheds would be impacted. It was considered an impact on a dwelling or garage if the water surface touched the structure regardless of how deep the water was at the structure.

Existing Conditions:

The following number of dwellings/garages were impacted under the existing conditions model.

2-inch Storm	Calibrated Storm
0	10

Finished Floor Elevation: There is 1 house that is impacted above the Finished Floor Elevation (FFE). 116 Carol Street is impacted during the Calibrated Storm Event.

Finished Basements: There are 2 houses with Finished Basements. These are located at 206 James Street and 100 James Street. Both of these Finished Basements are impacted during the Calibrated Storm Event.

Garages: There are 2 houses where the garage will be impacted. The garages located at 204 James Street and 403 Lorraine Street are impacted during the Calibrated Storm Event.

Twelve different alternatives were analyzed with differing variations in pipe size to determine how much, if any, change in impact that the alternatives would have on the dwellings located within the Tom's Creek floodplain between W. Main Street and the James Street crossing. Of the twelve alternatives, most produced similar results. Therefore, three alternatives were chosen that in Sungate's opinion had the greatest reduction in impact to some of the dwellings within the floodplain, while having the least additional impact to other dwellings.

Alternative #1:

Alternative #1 would upgrade the culverts on Rainbow Drive, Carol Street and Lorraine Street. These upgrades consist of 1 @ 72" RCP at Rainbow Drive, 1 @ 72" RCP at Carol Street and 1 @ 96" RCP at Lorraine Street.

The following number of dwellings/garages were impacted under Alternative #1.

2-inch Storm	Calibrated Storm
0	10

Finished Floor Elevation: There are 2 houses that are impacted above the Finished Floor Elevation (FFE). 116 Carol Street and 102 James Street are impacted during the Calibrated Storm Event. *There is a 1.3 feet increase in flood level at 102 James Street during the calibrated storm.*

Finished Basements: There is 1 house, located at 100 James Street, with a Finished Basement that is impacted during the Calibrated Storm Event. *The Finished Basement at 206 James Street is no longer impacted in this alternative.*

Garages: There is 1 house, located at 403 Lorraine Street, where the garage will be impacted during the Calibrated Storm Event. *The impact to the garage at 204 James Street is no longer impacted in this alternative.*

Alternative #2:

Alternative #2 would upgrade the culverts on Rainbow Drive, Carol Street and Lorraine Street. These upgrades consist of 2 @ 66" RCP at Rainbow Drive, 2 @ 66" RCP at Carol Street and 1 @ 96" RCP at Lorraine Street.

The following number of dwellings/garages were impacted under Alternative #2.

2-inch Storm	Calibrated Storm
0	9

Finished Floor Elevation: There are 2 houses that are impacted above the Finished Floor Elevation (FFE). 116 Carol Street and 102 James Street are impacted during the Calibrated Storm Event. *There is a 2.0 feet increase in flood level at 102 James Street during the calibrated storm.*

Finished Basements: There are 2 houses with Finished Basements that are impacted at 206 James Street and 100 James Street during the Calibrated Storm Event.

Garages: There is 1 house, located at 403 Lorraine Street, where the garage will be impacted during the Calibrated Storm Event. *The impact to the garage at 204 James Street is no longer impacted in this alternative.*

Alternative #3:

Alternative #3 would keep the existing culverts at Rainbow in the current configuration and upgrade the culverts on Carol Street and Lorraine Street. These upgrades consist of 2 @ 66" RCP at Carol Street and 1 @ 96" RCP at Lorraine Street.

The following number of dwellings/garages were impacted under Alternative #3.

2-inch Storm	Calibrated Storm
0	8

Finished Floor Elevation: There is 1 house, located at 102 James Street, that is impacted above the Finished Floor Elevation (FFE) during the Calibrated Storm Event. *The house at 116 Carol Street is no longer impacted above the FFE in this alternative. There is a 1.2 feet increase in flood level at 102 James Street during the calibrated storm.*

Finished Basements: There is 1 house, located at 100 James Street, with a Finished Basement that is impacted during the Calibrated Storm Event. *The Finished Basement at 206 James Street is no longer impacted in this alternative.*

Garages: There is 1 house, located at 403 Lorraine Street, where the garage will be impacted during the Calibrated Storm Event. *The Garage at 204 James Street is no longer impacted in this alternative.*

Alternative #4:

Providing detention or other infiltration devices in the watershed upstream of these crossings was also investigated. This included investigating the possibility of enlarging the existing detention basins located on the McDougle Middle School property. However, the enlargement of these existing detention basins had minimal impact on the downstream flood elevations. Concerning any other potential sites, no other areas were identified that were either owned by the Town or privately owned where there is sufficient open area to provide site detention or other infiltration devices that would significantly benefit the houses being impacted downstream.

Summary:

	Existing	Alt. #1	Alt. #2	Alt. #3
Rainbow Drive	2@30" RCP	1@72" RCP	2@66" RCP	Retain 2@30"
Carol Street	2@36" RCP	1@72" RCP	2@66" RCP	2@66" RCP
Lorraine Street	1@66" CMP	1@96" RCP	1@96" RCP	1@96" RCP

The following number of dwellings/garages were found to have floodwater above the FFE / garage elevation. In parenthesis are the number of dwellings where the floodwater is up on the foundation, but below the FFE / garage elevation.

	Existing	Alt. #1	Alt. #2	Alt. #3
June 30, 2013 Storm	5 (5)	4 (6)	5 (4)	3 (5)

All three of the Alternatives increase the amount of discharge downstream of Lorraine Street during the 2-inch and calibrated June 30, 2013 Storms. In all 3 alternatives, the FFE is impacted at 102 James Street where it was not impacted in the existing conditions.

Type of impact along with the change in the Calibrated Storm Event water surface elevation (ft):

	Existing	**Alt. #1**	**Alt. #2**	**Alt. #3**
101 Dove Street	Foundation	Foundation (-0.3)	No Impact (-1.8)	Foundation (0.0)
200 Rainbow Drive	Foundation	Foundation (-0.3)	No Impact (-2.2)	Foundation (0.0)
201 Rainbow Drive	No Impact	No Impact (0.0)	No Impact (-1.2)	No Impact (-1.7)
300 James Street	No Impact	No Impact (0.0)	No Impact (-1.2)	No Impact (-1.7)
118 Carol Street	No Impact	No Impact (-0.1)	No Impact (-2.2)	No Impact (-2.8)
116 Carol Street	FFE	FFE (-0.1)	FFE (-1.9)	Foundation (-2.5)
115 Carol Street	No Impact	No Impact (+0.4)	No Impact (+0.7)	No Impact (+0.3)
208 James Street	No Impact	No Impact (-2.5)	No Impact (-1.9)	No Impact (-3.1)
206 James Street	Basement	Foundation (-2.6)	Basement (-1.9)	No Impact (-3.1)
204 James Street	Garage	Foundation (-2.6)	Foundation (-2.0)	No Impact (-3.2)
400 Lorraine Street	Foundation	Foundation (-2.6)	Foundation (-2.0)	Foundation (-3.3)
202 James Street	No Impact	No Impact (-2.6)	No Impact (-2.0)	No Impact (-3.3)
200 James Street	Foundation	No Impact (-2.6)	No Impact (-2.0)	No Impact (-3.3)
401 Lorraine Street	No Impact	No Impact (+1.1)	No Impact (+1.7)	No Impact (+0.9)
109 Mary Street	No Impact	No Impact (+1.1)	No Impact (+1.7)	No Impact (+0.9)
107 Mary Street	No Impact	No Impact (+1.2)	No Impact (+1.8)	No Impact (+1.1)
403 Lorraine Street	Garage	Garage (+1.3)	Garage (+2.0)	Garage (+1.2)
106 James Street	No Impact	No Impact (+1.3)	Foundation(+2.0)	No Impact (+1.2)
104 James Street	No Impact	Foundation(+1.3)	Foundation(+2.0)	Foundation(+1.1)
102 James Street	Foundation	FFE (+1.3)	FFE (+2.0)	FFE (+1.2)
100 James Street	Basement	Basement (+1.3)	Basement (+2.0)	Basement (+1.2)
302 Simpson Street	No Impact	No Impact (+1.3)	No Impact (+2.2)	No Impact (+1.1)

Impact – Dwelling is impacted by floodwater.
No Impact – Dwelling is not impacted by floodwater.
*** See Appendix D for more detailed information on water surface elevations and impacts to structures.*

Tom's Creek

Impact to foundation, but below Finished Floor Elevation
Impact above the Finished Floor Elevation
Impact to Finished Basement, but below Finished Floor Elevation
Impact to Garage, but below Finished Floor Elevation

Dwelling	Existing	Alt #1	Alt #2	Alt #3
101 Dove St	**Impact**	**Impact**	---	**Impact**
200 Rainbow Dr	**Impact**	**Impact**	---	**Impact**
Rainbow Dr	2-30" RCP	1-72" RCP	2-66" RCP	No Change
201 Rainbow Dr	---	---	---	---
300 James St	---	---	---	---
118 Carol St	---	---	---	---
116 Carol St	**Impact**	**Impact**	**Impact**	**Impact**
Carol St	2-36" RCP	1-72" RCP	2-66" RCP	2-66" RCP
115 Carol St	---	---	---	---
107 Melba Cir	---	---	---	---
105 Melba Cir	---	---	---	---
208 James St	---	---	---	---
206 James St	**Impact**	**Impact**	**Impact**	---
204 James St	**Impact**	**Impact**	**Impact**	---
400 Lorraine St	**Impact**	**Impact**	**Impact**	**Impact**
202 James St	---	---	---	---
200 James St	**Impact**	---	---	---
Lorraine St	1-66" CMP	1-96" RCP	1-96" RCP	1-96" RCP
401 Lorraine St	---	---	---	---
109 Mary St	---	---	---	---
107 Mary St	---	---	---	---
403 Lorraine St	**Impact**	**Impact**	**Impact**	**Impact**
106 James St	---	---	**Impact**	---
104 James St	---	**Impact**	**Impact**	**Impact**
102 James St	**Impact**	**Impact**	**Impact**	**Impact**
100 James St	**Impact**	**Impact**	**Impact**	**Impact**
302 Simpson St	---	---	---	---

VI. Conclusions

Based on the above information and computations, it does not appear that a single solution exists that will decrease flooding impacts for all affected property owners. The number of property owners that are potentially impacted by flooding along Tom's Creek and the number of existing road crossings make this a complex issue. The model indicates that reduction in flood elevations upstream will likely cause an increase in flood elevations downstream. Potentially significant reductions in flood impacts can be achieved, but the improvements will not be without increased impacts elsewhere. The Town must consider whether increased impacts on a few properties will be worth the tradeoff for an overall reduction in flooding occurrences.

Based on the study results, Sungate recommends Alternative #3. This alternative will need to also include some type of mitigation measures for the dwellings that are adversely impacted by the increased flood elevations. This could include FEMA buyouts, raising the elevation of the dwellings, or other measures.

	Existing	Alt. #1	Alt. #2	**Alt. #3**
Rainbow Drive	2@30" RCP	1@72" RCP	2@66" RCP	Retain 2@30"
Carol Street	2@36" RCP	1@72" RCP	2@66" RCP	2@66" RCP
Lorraine Street	1@66" CMP	1@96" RCP	1@96" RCP	1@96" RCP

It appears that most of the structures that are experiencing flooding in this study were built in the natural floodplain. This is evident by modeling the removal of all road crossing (Rainbow, Carol, Lorraine, and West Main Street). Floodplains are vital to the stability of streams and their ability to abate downstream flooding. Floodplains do get flooded as part of a properly functioning and healthy stream. Due to this, even the best-case alternative studied is not capable of eliminating the threat of flooding to all of the dwellings in the study.

Sungate makes no claims or representations that the June 30, 2013 is the ultimate storm event. Even with implementation of the recommended alternative, it is feasible that a larger storm event could cause flood damage to many of the dwellings located in the floodplain. Several of the dwellings are upstream of a road crossing with the finished floor elevation below the roadway sag overtopping elevation.

It is also recommended that these flooding events be added to the Town's list of flooding problems and to be evaluated for inclusion in one of the tiers (TBD).

VII. FEMA

The FEMA Effective Flood Insurance Study (FIS) is dated February 2, 2007 and is currently being restudied. The restudy is referred to as the Preliminary Study and is currently in the public comments phase.

In comparing the discharges from the different models, it was found that the Preliminary FEMA discharges are much larger than those used in the Effective FEMA HEC-RAS model and those obtained from the HydroCAD calibrated June 30, 2013 storm.

Street	Calibrated Existing HydroCad 6-30-2016 Storm (cfs)	FEMA Preliminary (cfs)	FEMA Effective (cfs)	USGS SIR 2014-5030 (20% Impervious) (cfs)
Rainbow Dr	218	445	278	228
Carol St	195	445	401	255
Lorraine St	280	668	525	366
W Main St	266	705	525	438

The peak discharges shown above from the FEMA Preliminary and FEMA Effective are different from one another because they each use a different method for determining the hydrology. According to the FIS, the Effective FEMA discharges were determined using the flood flow-frequency methods developed by USGS (1965). The Preliminary FEMA discharges were found using the USGS Urban Regression equations (FS-007-00) using an impervious cover of 20%. The HydroCAD model uses the SCS method which utilizes the 24-hour storm with land use and soil type inputs and was calibrated using the June 30, 2013 storm event. The HydroCAD model also considers the timing of the storm along with detention in the watershed.

The USGS has released an updated report (SIR 2014-5030) that contains new Urban Regression equations. Using these new equations with an impervious cover of 20%, the resulting peak discharge rates are much closer to those determined from the calibrated HydroCAD model. Should the Town elect to move forward with any of the pipe replacement projects, a Conditional Letter of Map (CLOMR) will need to be prepared and submitted to the North Carolina Floodplain Mapping Program (NCFMP). Sungate intends to use the discharge rates from USGS SIR 2014-5030 in the CLOMR submittal to NCFMP should the Town elect to move forward. These discharge rates will likely produce flood elevations different from those obtained in this study. **It is not the intent of this study to determine floodplain limits as it relates to FEMA.**

8/17/99

REVISIONS

APPENDIX A
TOMS CREEK DRAINAGE AREA

PROJECT REFERENCE NO.	SHEET NO.
R/W SHEET NO.	
ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER

250 125 0 250 500
PLANS

5/5/2016
TOMS CREEK_Appendix A.dgn
wjones

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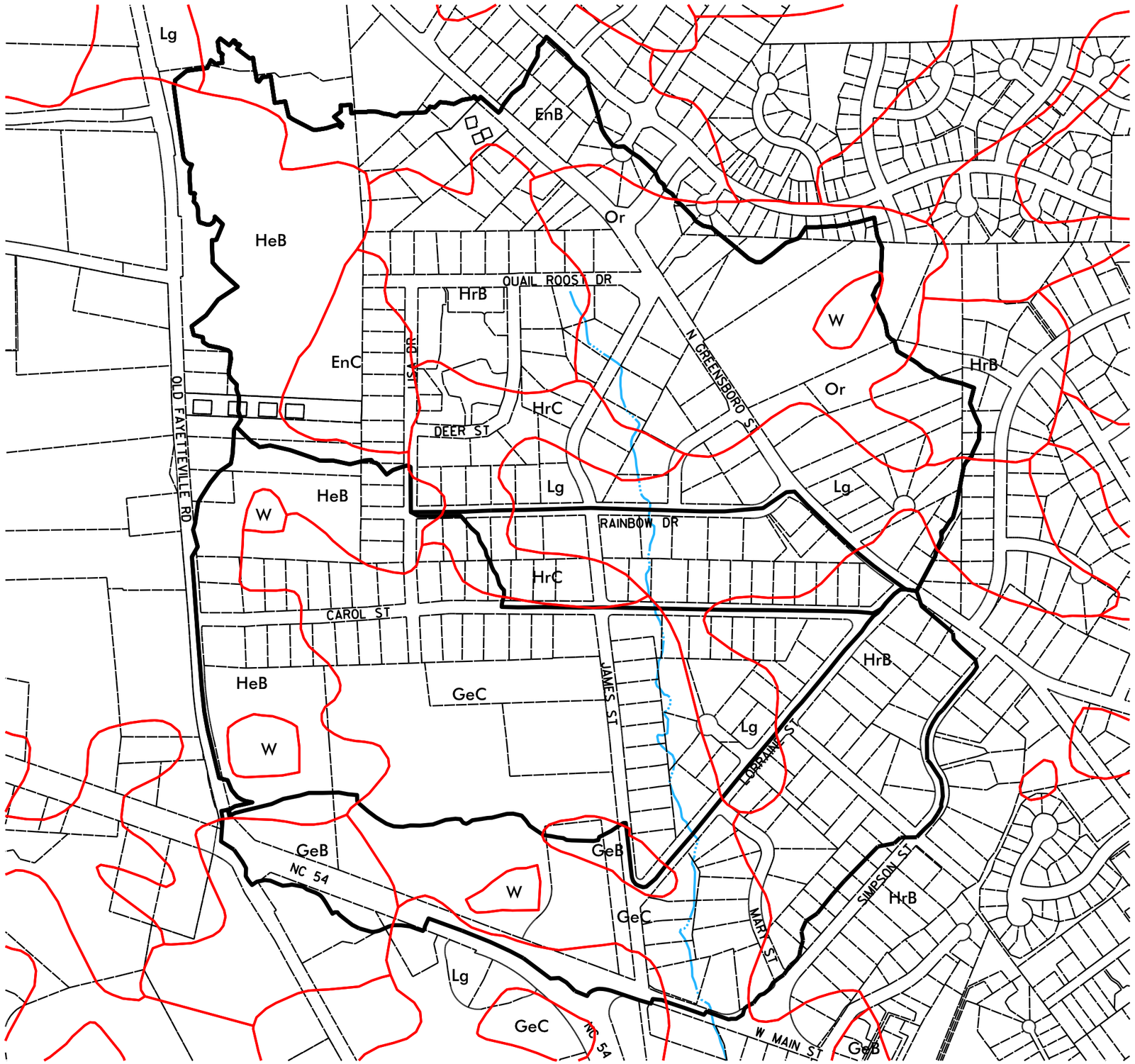
APPENDIX B
TOMS CREEK SOILS

PROJECT REFERENCE NO.	SHEET NO.
R/W SHEET NO.	
ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER



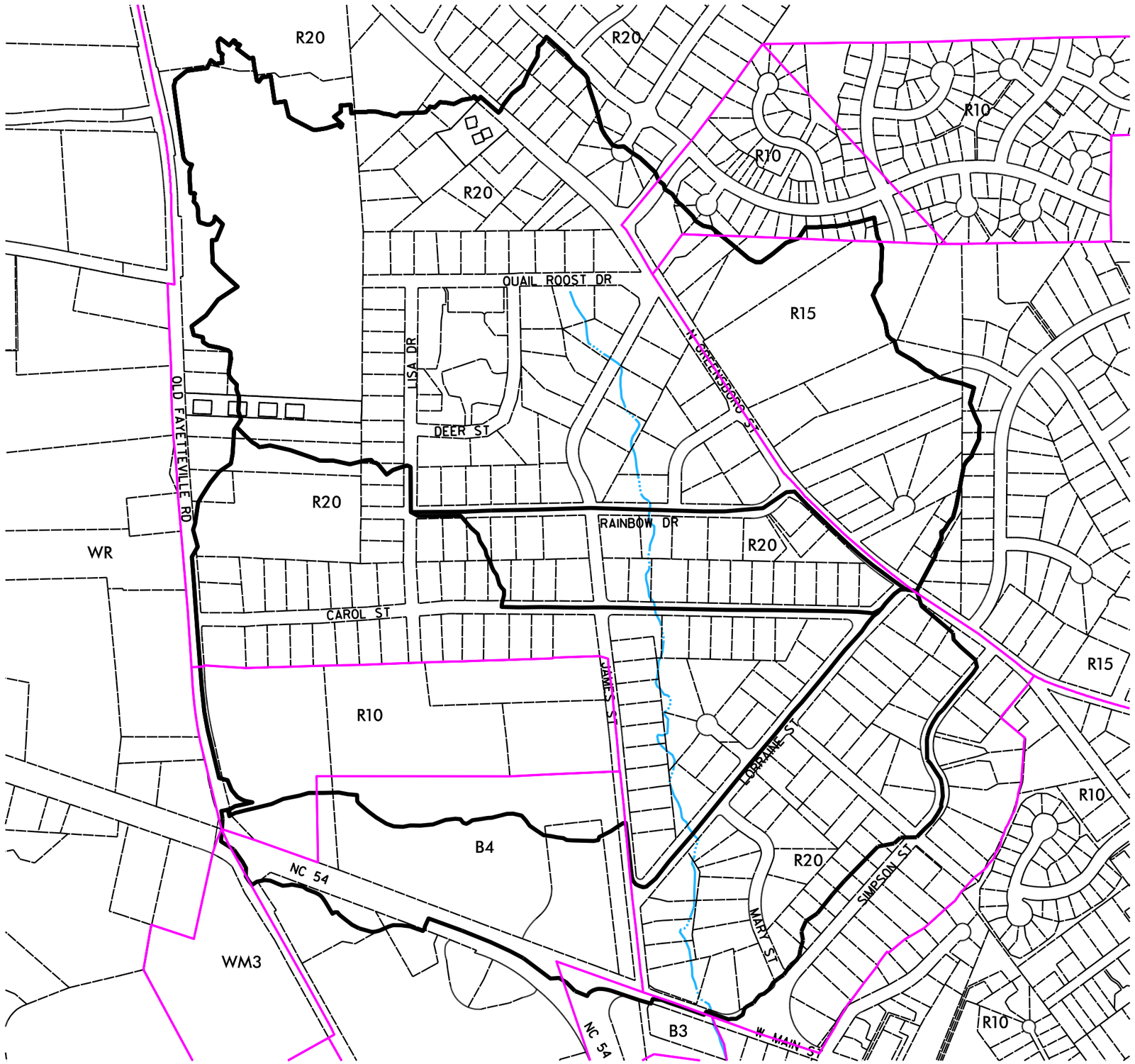
250 125 0 250 500
PLANS

REVISIONS

5/5/2016
TOMS CREEK_Appendix B.dgn

PROJECT REFERENCE NO.	SHEET NO.
R/W SHEET NO.	
ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER

APPENDIX C
TOMS CREEK ZONING



250 125 0 250 500
PLANS

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TOMS CREEK_Appendix C.dgn

Appendix D

NG	Indicates that flood water is up on the foundation, but below the Finished Floor Elevation.
FFE	Indicates that flood water is up above the finished floor elevation.
FFB	Indicates that flood water is above the Finished Basement Elevation, but below the Finished Floor Elevation.
Garage	Indicates that flood water is above the Garage Floor Elevation.

Decrease
Increase

Rainbow Dr	2 @ 30" RCP	1 @ 72" RCP	2 @ 66" RCP	Leave Existing 2 @ 30" RCP
Carol St	2 @ 36" RCP	1 @ 72" RCP	2 @ 66" RCP	2 @ 66" RCP
Lorraine St	1 @ 66" CMP	1 @ 96" RCP	1 @ 96" RCP	1 @ 96" RCP

		River Sta	Profile	Existing W.S. Elev (ft)		Alternate 1 W.S. Elev (ft)	Diff. (ft)		Alternate 2 W.S. Elev (ft)	Diff. (ft)	Alternate 3 W.S. Elev (ft)	Diff. (ft)	
		14111	2" Storm	475.52		475.48	0.0		475.48	0.0	475.48	0.0	
		14111	4.4" Storm	475.88		475.88	0.0		475.88	0.0	475.88	0.0	
		13876	2" Storm	471.94		471.94	0.0		471.94	0.0	471.94	0.0	
		13876	4.4" Storm	473.44		473.44	0.0		473.44	0.0	473.44	0.0	
		13827	2" Storm	471.42		471.42	0.0		471.42	0.0	471.42	0.0	
		13827	4.4" Storm	473.40		473.40	0.0		473.40	0.0	473.40	0.0	
	James St	13796											
		13761	2" Storm	470.22		470.22	0.0		470.22	0.0	470.22	0.0	
		13761	4.4" Storm	471.12		471.12	0.0		471.12	0.0	471.12	0.0	
		13622	2" Storm	467.82		467.82	0.0		467.82	0.0	467.82	0.0	
		13622	4.4" Storm	469.19		469.19	0.0		469.19	0.0	469.19	0.0	
	Driveway	13597											
		13579	2" Storm	467.10		467.10	0.0		467.10	0.0	467.10	0.0	
		13579	4.4" Storm	468.03		468.03	0.0		468.03	0.0	468.03	0.0	
House - 1	NG 464.52	13236	2" Storm	461.05		461.04	0.0		460.98	-0.1	461.02	0.0	
101 Dove St	FFE 467.65	13236	4.4" Storm	464.86		464.59	-0.3		463.10	-1.8	464.87	0.0	
House - 2	NG 463.11	13121	2" Storm	460.63		460.65	0.0		460.29	-0.3	460.60	0.0	
200 Rainbow Dr	FFE 468.09	13121	4.4" Storm	464.83		464.55	-0.3		462.64	-2.2	464.84	0.0	
	Garage 464.96												
		13057	2" Storm	460.51		460.54	0.0		459.85	-0.7	460.47	0.0	
		13057	4.4" Storm	464.82	OT	464.42	-0.4		462.22	-2.6	464.83	0.0	OT
	Rainbow Dr	13029		2 @ 30" RCP		**1 @ 72" RCP**			**2 @ 66" RCP**		**2 @ 30" RCP**		
	OT Elev = 464.45												
		12998	2" Storm	457.30		457.30	0.0		457.29	0.0	457.29	0.0	
		12998	4.4" Storm	460.78		460.79	0.0		459.95	-0.8	459.44	-1.3	
House - 3	NG 461.16												
201 Rainbow Dr	FFE 470.96												
House - 4	NG 463.43	12824	2" Storm	456.98		457.01	0.0		456.99	0.0	456.99	0.0	
300 James St	FFE 466.93	12824	4.4" Storm	460.72		460.70	0.0		459.52	-1.2	459.05	-1.7	
	Garage 461.93												
House - 5	NG 460.93	**12635**	2" Storm	456.27		456.47	0.2		455.98	-0.3	455.98	-0.3	
118 Carol St	FFE 464.99	**12635**	4.4" Storm	460.66		460.60	-0.1		458.51	-2.2	457.86	-2.8	
House - 6	NG 458.02	12607	2" Storm	456.28		456.49	0.2		455.94	-0.3	455.94	-0.3	
116 Carol St	FFE 458.64	12607	4.4" Storm	460.69		460.64	-0.1		458.83	-1.9	458.20	-2.5	
		12576	2" Storm	456.21		456.44	0.2		455.66	-0.5	455.66	-0.5	
		12576	4.4" Storm	460.68	OT	460.63	-0.1	OT	458.44	-2.2	457.84	-2.8	
	Carol St	12544		2 @ 36" RCP		**1 @ 72" RCP**			**2 @ 66" RCP**		**2 @ 66" RCP**		
	OT Elev = 460.53												
		12513	2" Storm	453.69		453.69	0.0		453.69	0.0	453.69	0.0	
		12513	4.4" Storm	455.18		455.45	0.3		455.64	0.5	455.34	0.2	

Appendix D

NG	Indicates that flood water is up on the foundation, but below the Finished Floor Elevation.
FFE	Indicates that flood water is up above the finished floor elevation.
FFB	Indicates that flood water is above the Finished Basement Elevation, but below the Finished Floor Elevation.
Garage	Indicates that flood water is above the Garage Floor Elevation.

Decrease	
Increase	

Rainbow Dr	2 @ 30" RCP	1 @ 72" RCP	2 @ 66" RCP	Leave Existing 2 @ 30" RCP
Carol St	2 @ 36" RCP	1 @ 72" RCP	2 @ 66" RCP	2 @ 66" RCP
Lorraine St	1 @ 66" CMP	1 @ 96" RCP	1 @ 96" RCP	1 @ 96" RCP

		River Sta	Profile	Existing W.S. Elev (ft)		Alternate 1 W.S. Elev (ft)	Diff. (ft)	Alternate 2 W.S. Elev (ft)	Diff. (ft)	Alternate 3 W.S. Elev (ft)	Diff. (ft)
House - 7	NG 454.97	**12442**	2" Storm	452.34		452.34	0.0	452.34	0.0	452.34	0.0
115 Carol St	FFE 455.80	**12442**	4.4" Storm	453.85		454.30	0.4	454.55	0.7	454.17	0.3
		12377	2" Storm	450.40		450.33	-0.1	450.34	-0.1	450.34	-0.1
		12377	4.4" Storm	451.41		451.89	0.5	452.09	0.7	451.79	0.4
		12170	2" Storm	446.55		446.66	0.1	446.65	0.1	446.65	0.1
		12170	4.4" Storm	450.23		448.11	-2.1	448.36	-1.9	447.97	-2.3
House - 8	NG 450.88	11753	2" Storm	444.70		444.35	-0.3	444.37	-0.3	444.37	-0.3
208 James St	FFE 455.84	11753	4.4" Storm	450.26		447.72	-2.5	448.33	-1.9	447.16	-3.1
House - 9	NG 447.40		2" Storm	444.62		444.13	-0.5	444.15	-0.5	444.20	-0.4
206 James St	FFE 456.56		4.4" Storm	450.26		447.69	-2.6	448.31	-1.9	447.11	-3.1
	FFB 447.88										
House - 10	NG 447.40		2" Storm	444.49		443.79	-0.7	443.79	-0.7	443.80	-0.7
204 James St	FFE 456.97		4.4" Storm	450.25		447.65	-2.6	448.28	-2.0	447.03	-3.2
	Garage 448.32										
House - 11	NG 446.76	**11457**	2" Storm	444.43		443.62	-0.8	443.62	-0.8	443.62	-0.8
400 Lorraine St	FFE 450.54	**11457**	4.4" Storm	450.25		447.61	-2.6	448.26	-2.0	446.99	-3.3
House - 12	NG 450.59	11382	2" Storm	444.39		443.47	-0.9	443.47	-0.9	443.47	-0.9
202 James St	FFE 451.86	11382	4.4" Storm	450.25		447.60	-2.6	448.25	-2.0	446.97	-3.3
House - 13	NG 449.92	11382	2" Storm	444.39		443.47	-0.9	443.47	-0.9	443.47	-0.9
200 James St	FFE 455.32	11382	4.4" Storm	450.25		447.60	-2.6	448.25	-2.0	446.97	-3.3
		11368	2" Storm	444.36		443.39	-1.0	443.39	-1.0	443.39	-1.0
		11368	4.4" Storm	450.25	OT	447.26	-3.0	447.89	-2.4	446.66	-3.6
	Lorraine St	11329		1 @ 66" CMP		**1 @ 96" RCP**		**1 @ 96" RCP**		**1 @ 96" RCP**	
	OT Elev = 450.01										
House - 14	NG 445.43	11294	2" Storm	442.24		442.30	0.1	442.30	0.1	442.30	0.1
401 Lorraine St	FFE 449.70	11294	4.4" Storm	443.22		444.29	1.1	444.90	1.7	444.16	0.9
House - 15	NG 446.86		2" Storm	442.24		442.30	0.1	442.30	0.1	442.30	0.1
109 Mary St	FFE 450.62		4.4" Storm	443.22		444.29	1.1	444.90	1.7	444.16	0.9
House - 16	NG 446.82		2" Storm	441.03		441.09	0.1	441.09	0.1	441.09	0.1
107 Mary St	FFE 451.74		4.4" Storm	443.02		444.21	1.2	444.86	1.8	444.08	1.1
House - 17	NG 442.98	11012	2" Storm	439.82		439.87	0.1	439.87	0.1	439.87	0.1
403 Lorraine St	FFE 445.84	11012	4.4" Storm	442.83		444.12	1.3	444.81	2.0	443.99	1.2
	Garage 442.67										
House - 18	NG 444.26		2" Storm	439.82		439.87	0.1	439.87	0.1	439.87	0.1
106 James St	FFE 446.70		4.4" Storm	442.83		444.12	1.3	444.81	2.0	443.99	1.2
House - 19	NG 442.89		2" Storm	439.64		439.70	0.1	439.70	0.1	439.70	0.1
104 James St	FFE 446.52		4.4" Storm	442.80		444.10	1.3	444.79	2.0	443.95	1.1
House - 20	NG 442.50		2" Storm	439.49		439.54	0.1	439.54	0.1	439.54	0.1
102 James St	FFE 443.51		4.4" Storm	442.76		444.08	1.3	444.77	2.0	443.93	1.2

Appendix D

NG	Indicates that flood water is up on the foundation, but below the Finished Floor Elevation.
FFE	Indicates that flood water is up above the finished floor elevation.
FFB	Indicates that flood water is above the Finished Basement Elevation, but below the Finished Floor Elevation.
Garage	Indicates that flood water is above the Garage Floor Elevation.

Decrease
Increase

Rainbow Dr	2 @ 30" RCP	1 @ 72" RCP	2 @ 66" RCP	Leave Existing 2 @ 30" RCP
Carol St	2 @ 36" RCP	1 @ 72" RCP	2 @ 66" RCP	2 @ 66" RCP
Lorraine St	1 @ 66" CMP	1 @ 96" RCP	1 @ 96" RCP	1 @ 96" RCP

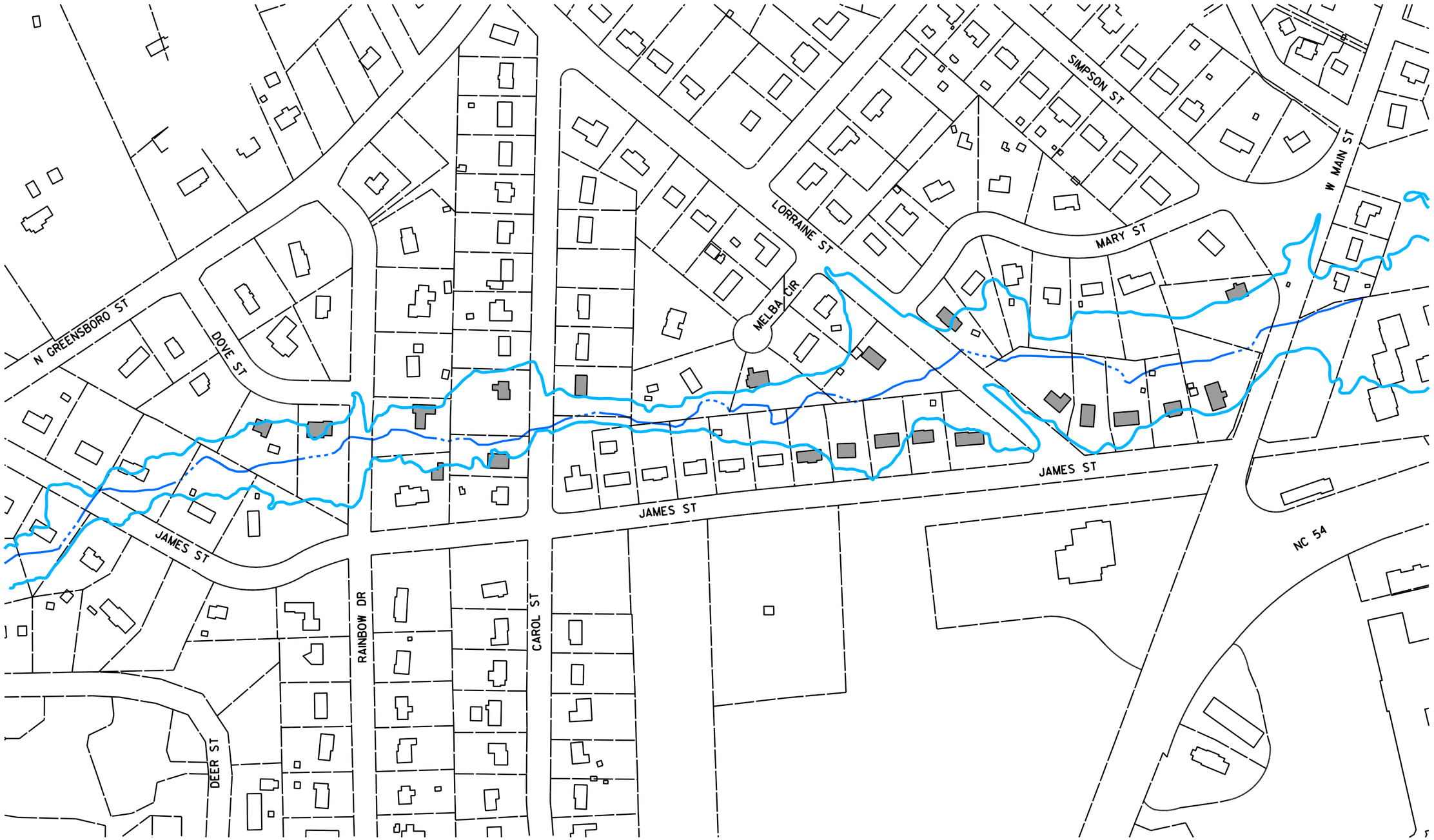
		River Sta	Profile	Existing W.S. Elev (ft)	Alternate 1 W.S. Elev (ft)	Diff. (ft)	Alternate 2 W.S. Elev (ft)	Diff. (ft)		Alternate 3 W.S. Elev (ft)	Diff. (ft)
House - 21	NG 440.72	10605	2" Storm	439.36	439.42	0.1	439.44	0.1		439.44	0.1
100 James St	FFE 448.33	10605	4.4" Storm	442.74	444.06	1.3	444.76	2.0		443.92	1.2
	FFB 439.83										
House - 22	NG 446.05	10439	2" Storm	439.25	439.31	0.1	439.33	0.1		439.33	0.1
302 Simpson St	FFE 449.62	10439	4.4" Storm	442.55	443.87	1.3	444.75	2.2	OT	443.70	1.1
	W. Main St	10395			1 @ 6' x 6' RCBC		1 @ 6' x 6' RCBC			1 @ 6' x 6' RCBC	
	OT Elev = 444.54										
		10346	2" Storm	438.85	438.89	0.0	438.9	0.0		438.90	0.0
		10346	4.4" Storm	440.65	441.09	0.4	441.17	0.5		441.06	0.4

APPENDIX E
TOMS CREEK

HOUSES WITHIN THE STUDY AREA THAT ARE IMPACTED
BY THE 100-YEAR FLOODPLAIN ARE SHADED.
(PRELIMINARY FEMA FIS)

125 62.5 0 125 250
PLANS

PROJECT REFERENCE NO.	SHEET NO.
R/W SHEET NO.	
ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER



REVISIONS

8/17/99

5/16/2016
TOMS CREEK_Appendix E.dgn

Lorraine Street

Downstream Face – 1 @ 66” Corrugated Metal Pipe

Looking Inside of Pipe

Lorraine Street

Looking Upstream

Looking Upstream at 400 Lorraine Street

Lorraine Street

Looking Downstream

Looking Downstream at 401 Lorraine Street

Carol Street

Upstream Face – 2 @ 36” Concrete Pipes

Looking inside 36” Concrete Pipe – Pipe Separation

Carol Street

Looking Upstream at 116 Carol Street

116 Carol Street – Flooding December 2015

Carol Street

Looking Upstream at 118 Carol Street

Looking Downstream at 115 Carol Street

Rainbow Drive

Upstream Face – 2 @ 30” Concrete Pipes

Downstream Face – 2 @ 30” Concrete Pipes

Rainbow Drive

Looking Upstream at 200 Rainbow Drive

Looking Downstream at 201 Rainbow Drive

Rainbow Drive

Secondary Dwelling / Garage at 300 James Street